Thu. Jun 3, 2021

[E] Oral | U (Union)：Union

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.01 Zoom Room 01

[U-05] Special session for a borderless World of Geoscience (GEOethics)

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Brooks Hanson(American Geophysical Union), Takashi Furumura(Earthquake Research Institute The University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Brooks Hanson(American Geophysical Union), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Takashi Furumura(Earthquake Research Institute The University of Tokyo)

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

[U05-01] The AGU GeoHealth and Thriving Earth Exchange Programs: Engaging our Geoscience Community for a Sustainable Future

★Invited Papers

Brooks Hanson[1], Janice Lachance[1], Mark Shimamoto[1], Raj Pandya[1], *Billy M Williams[1] (1.American Geophysical Union)

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

[U05-02] Climate science and social values

★Invited Papers

*Seita Emori[1] (1.National Institute for Environmental Studies)

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

[U05-03] Transdisciplinary research on geoscience in society

★Invited Papers

*Makoto Taniguchi[1] (1.Research Institute for Humanity and Nature)

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

[U05-04] How can we effectively utilize atmospheric forecasts that include uncertainties?

★Invited Papers

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

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

[U05-05] Geodiversity and its conservation as a framing guideline for Geoethics in the 21st Century

★Invited Papers

*Abhik Chakraborty[1] (1.Wakayama University)

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

[U05-06] Communicating uncertainty of geoscience for the disaster risk reduction -Geoscience, the ambiguous, and ourselves-

★Invited Papers

*Satoko Oki[1] (1.Faculty of Environment and information Studies)

[E] Oral | U (Union)：Union

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.01 Zoom Room 01

[U-05] Special session for a borderless World of Geoscience (GEOethics)

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Brooks Hanson(American Geophysical Union), Takashi Furumura(Earthquake Research Institute The University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Brooks Hanson(American Geophysical Union), Kiyoshi Suyehiro(Japan Agency for Marine-Earth Science and Technology), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo)

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

[U05-07] Promoting equality, diversity and inclusion (EDI) in a global forum: benefits of joint borderless actions

★Invited Papers

*Claudia Jesus-Rydin[1], Helen Glaves (1.European Research Council)

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

[U05-08] The Key Role of Scientific Societies

★Invited Papers

*Brooks Hanson[1] (1.American Geophysical Union)

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

[U05-09] Promotion of Earth and Planetary Science by valuing diversity, equality, equity, and inclusion after CONVID-19

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

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

[U05-10] Discussion

[J] Oral | U (Union) : Union

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.01 Zoom Room 01

[U-06] Science Council of Japan in one hour: How it supports international organizations

convener:Nobuko Saigusa(National Institute for Environmental Studies), Takuji Nakamura(National Institute of Polar Research), Shigeko Haruyama(Mie University .Emeritus Prof.), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Takuji Nakamura(National Institute of Polar Research), Nobuko Saigusa(National Institute for Environmental Studies)

1:45 PM - 1:55 PM JST | 4:45 AM - 4:55 AM UTC

[U06-01] Introduction

1:55 PM - 2:00 PM JST | 4:55 AM - 5:00 AM UTC

[U06-02] Achievements and Prospects of the Committee on Space Research (COSPAR): Promoting International Activities through the Science Council of Japan (SCJ)

*Takuji Nakamura[1], Masaki Fujimoto[2], Akiko Nakamura[3], Hajime Yano[2] (1.National Institute of Polar Research, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Graduate School of Science, Kobe University)

2:00 PM - 2:05 PM JST | 5:00 AM - 5:05 AM UTC

[U06-03] Achievements and Prospects of the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP): Promoting International Activities through the Science Council of Japan (SCJ)

*Kazuo Shiokawa[1], Yoshizumi Miyoshi[1], Akimasa Yoshikawa[2], Takuji Nakamura[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.International Center for Space Weather Science and Education, Kyusyu University, 3.National Institute of Polar Research)

2:05 PM - 2:10 PM JST | 5:05 AM - 5:10 AM UTC

[U06-04] Achievements and Prospects of the Scientific Committee on Antarctic Research (SCAR): Promoting International Activities through the Science Council of Japan (SCJ)

*Takuji Nakamura[1,2], Satoshi Imura[1,2], Gen Hashida[1,2] (1.National Institute of Polar Research, 2.SOKENDAI, the Graduate University for Advanced Studies)

2:10 PM - 2:15 PM JST | 5:10 AM - 5:15 AM UTC

[U06-05] Achievements and Prospects of the International Arctic Science Committee (IASC): Promoting International Activities through the Science Council of Japan (SCJ)

*Hiroyuki Enomoto[1] (1.National Institute of Polar Research)

2:15 PM - 2:20 PM JST | 5:15 AM - 5:20 AM UTC

[U06-06] Elucidating mechanisms of the ocean and its variations and changes-Activities of the Scientific Committee on Oceanic Research (SCOR) and Japan's contribution-

*Yukio Masumoto[1], Naomi Harada[2] (1.Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

2:20 PM - 2:25 PM JST | 5:20 AM - 5:25 AM UTC

[U06-07] Achievements and Prospects of the World Climate Research Programme (WCRP): Promoting International Activities through the SCJ

*Nobuko Saigusa[1] (1.National Institute for Environmental Studies)

2:25 PM - 2:30 PM JST | 5:25 AM - 5:30 AM UTC

[U06-08] Achievements and Prospects of the International Cartographic Association (ICA): Promoting International Activities through the Science Council of Japan (SCJ)

*Kaori Ito[1], Takashi Morita[2] (1.Tokyo University of Science, 2.Hosei University)

2:30 PM - 2:35 PM JST | 5:30 AM - 5:35 AM UTC

[U06-09] Achievements and Prospects of the International Geographical Union (IGU): Promoting International Activities through the Science Council of Japan (SCJ)

*Yasuhiro Suzuki[1] (1.Nagoya University)

2:35 PM - 2:40 PM JST | 5:35 AM - 5:40 AM UTC

[U06-10] Activities of INQUA (International Union for Quaternary Research) and Contributions from Japan

*Yoshiki Saito[1] (1.Estuary Research Center, Shimane University)

2:40 PM - 2:45 PM JST | 5:40 AM - 5:45 AM UTC

[U06-11] Achievements and Prospects of the International Mineralogical Association (IMA): Promoting International Activities through the Science Council of Japan (SCJ)

*Eiji Ohtani[1] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

2:45 PM - 2:50 PM JST | 5:45 AM - 5:50 AM UTC

[U06-12] Activities and Roles of International Union of Geodesy and Geophysics (IUGG): Standardization of Earth Observation and Models

*Kenji Satake[1], Kumiko Goto-Azuma[2], Masato Furuya[3], Takuji Nakamura[2], Toshio Koike[4], Maki Tsujimura[5], Hisashi Nakamura[6], Toshiyuki Hibiya[7], Keiko Kuge[8], Setsuya Nakada[9] (1.Earthquake Research Institute, University of Tokyo, 2.National Institute of Polar Research & SOKENDAI, 3.Earth and Planetary Science, Hokkaido University, 4.ICHARM, Public Works Research Institute, 5.Faculty of Life and Environmental Sciences, University of Tsukuba, 6.RCAST, University of Tokyo, 7.Earth and Planetary Science, The University of Tokyo , 8.Dept. of Geophysics, Kyoto University, 9.National Research Institute for Earth Science and Disaster Resilience)

2:50 PM - 2:55 PM JST | 5:50 AM - 5:55 AM UTC

[U06-13] International Union of Geological Sciences: its activities and social contributions

*Hiroshi Kitazato[1], Hiroshi Nishi[2] (1.Tokyo University of Marine Science and Technology (TUMSAT), 2.Fukui Prefectural University, Institute of Dinosaur Research)

2:55 PM - 3:15 PM JST | 5:55 AM - 6:15 AM UTC

[U06-14] Discussion

[J] Oral | U (Union)：Union

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.01 Zoom Room 01

[U-07] Open Science and Open Data in Academic Publishing from Japan

convener:Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo)

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

[U07-01] Advanced publication of scientific journals by JpGU and the related academic societies

★Invited Papers

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

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

[U07-02] Current status and issues of PEPS journal

★Invited Papers

*Eiji Ohtani[1] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

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

[U07-03] ”Earth, Planets and Space": The current status

★Invited Papers

*Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University)

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

[U07-04] STAM and STAM-M : Open Data and Open Science with Open Access Journal from Japan

★Invited Papers

*Masanobu NAITO[1] (1.National Institute for Materials Science)

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

[U07-05] Research data repository for journals “J-STAGE Data” launching

★Invited Papers

*Ritsuko Nakajima[1] (1.Japan Science and Technology Agency)

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

[U07-06] Norms in scholarly communication: changes brought by open science

★Invited Papers

*Nobuko Miyairi

[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 | Ch.02 Zoom Room 02

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Kevin McGouldrick(University of Colorado Boulder)

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[PPS02-01] Introduction

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[PPS02-02] Mission Concept Study for Japan's Next Venus Exploration

*Ryoma Yamashiro[1], Masato Nakamura[1], Chikako Hirose[1], Nobuaki Ishii[1], Ryoh Nakamura[1], Takehiro Matsumoto[1], Yuuki Akiyama[1], Junichi Nakatsuka[1], Kenta Goto[1], Hiroyuki Toyota[1], Tomoaki Toda[1], Atsushi Yamazaki[1], Takehiko Satoh[1], Takumi Abe[1], Toru Kouyama[2], Masataka Imai[2], Hideo Sagawa[3], Mitsuteru Sato[4], Yukihiro Takahashi[4], Makoto Taguchi[5], Tetsuya Fukuhara[5], Takao M. Sato[6], Shin-ya Murakami[7], Yoshi-Yuki Hayashi[8], Takeshi Imamura[9] (1.Japan Aerospace eXploration Agency, 2.National Institute of Advanced Industrial Science and Technology, 3.Kyoto Sangyo Univ., 4.Hokkaido Univ., 5.Rikkyo Univ., 6.Hokkaido Information Univ., 7.Keio Univ., 8.Kobe Univ., 9.Tokyo Univ.)

9:20 AM - 9:45 AM JST | 12:20 AM - 12:45 AM UTC

[PPS02-03] Venus Atmospheric Structure Investigation (VASI) on the Proposed DAVINCI+ Probe

★Invited Papers

*Ralph Lorenz[1], James Garvin[2], Natasha Johnson[2], Stephanie Getty[2], Giada Arney[2], Francois Forget[4], Sebastien Lebonnois[4], Noam Izenberg[1], David Atkinson[3], David Crisp[3] (1.Johns Hopkins University Applied Physics Laboratory, 2.NASA Goddard SpaceFlight Center, 3.Jet Propulsion Laboratory, 4.LMD, Universite de Paris)

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

[PPS02-04] Venus cloud-aerosol observation using Life-signature Detection Microscope (Venus LDM)

*Satoshi Sasaki[1], Akihiko Yamagishi[2], Yoshitaka Yoshimura[3], Keigo Enya[4], Atsuo Miyakawa[2], Sosuke Ohno[5], Kazuhisa Fujita[4], Tomohiro Usui[4], Sanjay Limaye[6] (1.Tokyo University of Technology, 2.Tokyo University of Pharmacy and Life Sciences, 3.Tamagawa University, 4.JAXA, 5.Chiba Institute of Technology, 6.University of Wisconsin)

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

[PPS02-05] Venus, an astrobiology target

*Sanjay S Limaye[1] (1.University of Wisconsin Madison)

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

[PPS02-06] Discussion

[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 | Ch.02 Zoom Room 02

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS02-07] Microphysics Implications of the Venus Bow Wave seen by LIR on Akatsuki

*Kevin McGouldrick[1] (1.Laboratory for Atmospheric and Space Physics, University of Colorado Boulder)

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

[PPS02-08] Barotropic instability and traveling linear features detected in the near-infrared images from Akatsuki

*Takeshi Horinouchi[1], Takehiko Satoh[2], Choon Wei Vun[2], Eliot F. Young[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.ISAS, 3.Southwest Research Institute)

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

[PPS02-09] Statistical analysis of the morphology of Venusian clouds

*Tomoya Suda[1], Takeshi Imamura[1] (1.Graduate School of Frontier Sciences, The University of Tokyo)

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

[PPS02-10] Simulation of sulfuric acid cloud distributions by a Venus GCM for the comparison with observations

*Hiroki Karyu[1], Takeshi Kuroda[1], Naoki Terada[1], Yasumasa Kasaba[1], Masaru Yamamoto[2], Masaaki Takahashi[3], Kohei Ikeda[4] (1.Tohoku University, 2.Kyushu University, 3.University of Tokyo, 4.National Institute for Environmental Studies)

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

[PPS02-11] A development of a broadband radiative transfer model "Mstrn-Venus" for Venus atmosphere

*Miho Sekiguchi[1], Reiko Kurihara[1], Naohiro Manago[2], Masahiro Takagi[3], Hideo Sagawa[3], Yoshihisa Matsuda[4] (1.Tokyo University of Marine Science and Technology, 2.Chiba University, 3.Kyoto Sangyo University, 4.Tokyo Gakugei University)

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

[PPS02-12] Discussion

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.02 Zoom Room 02

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Hideo Sagawa(Kyoto Sangyo University)

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[PPS02-13] Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[PPS02-14] Spatial distribution of HCl abundance at the cloud top of Venus retrieved from IRTF/iSHELL spectra

*Takao M. Sato[1], Hideo Sagawa[2] (1.Hokkaido Information University, 2.Kyoto Sangyo University)

2:05 PM - 2:30 PM JST | 5:05 AM - 5:30 AM UTC

[PPS02-15] Day-night contrast of the atmospheric circulation at the cloud top of Venus revealed by Akatsuki LIR

★Invited Papers

Kiichi Fukuya[1], *Takeshi Imamura[2], Makoto Taguchi[3], Tetsuya Fukuhara[3], Toru Kouyama[4], Takeshi Horinouchi[5], Javier Peralta[6], Masahiko Futaguchi[11], Takeru Yamada[3], Takao M. Sato[7], Atsushi Yamazaki[8], Shin-ya Murakami[10], Takehiko Satoh[8], Masahiro Takagi[9], Masato Nakamura[8] (1.Department of Earth and Planetary Science, The University of Tokyo, Japan, 2.Graduate School of Frontier Sciences, The University of Tokyo, Japan, 3.Rikkyo University, Japan, 4.Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, Japan, 5.Faculty of Environmental Earth Science, Hokkaido University, Japan, 6.Instituto de Astrofísica e Ciências do Espaço, Portugal, 7.Space Information Center, Hokkaido Information University, Japan, 8.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan, 9.Faculty of Science, Kyoto Sangyo University, Japan, 10.Research and Education Center for Natural Sciences, Keio University, 11.Omori Medical Center, Toho University, Japan)

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

[PPS02-16] Identification and characterization of quiescent cloud region "CALM" in the Akatsuki and Venus Express data

*Takehiko Satoh[1,2], Choon Wei Vun[3,2], Takeshi Horinouchi[4], Kevin McGouldrick[5], Takao M. Sato[6] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Dept of Space and Astronautical Science, SOKENDAI, 3.ZMP Inc., 4.Hokkaido University, 5.University of Colorado, Boulder, 6.Hokkaido Information University)

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

[PPS02-17] EnVision: Understanding why Earth's closest neighbour is so different

*Thomas Widemann[1], Richard Ghail[2], Colin Wilson[3], Dmitri Titov[4] (1.Observatoire de Paris, France, 2.Royal Holloway, U. of London, UK, 3.U. of Oxford, UK, 4.ESA-ESTEC, Noordwijk, Netherlands)

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

[PPS02-18] Discussion

[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 | Ch.01_1

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University)

[PPS02-P01] Observation and analysis of planetary lightning flashes using the ground-based telescope with Photomultiplier tube

*Tatsuharu Ono[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Shigeto Watanabe[1], Seiko Takagi[1], Masataka Imai[2] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 2.The National Institute of Advanced Industrial Science and Technology)

[PPS02-P02] Light curve recorded in Venus by LAC onboard Akatsuki

★Invited Papers

*Yukihiro Takahashi[1,4], Mitsuteru Sato[1,4], Masataka Imai[2], Ralph Lorenz[3], Tatsuharu Ono[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 2.The National Institute of Advanced Industrial Science and Technology (AIST), 3.Johns Hopkins Applied Physics Lab., 4.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

[PPS02-P03] Updates on the point-spread function of Akatsuki IR2 for improvement of night-side photometry

*Takehiko Satoh[1,2], Choon Wei Vun[3,2], Masafumi Kimata[4], Takao M. Sato[5] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Dept of Space and Astronautical Science, SOKENDAI, 3.ZMP Inc., 4.Ritsumeikan University, 5.Hokkaido Information University)

[PPS02-P04] Development of a Radiative Transfer Code of Venus Atmosphere in UV Region

*Tatsuro Iwanaka[1], Takeshi Imamura[1] (1.Graduate School of Science, The University of Tokyo)

[PPS02-P05] Topographic feature extraction from Akatsuki/LIR image using Conditional Generative Adversarial Network (CGAN) and Deep learning

*Masataka Imai[1], Toru Kouyama[1], Makoto Taguchi[2], Hiroki Ando[3], Masahiro Takagi[3] (1.Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, 2.Graduate School of Science, Rikkyo University, 3.Faculty of Science, Kyoto Sangyo University)

[PPS02-P06] Data assimilation of horizontal wind obtained from Akatsuki UVI observations focusing on thermal tides and attempts to produce Venus first analysis

*Yukiko Fujisawa[1], Shin-ya Murakami[1], Norihiko Sugimoto[1], Masahiro Takagi[2], Takeshi Imamura[3], Takeshi Horinouchi[4], George HASHIMOTO[5], Masaki Ishiwatari[4], Takeshi Enomoto[6], Takemasa Miyoshi[7], Yoshi-Yuki Hayashi[8] (1.Keio University, 2.Kyoto Sangyo University, 3.Tokyo University, 4.Hokkaido University, 5.Okayama University, 6.Disaster prevention Research Institute, Kyoto University, 7.RIKEN, 8.Kobe University)

[PPS02-P07] Revisiting Venus Doppler-wind maps obtained by ALMA: Impact of missing short-baseline data and uncertainty in the flux calibration

*Hideo Sagawa[1] (1.Kyoto Sangyo University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.04 Zoom Room 04

[P-PS06] Planetary Sciences

convener:Yusuke Nakauchi(Japan Aerospace Exploration Agency), Hiroshi Kikuchi(Japan Aerospace Exploration Agency), Chairperson:Yuri Fujii(Graduate School of Human and Environmental Studies, Kyoto University), Haruka Hoshino(Department of Astronomy, Graduate School of Science, The University of Tokyo)

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

[PPS06-01] Size evolution of close-in super-Earths: effects of giant impacts and photoevaporation

*Yuji Matsumoto[1], Eiichiro Kokubo[2], Pin-Gao Gu[1], Kenji Kurosaki[3] (1.ASIAA, 2.NAOJ, 3.Nagoya Univ.)

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

[PPS06-02] Stellar mass dependence of planetary systems formed by giant impacts: minimum-mass exstrasolar nebula model and habitable planets

*Haruka Hoshino[1,2], Eiichiro Kokubo[2,1] (1.Department of Astronomy, Graduate School of Science, The University of Tokyo, 2.Division of Science, National Astronomical Observatory of Japan)

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

[PPS06-03] Collisional Growth and Fragmentation of Dust Aggregates with Low Mass Ratios

*Yukihiko Hasegawa[1], Takeru Suzuki[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Koji Wada[4] (1.The University of Tokyo, 2.Tohoku University, 3.Nagoya University, 4.Chiba Institute of Technology)

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

[PPS06-04] The amount of cosmic rays in protoplanetary disks and their effects on ionization degrees

*Yuri I. Fujii[1], Shigeo Kimura[2] (1.Kyoto University, 2.Tohoku University)

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

[PPS06-05] Suppression of the vertical shear instability in protoplanetary disks by dust growth : Implications for disk observations

*Yuya Fukuhara[1], Satoshi Okuzumi[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

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

[PPS06-06] Constructing a model of metal accretion disks around white dwarf stars: toward understanding the evolution of remnant planetary systems

*Ayaka Okuya[1], Shigeru Ida[2], Ryuki Hyodo[3] (1.Department of Earth & Planetary Sciences, Tokyo Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.JAXA/ISAS)

[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 | Ch.04 Zoom Room 04

[P-PS06] Planetary Sciences

convener:Yusuke Nakauchi(Japan Aerospace Exploration Agency), Hiroshi Kikuchi(Japan Aerospace Exploration Agency), Chairperson:Hiroshi Kikuchi(Japan Aerospace Exploration Agency), Yusuke Nakauchi(Japan Aerospace Exploration Agency)

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

[PPS06-07] ALMA high resolution observations of the transitional disk around SY Cha.

*Ryuta Orihara[1], Munetake Momose[1], Takayuki Muto[2], Jun Hashimoto[3], Hauyu Baobab Liu[4], Takashi Tsukagoshi[5], Tomoyuki Kudo[5], Sanemichi Takahashi[5], Yi Yang[5,6], Yasuhiro Hasegawa[7], Ruobing Dong[8], Mihoko Konisi[9], Eiji Akiyama[10], Masato Ishiduka[6] (1.Ibaraki University, 2.Kogakuin University, 3.Astrobiology Center, 4.Academia Sinica Institute of Astronomy and Astrophysics, 5.National Astronomical Observatory of Japan, 6.University of Tokyo, 7.NASA Jet Propulsion Laboratory, 8.University of Victoria, 9.Oita University, 10.Niigata institute of technology)

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

[PPS06-08] Model calculation of infrared and radio observations of the circumplanetary disks: Conditions for satellite formation

*Bochao Hu[1], Hideko Nomura[2] (1.Tokyo Institute of Technology/National Astronomical Observatory of Japan, 2.National Astronomical Observatory of Japan)

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

[PPS06-09] Development of a Hayabusa2 ONC image retrieval system with 2D/3D switchable maps in a web browser

*Hiroshi Kikuchi[1], Mitsuo Yamamoto[1], Yasuhiro Yokota[1], Hiroyuki Sato[1], Hisashi Otake[1], Rie Honda[2], Seiji Sugita[3], Tomokatsu Morota[3], Toru Ishikawa[4], Kazuya Imaki[4], Yasuyuki Watabe[4], Takeshi Konishi[5], Ryodo Hemmi[3], Hideaki Miyamoto[3], Yukio Yamamoto[1], Naru Hirata[6], Naoyuki Hirata[7], Sho Sasaki[8], Goro Komatsu[9], Hirohide Demura[6], Chikatoshi Honda[6], Manabu Yamada[10], ERI TATSUMI[11], Yuichiro Cho[3], Kazuo Yoshioka[3], Hirotaka Sawada[1], Naoya Sakatani[12], Masahiko Hayakawa[1], Moe Matsuoka[1], Toru Kouyama[13], Hidehiko Suzuki[14], Kazunori Ogawa[1] (1.JAXA, 2.Kochi Univ., 3.Univ. of Tokyo, 4.JAMSS, 5.Konniesystem, 6.Univ. of Aizu, 7.Kobe Univ., 8.Osaka Univ., 9.IRSPS, Università d'Annunzio, 10.Chiba Inst. Tech., 11.IAC, 12.Rikkyo Univ., 13.AIST, 14.Meiji Univ.)

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

[PPS06-10] Martian Moons eXploration MMX: Current Status Report 2021

*Kiyoshi Kuramoto[1,2], Yasuhiro Kawakatsu[2], Masaki Fujimoto[2], Maria Antonietta Barucci[3], Hidenori Genda[4], Naru Hirata[5], Takeshi Imamura[6], Jörn Helbert[7], Shingo Kameda[8], Masanori Kobayashi[9], Hiroki Kusano[10], David J. Lawrence[11], Koji Matsumoto[12], Patrick Michel[13], Hideaki Miyamoto[6], Hiromu Nakagawa[14], Tomoki Nakamura[14], Kazunori Ogawa[2], Hisashi Otake[2], Masanobu Ozaki[2], Sara Russell[15], Sho Sasaki[16], Hiroki Senshu[9], Naoki Terada[14], Stephan Ulamec[7], Tomohiro Usui[2], Koji Wada[9], Shoichiro Yokota[16] (1.Hokkaido University, 2.JAXA, 3.Paris Observatory, 4.Tokyo Institute of Technology, 5.Aizu University, 6.The University of Tokyo, 7.DLR, 8.Rikkyo University, 9.Chiba Institute of Technology, 10.QST, 11.Johns Hopkins University APL, 12.NAOJ, 13.Université Côte d'azur, 14.Tohoku University, 15.Natural History Museum, 16.Osaka University)

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

[PPS06-11] The orbital evolution of Phobos in the expanded atmosphere of early Mars under an intense solar EUV radiation

*Kohei Fujita[1], Naoki Terada[1], Shotaro Sakai[1], Kaori Terada[1] (1.Tohoku University)

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

[PPS06-12] Hydrodynamic escape of reduced proto-atmospheres: different consequences for surface volatile inventories between Mars and Earth

*Tatsuya Yoshida[1], Kiyoshi Kuramoto[1] (1.Hokkaido University)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Masaru Kogure(National Institute of Polar Research)

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

[PEM11-01] **Forecasting Multi-scale Space Weather Phenomena in the Upper Atmosphere**

★Invited Papers

*Tzu-Wei Fang[1,2], Tim Fuller-Rowell[1,2], David L Hysell[3], Valery Yudin[1], Adam Kubaryk[1,2], Raffaele Montuoro[1,2], Houjun Wang[1] (1.University of Colorado Boulder, USA, 2.NOAA Space Weather Prediction Center, USA, 3.Earth and Atmosphere Sciences, Cornell University, USA)

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

[PEM11-02] Model Simulation and Observation of Equatorial Ionospheric Response to Substorm

*Qian Wu[1,2], Wenbin Wang[1], Dong Lin[1] (1.National Center for Atmospheric Research, 2.COSMIC, UCAR)

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

[PEM11-03] High Resolution Ionosphere/Thermosphere Modeling Studies of Equatorial Plasma Bubbles

★Invited Papers

*Joseph Huba[1], Hanli Liu, Erich Becker (1.Syntek Technologies, Inc)

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

[PEM11-04] Temporal evolution of three-dimensional structures of metal ion layer around Japan simulated by mid-latitude ionospheric model

*Satoshi Andoh[1], Akinori Saito[1], Hiroyuki Shinagawa[2] (1.Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

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

[PEM11-05] **Statistical behavior of large-scale ionospheric disturbances during geomagnetic storms using 20-years GNSS-TEC data**

*Atsuki Shinbori[1], Yuichi Otsuka[1], Sori Takuya[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2.National Institute of Information and Communications Technology (NICT))

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

[PEM11-06] **Generation mechanisms of plasma density irregularity from equatorial to midlatitude ionosphere during a geomagnetic storm on 21 and 22 December 2014**

*Sori Takuya[1], Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Tsugawa[2], Michi Nishioka[2], Akimasa Yoshikawa[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Information and Communications Technology, 3.International Center for Space Weather Science and Education, Kyushu University)

[E] Oral | 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 | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Atsuki Shinbori(Institute for Space-Earth Environment Research (ISEE), Nagoya University)

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

[PEM11-07] Ionospheric plasma irregularities and GPS scintillation/outage observed by Swarm and other LEO satellites

★Invited Papers

*Chao Xiong[1,3], Xin Wan[2], Claudia Stolle[3], Yiwen Liu[4], Jisheng Xu[1] (1.Department of Space Physics, College of Electronic and Information, Wuhan University, 430072 Wuhan, China, 2.Planetary Environmental and Astrobiological Research Laboratory (PEARL), School of Atmospheric Sciences, Sun Yat-sen Univeristy, Zhuhai, China, 3.GFZ German Research Centre for Geosciences, Telegrafenberg, 14473, Potsdam, Germany, 4.Scholl of Physics and Electronic Information, Shangrao Normal University, Shangrao, China)

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

[PEM11-08] Regional ionospheric parameter estimation by assimilating the LSTM trained results into the SAMI2 model

★Invited Papers

Jeong-Heon Kim[1], *Young-Sil Kwak[1,2], Yong Ha Kim[3], Se Heon Jeong[3], Jong Yeon Yun[4] (1.Korea Astronomy and Space Science Institute, 2.University of Science and Technology, 3.Chungnam National University, 4.Korea Space Weather Center)

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

[PEM11-09] Thermospheric variability investigation and thermospheric prediction using machine learning techniques

★Invited Papers

*Jiuhou Lei[1], Denxin Ren[1], Libing Weng[1] (1.USTC University of Science and Technology of China)

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

[PEM11-10] Ionospheric ring current system accounting for ground-level magnetic observations during the 2011 Tohoku earthquake tsunami

*Takuto Minami[1], Masashi Kamogawa[2], Tsutomu Ogawa[3], Makoto Uyeshima[3], Toru Mogi[4], Hiroshi Ichihara[4] (1.Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University, 2.University of Shizuoka, 3.Earthquake Research Institute, University of Tokyo, 4.Graduate School of Environmental Studies, Nagoya University)

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

[PEM11-11] Simultaneous measurement of ion drift and neutral wind using Ba/Sr chemical releases of CHI sounding rocket experiment

*Taro Watanabe[1], Yoshihiro Kakinami[2], Masa-yuki Yamamoto[1], Miguel F. Larsen[4], Mark Conde[3], Takao M. Sato[2], Yuuichi Kaga[2], Takako Kaga[2] (1.Kochi University of Technology, 2.Hokkaido Information University, 3.University of Alaska Fairbanks, 4.Clemson University)

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

[PEM11-12] EUV signals associated with O+ ions observed from ISS-IMAP/EUVI in the nightside ionosphere

*Shin ya Nakano[1,2], Yuta Hozumi[3], Akinori Saito[4] (1.The Institute of Statistical Mathematics, 2.Center for Data Assimilation Research and Applications, Joint-Support Center for Data Science Research, 3.University of Electro-Communications, 4.Graduate School of Science, Kyoto University)

[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 | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Hiroyuki Nakata(Graduate School of Engineering, Chiba University), Hiroyo Ohya(Graduate School of Engineering, Chiba University)

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

[PEM11-13] Study on variations in the D-region ionosphere after the 2015 Nepal earthquake using VLF/LF transmitter signals

*Tekkna Akashi[1], Hiroyo Ohya[1], Fuminori Tsuchiya[2], Kenro Nozaki[3], Hiroyuki Nakata[1] (1.Chiba University , 2.Tohoku University , 3.The University of Electro-Communications)

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

[PEM11-14] D-region ionospheric effects for 2016 eruptions of Mt. Aso using LF transmitter signals

*Hiroyo Ohya[1], Yuhi Orito[2], Fuminori Tsuchiya[3], Masa-yuki Yamamoto[4], Hiroyuki Nakata[1], Akimasa Yoshikawa[5] (1.Graduate School of Engineering, Chiba University, 2.Faculty of Engineering, Chiba University, 3.Tohoku University, 4.Kochi University of Technology, 5.Kyushu University)

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

[PEM11-15] **Ionospheric effects caused by June 11-16, 2009 Sarychev Peak volcano eruption**

*Nikolai Shestakov[1,2], Alexander Orlykovskii[2], Natalia Perevalova[3], Nikolai Titkov[4], Danila Chebrov[4], Mako Ohzono[5,6], Hiroaki Takahashi[5], Evgenii Lialiushko[2] (1.Institute for Applied Mathematics FEB RAS, Vladivostok, Russia, 2.Far Eastern Federal University, Vladivostok, Russia, 3.Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia, 4.Kamchatka Branch of Geophysical Survey of RAS, Petropavlovsk-Kamchatsky, Russia, 5.Institute of Seismology and Volcanology, Hokkaido University, Sapporo, Japan, 6.Earthquake Research Institute, University of Tokyo, Tokyo, Japan)

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

[PEM11-16] A possible effect of rainfall on medium scale electron density fluctuations in dayside ionosphere

*Toshihiko Iyemori[1], Tadashi Aoyama[1,2], Yoshihiro Yokoyama[1] (1.Kyoto University, 2.F-Factory)

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

[PEM11-17] Pattern matching of polar mesospheric clouds with data from the meteorological satellite Himawari-8

*Yuta Hozumi[1], Takuo T. Tsuda[1], Yoshiaki Ando[1], Keisuke Hosokawa[1], Hidehiko Suzuki[2], Takuji Nakamura[3], Ken T. Murata[4] (1.University of Electro-Communications, 2.Department of physics, Meiji university, 3.National Institute of Polar Research, 4.National Institute of Information and Communications Technology)

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

[PEM11-18] Analysis of spatial distributions of Coseismic ionospheric disturbances using HFD

*Tomoaki Horikiri[1], Hiroyuki Nakata[2], Hiroyo Ohya[2], Keisuke Hosokawa[3] (1.Graduate School of Science and Engineering, Chiba University, 2.Graduate School of Engineering, Chiba University, 3.Department of Communication Engineering and Informatics, University of Electro-Communications)

[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 | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Loren Chang(Institute of Space Science, National Central University), Yuta Hozumi(University of Electro-Communications)

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

[PEM11-19] Ionospheric Quai-6-Day Oscillation generated by the Secondary Waves During the 2019 Antarctic Sudden Stratosphere Warming

*Jia-Ting Lin[1], Charles Lin[1], Loren Chang[2,3], Nicholas M Pedatella[4,5], P. K. Rajesh[1], CHIYEN LIN[2,3] (1.Department of Earth Science, National Cheng Kung University, Tainan, Taiwan, 2.Department of Space Science & Engineering, National Central University, Taoyuan, Taiwan, 3.Center for Astronautical Physics and Engineering, National Central University, Taoyuan, Taiwan, 4.High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO, USA, 5.COSMIC Program Office, University Corporation for Atmospheric Research, Boulder, CO, USA)

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

[PEM11-20] Southern hemisphere response to northern hemisphere stratospheric warming events

*Patrick J Espy[1,2], Kristina Shizuka Yamase Skarvang[1,2], Willem van Caspel[1,2], Robert Hibbins[1,2], Andrew Kavanagh[3] (1.Norwegian University of Science and Technology, 2.Birkeland Centre for Space Science, 3.The British Antarctic Survey)

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

[PEM11-21] The 2019 Antarctic Stratospheric Sudden Warming effect on Gravity Wave in the Middle Atmosphere

★Invited Papers

*Masaru Kogure[1], Yue Jia[2,3], Huixin Liu[1] (1.Kyushu University, 2.NASA Goddard Space Flight Center, 3.Catholic University of America)

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

[PEM11-22] Nonlinear interactions of planetary-scale MLT waves using multi-radar techniques

★Invited Papers

*Maosheng He[1], Jorge L. Chau[1], Jeffrey M. Forbes[2], Guozhu Li[3,4] (1.Leibniz Institute of Atmospheric Physics at the Rostock University, Kühlungsborn, Germany,, 2.Ann and H.J. SmeadDepartment of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA,, 3.Beijing National Observatory of Space Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China,, 4.College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China)

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

[PEM11-23] Seasonal Dependence of the Quasi-6-Day Oscillation in the Sq-EEJ current system

*Takayama Kumi[1], Akimasa Yoshikawa[1], Yasunobu Miyoshi[1] (1.Kyushu University)

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

[PEM11-24] Turbulent signatures in the Auroral Cusp Ionosphere based on sounding rocket observations

*Francesca Di Mare[1], Andres Spicher[2], Lasse Boy Novock Clausen[1], Wojciech Jacek Miloch[1], Joran Idar Moen[3] (1.Dep. of Physics, University of Oslo, Norway, 2.Dep. of Physics and Technology, University of Tromso, Norway, 3.University Centre in Svalbard, Longyearbyen, Norway)

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.02 Zoom Room 02

[P-CG17] Future missions and instrumentation for space and planetary science

convener:Kazunori Ogawa(Japan Aerospace Exploration Agency), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Naoya Sakatani(Department of Physics, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University)

3:30 PM - 4:15 PM JST | 6:30 AM - 7:15 AM UTC

[PCG17-01] JAXA's Strategic Mars Exploration Program (JSMEP) for Understanding the Origin, Evolution, Inventory of Water on Mars

★Invited Papers

*Tomohiro Usui[1] (1.Japan Aerospace Exploration Agency)

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

[PCG17-02] Constraints on the origin of Phobos using multivariate element data obtained by MMX MEGANE

*Kaori Hirata[1,2], Tomohiro Usui[2], Ryuki Hyodo[2], Hidenori Genda[3], Ryota Fukai[2], David J. Lawrence[4], Nancy L. Chabot[4], Patrick N. Peplowski[4], Hiroki Kusano[5] (1.University of Tokyo, 2.Institute of Space and Astronautical Science, 3.Earth-Life Science Institute, Tokyo Institute of Technology, 4.Johns Hopkins University Applied Physics Laboratory, 5.National Institute for Quantum and Radiological Science and Technology)

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

[PCG17-03] Development of the Autofocusing Subsystem for the Raman Spectrometer on the MMX Rover

*Shoki Mori[1], Tomàs Belenguer[2], Ute Böttger[3], Maximilian Buder[3], Yuichiro Cho[1], Enrico Dietz[3], Till Hagelschuer[3], Heinz-Wilhelm Hübers[3], Shingo Kameda[4], Emanuel Kopp[3], Guillermo Lopez-Reyes[5], Andoni Gaizka Moral Inza[2], Akinojo Ogura[1], Olga Prieto-Ballesteros[6], Steve Rockstein[3], Selene Rodd-Routley[3], Fernando Rull[5], Conor Ryan[3], Thomas Säuberlich[3], Friedrich Schrandt[3], Susanne Schröder[3], Stephan Ulamec[7], Tomohiro Usui[8], Koki Yumoto[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Instituto Nacional de Técnica Aerospacial (INTA), 3.Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Optical Sensor Systems, 4.School of Science, Rikkyo University, 5.Universidad de Valladolid – GIR ERICA, 6.Centro de Astrobiología (CAB-INTA-CSIC), 7.Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), 8.Japan Aerospace Exploration Agency (JAXA), Institute of Space and Astronautical Science, Department of Solar System Sciences)

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

[PCG17-04] Discussion

[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 | Ch.04 Zoom Room 04

[P-CG18] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Tomoki Kimura(Tokyo University of Science), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Kanako Seki(Graduate School of Science, University of Tokyo)

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

[PCG18-01] Current status, initial results, and upcoming observation plans during cruise of BepiColombo

*Go Murakami[1], Johannes Benkhoff[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.European Space Agency)

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

[PCG18-02] Revisiting Mariner-10 and MESSENGER observations: Anticipation for BepiColombo's Mercury flybys

*Sae Aizawa[1,2], Nicolas André[1], Ronan Modolo[3], James A. Slavin[4], Scott A. Boardsen[5] (1.Institute de Recherche en Astrophysique et Planetologie, 2.Graduate School of Science, Tohoku University, 3.LATMOS, 4.University of Michigan, 5.NASA/GSFC)

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

[PCG18-03] A belt-like distribution of gaseous hydrogen cyanide on Neptune's equatorial stratosphere detected by ALMA

*Takahiro IINO[1], Hideo Sagawa[2], Takashi Tsukagoshi[3], Satonori Nozawa[4] (1.Information Technology Center, the University of Tokyo, 2.Department of Science, Kyoto Sangyo University, 3.NAOJ, 4.ISEE, Nagoya University)

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

[PCG18-04] Estimation of the drift rate and intensity of Neptune's storm in 2018-2020 with Pirka Telescope

*Yuuki Sato[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Seiko Takagi[1], Masataka Imai[2], Tatsuharu Ono[1] (1.Graduate School of Science, Hokkaido University, 2.National Institute of Advanced Industrial Science and Technology)

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

[PCG18-05] Ion escape mechanism from a Mars-like planet under weak intrinsic magnetic field conditions: Dependence of IMF clock angle

*Shotaro Sakai[1,2], Kanako Seki[3], Naoki Terada[1], Hiroyuki Shinagawa[4], Ryoya Sakata[3], Takashi Tanaka[4,5], Yusuke Ebihara[6] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 3.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 4.National Institute of Information and Communications Technology, 5.International Center for Space Weather Science and Education, Kyushu University, 6.Research Institute for Sustainable Humanosphere, Kyoto University)

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

[PCG18-06] Dependences of ion escape from Mars on the intrinsic magnetic field strength under CME-like solar conditions at 3.5 Ga

*Ryoya Sakata[1], Kanako Seki[1], Shotaro Sakai[2], Naoki Terada[2], Hiroyuki Shinagawa[3], Takashi Tanaka[3,4] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Department of Geophysics, Graduate School of Science, Tohoku University, 3.National Institute of Information and Communications Technology, 4.International Center for Space Weather Science and Education, Kyushu University)

[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 | Ch.04 Zoom Room 04

[P-CG18] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Yuki Harada(Kyoto University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University)

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

[PCG18-07] Investigation of periodic electron injection observed in Martian crustal magnetic fields with MAVEN and MGS

*Michio Kato[1], Yuki Harada[1], David L Mitchell[2], Christian Mazelle[3], Gina A DiBraccio[4], Jasper S Halekas[5], Suranga Ruhunusiri[5] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Space Sciences Laboratory, University of California, Berkeley, 3.RAP, University of Toulouse, CNRS, UPS, CNES , 4.NASA Goddard Space Flight Center, 5.Department of Physics and Astronomy, University of Iowa)

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

[PCG18-08] Modeling diffuse auroral emissions at Mars: Contribution of precipitating protons and mirror effects of crustal fields

*Yuki Nakamura[1,2], Naoki Terada[1], Francois Leblanc[2], Hiromu Nakagawa[1], Shotaro Sakai[1], Sayano Hiruba[1], Ryuho Kataoka[3], Kiyoka Murase[4] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.LATMOS, Sorbonne University, 3.National Institute of Polar Research, 4.The Graduate University for Advanced Studies)

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

[PCG18-09] Effects of the magnetic field orientation on the vertical emission profile of Martian diffuse aurora: A Monte Carlo model development

*Taishin Okiyama[1], Kanako Seki[1], Nicholas M. Schneider[2], Sonal K. Jain[2] (1.Graduate School of Science, University of Tokyo, 2.LASP, University of Colorado, Boulder)

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

[PCG18-10] Extraction of Martian atmospheric fine structures by analyzing Mars Global Surveyor radio occultation data

*Ryutaro Sakurai[1], Takeshi Imamura[1] (1.Graduate School of Frontier Sciences, The University of Tokyo)

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

[PCG18-11] Variation of CO/CO_2 profile in the Martian middle atmosphere observed by TGO/NOMAD

*Nao Yoshida[1], Hiromu Nakagawa[1], Shohei Aoki[2,3], Justin Erwin[2], Ann Carine Vandaele[2], Isao Murata[1], Ian Thomas[2], Frank Daerden[2], Lori Neary[2], Shungo Koyama[1], Naoki Terada[1], Yasumasa Kasaba[1], Bojan Ristic[2], Manish R Patel[4], Giancarlo Bellucci[5], Jose-Juan Lopez-Moreno[6] (1.Dep. Geophysics Graduate School of Science Tohoku University, 2.Royal Belgian Institute for Space Aeronomy, BIRA-IASB, 3.LPAP, STAR Institute, Université de Liège, 4.School of Physical Sciences, The Open University, 5.Instituto di Astrofisica e Planetologia Spaziali (IAPS/INAF), 6.Instituto de Astrofisica de Andalucia (IAA/CSIC))

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

[PCG18-12] Periodic variations of hydrogen and oxygen airglow in the Martian upper atmosphere during a rapid growth of a regional dust storm

*Kei Masunaga[1], Naoki Terada[2], Nao Yoshida[2], Takeshi Kuroda[2], Kazuo Yoshioka[3], Tomoki Kimura[2], Fuminori Tsuchiya[2], Go Murakami[4], Atsushi Yamazaki[4], Ichiro Yoshikawa[3] (1.University of Colorado Boulder, 2.Tohoku University, 3.University of Tokyo, 4.Institute of Space and Astronautical Science)

[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 | Ch.01_2

[P-CG18] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University)

[PCG18-P01] Hybrid particle simulation on Mercury's dayside magnetopause

*Hideyuki Usui[1], Yohei Miyake[2], Naoshi Motoda[1], Masaharu Matsumoto[3] (1.Graduate school of system informatics Kobe University, 2.Education Center for Computational and Engineering Science, 3.Graduate school of information science and technology, The University of Tokyo)

[PCG18-P02] Numerical calculation of moist convection in Jupiter's atmosphere - A case study with an average cooling vertical profile based on a radiative transfer calculation -

Taro Sekiguchi[1], *Ko-ichiro SUGIYAMA[2], Masaki Ishiwatari[1], Kensuke Nakajima[3], Kiyoshi Kuramoto[1], Yoshi-Yuki Hayashi[4] (1.Department of Cosmoscience, Graduate School of Science, Hokkaido University, 2.National Institute of Technology, Matsue College, 3.Department of Earth and Planetary Sciences,Flculty of Sciences,Kyushu University, 4.Department of Planetology, Graduate School of Science, Kobe University / Center for Planetary Science (CPS))

[PCG18-P03] High dynamic range observation using a 1.8-m off-axis telescope PLANETS: feasibility study and telescope assembly

*Masato Kagitani[1], Takeshi Sakanoi[1], Kazuya Nagta[1], Yasumasa Kasaba[1], Yasuhiro Hirahara[2], Mikio Kurita[3], Jeffry Kuhn[4], Svetlana Berdyugina[5], Emilio Marcelo[6] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Science, Kyoto University, 4.Institute for Astronomy, Univesity of Hawaii, USA, 5.Kiepenheuer Institute for Solar Physics, Germany, 6.Universidade Estadual de Ponta Grossa, Brazil)

[PCG18-P04] A search for atomic sodium and calcium in the atmosphere of the icy Galilean moons of Jupiter with ground-based telescope

*Seiko Takagi[1], Taro Matsuo[2], Jun Kimura[3], Kazuo Yoshioka[4] (1.Hokkaido University, Graduate School of Science, 2.Nagoya University, 3.Osaka University, 4.The University of Tokyo)

[PCG18-P05] Development of PLANETS telescope: An attempt to reduce polishing volume in final polishing process by using an active mirror support

*Kazuya Nagata[1], Masato Kagitani[1], Yasumasa Kasaba[1], Takeshi Sakanoi[1], Yasuhiro Hirahara[2], Mikio Kurita[3] (1.Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Science, Kyoto University)

[PCG18-P06] Numerical simulations of 500eV-50keV electron elastic collisions with neutral H_2O around Enceladus ~estimation of electron loss rate and auroral brightness~

*Hiroyasu Tadokoro[1], Yuto Katoh[2] (1.Surugadai University, 2.Tohoku University)

[PCG18-P07] Development of the near-infrared camera TOPICS and the Echelle spectrograph ESPRIT for planetary observations

Ayumu Kambara[1], *Takeshi Sakanoi[1], Yasuhiro Hirahara[2], Takashi Ichikawa[3], Masato Kagitani[1], Yasumasa Kasaba[1], Aya Otomo[1], Kazuya Nagata[1] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Astronomical Institute, Graduate School of Science, Tohoku University)

[PCG18-P08] Effects of the magnetic field configuration in the ionosphere on solar energetic electron precipitation into the Martian upper atmosphere observed by MAVEN

*Kanako Seki[1], Takuya Hara[2], Dave A Brain[3], Robert J Lillis[2], Darvin E Larson[2], Dave L Mitchell[2], Gina A Dibraccio[4], Janet G Luhmann[2], Bruce M Jakosky[3] (1.Graduate School of Science, University of Tokyo, 2.Space Sciences Laboratory, University of California, Berkeley, 3.Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder., 4.Goddard Space Flight Center, NASA)

[PCG18-P09] Observations of minor constituents in the Venusian atmosphere, CO and SOx using the millimeter/submillimeter-wave band radio telescopes, SPART/ALMA

Ayaka Tomihara[1], Teppei Yonetsu[1], Yuki Hamaguchi[1], Hideo Sagawa[2], *Hiroyuki Maezawa[1] (1.Department of Physical Science Osaka Prefecture University, 2.Kyoto Sangyo University)

[PCG18-P10] Influences of solar energetic particles on the Martian ozone layer

*Sayano Hiruba[1], Yuki Nakamura[1], Hiromu Nakagawa[1], Naoki Terada[1], Shotaro Sakai[1], Isao Murata[1], Yoshifumi Futaana[2] (1.Dept. of Geophysics, Graduate school of science, Tohoku University, 2.Swedish Institute of Space Physics)

[PCG18-P11] Simultaneous remote and in-situ observations of ionospheric irregularities at Mars

*Hina Bando[1], Yuki Harada[1], Naoki Terada[2], Hiromu Nakagawa[2] (1.Kyoto University, 2.Tohoku University)

[PCG18-P12] Annual variability in the thermospheric wave perturbations at Mars

*Hiromu Nakagawa[1], Nao Yoshida[1], Kaori Terada[1], Naoki Terada[1], Yuki Harada[2], Shotaro Sakai[1], Takeshi Imamura[3], Hitoshi Fujiwara[4], Kanako Seki[5] (1.Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2.Kyoto University, 3.Graduate School of Frontier Scienfes, The University of Tokyo, 4.Faculty of Science and Technology, Seikei University, 5.Graduate School of Science, University of Tokyo)

[PCG18-P13] **Study of atmospheric ion escape from exoplanet TOI-700 d**

*Tomoaki Nishioka[1], Kanako Seki[1], Ryoya Sakata[1], Kazuhiro Yamamoto[1], Naoki Terada[2], Hiroyuki Shinagawa[3] (1.Graduate School of Science, University of Tokyo , 2.Graduate School of Science, Tohoku University , 3.NICT)

[PCG18-P14] DSMC simulations of slow hydrodynamic escape from Earth-like and Mars-like planets

*Naoki Terada[1], Kaori Terada[1], Hitoshi Fujiwara[2], Masahiro Ikoma[3] (1.Graduate School of Science, Tohoku University, 2.Faculty of Science and Technology, Seikei University, 3.Graduate School of Science, The University of Tokyo)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.07 Zoom Room 07

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Sachie Kanada(Nagoya University)

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[AAS03-01] Introduction

9:05 AM - 9:35 AM JST | 12:05 AM - 12:35 AM UTC

[AAS03-02] Hurricane ocean surface wind retrieval from ALOS-2/PALSAR-2

★Invited Papers

*Osamu Isoguchi[1], Takeo Tadono[2], Masato Ohki[2], Udai Shimada[3], Munehiko Yamaguchi[3], Masahiro Hayashi[3], Wataru Yanase[3] (1.RESTEC, 2.JAXA, 3.Meteorological Research Institute)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[AAS03-03] Impact of Aeolus DWL data assimilation in the JMA's global data assimilation system on forecasting skills for typhoons

*Izumi Okabe[1], Kozo OKAMOTO[1] (1.Meteorological Research Institute of Japan Meteorological Agency)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[AAS03-04] Wind speed structure of Typhoon 201821 as seen by CYGNSS and AMSR2

*Dexin Gu[1], Kaoru Ichikawa[1], Kako Shinichiro[2], Hiroyuki Tomita[3] (1.Kyushu Univ, 2.Kagoshima Univ, 3.Nagoya Univ)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[AAS03-05] Oceanic environmental change due to Typhoon Faxai(T1915) and Hagibis(T1919)

*Koki Iida[1,2], Fudeyasu Hironori[1], Yuusuke Tanaka[2], Satoshi Iizuka[3], Yoshiaki Miyamoto[4] (1.Yokohama National University, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Keio University)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

[AAS03-06] Discussion

[E] Oral | 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 | Ch.07 Zoom Room 07

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University)

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

[AAS03-07] Three-Dimensional Aspects of the Fujiwara Effect

Jae-Deok Lee[1], *Kosuke Ito[2], Johnny C. L. Chan[3] (1.Kyungpook National University, 2.University of the Ryukyus, 3.City University of Hong Kong)

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

[AAS03-08] Precipitation Enhancement by Northward Ageostrophic Winds Associated with a Tropical Cyclone. - -Cloud Resolving Simulation- -

*Kazuo Saito[1,2,3], Takumi Matsunobu[4], Tsutao Oizumi[2,3] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Japan Meteorological Business Support Center, 3.Meteorological Research Institute , 4.Meteorologisches Institut, Ludwig-Maximilians-Universität)

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

[AAS03-09] Climatology of Tropical Cyclone Seeds and Survival Rates to Tropical Storms

*Kohsuke Ikehata[1], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AAS03-10] Change of Tropial Cyclone Characteristics under the Changing Climate

*Fumiya Matsushima[1], Kazuhisa Tsuboki[1], Sachie Kanada[1] (1. Institute for Space-Earth Environmental Research, Nagoya University)

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

[AAS03-11] Future Changes of a Slow-moving Intense Typhoon with Global Warming: A Case Study using a regional 1-km-mesh atmosphere–ocean coupled model

*Sachie Kanada[1], Hidenori AIKI[1], Kazuhisa Tsuboki[1], Izuru Takayabu[2] (1.Nagoya University, 2.MRI/JMA)

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

[AAS03-12] Discussion

[E] 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 | Ch.02_1

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus)

[AAS03-P01] Meso–scale structure in the eye of Typhoon Trami(2018)

*Lana Yamashiro[1], Kazuhisa Tsuboki[1], Hiroyuki Yamada[2] (1.Nagoya University Institute for Space - Earth Environmental Research , 2.University of the Ryukyus)

[AAS03-P02] Simulation of sea salt transport and deposition assuming salt damage by typhoon using NHM-Chem

*Mirai Abe[1], Yoshiaki Miyamoto[1], Mizuo Kajino[2] (1.Keio University, 2.Meteorological Research Institute, Japan Meteorological Agency)

[AAS03-P03] Accelerated increase in tropical cyclone heat potential within typhoon rapidly intensifying region during 1955-2019

*Haruka Sasaki[1], Tatsuo Motoi[1] (1.Meteorological College)

[AAS03-P04] Analysis of Precipitation Distribution Associated with the Tropical Cyclones in the Northwest Pacific

Ayano Shirakawa[1], *Akiyo Yatagai[2], Ryuji Yoshida[3,4], Yuno Sakashita[1] (1.Faculty of Science and Technology, Hirosaki University, 2.Graduate School of Science and Technology, Hirosaki University, 3.CIRES University of Colorado Boulder, 4.NOAA Earth System Research Laboratories, CSL)

[AAS03-P05] The mechanism by which updraft and the downdraft of a cumulonimbus cloud in subtropical waters turn in the opposite direction.

*Shinji Karasawa[1] (1.Miyagi National College of Technology Professor emeritus)

[AAS03-P06] Correlation Analysis of Microphysical Parameters in Typhoon Deep Convective Cloud Based on CloudSat

*Shuang Luo[1] (1.Shanghai Ecological Forecasting and Remote Sensing Center)

[AAS03-P07] An Advancement of the Korean Typhoon Pre-disaster Prevention Model for Improving the Prediction Accuracy of 3-second Gust and the Damage Cost During the Typhoon Period

*Woo-Sik JUNG[1] (1.Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.)

[AAS03-P08] Evaluation of the Sensitivity of Typhoon Pre-disaster Prevention Model According to the Application of the Type of Soil Data During Typhoon Season

*Woo-Sik JUNG[1], HANA NA[1] (1.Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.)

[AAS03-P09] Maximum Wind Speed Radius Formula That Can Be Used for Typhoons Affecting the Korean Peninsula – Evaluation of the Pilot Study-

*Woo-Sik JUNG[1] (1.Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.06 Zoom Room 06

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology)

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[AAS06-01] Updated atmospheric composition chemica reanalysis and emission estimates

★Invited Papers

*Kazuyuki Miyazaki[1] (1.NASA Jet Propulsion Laboratory)

9:20 AM - 9:40 AM JST | 12:20 AM - 12:40 AM UTC

[AAS06-02] Ozone variability associated with the dynamical fields during YMC-Sumatra2017 field campaign

★Invited Papers

*Junko Suzuki[1], Shin-Ya Ogino[1], Takenari Kinoshita[1], Ryuichi Shirooka[1], Suginori Iwasaki[2], Kunio Yoneyama[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Defense Academy of Japan)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[AAS06-03] Tropical coastal bidirectional gravity waves robustizing QBO

*Manabu D. Yamanaka[1,2], Shin-Ya Ogino[2] (1.Research Institute for Humanity and Nature / Professor Emeritus of Kobe University, 2.Japan Agency for Marine-Earth Science and Technology)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[AAS06-04] Study for influence of temperature at TTL on evolution of deep convection and tropical cyclones

Kenta Kobayashi[1], *Nawo Eguchi[1], Tomoe Nasuno[2], Yohei Yamada[2], Kunihiko Kodera[3] (1.Kyushu University, 2.JAMSTEC, 3.Meteorological Research Institute)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[AAS06-05] Stratospheric Influence on the Troposphere During the Remarkably Strong Arctic Circumpolar Vortex Condition in 2019-2020 Winter

*Shunsuke Noguchi[1,2], Kunihiko Kodera[2], Ryo Mizuta[2], Seiji Yukimoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

[AAS06-06] Discussion

[J] Oral | 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 | Ch.06 Zoom Room 06

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Takatoshi Sakazaki(Graduate School of Science, Kyoto University)

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

[AAS06-07] Do sudden stratospheric warmings boost convective activity in the tropics?

★Invited Papers

*Kohei Yoshida[1], Ryo Mizuta[1] (1.Meteorological Research Institute)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AAS06-08] Dynamical Features of Antarctic Sudden Stratospheric Warming in 2019

*Guangyu Liu[1], Toshihiko Hirooka[2], Nawo Eguchi[3], Kirstin Krüger[4] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Research Institute for Applied Mechanics, Kyushu University, 4.Department of Geosciences, University of Oslo)

11:20 AM - 11:40 AM JST | 2:20 AM - 2:40 AM UTC

[AAS06-09] Seasonal predictability of the persisted negative Antarctic oscillations after sudden stratospheric warming in the Southern Hemisphere in 2019

★Invited Papers

*Chiaki Kobayashi[1], Shuhei Maeda[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[AAS06-10] **The stratospheric QBO affects Antarctic sea ice through the tropical convection in early austral winter**

*Koji Yamazaki[1], Tetsu Nakamura[1] (1.Hokkaido University)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[AAS06-11] A study of Kelvin-Helmholtz billow in the Antarctic troposphere and lower stratosphere based on the PANSY radar observation using a frequency domain interferometry technique

*Yuichi Minamihara[1], Kaoru Sato[1], Masaki Tsutsumi[2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.National Institute of Polar Research)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[AAS06-12] Discussion

[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 | Ch.06 Zoom Room 06

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo)

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

[AAS06-13] LODEWAVE (LOng-Duration balloon Experiment of gravity WAVE over Antarctica)

*Yoshihiro Tomikawa[1,2], Kaoru Sato[3], Yoshitaka Saito[4], Isao Murata[5], Naohiko Hirasawa[1,2], Masashi Kohma[3], Kyoichi Nakashino[6], Daisuke Akita[7], Takuma Matsuo[8], Masatomo Fujiwara[9], Lihito Yoshida[2] (1.National Institute of Polar Research, 2.School of Multidisciplinary Sciences, The Graduate University for Advanced Studies, SOKENDAI, 3.Graduate School of Science, The University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 5.Graduate school of Environmental Studies, Tohoku University, 6.School of Engineering, Tokai University, 7.School of Environment and Society, Tokyo Institute of Technology, 8.School of Science and Technology, Meiji University, 9.Faculty of Environmental Earth Science, Hokkaido University)

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

[AAS06-14] Sporadic, large gravity wave events over Syowa Station in summer -Comparison between the PANSY radar and the ERA5 reanalysis-

*Lihito Yoshida[1], Yoshihiro Tomikawa[2,1], Mitsumu K. Ejiri[2,1], Masashi Kohma[3], Kaoru Sato[3] (1.Department of Polar Science, School of Multidisciplinary Sciences, The Graduate University for Advanced Studies, 2.National Institute of Polar Research, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:15 PM - 2:35 PM JST | 5:15 AM - 5:35 AM UTC

[AAS06-15] Detection of a climatological short break in the polar night jet in early winter and its relation to cooling over Siberia

★Invited Papers

*Yuta Ando[1,2], Koji Yamazaki[3], Yoshihiro Tachibana[2], Masayo Ogi[3], Jinro Ukita[1] (1.Faculty of Science, Niigata University, 2.Weather and Climate Dynamics Division, Mie Univesity, 3.Hokkaido University)

2:35 PM - 2:55 PM JST | 5:35 AM - 5:55 AM UTC

[AAS06-16] Characteristics of planetary-wave packet propagation during a major sudden stratospheric warming event in January 2021

★Invited Papers

*Yayoi Harada[1], Takenari Kinoshita[2], Kaoru Sato[3], Toshihiko Hirooka[4] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) , 3.Department of Earth and Planetary Sciences, University of Tokyo, 4.Department of Earth and Planetary Sciences, Kyushu University)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[AAS06-17] A Statistical Analysis of Downward Propagation of Planetary Wave Packets in the Stratosphere Using Large Ensemble Data

*Matsuyama Yuya[1], Toshihiko Hirooka[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)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

[AAS06-18] Discussion

[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 | Ch.02_2

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University)

[AAS06-P01] Radiosonde Observations in the 30-40 km Altitude Range Using 3000 g Balloons

*Takenari Kinoshita[1], Shin-Ya Ogino[1], Junko Suzuki[1], Ryuichi Shirooka[1], Takuji Sugidachi[2], Kensaku Shimizu[2], Matthew H Hitchman[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meisei Electric Co. Ltd., 3.University of Wisconsin-Madison)

[AAS06-P02] Influence of a SH SSW in September 2019 on tropical tropospheric circulation and deep convective activity

*Kunihiko Kodera[1], Shunnsuke Noguchi[2], Nawo Eguchi[3], Tomoe Nasuno[2] (1.Meteorological Research Institute, 2.JAMSTEC, 3.Kyushu University)

[AAS06-P03] Dynamical analysis of extreme tropopause folding events in the coastal region of Antarctica

Masatoshi Mizukoshi[1], *Masashi Kohma[1], Kaoru Sato[1] (1.Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo)

[AAS06-P04] Response of the Brewer-Dobson circulation to the major volcanic eruptions in reanalysis datasets

*Masatomo Fujiwara[1], Marta Abalos[2], Patrick Martineau[3], Jonathon Wright[4] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Universidad Complutense de Madrid, 3.JAMSTEC, 4.Tsinghua University)

[AAS06-P05] Impact of the upper troposphere and stratosphere on the climate change around Japan

*Yoshio Kawatani[1], Takeshi Horinouchi[2], Naoki Sato[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Faculty of Environmental Earth Science, Hokkaido University, 3.Tokyo Gakugei University)

[AAS06-P06] Analysis of Arctic spring ozone anomaly in the phases of QBO and 11-year solar cycle for 1979–2011

Yousuke Yamashita[1,2], *Hideharu Akiyoshi[1], Masaaki Takahashi[1,3] (1.National Institute for Environmental Studies, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AAS06-P07] Morphology of zonal asymmetry of QBO zonal wind

*Takatoshi Sakazaki[1], Kevin Hamilton[2], Yoshio Kawatani[3] (1.Graduate School of Science, Kyoto University, 2.International Pacific Research Center, University of Hawai'i, 3.Japan Agency for Marine-Earth Science and Technology)

[AAS06-P08] Relationships between Unusual Antarctic Ozone Hole in 2019 and Dynamical Fields

*Guangyu Liu[1], Toshihiko Hirooka[2], Nawo Eguchi[3] (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, 3.Research Institute for Applied Mechanics, Kyushu 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 | Ch.09 Zoom Room 09

[A-OS09] Climate variability and predictability on subseasonal to multidecadal timescales

convener:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Chairperson:Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology)

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

[AOS09-01] Beyond day 2: Variable-resolution convective-scale prediction on medium-range, subseasonal, and longer timescales.

★Invited Papers

*Lucas Harris[1] (1.NOAA/Geophysical Fluid Dynamics Laboratory)

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

[AOS09-02] Background Factors for the Interannual Variations of the Realization of the Madden–Julian Oscillation

*Daisuke Takasuka[1], Tsubasa Kohyama[1], Tamaki Suematsu[2], Hiroaki Miura[3] (1.Department of Information Sciences, Ochanomizu University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Department of Earth and Planetary Science, The University of Tokyo)

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

[AOS09-03] Warming of the Indian Ocean weakens the Atlantic Niño - El Niño Southern Oscillation connection

*Shreya Dhame[1], Andrea Taschetto[1], Agus Santoso[1,2], Giovanni Liguori[3], Katrin Meissner[1] (1.ARC Centre of Excellence for Climate Extremes, Climate Change Research Centre, University of New South Wales, Sydney, Australia, 2.Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Australia, 3.ARC Centre of Excellence for Climate Extremes, School of Earth, Atmosphere and Environment, Monash University, Melbourne, Australia)

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

[AOS09-04] Decadal Variability of the Pacific Meridional Modes without Equatorial Pacific Influence

*Yu Zhang[1,2], Shiyun Yu[1,2], Dillon J. Amaya[3], Yu Kosaka[4], Sarah M. Larson[5], Xudong Wang[6], Jun-Chao Yang[1,2], Malte F. Stuecker[7], Shang-Ping Xie[8], Arthur J. Miller[8], Xiaopei Lin[1,2] (1.Ocean University of China, 2.Qingdao National Laboratory for Marine Science and Technology, 3.University of Colorado Boulder, 4.The University of Tokyo, 5.North Carolina State University, 6.Nanjing University of Information Science and Technology, 7.University of Hawai'i at Mānoa, 8.University of California San Diego)

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

[AOS09-05] Synchronized Tropical Pacific Decadal Variability and Cold Ocean-Warm Land Pattern Modulate Global Warming Rate

*Jun-Chao Yang[1,2], Xiaopei Lin[1,2], Shang-Ping Xie[3], Yu Zhang[1,2], Yu Kosaka[4], Ziguang Li[1,2] (1.Frontiers Science Center for Deep Ocean Multispheres and Earth System and Physical Oceanography Laboratory, Ocean University of China, 2.Qingdao National Laboratory for Marine Science and Technology, 3.Scripps Institution of Oceanography, University of California, 4.Research Center for Advanced Science and Technology, University of Tokyo)

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

[AOS09-06] A consecutive development of MJO events reproduced by three-month SST-forced experiments with NICAM

★Invited Papers

*Tamaki Suematsu[1], Tomoro Yanase[4,2], Hiroaki Miura[3], Chihiro Kodama[5], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.RIKEN Center for Computational Science, 3.Graduate School of Science, The University of Tokyo , 4.Graduate School of Science, Kyoto University , 5.Japan Agency for Marine-Earth Science and Technology)

[E] 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 | Ch.09 Zoom Room 09

[A-OS09] Climate variability and predictability on subseasonal to multidecadal timescales

convener:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Chairperson:V Ramaswamy(NOAA GFDL), Yushi Morioka(Japan Agency for Marine-Earth Science and Technology)

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

[AOS09-07] GFDL's SPEAR Seasonal Prediction

★Invited Papers

*Feiyu Lu[1,2], Matt Harrison[2], Anthony Rosati[2,3], Tom Delworth[2], Xiaosong Yang[2], William Cooke[2,3], Liwei Jia[3,2], Colleen McHugh[2,4], Nathaniel Johnson[2], Mitchell Bushuk[2,3], Yongfei Zhang[1,2], Alistair Adcroft[1,2] (1.Princeton University, 2.NOAA/GFDL, 3.UCAR, 4.SAIC)

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

[AOS09-08] Summertime sea-ice prediction in the Weddell Sea improved by sea-ice thickness initialization

*Yushi Morioka[1], Doroteaciro Iovino[2], Andrea Cipollone[2], Simona Masina[2], Swadhin Behera[1] (1.JAMSTEC/VAiG/APL, 2.CMCC/ODA)

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

[AOS09-09] Changes and future predictions of Oyashio Intermediate Water: Weakened overturning vs. enhanced tidal mixing

*Vigan Mensah[1], Kay I. Ohshima[1] (1.Institute of Low Temperature Science)

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

[AOS09-10] Interdecadal Variation of Perturbational Feedback Parameter in MIROC6 piControl Simulation

*Kou Tsuchida[1], Takashi Mochizuki[1], Ryuichi Kawamura[1], Tetsuya Kawano[1] (1.Kyushu Univ.)

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

[AOS09-11] A paleoclimatological approach to the multidecadal climate variability

*Takeshi Nakatsuka[1], Tsukasa Mizutani[2] (1.Graduate School of Environmental Studies, Nagoya University, 2.Institute of Industrial Science, The University of Tokyo)

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

[AOS09-12] Towards understanding climate extremes, variability and predictability under changing climate over East Asia

★Invited Papers

*Takashi Mochizuki[1,2], Yu Kosaka[3], Masato Mori[4], Yukiko Imada[5], Tomoki Miyakawa[6] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Research Center for Advanced Science and Technology, The University of Tokyo, 4.Research Institute for Applied Mechanics, Kyushu University, 5.Meteorological Research Institute, 6.Atmosphere and Ocean Research Institute, The University of Tokyo)

[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 | Ch.03_1

[A-OS09] Climate variability and predictability on subseasonal to multidecadal timescales

convener:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL)

[AOS09-P01] **Trigger of multi-year La Niña and its physical link with preceding extreme El Niño**

*Tomoki Iwakiri[1], Masahiro Watanabe[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[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 | Ch.11 Zoom Room 11

[A-OS10] Continental Oceanic Mutual Interaction - Planetary Scale Material Circulationn

convener:Alexandre Yosuke Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Takanori Sasaki(Department of Astronomy, Kyoto University), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001), Chairperson:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001)

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

[AOS10-01] Wintertime impacts of the 2019 Super Indian Ocean Dipole on East Asia

★Invited Papers

*Takeshi Doi[1], Swadhin Behera[1], Toshio Yamagata[1,2] (1.JAMSTEC/VAiG/APL, 2.NUITS/ICAR)

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

[AOS10-02] River-ocean interaction across a mega-delta

*Shinichiro Kida[1], Dai Yamazaki[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Institute of Industrial Sciences, The University of Tokyo)

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

[AOS10-03] Vegetation indices using unmanned aerial vehicle to monitor plant-level tomato plant height under till and no-till farming conditions

*Kenichi TATSUMI[1], Noa Igarashi[1], Mengxue Xiao[1] (1.Tokyo University of Agriculture and Technology)

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

[AOS10-04] **An ocean-atmosphere wave number-4 pattern in the southern subtropics**

*Swadhin Behera[1], Balaji Senapati[2], Mihir Dash[2] (1.Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001, 2.Centre for Oceans, Rivers, Atmosphere and Land Sciences, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, India)

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

[AOS10-05] **Hydrological Hindcasts and Parameterizations for Flash Floods Real-Time Forecasting of Typhoon Hagibis 2019 in Japan**

*Josko Troselj[1], Han Soo Lee[1] (1.Graduate School of Advanced Science and Engineering, Hiroshima University)

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

[AOS10-06] Long-Term Stay Facility for Living with the Sea on the Mars

★Invited Papers

*takuya ONO[1] (1.Kajima corporation)

[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 | Ch.11 Zoom Room 11

[A-OS10] Continental Oceanic Mutual Interaction - Planetary Scale Material Circulationn

convener:Alexandre Yosuke Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Takanori Sasaki(Department of Astronomy, Kyoto University), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001), Chairperson:Yosuke Alexandre Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Takanori Sasaki(Department of Astronomy, Kyoto University)

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

[AOS10-07] The Atmospheric Response of Earth-like Exoplanets to X-ray and Extreme UV emission from G-M planet hosts: Case of TOI-700b

★Invited Papers

*Vladimir Airapetian[1], Jared M. Bell[1], Alex Glocer[1] (1.NASA Goddard Space Flight Center, USA)

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

[AOS10-08] How do we understand habitable climets on exoplanets?

★Invited Papers

*Takanori Kodama[1] (1.Kodama Institute for Science, The University of Tokyo)

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

[AOS10-09] Building Sustainable Human Society on the Moon

★Invited Papers

*Yoshiufumi Inatani[1] (1.Japan Aerospace Exploration Agency)

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

[AOS10-10] Space camp at Bioshere2: Field educational activity for future space mission, environmental research and international coordination

*Tomoyuki Tajima[1], Masahiro Terada[1], Satoko Tsujihiro[1], Takao Doi[2], Yosuke Alexandre Yamashiki[2,1] (1.Unit of Synergetic Studies for Space, Kyoto University, 2.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

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

[AOS10-11] Relationship between three-dimensional velocity of filament eruptions and CME association

*Daikichi SEKI[1,3], Kenichi Otsuji[2], Takako T. Ishii[3], Ayumi Asai[3], Kiyoshi Ichimoto[3] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2.National Institute of Information and Communications Technology, 3.Astronomical Observatory, Kyoto University)

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

[AOS10-12] Development of virus container for exposure to stratospheric environment

*Kenji Miki[1,2], Osamu Sahara[3], Takanori Endo[4] (1.Tokyo Institute of Technology Earth-Life Science Institute, 2.Keio University Faculty of Science and Technology, 3.Tokushima University, 4.GOCCO Co., Ltd.)

[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 | Ch.03_2

[A-OS10] Continental Oceanic Mutual Interaction - Planetary Scale Material Circulationn

convener:Alexandre Yosuke Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Takanori Sasaki(Department of Astronomy, Kyoto University), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001)

[AOS10-P01] How the delay time the rainfall flow into the lake?

*Maho Iwaki[1], Yosuke Alexandre Yamashiki[2], Takashi Toda[1], Chunmeng Jiao[3], Michio Kumagai[4] (1.Lake Biwa Museum, 2.Kyoto University, 3.Lake Biwa Environmental Research Institute, 4.Ritsumeikan University)

[AOS10-P02] A Proposal of a Preprocessing Using Deep Reinforcement Learning for Improving the Accuracy of Marine Animal Identification

*Okamura Shin[1], Yosuke Yamashiki[1] (1.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University)

[AOS10-P03] Quantification of Submerged Aquatic Vegetation in Lake Biwa using GCOM-C

*Hiroaki Sato[1], Yosuke Alexandre Yamashiki[2], Junichi Susaki[1], Kanako Ishikawa[3] (1.Kyoto University, 2.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 3.Lake Biwa Environmental Research Institute)

[AOS10-P04] Mangrove as the third way to obtain salt in space colonization

*Kaho Jasmine Takahata[1], Kazusa Fukuhara[1], Keiko Kurooka[1], Erina Kawashima[1], Kiyotaka Okada[2], Yosuke Alexandre Yamashiki[3] (1.Kindai University, Faculty of Medicine, 2.Department of Arts and Science, Kindai University Faculty of Medicine, 3.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University)

[AOS10-P05] Characteristics of the filament eruption event on August 9, 2016 with CME using Hα Doppler velocity field analysis.

*Nami Kimura[1], Ayumi Asai[2], Kenichi Otsuji[3], Yosuke Alexandre Yamashiki[4] (1.Kyoto University, 2.Astronomical Observatory, Kyoto University, 3.National Institute of Information and Communications Technology, 4.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Japan)

[AOS10-P06] Characterization of long-term groundwater level changes associated with the 2016 Kumamoto Earthquake

*Shun Yamamoto[1], Katsuaki Koike[2], Yosuke Alexandre Yamashiki[1] (1.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2. Environmental Geosphere Engineering Laboratory, Department of Urban Management, Graduate School of Engineering, Kyoto University)

[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 | Ch.07 Zoom Room 07

[A-OS18] Kuroshio Large Meander

convener:Toru Miyama(Japan Agency for Marine-Earth Science and Technology, Application Laboratory), Norihisa Usui(Meteorological Research Institute), Hidetaka Hirata(Rissho University), Takashi SETOU(Japan Fisheries Research and Education Agency), Chairperson:Hidetaka Hirata(Rissho University), Takashi Setou(Japan Fisheries Research and Education Agency)

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

[AOS18-01] Impact of the 2017 Kuroshio Large Meander on the Decadal Kuroshio Extension Variability

★Invited Papers

*Bo Qiu[1], Shuiming Chen[1], Niklas Schneider[1], Eitarou Oka[2], Shusaku Sugimoto[3] (1.University of Hawaii at Manoa, 2.University of Tokyo , 3.Tohoku University)

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

[AOS18-02] Subtropical Mode Water in a recent persisting Kuroshio large meander period. Part I: Formation and advection over the entire distribution region

*Eitarou Oka[1], Hatsumi Nishikawa[1], Shusaku Sugimoto[2], Bo Qiu[3], Niklas Schneider[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.Department of Oceanography, University of Hawaii at Manoa)

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

[AOS18-03] Subtropical Mode Water in a recent persisting Kuroshio large meander period. Part II: Formation and temporal evolution in the recirculation gyre off Shikoku.

*Hatsumi Nishikawa[1], Shusaku Sugimoto[2], Eitarou Oka[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Graduate School of Science, Tohoku University)

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

[AOS18-04] Increase in summer surface air temperature at the Kanto district attributable to Kuroshio large meander

*Shusaku Sugimoto[1], Bo Qiu[2], Niklas Schneider[2] (1.Graduate School of Science, Tohoku University, 2.The University of Hawaii)

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

[AOS18-05] Comparison of the processes of their response to the Kuroshio Large Meander between explosive cyclones that differ in the development type

*Hidetaka Hirata[1], Ryuichi Kawamura[2], Masami Nonaka[3] (1.Rissho University, 2.Kyushu University, 3.Japan Agency for Marine-Earth Science and Technology)

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

[AOS18-06] Why has the 2017 Kuroshio large meander lasted so long?

*Norihisa Usui[1], Nariaki Hirose[1], Yosuke Fujii[1], Nadao Kohno[1] (1.Meteorological Research Institute)

[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 | Ch.03_3

[A-OS18] Kuroshio Large Meander

convener:Toru Miyama(Japan Agency for Marine-Earth Science and Technology, Application Laboratory), Norihisa Usui(Meteorological Research Institute), Hidetaka Hirata(Rissho University), Takashi SETOU(Japan Fisheries Research and Education Agency)

[AOS18-P01] Characteristics and evolution of the cyclonic eddy in the Kuroshio coastal area in association with the Kuroshio large meander

★Invited Papers

*Daiki Ito[1], Takashi Setou[1], Daisuke Ambe[1], Yugo Shimizu[1,2] (1.Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 2.(Present affiliation) Fisheries Agency)

[AOS18-P02] The relationship between Kuroshio meander and observed tidal-regime shift along southern coast of Japan

*Takumi Kamura[1], Hiromi Matsuura[1], Katsuto Uehara[2] (1.Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Research Institute for Applied Mechanics, Kyushu University)

[AOS18-P03] Eddy separation from the Kuroshio Large Meander in 2020

*Toru Miyama[1], Yasumasa Miyazawa[1], Sergey M Varlamov[1], Zhang Ruochao[1] (1.Japan Agency for Marine-Earth Science and Technology, Application Laboratory)

[AOS18-P04] Study on the temporal and spatial variation of the Kuroshio Current path

*Yuya Hirano[1], Kazuyuki Uehara[1] (1.Graduate School of Earth Environmental Science, Tokai University)

[AOS18-P05] Impact of a Marine Heatwave Attributable to a Kuroshio Large Meander on Extreme Heavy Rainfall Caused by an Extratropical Cyclone

*Eigo Tochimoto[1], Satoshi Iizuka[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[AOS18-P06] **The Kuroshio volume transport in near future estimated by Reduced Gravity model**

*Takashi SETOU[1], Akira KUSAKA, Daisuke Ambe, Daiki Ito[1], Takashiko Kameda (1.Japan Fisheries Research and Education Agency)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.13 Zoom Room 13

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Hiroto Nagai(Waseda Univ., School of Education)

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

[ACC25-01] Fieldwork under the COVID19 circumstances –Examples from Alaska and Siberia–

★Invited Papers

*Go Iwahana[1] (1.International Arctic Research Center, University of Alaska Fairbanks)

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

[ACC25-02] Mapping of permafrost distribution in mid-Amur basin by satellite data analysis and local vegetation research

*Yuto Tashiro[1], Muneoki Yoh[2], Takayuki Shiraiwa[3], Takeo Onishi[4] (1.Institute for Space Earth Environmental Research, Nagoya University, 2.Tokyo University of Agriculture and Technology, 3.Institute of Low Temperature Science, Hokkaido University, 4.Gifu University)

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

[ACC25-03] Observation at Ny-Alesund, Svalbard under the COVID-19 situation

★Invited Papers

*Junji Matsushita[1], Hiroshi Miyaoka[1] (1.National Institute of Polar Research)

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

[ACC25-04] Study of the formation of stratified firn on the snow surface near Dome Fuji, Antarctica, by multiple physicochemical analyses

*Ryo Inoue[1], Shuji Fujita[2,1], Kenji Kawamura[2,1,3], Jun Ogata[2], Motohiro Hirabayashi[2], Kaori Fukuda[2], Kyotaro Kitamura[2], Ayaka Yonekura[1], Kumiko Goto-Azuma[2,1], Fumio Nakazawa[2,1], Ikumi Oyabu[2], Hideaki Motoyama[2,1] (1.The Graduate University for Advanced Studies, 2.National Institute of Polar Research, 3.Japan Agency for Marine-Earth Science and Technology)

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

[ACC25-05] Evolution of supraglacial ponds at the southern Inylchek Glacier, Kyrgyz Republic

*Natsumi Homma[1], Chiyuki Narama[1], Naoki Sakurai[2] (1.Niigata Univ., 2.Aero Asahi Co.)

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

[ACC25-06] **The area fluctuations of short-lived glacial lake in the Teskey Range, Central Asia**

*Naho Yamada[1], Chiyuki Narama[1], Mirlan Daiyrov[2] (1.niigata university, 2.CAIAG)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.13 Zoom Room 13

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

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

[ACC25-07] The formation environment of glacier-derived rock glacier in the Tien Shan, Central Asia

*Shun Okuyama[1], Chiyuki Narama[2], Akiko Yamamura[3], Hideyuki Takadama[4], yamanokuti Tsutomu[5] (1.Graduate Student,Niigata Univ., 2.Niigata Univ., 3.Aero Asahi Co., 4.PASCO Co., 5.Remote Sensing Technology Center of Japan)

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

[ACC25-08] Collapse of snow patch in the Hakuba-Daisekkei, northern Japanese Alps

*Ryoji Yoshimura[1], Chiyuki Narama[1] (1.Niigata Univ.)

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

[ACC25-09] Characteristics of topography where glaciers can exist in the northern Japanese Alps

*Kenshiro Arie[1], Chiyuki Narama[1], Kotaro FUKUI[2], Hajime IIDA[2], Ryohei Yamamoto[3] (1.Niigata University, 2.Tateyama Caldera Sabo Museum, 3.Aero Asahi corporation)

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

[ACC25-10] Seasonal and altitudinal variations in snow algal bloomings in Mt. Gassan in Yamagata prefecture, Japan

*Takumi Suzuki[1], Nozomu Takeuchi[1] (1.Chiba University)

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

[ACC25-11] Research life under COVID19 in Colorado, USA

★Invited Papers

*Uetake Jun[1] (1.Field Science Center for Northern Biosphere, Hokkaido University)

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

[ACC25-12] Discussion

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.04_1

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

[ACC25-P01] Evidence for long-range transport of atmospheric microplastic

*Osamu Nagafuchi[1], Koyomi Nakazawa[1] (1.Fukuoka Institute of Techology)

[ACC25-P02] **A discussion of the circumstances and causes of the massive avalanche that occurred at Mt. Kiso Ontake on May 21st 2019**

*Hideo Suzuki[1], Takeshi Saito[2], Kuniaki Makino[2] (1.Institute of Science, Academic Assembly School of Science and Technology, Shinshu University, 2.Department of Geology, Faculty of Science, Shinshu University)

[ACC25-P03] Preliminary observation report of snow-buried corner reflectors for SAR-based snow-depth monitoring in Nagaoka, Niigata (2020/2021)

*Hiroto Nagai[1,2], Sojiro Sunako[2], Katsuya Yamashita[2], Satoru Yamaguchi[2] (1.Waseda Univ., School of Education, 2.National Research Institute for Earth Science and Disaster Resilience)

[ACC25-P04] Radiation characteristics of thin sea ice in the ice tank experiment using multifrequency passive microwave radiometers

*Kzutaka Tateyama[1], Hiroyuki Enomoto[2], Masashige Nakayama[3], Naoto Shoji[1], Yurika Watanabe[1], Sae Ohira[1], Kohei Sato[1] (1.National University Corporation Kitami Institute of Technology, 2.Arctic Environment Research Center, National Institute of Polar Research, 3.National University Corporation Hokkaido University of Education, Kushiro campus)

[ACC25-P05] Polar snow monitoring by satellite microwave radiometer

*Nuerasimuguli Alimasi[1], Hiroyuki Enomoto[1] (1.National Institute of Polar Research)

[ACC25-P06] The observation plan of glacier research and its modification due to covid-19

*Keiko Konya[1] (1.Japan Agency for Marine-Earth Science and Technology)

[ACC25-P07] **Relationship between Haliaeetus pelagicus flights route over the Russian Far East and surface atmospheric conditions**

*Kazutoshi Sato[1], Kzutaka Tateyama[1], Saiko Shiraki[2], Yusuke Murata[1] (1.Kitami Institute of Technology, 2.Tokyo University of Agriculture)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.13 Zoom Room 13

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Nozomu Takeuchi(Chiba University), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(Nagoya University), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Chairperson:Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems)

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

[ACC26-01] Fractionation of O_2/N_2 and Ar/N_2 in polar ice cores during bubble formation, bubble-clathrate hydrate transition, and gas loss during storage from precise gas measurements of the Dome Fuji ice core, Antarctica

★Invited Papers

*Ikumi Oyabu[1], Kenji Kawamura[1,2,3], Tsutomu Uchida[4], Shuji Fujita[1,2], Kyotaro Kitamura[1], Motohiro Hirabayashi[1], Jeffrey Severinghaus[5], Morgan Jacob[5] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.The Graduate University of Advanced Studies (SOKENDAI), 3.Japan Agency for Marine Science and Technology (JAMSTEC), 4.Hokkaido University, 5.Scripps Institution of Oceanography)

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

[ACC26-02] Analysis of Dome Fuji ice core fabric by dielectric tensor measurement

★Invited Papers

*Tomotaka Saruya[1], Shuji Fujita[1,2] (1.National Institute of Polar Research, 2.SOKENDAI (The Graduate University for Advanced Studies))

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

[ACC26-03] Methane concentration in Dome Fuji ice core measured with a continuous flow analysis system

*Ayaka Yonekura[1], Kenji Kawamura[1,2,3], Ikumi Oyabu[2], Kyotaro Kitamura[2], Jun Ogata[2], Motohiro Hirabayashi[2], Kaori Fukuda[2], Yoshimi Tsukagawa[2], Tomotaka Saruya[2], Fumio Nakazawa[1,2], Shuji Fujita[1,2], Kumiko Goto-Azuma[1,2], Hideaki Motoyama[1,2] (1.The Graduate University for Advanced Studies, SOKENDAI, 2.National Insutitute of Polar Research, 3.JAMSTEC)

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

[ACC26-04] The role of Southern warming on global ocean states and abrupt warming events during the last deglaciation

★Invited Papers

*Takashi Obase[1], Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1], Tristan Vadsaria[1], Christo Buizert[2] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Oregon State University)

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

[ACC26-05] Climate model study on the driving mechanisms for abrupt climate changes during glacial periods and the effects of climatic precessions on the stability of the AMOC

*Yuta Kuniyoshi[1], Ayako Abe-Ouchi[1], Sam Sherriff-Tadano[2], Wing-Le Chan[1], Fuyuki SAITO[3] (1.The University of Tokyo, 2.University of Leeds, 3.JAMSTEC)

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

[ACC26-06] Comparative analysis of interglacial (MIS1, 5e, 11) climate responses to orbital elements and internal feedbacks

*Lynn Hirose[1], Ayako Abe-Ouchi[1], Wing-Le Chan[1] (1.the University of Tokyo)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.13 Zoom Room 13

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Nozomu Takeuchi(Chiba University), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(Nagoya University), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Chairperson:Nozomu Takeuchi(Chiba University), Ryu Uemura(Nagoya University)

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

[ACC26-07] Impacts of large scale atmospheric circulation on water isotopes of daily precipitation at Dome Fuji Station: A study with an isotope-enabled AGCM MIROC5-iso

*Kanon Kino[1,2], Okazaki Atsushi[3], Alexandre Cauquoin[2], Kei Yoshimura[2] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Institute of Industrial Science, the University of Tokyo, 3.The Pennsylvania State University)

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

[ACC26-08] The correlations between cloud amount over Northern mid-high latitudes and aerosol proxies preserved in the SE-Dome ice core, Greenland

* AKIHISA WATARI[1], Iizuka Yoshinori[1], Koji Fujita[2], Hirohiko Masunaga[2], Kazuaki Kawamoto[3] (1.Hokkaido university, 2.Nagoya university, 3.Nagasaki university)

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

[ACC26-09] Possible albedo reduction of snow surface due to black carbon over the past 350 years on the Greenland Ice Sheet estimated from the SIGMA-D ice core

*Teruo Aoki[1,2], Kumiko Goto-Azuma[1,2], Sumito Matoba[3], Rigen Shimada[4], Yutaka Kondo[1], Nobuhiro Moteki[5], Makoto Koike[5], Koji Fujita[6], Hideaki Motoyama[1,2], Masahiro Hori[7] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Institute of Low Temperature Science, Hokkaido University, 4.Earth Observation Research Center, Japan Aerospace Exploration Agency, 5.School of Science, University of Tokyo, 6.Graduate School of Environmental Studies, Nagoya University, 7.School of Sustainable Design, University of Toyama)

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

[ACC26-10] Intra-ice and intra-sediment cryopeg brine occurrence in permafrost near Utqiagvik (Barrow)

*Go Iwahana[1], Zachary S. Cooper[2], Shelly D. Carpenter[2], Jody W. Deming[2], Hajo Eicken[1] (1.International Arctic Research Center, University of Alaska Fairbanks, 2.School of Oceanography, University of Washington)

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

[ACC26-11] Ice core drilling on a high-elevation accumulation zone of Trambau Glacier in the Nepal Himalaya

*Nao Esashi[1], Akane Tsushima[2], Ryu Uemura[1], Yoshinori Iizuka[3], Sumito Matoba[3], Koji Fujita[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Graduate School of Science, Chiba University, 3.Institute of Low Temperature Science, Hokkaido University)

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

[ACC26-12] An attempt to reconstruct air temperature in the past using DNA information in ice core samples on Gregoriev Glacier, Kyrgyz Tienshan

★Invited Papers

*Segawa Takahiro[1], Koji Fujita[2], Ayumi Akiyoshi[3], Nozomu Takeuchi[4] (1.University of Yamanashi, 2.Nagoya University, 3.National Institute of Polar Research, 4.Chiba University)

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.04_2

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Nozomu Takeuchi(Chiba University), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(Nagoya University), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems)

[ACC26-P01] A biomass burning record over the past 350 years in an ice core from Northwest Greenland

*Kumiko Goto-Azuma[1,2], Yoshimi Ogawa-Tsukagawa[1], Yutaka Kondo[1], Remi Dallmayr[9], Jun ogata[1], Nobuhiro Moteki[3], Sho Ohata[4], Tatsuhiro Mori[5], Makoto Koike[3], Kaori Fukuda[1], Motohiro Hirabayashi[1], Sumito Matoba[6], Yuki Komuro[1], Akane Tsushima[7], Naoko Nagatsuka[1], Koji Fujita[4], Naga Oshima[8], Kyotaro Kitamura[1], Kenji Kawamura[1,2], Wataru Shigeyama[1,2], Hideaki Motoyama[1,2], Teruo Aoki[1,2] (1.National Institute of Polar Research, 2.SOKENDAI, 3.University of Tokyo, 4.Nagoya Univeristy, 5.Tokyo University of Science, 6.Hokkaido University, 7.Chiba University, 8.Meteorological Research Institute, 9.Alfred Wegner Institute for Polar and Marine Research)

[ACC26-P02] Seasonal changes in concentration, metal composition and size distribution of mineral particles in recent snow at EGRIP, Greenland

*Yuki Komuro[1], Fumio Nakazawa[1,2], Kumiko Goto-Azuma[1,2], Motohiro Hirabayashi[1], Wataru Shigeyama[1,2], Naoko Nagatsuka[1] (1.National Institute of Polar Research, 2.The Graduate University for Advanced Studies, SOKENDAI)

[ACC26-P03] Implementation of higher-order advection schemes in a numerical ice-sheet model for ice-core studies

*Fuyuki SAITO[1], Takashi Obase[2], Ayako Abe-Ouchi[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

[ACC26-P04] An ice-flow modeling study for evaluation of sites for an oldest ice core around Dome Fuji, Antarctica

*Takashi Obase[1], Ayako Abe-Ouchi[1,2], Fuyuki SAITO[3], Shun Tsutaki[2], Shuji Fujita[2,4], Kenji Kawamura[2,4] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.National Institute of Polar Research, Japan, 3.Japan Agency for Marine-Earth Science and Technology, 4.SOKENDAI, the Graduate University for Advanced Studies)

[ACC26-P05] The effect of ocean circulation on glacial-interglacial cycles

*Ryotaro Todoroki[1], Ayako Abe-Ouchi[1], Fuyuki SAITO[2], Takashi Obase[1], Wing-Le Chan[1], Sam Sherriff-Tadano[3], Yasuto Watanabe[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 3.The University of Leeds, 4.The University of Tokyo)

[ACC26-P06] Transient simulations of the last deglaciation using MIROC AOGCM and time evolving ice-topography

*Tristan Vadsaria[1], Takashi Obase[1], Ayako Abe-Ouchi[1], Sam Sherriff-Tadano [2,1], Wing-Le Chan[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, Japan, 2.School of Earth and Environment, The University of Leeds, Leeds, UK)

[ACC26-P07] Inactivating microorganisms in melted snow and ice samples using ultraviolet germicidal radiation

*Fumio Nakazawa[1,2], Kumiko Goto-Azuma[1,2] (1.National Institute of Polar Research, 2.The Graduate University for Advanced Studies, SOKENDAI)

[ACC26-P08] The origin of moisture inferred from water stable-isotopes of an ice-core drilled in the Pamir-Alay Mountains in Central Asia

*Daiki Seto[1], Nozomu Takeuchi[1], Aizen Vladimir[2], Akane Tsushima[3], Kenji Kawamura[4], Koji Fujita[5] (1.CHIBA university, 2.University of Idaho, 3.Graduate School of science, Chiba university, 4.Graduate School of Environmental Studies, Nagoya University, 5.National Institute of Polar Research, Research Organization of Information and Systems)

[ACC26-P09] Analyses of pollen grains and insoluble particles in an ice core drilled in the Pamir-Arai Mountains in central Asia

*Nozomu Takeuchi[1], Haruka Ogaya[1], Koji Fujita[2], Kenji Kawamura[3], Akane Tsushima[1], Vladimir Aizen[4] (1.Chiba University, 2.Nagoya University, 3.National Institute of Polar Research, 4.University of Idaho)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.12 Zoom Room 12

[A-GE27] Subsurface Mass Transport and Environmental Assessment

convener:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Chihiro Kato(Faculty of Agriculture and Life Science, Hirosaki University), Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo), Chairperson:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Zi feng Wu (Guangzhou University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo),Yuki Kojima(Department of Civil Engineering, Gifu University)

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

[AGE27-01] Numerical simulation of soil moisture dynamics using physics-informed neural networks

★Invited Papers

*Toshiyuki Bandai[1], Teamrat A. Ghezzehei[1] (1.The University of California, Merced)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AGE27-02] Improvement of contaminant plume estimation by a geostatistical method considering groundwater flow and non-negativity

*Shizuka Takai[1], Taro Shimada[1], Seiji Takeda[1], Katsuaki Koike[2] (1.Japan Atomic Energy Agency, 2.Graduate School of Engineering, Kyoto-University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[AGE27-03] [Comparison of experiments and model calculations on the capillary rise of water and the air entrapment in rock pores]

*Ryoto Nomura[1], Tadashi Yokoyama[2], Naoki Nishiyama[3] (1.Graduate School of Advanced Science and Engineering, Hiroshima University, 2.Graduate School of Integrated Arts and Sciences, Hiroshima University, 3.University of Tsukuba)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[AGE27-04] Open-Loop System Ground Source Heat Pump on the Nagara River Alluvial Fan: An Assessment of Thermal Environmental Impact

*Randa Permanda[1], Tomoyuki Ohtani[1] (1.Gifu University)

11:50 AM - 12:15 PM JST | 2:50 AM - 3:15 AM UTC

[AGE27-05] Discussion

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.05_1

[A-GE27] Subsurface Mass Transport and Environmental Assessment

convener:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Chihiro Kato(Faculty of Agriculture and Life Science, Hirosaki University), Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo)

[AGE27-P01] Chemical and Biological Properties of Apple Orchard Soils under Natural, Hybrid, and Conventional Farming Methods

★Invited Papers

*Takamitsu Kai[1], Motoki Kubo[2] (1.Meiji University, 2.Ritsumeikan University)

[AGE27-P02] **Impact of Macropore structure and water management on greenhouse gas emissions, total soil carbon and nitrogen, and soil mineral distribution in agricultural field**

*Thanh Long Bui[1], Yasushi Mori[1], Morihiro Maeda[1] (1.Graduate School of Environmental and Life Science, Okayama University)

[AGE27-P03] Evaluation of radioactive cesium-bearing microparticles discharged with suspended solids from a small forested watershed

Satoshi Hadano[1], Shoichiro Hamamoto[1], Taiga Okumura[2], Toshihiro Kogure[2], *Taku Nishimura[1] (1.Deptartment of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

[AGE27-P04] Evaluating effects of plant roots on soil thermal properties with a thermo-TDR sensor

*Nanae Oda[1], Yuki Kojima[1], Kohji Kamiya[1] (1.Gifu University)

[AGE27-P05] Quantifying in-situ fine bubble concentration in water and soil with thermo-TDR

*Ryunosuke Tanigawara[1], Yuki Kojima[1], Shoichiro Hamamoto[2], Kohji Kamiya[1] (1.Faculty of Engineering, Gifu University, 2.Graduate School of Life and Agricultural Sciences, University of Tokyo)

[AGE27-P06] A laboratory test of heavy metal accumulation by using soil cooling and heating technique inducing dynamic soil water freezing and evaporation

*Yuki Kojima[1], Hayata Terada[2], Kohji Kamiya[1] (1.Department of Civil Engineering, Gifu University, 2.Graduate School of Natural Science and Technology, Gifu University)

[AGE27-P07] Effect of the gravity differences on early stage water movement in soils.

*Ryoki Ihara[1], Yasushi Mori[2] (1.Faculty of Environmental Science and Technology, Okayama University, 2.Graduate School of Environmental and Life Science, Okayama University)

[AGE27-P08] Neural network estimation of soil organic matter contents and its relation to other soil components.

Masaki Kiyohiro[1], *Yasushi Mori[1], Takayuki Shuku[1] (1.Graduate School of Environmental and Life Science, Okayama University)

[AGE27-P09] Water and Mass Transfer in Soils and Optimal Farmland Management in the Rice Terraces of the Philippine Cordillera

Tomoyo Kurozumi[1], *Yasushi Mori[1], Hiroaki Somura[1], Pearl Basilio Sanchez[2], Gina Villegas-Pangga[2] (1.Graduate School of Environmental and Life Science, Okayama University, 2. University of the Philippines Los Baños)

[AGE27-P10] Estimation of Soil Water Retention Parameters by Ground Penetrating Radar Reflection Wave Inversion

*Hiroki Kawasumi[1], Hirotaka Saito[2], Koki Oikawa[2] (1.Department of Ecoregion Science, Tokyo University of Agriculture and Technology, 2.Department of Ecoregion Science, Tokyo University of Agriculture and Technology)

[AGE27-P11] Effects of elevated air temperature and CO_2 concentration on soil CO_2 dynamics in an apple orchard

*Chihiro Kato[1], Akira Endo[1], Daiyu Ito[2], Sachinobu Ishida[3] (1.Faculty of Agriculture and Life Science, Hirosaki University, 2.Teaching and Research Center for Bio-coexistence, Faculty of Agriculture and Life Science, Hirosaki

University, 3.Graduate school of Science and Technology, Hirosaki University)

[AGE27-P12] Effect of soil air on pore network properties and mass transport in porous media

Yushi Ohko[1], *Shoichiro Hamamoto[1], Yutaka Ohtake[2], Taku Nishimura[1] (1.Graduate School of Agricultural and Life Sciences, the University of Tokyo, 2.Graduate School of Engineering, the University of Tokyo)

[AGE27-P13] Monitoring of soil gas environment in soybean fields under different fertilizer managements

*Ayato Nishimura[1], Shoichiro Hamamoto[1], Naoto Nihei[2], Toshinobu Taira[3], Katsuo Tanji[3], Yasunori Ichihashi[4], Taku Nishimura[1] (1.Graduate School of Agricultural and Life Sciences, the University of Tokyo, 2.Faculty of Food and Agricultural Sciences, Fukushima University , 3.Fukushima Agricultural Technology Centre, 4.RIKEN BioResource Research Center)

[AGE27-P14] Effects of Cation Exchange on Colloid Transport in Saturated Porous Media

*Rikutaro Higashi[1], Shoichiro Hamamoto[1], Taku Nishimura[1] (1.Graduate School of Agricultural and Life Sciences, the University of Tokyo)

[AGE27-P15] Seasonal Variation of the Effect of Ridge Orientation on Water and Temperature Distribution Inside Ridges

*Keito MASUMOTO[1], Shintaro Kubota[2], Hirotaka Saito[3] (1.Department of Ecoregion Science, Tokyo University of Agriculture and Technology, 2.Graduate School of Agriculture, Tokyo University of Agriculture and Technology, 3.Institute of Agriculture, Tokyo University of Agriculture and Technology)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.12 Zoom Room 12

[A-GE28] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Yonghong Hao(Tianjin Normal University), Jet-Chau Wen(National Yunlin University of Science and Technology), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Chairperson:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University)

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[AGE28-01] Introduction

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[AGE28-02] **Investigate the Benefit of Micro-hydropower Generation on Water-energy-food Nexus : A case study in Linnei channel**

★Invited Papers

*Shih Jen-Chieh[1], Fu-Yuan Lin[2], Ming-Der Hong[2], Hong-Ru Lin [3], Jet-Chau Wen[4,5] (1.Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology., 2.Irrigation and Engineering, Council of Agriculture, Executive Yuan., 3.Graduate School of Engineering Science and Technology, National Yunlin University of Science and Technology., 4.Research Center for Soil and Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science and Technology., 5.Department and Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology.)

2:10 PM - 2:25 PM JST | 5:10 AM - 5:25 AM UTC

[AGE28-03] Preliminarily environmental magnetic results from packed snow along the roadside at Mt. Tateyama, Toyama, Japan.

*Kazuo Kawasaki[1] (1.School of Sustainable Design, University of Toyama)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[AGE28-04] **Gas Transport and Pore Structural Parameters of Granulated Bentonite Mixtures at Varied Densities**

*Mazhar Nazir[1], Akihiro Matsuno[1], Ken Kawamoto[1], Sakaki Toshihiro[2] (1.Graduate School of Science and Engineering, Saitama University, Japan, 2.Environmental Science and Engineering Consulting, Japan)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[AGE28-05] **Exploring the Spatial and Temporal Variability of the Hydraulic Tomography Estimates**

*Si-Xian Liu[1], Jyun-Lin Chen[2], Hong-Ru Lin[2], Tian-Chyi Jim Yeh[3], Jet-Chau Wen[2,4] (1.Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology., 2.Research Center for Soil and Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science and Technology., 3.Department of Hydrology and Atmospheric Sciences, The University of Arizona., 4.Department and Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[AGE28-06] **Characterization of particle breakage of recycled concrete aggregates with different fines contents under different compaction energies**

*Thai Hong Nam[1], Akira Kato[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University, Saitama, Japan)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

[AGE28-07] Discussion

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.05_2

[A-GE28] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Yonghong Hao(Tianjin Normal University), Jet-Chau Wen(National Yunlin University of Science and Technology), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University)

[AGE28-P01] **Assessment of Hydrophobicity/Oleophilicity for Artificially Coated Autoclave Aerated Concrete Grains**

*Muhammad Junaid Zafar[1], Akihiro Matsuno[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University, Japan)

[AGE28-P02] Measurements unsaturated hydraulic property of recycled concrete aggregates for a road - base layer

*Ryohei ITO[1], Akira Kato[1], Akihiro Matsuno[1], Ken Kawamoto[1,2] (1.Graduate School of Science and Engineering, Saitama University, Japan, 2.National University of Civil Engineering, Vietnam)

[AGE28-P03] Characterization of Physical and Chemical Properties for CDW Fine Residues of Dumped CDW in Hanoi,Vietnam

*NINGNING HAO[1], Akihiro Matsuno[1], Ken Kawamoto[1], Akira Kato[1] (1.Saitama University)

[AGE28-P04] Effects of Silicic Acid on Arsenite Leaching from Spent Magnesium-based Arsenic Adsorbents

*Hajime Sugita[1], Terumi Oguma[1], Ming Zhang[1], Junko Hara[1], Yoshishige Kawabe[1] (1.National Institute of Advanced Industrial Science and Technology)

[AGE28-P05] Identifying glacier sensitive zones based on mass balance anomaly and its linkage to climate change

*Yonghong Hao[1], Huiqing Hao[1], Yan Liu[1], Tian-Chyi Jim Yeh[2], Ming Zhang[3] (1.Tianjin Normal University, 2.The University of Arizona, 3.AIST)

[AGE28-P06] Tidal Method for the Estimation of Coastal Aquifer Properties Based on Theoretical Solutions: Advantages and Limitations

*Ming Zhang[1], Yonghong Hao[2], Zhixue Zhao[2], Tongke Wang[2], Ling Yang[2] (1.Research Promotion Division, Geological Survey of Japan, AIST, 2.Tianjin Normal University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.12 Zoom Room 12

[A-CG31] Aircraft and UAV Observations for Earth-planetary sciences

convener:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University), Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Toshinobu Machida(National Institute for Environmental Studies), Taro Shinoda(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

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

[ACG31-01] Aircraft observation of typhoon environments using dropsondes of the Taiwan ASTRA jet

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

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

[ACG31-02] Large Eddy Simulation on Horizontal Rolls in Atmospheric Boundary Layer at Narita Airport and its Evaluation

*Junshi Ito[1], Hiroshi Niino[2], Katsumi Yoshino (1.Tohoku University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[ACG31-03] Remote Sensing of Atmospheric Composition using Commercial Flights between Tokyo-Haneda and Fukuoka-city

*Akihiko Kuze[1], hiroshi Suto[1], Seiya Kosaki[1], Kei Shiomi[1], Ayako Matsumoto[2], YaYasuhiro Tubakihara[2], Fumie Kataoka[3], Tetsuya Kaku[3], Shigetaka Mori[4] (1.Japan Aerospace Exploration Agency, 2.ANA HD, 3.RESTEC, 4.JASTECS)

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

[ACG31-04] Arctic black carbon during PAMARCMiP 2018 and previous aircraft experiments in spring

*Sho Ohata[1,2], Makoto Koike[3], Atsushi Yoshida[3], Nobuhiro Moteki[3], Kouji Adachi[4], Naga Oshima[4], Hitoshi Matsui[5], Oliver Eppers[6,7], Heiko Bozem[6], Marco Zanatta[8,9], Andreas B. Herber[8] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute for Advanced Research, Nagoya University, 3.Graduate School of Science, The University of Tokyo, 4.Meteorological Research Institute, 5.Graduate School of Environmental Studies, Nagoya University, 6.Johannes Gutenberg University of Mainz, 7.Max Planck Institute for Chemistry, 8.Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, 9.Université Paris-Est-Créteil)

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

[ACG31-05] Observation of red tide in an estuary by a fixed-wind type unmanned aircraft

*Soichi Yamaguchi[1], Shota Koide[1], Takayuki Mine[2], Takuya Iwanaga[2] (1.Kyushu university, 2.Saga Ariake Fisheries Promotion Center)

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

[ACG31-06] Understory biomass estimation based on Structure from Motion data by Multi-layered forest drone survey

*Yupan Zhang[1], Yuichi Onda[1], Hiroaki Kato[1], Takashi Gomi[2] (1.University of Tsukuba, 2.Tokyo University of Agriculture and Technology)

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.06_1

[A-CG31] Aircraft and UAV Observations for Earth-planetary sciences

convener:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University), Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Toshinobu Machida(National Institute for Environmental Studies), Taro Shinoda(Institute for Space-Earth Environmental Research, Nagoya University)

[ACG31-P01] The drone techniques for earth science research operated by high school students and applying for efficiency environmental survey education

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

[ACG31-P02] Vegetation Monitoring by Aircraft Observation: Review and Requirement

*Kazuhito Ichii[1] (1.Chiba University)

[ACG31-P03] Cloud seeding experiment for precipitation augmentation with aircraft in-situ measurements

*Narihiro Orikasa[1], Masataka Murakami[2,1], Atsushi Saito[3], Takuya Tajiri[1], Yuji Zaizen[1], Taro Shinoda[2] (1.Meteorological Research Institute, 2.Nagoya University, ISEE, 3.Japan Meteorological Agency)

[ACG31-P04] Simulation of airborne dual-polarization phased array radar observation of a typhoon

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

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.08 Zoom Room 08

[A-CG33] Terrestrial monitoring using new-generation geostationary satellites

convener:Yuhei Yamamoto(Center for Environmental Remote Sensing, Chiba University), Tomoaki Miura(Univ Hawaii), Kazuhito Ichii(Chiba University), Chairperson:Tomoaki Miura(Univ Hawaii)

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

[ACG33-01] **Using the Diurnal Variability in GeoNEX TOA Reflectances for Earth Monitoring**

★Invited Papers

*Weile Wang[1,2], Hirofumi Hashimoto[1,2], Andrew Michaelis[1], Taejin Park[1,5], Ramakrishna Nemani[1], Yujie Wang[3,4], Alexei Lyapustin[3], Tsengdar Lee[6], Satya Kalluri[7] (1.NASA Ames Research Center, 2.California State University Monterey Bay, 3.NASA Goddard Space Flight Center, 4.University of Maryland Baltimore, 5.Bay Area Environment Research Institute, 6.NASA Headerquarter, 7.NOAA NESDIS Center for Satellite Applications and Research)

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

[ACG33-02] Uncertainty quantification in operational algorithms to retrieve land surface temperature from Himawari-8/AHI data

*Yuhei Yamamoto[1], Kazuhito Ichii[1] (1.Center for Environmental Remote Sensing, Chiba University)

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

[ACG33-03] Himawari-8 based near-real time meteorological drought monitoring and early warning system in Asia

★Invited Papers

*Wataru Takeuchi[1], Rizatus Shofiyati[2], Khiem Mai Van[3], Kei Oyoshi[4], Tanita Suepa[5] (1.Institute of Industrial Science, The University of Tokyo, 2.Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD), 3.National Center of Hydro-Meteorology Forecasting (NCHMF), Vietnam, 4.Japan Aerospace Exploration Agency (JAXA), 5.Geo-Informatics & Space Technology Development Agency (GISTDA), Thailand)

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

[ACG33-04] Validation of HIMAWARI-8 AHI Aerosol Products with SKYNET and AERONET Measurements

*Hirokazu YAMAMOTO[1], Hitoshi Irie[2] (1.Geological Survey of Japan, AIST, 2. Center for Environmental Remote Sensing, Chiba University)

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

[ACG33-05] On the relationship between photosynthesis measures from OzFlux tower sites and Himawari-8 geostationary observations

★Invited Papers

*Alfredo R Huete[1], Qiaoyun Xie[1], Ngoc Nguyen Tran[1,2] (1.University of Technology Sydney, 2.School of Information and Communication Technology, Hanoi University of Science and Technology)

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

[ACG33-06] Seasonal variations in photosynthesis activities across Southeast Asia detected by a new geostationary satellite, Himawari-8

*Kazuhito Ichii[1], Kodai Hayashi[1], Yuhei Yamamoto[1] (1.Chiba University)

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.06_2

[A-CG33] Terrestrial monitoring using new-generation geostationary satellites

convener:Yuhei Yamamoto(Center for Environmental Remote Sensing, Chiba University), Tomoaki Miura(Univ Hawaii), Kazuhito Ichii(Chiba University)

[ACG33-P01] Introduction

[ACG33-P02] Himawari-8 AHI NDVI Temporal Signature Variability of Broadleaf Deciduous Forests Along Temperature, Elevation, and Latitudinal Gradients in Northern Japan

*Tomoaki Miura[1,2], Shin Nagai[2], Narumasa Tsutsumida[3], Yuhei Yamamoto[4] (1.University of Hawaii at Manoa, 2.JAMSTEC, 3.Saitama University, 4.Center for Environmental Remote Sensing, Chiba University)

[ACG33-P03] Geolocation accuracy assessment of CEReS released Himawari-8 gridded data

*Yuhei Yamamoto[1], Kazuhito Ichii[1], Atsushi Higuchi[1], Hideaki Takenaka[1] (1.Center for Environmental Remote Sensing, Chiba University)

[ACG33-P04] **Monitoring urban heat island of Jakarta using medium spatial resolution satellite data**

*Fitria Nucifera[1], Widiyana Riasasi[1], Da Wang[2], Yuhei Yamamoto[2], Kazuhito Ichii[2] (1.Universitas AMIKOM Yogyakarta, 2.Center for Environmental Remote Sensing (CeRES), Chiba University)

[ACG33-P05] Discussion

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.08 Zoom Room 08

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Hiroshi Murakami(Earth Observation Research Center, Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies)

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

[ACG36-01] Earth environment in 2020 observed by GCOM-C “SHIKISAI”

*Hiroshi Murakami[1], Kazuhisa Tanada[1], Rigen Shimada[1], Toshiyuki Kobayashi[1], Kazunori Ogata[1], Tomoko Koyama[1], Yukio Kurihara[1] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency)

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

[ACG36-02] **Validation of SGLI/GCOM-C cloud products using surface and MODIS observation data**

*Pradeep Khatri[1], Tadahiro Hayasaka[1], Hitoshi Irie[2], Tamio Takamura[2] (1.Center for Atmospheric and Oceanic Studies,Tohoku University, 2.Center for Environmental Remote Sensing, Chiba University)

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

[ACG36-03] Development of Above Ground Biomass estimation method by combined use of GCOM-C / SGLI and Space LiDAR observation data

*REI MITSUHASHI[1], Koji Kajiwara[2], Yoshiaki HONDA[2] (1.Japan Aerospace Exploration Agency, 2.Chiba University)

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

[ACG36-04] Spatial and Temporal Variations of XCO_2 and XCH_4 observed by GOSAT and GOSAT-2 in 2019 - 2020

★Invited Papers

*Tsuneo Matsunaga[1], Isamu Morino[1], Hirofumi Ohyama[1], Jiye Zeng[1], Hibiki M Noda[1], Makoto Saito[1], Yukio Yoshida[1], Akihide Kamei[1], Fumie Kawazoe[1], Tazu Saeki[1] (1.Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies)

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

[ACG36-05] Global high-resolution inverse model for application to space-based CO_2 observations

*Shamil Maksyutov[1], Tomohiro Oda[2], Jiye Zeng[1], Rajesh Janardanan[1], Yukio Yoshida[1], Johannes W Kaiser[3], David Crisp[4], Tsuneo Matsunaga[1] (1.National Institute for Environmental Studies, 2.Universities Space Research Association, 3.Deutscher Wetterdienst, 4.Jet Propulsion Laboratory/California Institute of Technology)

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

[ACG36-06] Observing anthropogenic emissions of greenhouse gases and air pollutants with the GOSAT-GW satellite: Scientific targets and policy contributions

*Hiroshi Tanimoto[1], Tsuneo Matsunaga[1], Nobuko Saigusa[1], Takafumi Sugita[1], Hisashi Yashiro[1], Isamu Morino[1], Makoto Saito[1], Hirofumi Ohyama[1], Kohei Ikeda[1], Yu Someya[1], Tamaki Fujinawa[1], Yousuke Yamashita[1], Tazu Saeki[1], Yugo Kanaya[2], Takashi Sekiya[2], Yasuko Kasai[3], Tomohiro Sato[3] (1.National Institute for Environmental Studies, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Institute of Information and Communications Technology)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.08 Zoom Room 08

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Naoto Ebuchi(Institute of Low Temperature Science, Hokkaido University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

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

[ACG36-07] Present Status of GCOM-W/AMSR2 and Outlook for GOSAT-GW/AMSR3

★Invited Papers

*Naoto Ebuchi[1,2], Misako Kachi[2], Marehito Kasahara[2], Hideyuki Fujii[2], Rigen Shimada[2], Keiichi Ohara[2], Takashi Maeda[2], Kazuya Inaoka[2], Yasushi Kojima[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.JAXA)

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

[ACG36-08] Examining possibility of cloud/rain/ice water path partitioning over land using passive microwave observations

*Rie Seto[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

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

[ACG36-09] Improvement in the GSMaP histogram matching algorithm for middle and lower level clouds

*Hitoshi Hirose[1], Tashima Tomoko[1], Takuji Kubota[1], Tomoaki Mega[2], Tomoo Ushio[2] (1.Japan Aerospace Exploration Agency, 2.Department of Engineering, Osaka University)

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

[ACG36-10] Current status of Level-2 algorithm for dual-frequency precipitation radar onboard GPM satellite

*Nobuhiro Takahashi[1], GPM International DPR L2 algorithm team - (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

[ACG36-11] Improvement of precipitation judgement by the GPM dual-frequency precipitation radar

*Kaya Kanemaru[1], Hiroshi HANADO[1], Katsuhiro Nakagawa[1] (1.National Institute of Information and Communications Technology)

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

[ACG36-12] Correction of path integrated attenuation estimates by considering soil moisture effect for the GPM Dual-frequency Precipitation Radar

★Invited Papers

*Shinta Seto[1] (1.Nagasaki University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.08 Zoom Room 08

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Kozo OKAMOTO(Meteorological Research Institute), Takemasa Miyoshi(RIKEN)

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

[ACG36-13] Statistical analysis of precipitation system characteristics observed by GPM/DPR over high-latitude land

*Atsushi Hamada[1], Rei Kawabata[1], Kazuaki Yasunaga[1] (1.University of Toyama)

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

[ACG36-14] Enhancement of Integrated Satellite Simulators for Data Assimilation

*Yasutaka Ikuta[1] (1.Japan Meteorological Agency/Meteorological Research Institute)

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

[ACG36-15] Addition of microwave humidity sounder radiance data to all-sky assimilation in the JMA global NWP system

*Hiroyuki Shimizu[1], Masahiro Kazumori[1], Hidehiko Murata[1] (1.Japan Meteorological Agency)

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

[ACG36-16] Improving Precipitation Prediction by Data Assimilation of GPM and Other Satellite Observations

*Takemasa Miyoshi[1], Shunji Kotsuki[2,1], Koji Terasaki[1], Shigenori Otsuka[1], Ting-Chi Wu[1], Hirofumi Tomita[1], Ying-Wen Chen[3], Kaya Kanemaru[4], Masaki Satoh[3], Hisashi Yashiro[5], Keiichi Kondo[6], Kozo OKAMOTO[6], Eugenia Kalnay[7], Takuji Kubota[8] (1.RIKEN, 2.Chiba University, 3.University of Tokyo, 4.NICT, 5.NIES, 6.Meteorological Research Institute, 7.University of Maryland, 8.JAXA)

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

[ACG36-17] Ensemble-Based Data Assimilation of GPM DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

★Invited Papers

*Shunji Kotsuki[1,2], Koji Terasaki[2], Masaki Satoh[3], Takemasa Miyoshi[2] (1.Center for Environmental Remote Sensing, Chiba University, 2.RIKEN Center for Computational Science, 3.Atmosphere and Ocean Research Institute, The University of Toky)

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

[ACG36-18] Recent progress in impact assessment of hyperspectral sounder for a Himawari follow-on satellite

*Kozo OKAMOTO[1], Hiromi OWADA[2], Tadashi Fujita[1], Masahiro Hayashi[1], Kotaro Bessho[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.06_3

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies)

[ACG36-P01] Evaluation of GCOM-C/SGLI L2 aerosol products: aerosol over the ocean, land aerosol by near-ultraviolet

*Tomoko Koyama[1], Kazuhisa Tanada[1], Hiroshi Murakami[1], Mayumi Yoshida[2] (1.JAXA, 2.RESTEC)

[ACG36-P02] The field campaign of DRAGON/J-ALPS in the mountain area of Japan for validation of satellite data

*Makiko Nakata[1], Itaru Sano[1], Sonoyo Mukai[2] (1.Kindai University, 2.The Kyoto College of Graduate Studies for Informatics)

[ACG36-P03] Advantages of GCOM-C/SGLI for characterization of biomass burning aerosols

*Makiko Nakata[1], Itaru Sano[1], Sonoyo Mukai[2] (1.Kindai University, 2.The Kyoto College of Graduate Studies for Informatics)

[ACG36-P04] Retrieval of aerosol properties from GOSAT-2/TANSO-CAI-2 and comparison with ground-based observations

*Makiko Hashimoto[1], Hideaki Takenaka[2], Chong Shi[3], Teruyuki Nakajima[3] (1.Japan Aerospace Explortion Agency, 2.Chiba University, 3. National Institute for Environmental Studies)

[ACG36-P05] Remote sensing of three-dimensional clouds from multispectral measurements using deep learning

*Hana Kato[1], Hironobu Iwabuchi[1] (1.Center for Atmospheric and Oceanic Studies, Graduate School of Science, Tohoku University)

[ACG36-P06] Long Term Analysis of TPW (total precipitable water vapor) product

*Ohara Keiichi[1], Takuji Kubota[1], Misako Kachi[1], Masahiro Kazumori[2] (1.Japan Aerosrpace Exploration Agency, 2.Japan Meteorological Agency)

[ACG36-P07] Evaluation of Himawari estimated precipitation product compared with GSMaP and JMA radar analysis

*Koichi Toyoshima[1], Hitoshi Hirose[2], Atsushi Higuchi[1] (1.Center for Environmental Remote Sensing, Chiba University, 2.Japan Aerospace Exploration Agency)

[ACG36-P08] Heavy orographic rainfall in Taiwan missed by the GPM Dual-Frequency Precipitation Radar (DPR) algorithm

*Riku Shimizu[1], Shoichi Shige[1], Toshio Iguchi[2], Cheng Ku Yu[3] (1.Graduate School of Science, Kyoto University, 2.University of Maryland, ESSIC, 3.National Taiwan University)

[ACG36-P09] Comparative analysis of the GSMaP and quantitative precipitation estimation based on surface observation by radars and gauges in heavy rainfall events over Vietnam

*Masato I. Nodzu[1], Jun Matsumoto[1,2], Hoa Khanh Thi Bui[3], Thanh-Hoa Pham-Thi[1], Thanh Ngo-Duc[4], Thu Nguyen-Vinh[3] (1.Tokyo Metropolitan University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Viet Nam Meteorological and Hydrological Administration, 4.University of Science and Technology of Hanoi, Vietnam Academy of Science and Technology)

[ACG36-P10] Improvement of cloud mask algorithm of CALIPSO lidar

*Eiji Oikawa[1], Hajime Okamoto[1], Kaori Sato[1] (1.Research Institute for Applied Mechanics, Kyushu University)

[ACG36-P11] Simultaneous retrieval of aerosols and ocean color parameters using GCOM-C/SGLI data

*Miho Sekiguchi[1], Makiko Hashimoto[2], Hideaki Takenaka[3], Chong Shi[4], Teruyuki Nakajima[4] (1.Tokyo University of Marine Science and Technology, 2.Japan Aerospace Exploration Agency/Earth Observation Research Center, 3.Chiba University, 4.National Institute for Environmental Studies)

[ACG36-P12] Verification of satellite-observed surface temperature in water areas and application to meteorological simulations

*Kanato Mano[1], Shozo Yamane[1] (1.Department of Environmental Systems Science, Doshisha University)

[ACG36-P13] Sampling simulation of spaceborne precipitation radar

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

[ACG36-P14] Comparative analysis between precipitation measurement by a satellite and meteorological observation by a high density ground surface observation network

*Hisato Iwashita[1] (1.Meisei Electric Co.,Ltd)

[ACG36-P15] **Comparison between random forest and multiple linear regression algorithms for digital soil mapping in the Thung Kula Ronghai region, Thailand**

*Sasirin Srisomkiew[1,2], Masayuki Kawahigashi[1], Pitayakon Limtong[2] (1.Department of Geography, Tokyo Metropolitan University, Tokyo 192-0397, Japan , 2.Land Development Department, Ministry of Agriculture and Cooperatives, Bangkok 10900, Thailand)

[ACG36-P16] Wildfire watch using SWIR data from SGLI/GCOM-C

*Yukio Kurihara[1], Hiroshi Murakami[1] (1.Japan Aerospace Exploration Agency / Earth Observation Research Center)

[ACG36-P17] Evolution of Global Satellite Mapping of Precipitation (GSMaP) Product version 05

*Takuji Kubota[1], Kazumasa Aonashi[1], Tomoo Ushio[2], Shoichi Shige[3], Tomoko Tashima[1], Munehisa Yamamoto[4], Moeka Yamaji[1], Hitoshi Hirose[1], Tomoaki Mega[2], Atsushi Hamada[5], Yukari Takayabu[6] (1.Earth Observation Research Center,Japan Aerospace Exploration Agency, 2.Osaka Unviversity, 3.Kyoto University, 4.RESTEC, 5.Toyama University, 6.University of Tokyo)

[ACG36-P18] Soil Moisture and Plant Water Content estimate in Pilot areas of the Mediterranean basin through multitemporal analysis of AMSR-E/2 images

*Giuliano Ramat[1], Fabrizio Baroni[1], Emanuele Santi[1], Simonetta Paloscia[1], Simone Pettinato[1] (1.CNR-IFAC, Earth Observation, Florence, Italy)

[ACG36-P19] GOSAT calibration activities and observation plans for advanced GHG measurements

*Kei Shiomi[1], Akihiko Kuze[1], Hiroshi Suto[1], Nobuhiro Kikuchi[1], Fumie Kataoka[2] (1.Japan Aerospace Exploration Agency, 2.Remote Sensing Technology Center of Japan)

[ACG36-P20] How can SAR small-satellite constellation potentially monitor flood area?

*Rie Seto[1], Natsumi Kitajima[1], Dai Yamazaki[2], Xudong Zhou[2], Wenchao MA[2], Shinjiro Kanae[1] (1.Tokyo Institute of Technology, 2.The University of Tokyo)

[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 | Ch.10 Zoom Room 10

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Makoto Yamada(Faculty of Economics, Ryukoku University), Chairperson:Masahiko Fujii(Faculty of Environmental Earth Science), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Makoto Yamada(Faculty of Economics, Ryukoku University)

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

[ACG40-01] Submarine groundwater discharge from Mt. Fuji in Suruga Bay(Ⅷ)

*Yasuhide Muranaka[1], Tomohide Kaneko[1], Tetsuhiro Watano[1], Tomoya Oka[1], Akira Ito[1], Masahiko Ono[2], Atsunao Marui[2] (1.Shizuoka Institute of Environment and Hygiene, 2.National Institute of Advanced Industrial Science and Technology)

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

[ACG40-02] Influence of groundwater-surface water exchange on riverine nutrient export to coastal seas: a comparative study at the six tide-less rivers in Wakasa Bay

*Toshimi Nakajima[1], Ryo Sugimoto[1] (1.Fukui Prefectural University)

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

[ACG40-03] Quantifying flux of groundwater-derived nutrients and phytoplankton assimilation rate of nutrients in a volcanic sandy beach

*Ryo Sugimoto[1], Ryoma Yagi[1], Toshimi Nakajima[1], Tatsuhiro Ishida[1], Makoto Yamada[2] (1.Faculty of Marine Biosciences, Fukui Prefectural University, 2.Faculty of Economics, Ryukoku University)

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

[ACG40-04] **Spatial and Temporal Patterns of the Physical and Biogeochemical Properties in the Nearshore Waters of Toyama Bay**

*Eligio de Raus Maure[1], Genki Terauchi[1], Yasuyuki Harada[1] (1.Northwest Pacific Region Environmental Cooperation Center)

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

[ACG40-05] The relationship between the timing and scale of *Karenia mikimotoi* bloom and environmental factors in the western Bungo Channel of Seto Inland Sea, Japan

*Yuma Hayashi[1], Naoki Yoshie[1], Goh Onitsuka[2] (1.Center for Marine Environmental Studies , Ehime University, 2.Japan Fisheries Research and Education Agency)

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

[ACG40-06] Continuous monitoring and future projection of ocean warming, acidification, and deoxygenation on the subarctic coast of Hokkaido, Japan

*Masahiko Fujii[1,2], Shintaro Takao[3], Takuto Yamaka[2], Tomoo Akamatsu[2], Yamato Fujita[2], Masahide Wakita[4], Akitomo Yamamoto[5], Tsuneo Ono[6] (1.Faculty of Environmental Earth Science, 2.Graduate School of Environmental Science, Hokkaido University, 3.National Institute for Environmental Studies, 4.Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology, 5.Japan Agency for Marine-Earth Science and Technology, 6.Japan Fisheries Research and Education Agency)

[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 | Ch.07_1

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Makoto Yamada(Faculty of Economics, Ryukoku University)

[ACG40-P01] Spatial extent of groundwater-derived heat in coastal area of volcanic sandy beach

*Makoto Yamada[1], Ryo Sugimoto[2], Toshimi Nakajima[2] (1.Faculty of Economics, Ryukoku University, 2.Faculty of Marine Biosciences, Fukui Prefectural University)

[ACG40-P02] Effects of fresh groundwater springs on phytoplankton primary productivity in a volcanic sandy beach

Kana Harada[1], *Ryo Sugimoto[1], Toshimi Nakajima[1], Osamu Tominaga[1] (1.Faculty of Marine Biosciences, Fukui Prefectural University)

[ACG40-P03] Spatial variation of ^{222}Rn concentration in river water and groundwater in the coastal area of Tokyo Bay

*Hiroya Kondo[1], Yu Umezawa[1], Misaki Ikari[1], Yosuke ONO[1], Shigeyoshi Otosaka[2], Muneoki Yoh[1] (1.Tokyo University of Agriculture and Technology , 2.Tokyo University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.10 Zoom Room 10

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

[ACG41-01] Introduction

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

[ACG41-02] Current status and future of ecosystem monitoring of seagrass beds in Japan and Asia: from basic field observation to the policy making and international planning.

★Invited Papers

*Takehisa Yamakita[1], Masakazu Hori[2], Yoshiyuki Tanaka[3], Misuzu Aoki[4], Masahiro Nakaoka[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Fisheries Research and Education Agency , 3.Hachinohe Institute of Technology, 4.Wetlands International Japan, 5.Hokkaido Univ)

11:10 AM - 11:30 AM JST | 2:10 AM - 2:30 AM UTC

[ACG41-03] Seagrass distribution and adaptation in a turbid tropical estuary (Brunei Bay, Borneo)

★Invited Papers

*Yasuaki Tanaka[1], Nadhirah Lamit[1] (1.Universiti Brunei Darussalam)

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

[ACG41-04] Detection of seagrass habitat in Himi, Toyama Bay using Google Earth Engine

*Genki Terauchi[1], Eligio de Raus Maure[1], Yasuyuki Harada[1], Wataru Matsumura[2], Tsuneo Maeda[3] (1.Northwest Pacific Region Environmental Cooperation Center, 2.Fisheries Research Institute, Toyama Prefectural Agricultural Forestry and Fisheries Research Center, 3.Toyama Prefectural Fisheries and Fishing Ports Division)

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

[ACG41-05] **Assessment of mangrove regeneration in abandoned aquaculture ponds using multi-temporal satellite imagery**

Kriselda Anna Delos Santos[2], Ram Avtar[1,2], *Masahiko Fujii[1,2] (1.Faculty of Environmental Earth Science, 2.Graduate School of Environmental Science, Hokkaido University)

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

[ACG41-06] Quantification of drag force and material trapping ability of a planted mangrove forest in the Philippines

*Yoshikai Masaya[1], Takashi Nakamura[1], Dominic Bautista[2], Eugene Herrera[2], Takuya Okamoto[1], Rempei Suwa[3], Kazuo Nadaoka[1] (1.School of Environment and Society, Tokyo Institute of Technology, 2.Institute of Civil Engineering, University of the Philippines, 3.Forestry Division, Japan International Research Center for Agricultural Sciences)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.10 Zoom Room 10

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[ACG41-07] **Photoinhibition as a strategy for corals to mitigate heat stress and resulting ROS production**

Reimi Terayama[1], *Agostini Sylvain[1], Takashi Nakamura[2], Tomihiko Higuchi[3], Ikuko Yuyama[5], Sung-Yin Yang[1], Toshihiro Miyajima[3], Hiroyuki Fujimura[4] (1.Shimoda Marine Research Center, University of Tsukuba, 2.Tokyo Institute of Technology, 3.AORI, University of Tokyo, 4.University of the Ryukyus, 5.Yamaguchi University)

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

[ACG41-08] Epizootiology of a temperate coral disease driven by thermal stress and macroalgal interactions

*Joshua Masataro Heitzman[1], Nicole Caputo[2], Sung-Yin Yang[1], Ben P Harvey[1], Sylvain Agostini[1] (1.Shimoda Marine Research Center, University of Tsukuba, 2.CIRI-FRAME, Alma Mater Studiorum, Università di Bologna)

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

[ACG41-09] Disease occurrence among various zonation: Status of Coral Reefs at Karimunjawa Island, Indonesia

*Dio Dirgantara[1], Rhesi Kristiana[2], Kuswadi bin Bunadi[3], Takashi Nakamura[1] (1.Faculty of Science, University of The Ryukyus, Nishihara, Okinawa 903-0213, Japan, 2.Marine Education and Research Organisation, Karangasem, Bali 80853, Indonesia, 3.Karimunjawa National Park Office, Semarang, Central Java 50273, Indonesia)

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

[ACG41-10] Degraded turf algal systems are ‘locked-in’ by ocean acidification

*Benjamin Paul Harvey[1], Ro Allen[2,3], Sylvain Agostini[1], Linn J Hoffmann[2], Koetsu Kon[1], Tina C Summerfield[2], Shigeki Wada[1], Jason M Hall-Spencer[1,4] (1.Shimoda Marine Research Center, University of Tsukuba, 5-10-1 Shimoda, Shizuoka 415-0025, Japan, 2.Department of Botany, University of Otago, Dunedin, New Zealand, 3.The Marine Biological Association, Plymouth, Devon PL1 2PB, UK, 4.School of Biological and Marine Sciences, University of Plymouth, Plymouth PL4 8AA, UK)

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

[ACG41-11] Development of Numerical Model for Dynamics of Partial Pressure of CO_2 in Seawater Considering Effects of Stratification in the Yatsushiro Sea

*Naoki Saito[1], Bing Xiong[2], Hiroto Komori[2], Shinichiro Yano[2], Keisuke Nakayama[3], Katsuaki Komai[4], Hiroshi Yajima[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Kyushu University, 3.Kobe University, 4.Kitami Institute of Technology, 5.Shimane University)

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

[ACG41-12] Two-way nested blue carbon tracing simulation for elucidating fates of exported organic carbon from coastal ecosystems

*Takashi Nakamura[1], Faisal Amri[1], Lawrence Patrick Cases Bernardo[2], Kazuo Nadaoka[1], Masakazu Hori[3], Masami Hamaguchi[3], Toshihiro Miyajima[4] (1.School of Environment and Society, Tokyo Institute of Technology, 2.Graduate School of Environmental Science, Hokkaido University, 3. Japan Fisheries Research and Education Agency, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

[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 | Ch.07_2

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

[ACG41-P01] **Skeleton microstructures and *in situ* colony morphometry analysis of the corals collected during Tara Pacific Expedition**

*Guinther Hiromu Mitushasi[1], Yuko Kitano[2], Emilie Boissin[3], Serge Planes[3], Denis Allemand[4], Tara Pacific Consortium[1], Sylvain Agostini[1] (1.Shimoda Marine Research Center, University of Tsukuba, 2. National Institute of Environmental Science, Japan (Tsukuba), 3. CRIOBE, Universite de Perpignan (Perpignan), 4. Monaco Scientific Center (Monaco))

[ACG41-P02] Diversity of coral distributions and the difference in Sakiyamawan-Amitoriwan nature conservation area, Iriomote Island, Japan

*Shinya Shimokawa[1], Tomokazu Murakami[1], Hiroyoshi Kohno[2], Akira Mizutani[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Okinawa Reagional Research Center, Tokai University)

[ACG41-P03] Characteristics of water temperature changes and coral breaching in Amitori Bay, Iriomote Island, Japan

*Shinya Shimokawa[1], Tomokazu Murakami[1], Hiroyoshi Kohno[2], Akira Mizutai[2] (1.National Research Institute for Earth Science and Disaster Prevention, 2.Okinawa Reagional Research Center, Tokai University)

[ACG41-P04] Coral bleaching countermeasures by supplying metal-containing feed ~evaluation the effect at gene expression levels~

*Ikuko Yuyama[1], Naoko Yasuda[2], Sayaka Higa[2], Sung-Yin Yang[3], Sylvain Agostini [3], Tomihiko Higuchi[4], Toshihiro Miyajima[4], Takashi Nakamura[5], Hiroyuki Fujimura[2] (1.Yamaguchi University, 2.University of the Ryukyus, 3.University of Tsukuba, 4.The University of Tokyo , 5.Tokyo Institute of Technology)

[ACG41-P05] Linear and non-linear analysis for high temperature and acidification event in the Great Barrier Reef based on the observation in the Coral Sea

*Tatsuki Tokoro[1,2], Shin-ichiro Nakaoka[1], Shintaro Takao[1] (1.National Institute for Environmental Studies, 2.Port and Airport Research Institute)

[ACG41-P06] Stratigraphy of seagrass bed at Bise in Okinawa Island.

*Wataru Sano[1], Kazuhiko Fujita[2], Yoshikatsu Nakano[3], Shoko Hirabayashi[4], Yusuke Yokoyama[5], Yosuke Miyairi[5], Naoko Isomura[6], Hironobu Kan[1] (1.Kyushu Univ., 2.Univ. of the Ryukyus, 3.Okinawa Institute of Science and Technology Graduate University , 4.Rissho Univ., 5.Univ. of Tokyo, 6.National Institute of Technology, Okinawa College)

[ACG41-P07] **Applying DPSIR framework for blue carbon ecosystems assessment: The case of Busuanga Island, Palawan, Philippines**

*Jay Mar Dioquito Quevedo[1], Yuta Uchiyama[2], Ryo Kohsaka[2] (1.Tohoku University, 2.Nagoya University)

[ACG41-P08] Detecting mangrove- and seagrass-derived eDNA from deep-sea sediment around Yaeyama Islands: Implication for offshore blue carbon sequestration

*Toshihiro Miyajima[1], Masami Hamaguchi[2], Takashi Nakamura[3], Hajime Katayama[4], Masakazu Hori[5] (1.Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Research Institute of Fisheries Technology, Japan Fisheries Research and Education Agency, 3.School of Environment and Society, Tokyo Institute of Technology, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.National Research Institute of Fisheries Resources, Japan Fisheries Research and Education Agency)

[ACG41-P09] Evaluation of the effect of differences in nitrogen loading on the chemical composition and decomposition characteristics of eelgrass(*Zostera marina*).

*Toru Miyata[1], Yu Umezawa[1], Takunari Ida[1], Yoshiki Horikawa[1], Makoto Watanabe[1], Shigeki Wada[2], Masahiro Nakaoka[3], Tomohiro Kuwae[4] (1.Tokyo University of Agriculture and Technology, 2.University of Tsukuba, 3.Hokkaido University, 4.Port and Airport Research Institute)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.11 Zoom Room 11

[A-CG42] Water and sediment dynamics from land to coastal zones

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Chairperson:Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Yuko Asano(The University of Tokyo), Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University)

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

[ACG42-01] The fate of riverine freshwater in the ocean

*Shinichiro Kida[1], Ryo Abe[2], Yosuke Alexandre Yamashiki[3] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Interdisciplinary Graduate School of Engineering Sciences, 3.Graduate School of Advanced Integrated Studies in Human Survivability)

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

[ACG42-02] Interpreting the sediment dynamics from mountains to the sea in the Saru River souce-to-sink system using radionuclide tracers

★Invited Papers

*Shigeru Mizugaki[1], Junichi Otsuka[1], Yasuhiro Murakami[1], Keiko Iwakura[1] (1.Civil Engineering Research Institute for Cold Region, Public Works Research Institute)

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

[ACG42-03] River survey using airborne laser bathymetry (ALB) and its applications

★Invited Papers

*Keigo Nakamura[1] (1.Public Works Research Institute)

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

[ACG42-04] How much suspended sediment is transported from land to oceans globally?

*Misako Hatono[1], Kei Yoshimura[2] (1.Hiroshima University, 2.The University of Tokyo)

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

[ACG42-05] Estimation of coastal freshwater discharge using surface salinity of Nanao Bay

*Shiho Kobayashi[1], Satoshi Nakada[2], Kei Senbokuya[3], Jun-ichi Okuno[3] (1.Kyoto University, 2.National Institute for Environmental Studies, 3.Ishikawa Prefecture Fisheries Research Center)

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

[ACG42-06] Storm runoff at hillslopes and channels in mountain catchment

*Yuko Asano[1], Taro Uchida[2], Mitsuhide Tomomura[3], Naoko Miura[1] (1.The University of Tokyo, 2.University of Tsukuba, 3.Meteorological Engineering Center)

[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 | Ch.11 Zoom Room 11

[A-CG42] Water and sediment dynamics from land to coastal zones

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Chairperson:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University)

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

[ACG42-07] Sediment budget analysis and geomorphological evolution in alluvial river – Case study in the lower Yodo River –

★Invited Papers

*Ryoukei Azuma[1] (1.Osaka Institute of Technology)

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

[ACG42-08] Toward an improvement of river runoff in the Japanese Coastal Ocean Monitoring and Forecasting System

★Invited Papers

*Kei Sakamoto[1], Shogo Urakawa[1], Nariaki Hirose[1], Hideyuki Nakano[1], Takahiro Toyoda[1], Norihisa Usui[1], Goro Yamanaka[1] (1.Meteorological Research Institute)

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

[ACG42-09] Long river plume around Akkeshi Bay formed by snowmelt runoff

*Satoshi Nakada[1], Tomonori Isada[2] (1.National Institute for Environmental Studies, 2.Hokkaido University)

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

[ACG42-10] Application of suspended sediment and physical process interaction to river-plume simulations in the microtidal coastal region during a flood

*Yasuhiro Hoshiba[3], Yoshimasa Matsumura[2], Sachihiko Itoh[3], Hiroyasu Hasumi[1] (1.Division of Climate System Research, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Division of Marine Life Science, Atmosphere and Ocean Research Institute, University of Tokyo, 3.Center for Earth Surface System Dynamics, Atmosphere and Ocean Research Institute, University of Tokyo)

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

[ACG42-11] Experimental study on the effect of vegetation cover and location by a forest floor model on reducing sediment transport

*Ako YAMAMOTO[1], Akira Kojima[2], Ryusei Shiotsuki[2], Keita Kawaharada[3], Makjoto Sotoyama[3], Tsuyoshi Tada[2], Yoshinori Shigihara[2], Yo Fukutani[3] (1.Forest of Research and Management Organization Forestry and Forest Products Research Institute, 2.National Defense Academy, 3.Kanto Gakuin University)

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

[ACG42-12] Sediment transport and morphology change in coastal areas

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

[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 | Ch.07_3

[A-CG42] Water and sediment dynamics from land to coastal zones

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo)

[ACG42-P01] Representing terrestrial water dynamics within Earth system modelling framework

*Dai Yamazaki[1] (1.Institute of Industrial Sciences, The University of Tokyo)

[ACG42-P02] Breaching flood impact analysis of landslide dams in the Yarlung Tsangpo River Basin

*Danyi Shen[1,2], Zhenming Shi[1,2], Ming Peng[1,2] (1.Key Laboratory of Geotechnical & Underground Engineering of Ministry of Education, Tongji University, Shanghai 200092, China, 2.Department of Geotechnical Engineering, Tongji University, Shanghai 200092, China)

[ACG42-P03] Sediment transport analysis from the Abukuma river to the sea by typhoon No.19 in 2019

Makoto Kobayashi[1], *Daisuke Nakahara[1], Keiko Udo[1], Hiroshi Takebayashi[2] (1.International Research Institute of Disaster Science, Tohoku University, 2.Disaster Prevention Research Institute, Kyoto University)

[ACG42-P04] Structural characteristics of airflow and blown sand flux over fine-grained gravel surfaces in wind tunnel

*Jiaqi Liu[1], Reiji Kimura[1], Jing Wu[1] (1.Arid Land Research Center, Tottori University)

[ACG42-P05] Predictive simulations of redeposition and seawater transportation after a tsunami in Osaka Bay where bottom sediments were disturbed by tsunami

*Mitsuru Hayashi[1,2], Satoshi Nakada[4], Soichi Hirokawa[2], Shuto Fujisawa[3] (1.Research Center for Inland Seas, Kobe University, 2.Graduate School of Maritime Sciences, 3.Faculty of Maritime Sciences, 4. National Institute for Environmental Studies)

[ACG42-P06] Application of an isopycnal-layered model to islands

*Hiroaki Sato[1], Yosuke Alexandre Yamashiki[2] (1.Kyoto University, 2.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.07 Zoom Room 07

[A-CG43] Earth & Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy), Chairperson:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology)

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[ACG43-01] Introduction

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[ACG43-02] Deep Learning that Ensures Laws of Physics and Other Constraints and Its Applications

★Invited Papers

*Takashi Matsubara[1] (1.Osaka University)

2:10 PM - 2:30 PM JST | 5:10 AM - 5:30 AM UTC

[ACG43-03] Recent trends in earth and environmental informatics

★Invited Papers

*Daisuke Matsuoka[1,2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Science and Technology Agency)

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

[ACG43-04] Adversarial Multi-task Learning Algorithm for Solving Partial Differential Equations

*Pongpisit Thanasutives[1], Masayuki Numao[1], Ken-ichi Fukui[1] (1.Osaka University)

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

[ACG43-05] Statistical Downscaling of Meteorological Fields from the Synoptic Scale to the Mesoscale Using Deep Convolutional Neural Networks

*Thomas Sekiyama[1] (1.Meteorological Research Institute)

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

[ACG43-06] Deep learning approach for rainfall forecasting using U-Net with data augmentation

*Ryo Kaneko[1], Shiho Onomura[2], Makoto Nakayoshi[2] (1.The University of Tokyo, 2.Tokyo University of Science)

[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 | Ch.06 Zoom Room 06

[A-CG43] Earth & Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy), Chairperson:Shigeki Hosoda(Japan Marine-Earth Science and Technology), Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University)

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[ACG43-07] Automated identification of tornadic vortex with Doppler radar data using deep learning approaches: Recent progress and challenges

★Invited Papers

*Kusunoki Kenichi[1], Naoki Ishitsu[2], Toru Adachi[1], Hanako Inoue[1], Osamu Suzuki[1], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd., 3.East Japan Railway Company)

3:50 PM - 4:10 PM JST | 6:50 AM - 7:10 AM UTC

[ACG43-08] **Estimation of cloud and meteorological state from satellite image by deep neural network**

★Invited Papers

*Hironobu Iwabuchi[1], Xinyue Wang[1], Hana Kato[1], Takaya Yamashita[1] (1.Graduate School of Science, Tohoku University)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[ACG43-09] Clustering global ocean profiles according to temperature-salinity structure

*Nozomi Sugiura[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[ACG43-10] **Automated Hybrid Machine Learning Approaches for Groundwater Level Forecasting in Kumamoto area, Japan**

*A T M Sakiur Rahman[1], Takahiro Hosono[4,5], John Quilty[2], Jayanta Das[3], Amiya Basak[3] (1.Postdoctoral researcher, Kumamoto University, 2.Department of Civil and Environmental Engineering , University of Waterloo, Waterloo, ON, Canada , 3.Department of Geography and Applied Geography, University of North Bengal, Darjeeling - 734013, India , 4.Faculty of Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan, 5.International Research Organization for Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[ACG43-11] **Improving Detection of Tropical Cyclones by Deep Convolutional Neural Network through a Two-step Training**

*TAKERU TSUCHIYA[1], Shunji Kotsuki[2], Ryota Kikuchi[3], Takeshi Umezawa[4], Noritaka Osawa[4] (1.Department of Information Engineering, Chiba University, Chiba, Japan, 2.Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3.Office of Society Academia Collaboration for Innovation, Kyoto University, Japan, 4.Graduate School & Faculty of Engineering, Chiba University, Chiba, Japan)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

[ACG43-12] Discussion

[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 | Ch.03_4

[A-CG43] Earth & Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy)

[ACG43-P01] **Machine learning for remote sounding of the ionosphere in Taiwan**

*ALEXEI DMITRIEV[1] (1.National Central University, Jungli City, Taiwan)

[ACG43-P02] Precipitation predictions using RNN and LSTM with simple time series observations and the comparison between them.

*He Zhang[1], Tomohiko Tomita[2], Ken-ichi Fukui[3], Satoshi Ono[4] (1.Kumamoto University, 2.Faculty of Advanced Science and Technology, 3.The Institute of Scientific and Industrial Research, Osaka University, 4.Faculty of Engineering, Kagoshima University)

[ACG43-P03] Hindcast of the July 2018 torrential rainfall event in Kagoshima City using LSTM

*Genki Shirasawa[1], Ryusei Hamasaki[1], Shinichiro Kako[2], Hirohiko Nakamura[3] (1.Kagoshima University, Faculty of Engineering, 2.Graduate School of Science and Engineering, Kagoshima University, 3.Kagoshima University, Faculty of Fisheries)

[ACG43-P04] Real-time Data Quality Control of Phased Array Weather Radar by using Semantic Segmentation

*Isoda Fusako[1], Shinsuke Satoh[1], Masashi Kimura[2], Takemasa Miyoshi[3] (1.National Institute of Information and Communications Technology, 2.Convergence Lab., 3.RIKEN)

[ACG43-P05] A Preliminary Study on Developing a Smartphone Application for Weather Classification Using AutoML

*Satoshi Ono[1], Kento Wakamatsu[1], Yusaku Hayashi[1], Tomohiko Tomita[2] (1.Kagoshima Univeristy, 2.Kumamoto University)

[ACG43-P06] Fundamental Study on Weather Judgement of Image Data using Machine Learning Classification

*Tomohiko Tomita[1], Kosuke Tanaka[2] (1.Faculty of Advanced Science and Technology, Kumamoto University, 2.Faculty of Science, Kumamoto University)

[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 | Ch.10 Zoom Room 10

[A-CG44] Biogeochemical linkages between the surface ocean and atmosphere

convener:Sohiko Kameyama(Hokkaido University), Yoko Iwamoto(Graduate School of Integrated Sciences for Life, Hiroshima University), Noguchi Maki Aita(Japan Agency for Marine-Earth Science and Technology), Daisuke Sasano(Japan Meteorological Agency), Chairperson:Sohiko Kameyama(Hokkaido University)

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

[ACG44-01] R/V Mirai cruise for IMPACT-SEA project 2021: Preliminary results

*Fumikazu Taketani[1], Kana Nagashima[1], Minoru Kitamura[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[ACG44-02] **Seasonal and interannual variations of surface water carbonate chemistry in the Indian sector of the Southern Ocean**

*Manami Tozawa[1], Daiki Nomura[1,2,3], Shin-ichiro Nakaoka[4], Masaaki Kiuchi[1], Daisuke Hirano[5], Shigeru Aoki[5], Hiroko Sasaki[6], Hiroto Murase[7] (1.Faculty of Fisheries Sciences, Hokkaido University, 2.Field Science Center for Northern Biosphere, Hokkaido University, 3.Arctic Research Center, Hokkaido University, 4.National Institute for Environmental Studies, 5.Institute of Low Temperature Science, Hokkaido University, 6.Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 7.Tokyo University of Marine Science and Technology)

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

[ACG44-03] **Summer carbonate chemistry near the Totten Ice Shelf, Sabrina Coast, East Antarctica**

*Tetsuya Tamura[1], Daiki Nomura[1,2,3], Daisuke Hirano[3,4], Takeshi Tamura[5], Masaaki Kiuchi[1], Gen Hashida[5], Shigeru Aoki[4], Hiroko Sasaki[6], Hiroto Murase[7] (1.Faculty of Fisheries Science, Hokkaido University, 2.Field Science Center for Northern Biosphere, 3.Arctic Research Center, 4.Institute of Low Temperature Science, 5.National Institute of Polar Research, 6.Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 7.Tokyo University of Marine Science and Technology)

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

[ACG44-04] Iodomethane and Iodoethane distributions in coastal seawater of subarctic Pacific and Northern Bering sea

*Atsushi Ooki[1], Keita Minamikawa[1], Fanxing Meng[1] (1.Hokkaido University)

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

[ACG44-05] Effects of marine nitrogen fixation on the formation of atmospheric water-soluble organic nitrogen revealed by a laboratory incubation experiment

*Tsukasa Dobashi[1,2], Koji Suzuki[2], Yuzo Miyazaki[1] (1. Institute of Low Temperature Science, Hokkaido Univ., 2.Graduate School of Env. Sci., Hokkaido Univ.)

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

[ACG44-06] Characterization of Adhesivity of marine organic aerosols by atomic force microscopy

*Kohei Ono[1], Ayumi Iwata[2], Takeshi Fukuma[3], Yoko Iwamoto[4], Koji Hamasaki[5], Atsushi Matsuki[6] (1.Graduate School of Natural Science and Technology, Kanazawa University, 2.Faculty of Science and Technology, Keio University, 3.Nano Life Science Institute, Kanazawa University, 4.Graduate School of Integrated Sciences for Life, Hiroshima University, 5.Atmosphere and Ocean Research Institute, The University of Tokyo, 6.Institute of Nature and Environmental Technology, Kanazawa University)

[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 | Ch.07_4

[A-CG44] Biogeochemical linkages between the surface ocean and atmosphere

convener:Sohiko Kameyama(Hokkaido University), Yoko Iwamoto(Graduate School of Integrated Sciences for Life, Hiroshima University), Noguchi Maki Aita(Japan Agency for Marine-Earth Science and Technology), Daisuke Sasano(Japan Meteorological Agency)

[ACG44-P01] Relationship between the variability in dissolved inorganic carbon in surface seawater and the formation volume of subtropical mode water along the 137°E line

*Ono Hisashi[1], Masao Ishii[1], Yosuke Iida[2], Kazutaka Enyo[2], Daisuke Sasano[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

[ACG44-P02] Verification of the effect of aerosol deposition on surface chlorophyll in subtropical oligotrophic waters using JRAero reanalysis datasets

*Naohiro Kosugi[1], Taichu Y Tanaka[1] (1.Meteorological Research Institute)

[ACG44-P03] Seasonal Variation of Phosphate in Atmospheric Aerosols in Higashi-Hiroshima

*Yoko Iwamoto[1], Mako Hirota[2], Kazuhiko Takeda[1], Hiroshi Sakugawa[1] (1.Graduate School of Integrated Sciences for Life, Hiroshima University, 2.School of Integrated Arts and Sciences, Hiroshima University)

[ACG44-P04] Modelling regional and global scale impacts of atmospheric nitrogen inputs on marine biogeochemistry

*Maki Noguchi Aita[1], Fumikazu Taketani[1], Yoko Iwamoto[2], Tomohiro Hajima[3] (1.Earth Surface System Research Center, Japan Agency for Marine-Earth Science and Technology, 2.Hiroshima University, 3.Research Center for Environmental Modeling and Application, Japan Agency for Marine-Earth Science and Technology)

[ACG44-P05] Contribution of lightning-induced nitgen oxide to nitrogen cycle in air-sea boundary estimated by plasma discharge in laboratory

Ryo Hashimoto[1], *Sohiko Kameyama[1], Kohki Satoh[2], Hiroshi Ogawa[3] (1.Hokkaido University, 2.Muroran Institute of Technology, 3.The University of Tokyo)

[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.15 Zoom Room 15

[H-RE12] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Kenzo Sanematsu(Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University)

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

[HRE12-01] **Formation of various types of iron ore deposits in the Earth's surface environments: A review**

*Tsubasa Otake[1] (1.Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University)

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

[HRE12-02] A rapid analytical method of Re-Os isotope on sulfides by MC-ICP-MS and sparging method: Its application to the Kamaishi deposit in NE Japan

*Mizuki Ogasawara[1], Junichiro Ohta[1,2], Mizuki Ishida[1], Moei Yano[2,1], Ryota Maki[1], Tatsuo Nozaki[3,1,4,2], Yutaro Takaya[5,3,2], Koichiro Fujinaga[2,1], Kazutaka Yasukawa[1,2], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC, 4.Kobe University, 5.Waseda University)

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

[HRE12-03] Geochemical Characterization of Rivers Contaminated by Acid Mine Drainage from an Abandoned Mine in Northern Japan

*Sereyroith Tum[1], Tatsuya Matsui[1], Frances Chikanda[1], Ryosuke Kikuchi[2], Yoko Ohtomo[2], Tsubasa Otake[2], Susumu Norota[3], Tsutomu Sato[2] (1.Graduate School of Engineering, Hokkaido University, 060-8628, Sapporo, Japan , 2.Faculty of Engineering, Hokkaido University, 060-8628, Sapporo, Japan, 3.Geological Survey of Hokkaido, Hokkaido Research Organization, 060-0819, Sapporo, Japan)

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

[HRE12-04] **Utilizing isotopic Fe fractionations to trace the behaviour of dissolved and colloidal Fe in mine drainages**

*Frances Chikanda[1], Tsubasa Otake[2], Tatsuya Matsui[1], Sereyroith Tum[1], Tsutomu Sato[2] (1.Division of Sustainable Resources Engineering, Graduate School of Engineering, Hokkaido University, 2.Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University)

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

[HRE12-05] Discussion

[J] Poster | H (Human Geosciences)：H-RE Resource and Engineering Geology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.08_1

[H-RE12] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Kenzo Sanematsu(Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

[HRE12-P01] Exploration of multiple geothermal resources in southern Yuzawa area, Akita prefecture

*Hayata Sato[1], Keishi Nunohara[1], Ryoichi Yamada[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1] (1.tohoku university)

[HRE12-P02] The Gold and Silver mineralization of layered yellow ore in Furutobe mine.

*Teruhiro Suzuki[1], Yasushi Watanabe[1], Takuya Echigo[1] (1.Graduate School of International Resource Sciences, Akita University)

[HRE12-P03] The significance of geology and sulfur isotope compositions of sulfates and sulfides at the ca.3.4 Ga Big Stubby Kuroko deposit in Pilbara, Western Australia

*Tomoaki Koya[1], Akizumi Ishida[1], Takeshi Kakegawa[1] (1.Graduate school of science, Tohoku University)

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.16 Zoom Room 16

[H-TT16] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Ki-Cheol Shin(Research Institute for Humanity and Nature), Nozomu Takeuchi(Chiba University), Chairperson:Nozomu Takeuchi(Chiba University)

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

[HTT16-01] Application of environmental traceability methodology by multi-isotopes

*Ichiro Tayasu[1], Ki-Cheol Shin[1] (1.Research Institute for Humanity and Nature)

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

[HTT16-02] Daily variation in winter precipitation isotopes over Hirosaki and associate atmospheric circulation - Case study of a winter season 2019/2020 -

*Akiyo Yatagai[1], Syota Nishioka[2], Kei Yoshimura[3] (1.Graduate School of Science and Technology, Hirosaki University, 2.Faculty of Science and Technology, Hirosaki University, 3.IIS Chiba Experimental Station, The University of Tokyo)

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

[HTT16-03] Identification of snow characteristics in the basin to applied chemical composition and meteorological hydrological data

*kawagoe seiki[1], shiho yabusaki[2] (1.Faculty of Symbiotic Systems science/Fukushima university, 2.Research institute for Humanity and Nature)

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

[HTT16-04] Distribution of trace element concentrations in groundwater and spring water near coastal and inland area of Fukushima prefecture

*Shiho Yabusaki[1] (1. Research Institute for Humanity and Nature・Faculty of Symbiotic Systems Science, Fukushima University)

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

[HTT16-05] Response of forest ecosystems to reduction of atmospheric sulfur deposition

*Hiroyuki Sase[1], Tsuyoshi Ohizumi[1], Yayoi Inomata[2], Naoyuki Yamashita[3], Toko Tanikawa[4], Masamichi Takahashi[3], Tatsuyoshi Saito[5], Masayuki Morohashi[1], Hiroki Yotsuyanagi[1] (1.Asia Center for Air Pollution Research, 2.Kanazawa University, 3.Forestry and Forest Products Research Institute, 4.Nagoya University, 5.Niigata Prefectural Government)

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

[HTT16-06] Estimate the origin of nutrients supplied to coastal areas using Ulva pertusa's nitrogen and carbon stable isotope ratios.

*Tatsuhiro Ishida[1], Osamu Tominaga[1], Ryo Sugimoto[1], Naoki Kisa[1], Keisuke Koba[2], Keitaro Fukushima[2] (1.Fukui Prefectural University, 2.Center for Ecological Research,Kyoto University)

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.16 Zoom Room 16

[H-TT16] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Ki-Cheol Shin(Research Institute for Humanity and Nature), Nozomu Takeuchi(Chiba University), Chairperson:Ichiro Tayasu(Research Institute for Humanity and Nature)

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

[HTT16-07] A comparative study of diet of winged and wingless stoneflies on alpine snow in Mt. Gassan, Yamagata Prefecture, using carbon and nitrogen stable isotopes

*Nozomu Takeuchi[1], Risako Yonechi[1] (1.Chiba University)

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

[HTT16-08] The spatial variations in carbon and nitrogen stable isotopes of organic matter on the surface of Gulkana Glacier in Alaska

*Tsubasa Takahashi[1], MASATO ONO[1], Ayumi Kizawa[2], Nozomu Takeuchi[1] (1.Chiba University, 2.Chuo University)

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

[HTT16-09] Reconstructing lifetime isotope baselines of fish from eye lenses

*Yota Harada[1], Shin-ichi Ito[2], Chisato Yoshikawa[1], Nanako O. Ogawa[1], Naoto Ishikawa[1], Naohiko Ohkouchi[1] (1.Biogeochemistry Research Center, Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[HTT16-10] Tracing habitat areas and migration of marine fishes from fish bone Pb isotopes

*Keiji Horikawa[1], Hinako Nishimura[2], Ki-Cheol Shin[3] (1.Faculty of Science, University of Toyama, 2.Graduate School of Engineering and Science for Education, University of Toyama, 3.Research Institute of Humanity and Nature)

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

[HTT16-11] Dietary evaluation through zinc isotope ratios of human skeletal remains from Yoshigo shell mound of Jomon period

*Soichiro Kusaka[1], Ki-Cheol Shin[2] (1.Tokai Univ., 2.RIHN)

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

[HTT16-12] Origin of prehistoric pottery clay deciphered from Sr-Nd-Pb isotope ratios

*Eriko Ishimaru[1], Ki-Cheol Shin[2], Makoto Tomii[3], Yoshiki Nobusato[4] (1.Hiroshima Univ., 2.RIHN, 3.Kyoto Univ., 4.Kagawa Mus.)

[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.08_2

[H-TT16] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Ki-Cheol Shin(Research Institute for Humanity and Nature), Nozomu Takeuchi(Chiba University)

[HTT16-P01] Oxygen and hydrogen isotopic signatures of surface and groundwater during a dry season in the Tonle Sap Lake basin

*Yumi Yoshioka[1], Takao Masumoto[2], Kumiko Tsujimoto[3], Yuji Ito[4] (1.Shimane University, 2.Akita Prefectural University, 3.Okayama Univerisity, 4.Kagoshima University)

[HTT16-P02] Identification of regional characteristics of the basin using elemental components as tracers

*Yusuke Hataya[1], Shiho Yabusaki[2], Seiki Kawagoe[3] (1.Fukushima University Faculty of Symbiotic Systems Science, 2.Research Institute for Humanity and Nature, 3.Fukushima University Faculty of Symbiotic Systems Sciences)

[HTT16-P03] Seasonal variation of $\delta^{34}S$ and $\delta^{18}O$ in sulfate in rain water and aerosols on the outskirts of Gifu City

*Masako Kagawa[1], Nagayoshi Katsuta[1], Yusuke Hashimoto[1], Yuto Yamagishi[1], Ichiro Tayasu[2], Chikage Yoshimizu[2] (1.Gifu University, Faculty of Education, 2.Research Institute for Humanity and Nature)

[HTT16-P04] Seasonal variations and trends of dissolved elements in rainwater and stream water in forest catchment area of central Japan

*Masayuki Morohashi[1], Hiroki Yotsuyanagi[1], Masaaki Takahashi[2], Tatsuyoshi Saito[2], Yayoi Inomata[3], Ki-Cheol Shin[4], Ichiro Tayasu[4], Tsuyoshi Ohizumi[1], Hiroyuki Sase[1] (1.Asia Center for Air Pollution Research, 2.Niigata Prefecture, 3.Kanazawa Univercity, 4.Research Institute for Humanity and Nature)

[HTT16-P05] Geochemical and isotopic study of river water from the Okayama and Tottori Prefectures, Japan.

*Katsuyuki Yamashita[1], Takahiro Kamei[1], Keisuke Kishimoto[1], Masahiko Mori[1], Yuga Kishimoto[2], Aya Ooi[2], Ayaka Onishi[2], Yoko Kurihara[2], Miyake Ryota[2], Ryosuke Yamano[2], Hitoshi Chiba[1], Takanori Nakano[3], Ki-Cheol Shin[4] (1.Graduate School of Natural Science and Technology, Okayama University, 2.Department of Earth Sciences, Okayama University, 3.Ono City, 4.Research Institute for Humanity and Nature)

[HTT16-P06] Stable sulfur isotope variations in lacustrine sediments in Mongolia and its paleo-environmental implication

Miku Yoichi[1], *Nagayoshi Katsuta[1], Shinya Ochiai[2], Sayuri Naito[1], Masako Kagawa[1], Yuma Masuki[1], Ichiro Tayasu[3] (1.Faculty of Education, Gifu University, 2.Institute of Nature and Environmental Technology, Kanazawa University, 3. Research Institute for Humanity and Nature)

[HTT16-P07] Variations in sedimentation rates of Tsuya River in the western Nobi Plain, central Japan over the last decades

*Takashi Tashiro[1], Ichiro Tayasu[2] (1.Nagoya University, 2.Research Institute for Huminity and Nature)

[HTT16-P08] Neutralization using recycled waste materials for acid wastewater from the Kusatsu hot spring area in Japan

*Takeshi Saito[1], Naoki Watanabe[2] (1.Graduate School of Science and Engineering, Saitama University, 2.Research Institute for Natural Hazards and Disaster Recovery, Niigata University)

[HTT16-P09] Evaluating temperature dependence of arsenic and boron adsorption onto sediments

*Keigo Kurita[1], Takeshi Saito[2] (1.Department of Civil and Environmental Engineering, Faculty of Engineering, Saitama University, 2.Graduate School of Science and Engineering, Saitama University)

[HTT16-P10] Soil food webs after more than a year since litter-removal experiment: an evaluation based on carbon and nitrogen stable isotope ratios

*Takashi F Haraguchi[1], Soshi Yoshida[2], Syuhei Fujimoto[2], Keiichiro Sato[2], Motohiro Hasegawa[2] (1.Biodiversity Research Center, RIEAF, Osaka, 2.Doshisha University Faculty of Science and Engineering, Environmental Systems Science)

[HTT16-P11] Evaluation of air pollution stress in roadside trees using stable carbon isotope ratio

*Yuko T. Hanba[1], Mayu Matsumoto[1], Takashi Kiyomizu[1], Tomomitsu Kinoshita[1], Atsushi Kume[2] (1.Kyoto Institute of Technology, 2.Kyushu University)

[HTT16-P12] **Effects of Traffic Volume on Photosynthetic Function and Water Use Efficiency of Tall Street Trees in Kyoto City**

*Takumi Matsuura[1], Yuko T. Hanba[1] (1.Kyoto Institute of Technology)

[HTT16-P13] Effect of flooding stress on photosynthesis of aquatic plants

*Yutaro Yasui[1], Yuko T. Hanba[1] (1.Kyoto Institute of Technology)

[HTT16-P14] The incubation method using ^{18}O-water and phosphate oxygen isotope for quantitative evaluation of bioavailable phosphate in soil.

*Takuya Ishida[1] (1.Hiroshima University)

[HTT16-P15] Trace element quantification in organic materials by low temperature plasma ashing

Taisuke Hino[1], Yuriko Umeda[1], Hibiki Shishime[1], Akane Ito[1], *Masaharu Tanimizu[1] (1.Kwansei Gakuin University)

[HTT16-P16] Metal element isotope analysis for Environmental Reference Materials

*Ki-Cheol Shin[1] (1.Research Institute for Humanity and Nature)

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.15 Zoom Room 15

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Toru Takahashi(Fukada Geological Institute), Kunio Aoike(Oyo corporation)

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[HTT17-01] Introduction

9:05 AM - 9:25 AM JST | 12:05 AM - 12:25 AM UTC

[HTT17-02] Accumulation pattern of near-seafloor methane gas revealed by a shallow seismic survey in the northern Tokyo Bay

*Tetsuro Tsuru[1], Kazuki Takanaka[1], Koichi Fujimoto[1], Osamu Takano[2], Yukio Nakagawa[3], Naoto Kumagai[1] (1.Tokyo University of Marine Science and Technology, 2.University of Tsukuba, 3.Tobako LLC)

9:25 AM - 9:45 AM JST | 12:25 AM - 12:45 AM UTC

[HTT17-03] Imaging of near surface structure beneath a coastal plain by means of high-resolution S-wave seismic reflection survey

*Tomio INAZAKI[1], Kyoko Kagohara[2], Shinsuke Okada[3], Takayuki Nakano[4], Nobuhisa Matta[5] (1.Research Institute of Geology and Geoinformation, AIST, 2.Yamaguchi Univ., 3.Iwate Univ., 4.GSI, 5.Okayama Univ.)

9:45 AM - 10:05 AM JST | 12:45 AM - 1:05 AM UTC

[HTT17-04] Differences in P-wave velocities due to velocity logging in overlapping sections of horizontal boring surveys in sedimentary rock tunnel ground

*Kenji OKAZAKI[1], Toshiyuki KURAHASHI[1] (1.Civil Engineering Research Institute for cold region, Public Works Research Institute)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[HTT17-05] Applicability of Distributed Acoustic Sensing (DAS) technology for surface wave measurement

*Hayato Nonaka[1], Peter Hubbard[2], Koichi Hayashi[3], Yasuhiro Yokota[1], Kensuke Date[1], Kazuhiko Masumoto[1], Kenichi Soga[2] (1.Kajima corporation, 2.University of California, Berkeley, 3.OYO Corporation)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

[HTT17-06] Discussion

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.15 Zoom Room 15

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Kyosuke Onishi(Public Works Research Institute), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology)

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

[HTT17-07] Introduction

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

[HTT17-08] CCR survey using plate electrodes

*Chisato Konishi[1], Hiroshi Kisanuki[1], Dennis Wilkison (1.OYO Corporation)

11:10 AM - 11:30 AM JST | 2:10 AM - 2:30 AM UTC

[HTT17-09] Differential tomography of continuously repeated measurement data using electrical exploration method - Application to monitor changes in soil moisture content due to rainfall

*Ryota Watatani[1], Koichi Suzuki[2] (1.Cooperative Program for Resources Engineering, Graduate School of Engineering, Hokkaido University, 2.Research Group of Geoenvironmental Engineering, Division of Sustainable Resource Engineering, Faculty of Engineering, Hokkaido University)

11:30 AM - 11:50 AM JST | 2:30 AM - 2:50 AM UTC

[HTT17-10] Subsurface exploration by multifrequency electromagnetic portable senser GEM-2 at the Goshogake geothermal area

*Shin'ya Sakanaka[1], Keigo Tsuboe[1], Yuya Tada[1], Inoue Yusuke[2], Shura Taomote[3], Ritsu Sakiyama[1] (1.Graduate school of International Resource Sciences, Akita University, 2.OYO corporation, 3.Faculty of International Resource Sciences, Akita University)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[HTT17-11] Bayesian estimation method of near-surface density under irregular distribution of gravity network

*Yuanyuan Niu[1], Jiancang Zhuang[1] (1.Institute of Statistical Mathematics)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[HTT17-12] Discussion

[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.08_3

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute)

[HTT17-P01] **An Atempt to Estimate the Water Level Change of Non-confined Groundwater by Earthing Resistance (III) - Characteristics of the Anniversary Changes -**

*Kunihiro Ryoki[1] (1.Polytechnic University)

[HTT17-P02] Estimation of underground structure beneath the debris control dams constructed during the Edo era based on the microtremor measurements

*Atsushi Mukai[1] (1.Faculty of Urban Management, Fukuyama City University)

[HTT17-P03] Measuring the distribution of surface thickness of pavement using ground-penetrating radar

*Kyosuke Onishi[1], Kobayashi Takayuki[1] (1.Public Works Research Institute)

[E] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.09_1

[H-CG20] International comparison of landscape appreciation

convener:yoji aoki(Open University of Japan)

[HCG20-P01] Appreciation of Japanese landscapes by western diplomat (1859-1861)

*yoji aoki[1], fumihoro konta[2] (1.Open University of Japan, 2.National Science Museum)

[HCG20-P02] Functional Assessment of the Outdoor Recreational Space in Matsudo Campus, Chiba University

*Zhao Yuqing[1], Lu Tingyu[1], Wang Huixin[1], Nakamura Marina[1], Luo Shixian[1], Cheng Yu[1], Liu Zhendong[1], Katsunori Furuya[1] (1.Chiba University)

[HCG20-P03] Impact of Campus lockdown on Student Spatial Behavior During COVID-19 Pandemic

*Huixin Wang[1], Tingyu Lu[1], Dan Li[1], Rosyi Damayanti T Manningtyas[1], Dibyanti Danniswari[1], Azuki Kiriyama[1], Junpei Watanabe[1], Mizuki Sakamoto[1], Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[E] Oral | H (Human Geosciences)：H-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.14 Zoom Room 14

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull), Chairperson:Robert Michael Dorrell(University of Hull), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology)

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[HCG21-01] An analysis of sedimentation processes in pyroclastic density currents based on a two-layer depth-averaged model

★Invited Papers

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[2], Yujiro J. Suzuki[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Earthquake Research Institute, The University of Tokyo)

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

[HCG21-02] A new empirical model of vertical profile of velocity and suspended sediment concentration of steady-state turbidity currents

*Sojiro Fukuda[1], Elena Bastianon[1], Bill McCaffrey[2], Hajime Naruse[3], Robert Michael Dorrell[1] (1.University of Hull, 2.University of Leeds, 3.Kyoto University)

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

[HCG21-03] **Modeling sand-rich submarine debris flow: Sand deposition, turbidity current generation and separation**

*Yuichi Sakai[1], Hajime Naruse[1] (1.Graduate School of Science, Kyoto University)

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

[HCG21-04] Velocity and deposition profile of experimentally produced quasi-steady turbidity current

*Nomura Shun[1], Mikito Furuichi[1], Giovanni De Cesare[2], Yasushi Takeda[3], Hide Sakaguchi[1] (1.JAMSTEC, 2.École Polytechnique Fédérale de Lausanne, 3.ETH Zürich)

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

[HCG21-05] Dynamics of turbidity currents influenced by tidal flows in submarine canyons

*Justine Louise Marie Poppeschi[1], Hajime Naruse[1], Robert Michael Dorrell[2] (1.Department of Geology an Mineralogy, Graduate School of Science, Kyoto University, 2.University of Hull)

[E] Oral | H (Human Geosciences)：H-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.14 Zoom Room 14

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull), Chairperson:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Robert Michael Dorrell(University of Hull), Miwa Yokokawa(Osaka Institute of Technology)

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

[HCG21-06] Sedimentological and organic geochemical characteristics of the turbiditic sequences in the Miocene Abetsu Formation, Hokkaido, Japan

*Hiroyasu Asahi[1], Ken Sawada[2] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Facility of Science, Hokkaido University)

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

[HCG21-07] X-ray fluorescence core scanning, magnetic signatures, and organic geochemistry analyses of turbidites of Ryukyu Trench floor

*KanHsi Hsiung[1], Toshiya Kanamatsu[1], Ken Ikehara[2], Kazuko Usami[3], Chorng-Shern Horng[4], Naohiko Ohkouchi[1], Nanako O. Ogawa[1], Saneatsu Saito[1], Masafumi MURAYAMA[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Japan NUS Co., Ltd., 4.Institute of Earth Sciences, Academia Sinica, 5.Faculty of Agriculture and Marine Science, Kochi University)

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

[HCG21-08] Variations in depositional environments reconstructed by biomarkers analysis of turbidite sediments from the Miocene Kawabata Formation, Hokkaido, Japan

*Muhammad Adam Ismail[1], Ken Sawada[1,2], Satoshi Furota[2,3] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

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

[HCG21-09] Sedimentary structures caused by submarine landslide southern Satsuma Peninsula

*Hiroto Yamaguchi[1], Mamoru Sano[2], Satoshi Shimizu[2], Hikaru Iwamaru[2], Nobukazu Seama[1,2], Yuzuru Yamamoto[1,2], Hironori Otsuka[1,2], Tetsuo Matsuno[1,2], Yoshiyuki Tatsumi[1,2] (1.Kobe university, 2.Kobe Ocean-bottom Exploration Center)

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

[HCG21-10] Formation process of submarine massive sandstones: Study based on grain fabric analysis using deep-learning image segmentation

*Sayo Ishii[1], Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

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

[HCG21-11] Discussion

[E] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.09_2

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull)

[HCG21-P01] Grain size segregation on cyclic steps formed by turbidity currents

*Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.14 Zoom Room 14

[H-CG28] Earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Masayuki Ikeda(University of Tokyo), 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(Geological Survey of Japan, AIST), Masayuki Ikeda(University of Tokyo), 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)

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

[HCG28-01] Sedimentary environment and earthquake history off Cape Muroto, SW Japan

*Juichiro Ashi[1], Toshiya Kanamatsu[2], Masafumi MURAYAMA[3] (1.The University of Tokyo, 2.JAMSTEC, 3.Kochi University)

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

[HCG28-02] Detrital Zircon and Provenance Analysis of Sedimentary Rock in the Nemuro and Urahoro Groups, Eastern Hokkaido, Northern Japan

*Harisma Harisma[1], Hisashi Asanuma[2], Takafumi Hirata[2], Hajime Naruse[1] (1.Kyoto University, 2.University of Tokyo)

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

[HCG28-03] Numerical study on formation mechanism of *shoal* and *cauldron* topographies on the seafloor in the eastern Seto Inland Sea

*Motoki Ubara[1], Yusuke Uchiyama[1], Taichi Kosako[2] (1.Graduate School of Engineering, Kobe University, 2.Coastal and Estuarine Environment Department, Port and Airport Research Institute)

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

[HCG28-04] Long-term perspectives on coastal changes of the Mekong delta, Vietnam

*Toru Tamura[1] (1.Institute of Geology and Geoinformation Geological Survey of Japan, AIST)

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

[HCG28-05] Ichnodiversity in the Upper Cretaceous submarine channel-levee deposits: examples from the northern and southwest Japan

*Kazuki Kikuchi[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University)

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

[HCG28-06] Behavior of plucking of bedrock with fully developed joints and its sensitivity to surface roughness

*Masahiro Ishizuka[1], Noritaka Endo[1] (1.Kanazawa University)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.09_3

[H-CG28] Earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Masayuki Ikeda(University of Tokyo), 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)

[HCG28-P01] Preliminary study on the relationships between landform of coastal to alluvial plain and sediments supply from watershed

*Taku Komatsubara[1] (1.Institute of Geology and Geoinformation, Advanced Industrial Science and Technology)

[HCG28-P02] Relationship between magnetic anisotropy and hydraulic conditions in modern flood deposits

*Ryo Tateishi[1], Ichiro Kimura[1], Naoto Ishikawa[1] (1.University of Toyama)

[HCG28-P03] Flume experiment on crevasse-splay deposits formed by the 2019 flooding of the Chikuma River

*Taichi Kato[1], Masaki Yamada[1], Hajime Naruse[2], Sakai Yuichi[2] (1.Department of Geology, Faculty of Science, Shinshu University, 2.Graduate school of Science, Kyoto University)

[HCG28-P04] Sedimentary environments and fluctuations in lake levels as recorded in the latest Pleistocene and Holocene core from the Suwa Basin, central Japan

*Nozomi Hatano[1], Ritsuho Kawano[2], Kohki Yoshida[2] (1.Natural Environment Division, Nagano Environmental Conservation Research Institute, 2.Department of Geology, Faculty of Science, Shinshu University)

[HCG28-P05] Microcodization in a Kasimovian section of the Omi Limestone (Niigata Prefecture, central Japan), the Upper Carboniferous

*Yoshihiro Kakizaki[1], Yasuhiro Ota[2], Kenji Kashiwagi[3], Akihiro Kano[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Kitakyushu Museum of Natural History & Human History, 3. Graduate School of Science and Engineering for Research, University of Toyama)

[HCG28-P06] Coastal transport process of pebble along the Seisho Coast, Kanagawa Prefecture, estimated from changes in lithological composition and form of pebble particles

*Masaaki Shirai[1], Tomomi Akiyama[1], Kiyokazu Kawajiri[2], Takako UTSUGAWA[3], Takayuki Takahashi[4] (1.Tokyo Metropolitan University, 2.Sagamihara Cuty Museum, 3.Rissho University, 4.Tohoku University)

[HCG28-P07] A consideration of the age of the higher terraces in the southeastern part of the Kashiwazaki plain, Niigata Prefecture, central Japan.

*Satoshi Kaneko[1], Toshimichi Kaneto[1], Akiko Miyawaki[2], Akira Fukuchi[2], Mitsugu Momose[2] (1.Tokyo Electric Power Company Holdings, Inc., 2.Hanshin Consultants Co., Ltd.)

[HCG28-P08] Linear stability analysis of plane beds with active suspended load

Koji Ohata[1], *Hajime Naruse[1], Norihiro Izumi[2] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2.Graduate School of Engineering)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.22 Zoom Room 22

[S-SS05] Crustal Deformation

convener:Masayuki Kano(Graduate school of science, Tohoku University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yoshiyuki Tanaka(Earth and Planetary Science, The University of Tokyo), Keisuke Yano(The Institute of Statistical Mathematics)

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

[SSS05-01] Formation simulation of imbrication and décollement under uniform compression based on the elasto-plastic soil mechanics

*Tomohiro Toyoda[1], Toshihiro Noda[1], Kazuya Onishi[2], Akira Asaoka[3] (1.Nagoya University, Disaster Mitigation Research Center, 2.Nagoya University, School of Engineering, 3.Association for the Development of Earthquake Prediction)

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

[SSS05-02] **Estimate of Strain Rate Field in Japan from GNSS Data: Comparison between Shen's Method and Basis Function Expansion**

*Tomohisa Okazaki[1], Yukitoshi Fukahata[2], Takuya NISHIMURA[2] (1.RIKEN Center for Advanced Intelligence Project, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SSS05-03] A Bayesian approach to estimating the crustal strain-rate fields from GNSS data and application to data from Mainland China

*ZIYAO XIONG[1], Jiancang Zhuang[1] (1.Institute of Statistical Mathematics)

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

[SSS05-04] Effects of curvature and lateral heterogeneities in elasticity constants on coseismic deformation

*Yoshiyuki Tanaka[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

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

[SSS05-05] Applicability of the Hamiltonian Monte Carlo method for single rectangular fault estimation

*Taisuke Yamada[1], Yusaku Ohta[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

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

[SSS05-06] Automatic detection of short-term slow slip events using GNSS data: An l1-trend filtering approach

*Keisuke Yano[1], Masayuki Kano[2] (1.The Institute of Statistical Mathematics, 2.Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.22 Zoom Room 22

[S-SS05] Crustal Deformation

convener:Masayuki Kano(Graduate school of science, Tohoku University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Yusuke Yokota(Institute of Industrial Science, The University of Tokyo)

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

[SSS05-07] New stable slip on the plate in a wide area after 2015 detected by postseismic deformation model of 2011 Tohoku-Oki Earthquake

*Satoshi Fujiwara[1], Mikio Tobita[1], Shinzaburo Ozawa[1] (1.Geospatial Information Authority of Japan)

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

[SSS05-08] Preliminary results of sea-floor crustal deformation measured by GNSS-Acoustic technique in Nemuro-Oki, southwestern part of Kuril Trench

*Yusaku Ohta[1], Motoyuki Kido[2], Chie Honsho[1], Yukiho Kimura[1], Makiko Sato[1], Syuichi Suzuki[1], Ryosuke Azuma[1], Mako Ohzono[3,5], Hiroki Aota[3], Hiroaki Takahashi[3], Fumiaki Tomita[4], Takeshi Iinuma[4], Masanao Shinohara[5], Ryota Hino[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. Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 4.Japan Agency for Marine-Earth Science and Technology, 5.Earthquake Research Institute,The University of Tokyo)

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

[SSS05-09] Monitoring of the inter-plate coupling using GNSS-A seafloor geodesy along the Nankai trough

*Tadashi Ishikawa[1], Shun-ichi Watanabe[1], Yuto Nakamura[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

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

[SSS05-10] Relationship between observation ability of GNSS-A and its detection ability for coupling condition and SSE

*Yusuke Yokota[1], Tadashi Ishikawa[2], Shun-ichi Watanabe[2], Yuto Nakamura[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic Department, Japan Coast Guard)

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

[SSS05-11] **Estimation of Average Displacement Rate Vector Using GNSS Data in Yaeyama Islands**

*Aoi Ikeichi[1], Masayuki Kano[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Kazuki Komano[2], Takuya NISHIMURA[3], SHINICHI MIYAZAKI[2] (1.Graduate School of Science, Tohoku University, 2.Graduate School of Science, Kyoto University, 3.Disaster Prevention Research Institute, Kyoto University)

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

[SSS05-12] **Possible overlap of coseismic slip and afterslip investigated by InSAR analysis**

*Kanami Sakamoto[1], Yo Fukushima[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.10_1

[S-SS05] Crustal Deformation

convener:Masayuki Kano(Graduate school of science, Tohoku University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology)

[SSS05-P01] Estimation of Afterslip Distribution and Viscoelastic Deformation by MCMC Method

*Ryoji Kawabata[1], Hiroshi Munekane[1] (1.GSI of Japan)

[SSS05-P02] Application of a slow slip objective detection method to GNSS 6-hour coordinates

*Akio Kobayashi[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[SSS05-P03] Long-term SSE along the Nankai trough detected by Geonet

*Shinzaburo Ozawa[1], Ryoji Kawabata[1], Hiroshi Munekane[1] (1.Geographical Survey Institute of Japan)

[SSS05-P04] Estimation of strain-rate field in the Japanese Islands using optimized distance-decaying constants

*Issei Kosugi[1], Yuta Mitsui[2] (1.Graduate School Of Science and Technology, Shizuoka University , 2.Faculty of Science, Shizuoka University)

[SSS05-P05] **Evaluation of inland seismic potential in southwest Japan using GNSS data and seismic catalog**

*Hiroki Sato[1], Takeo Ito[1] (1.Graduate School of Environmental Studies, Nagoya University)

[SSS05-P06] Re-evaluation of earthquake swarm activity in the offshore region to the northeast of Izu Peninsula focusing on crustal deformation for several months (1990-2011)

Keisuke Takeshita[1], *Kazuhiro Kimura[1], Takeshi Kimura[2] (1.Meteorological College, 2.National Research Institute for Earth Science and Disaster Resilience)

[SSS05-P07] Evaluation earthquake potential using a kinematic block motion model in Indonesia based on GNSS Observation

*Rio Raharja[1], Takeo Ito[1], Hiroshi Kimura[1], Irwan Meilano[2] (1.Graduate School of Environmental Studies, Nagoya University, Japan, 2.Faculty of Earth Sciences and Technology, Bandung Institute of Technology, Indonesia)

[SSS05-P08] **A recent example of active intraplate deformation in the Central Anatolia: Obruk-Bor (Nigde) earthquakes, Turkey**

*Dogan Kalafat[1] (1.Bogazici University Kandilli Observatory and Earthquake Research Institute Cengelkoy, Istanbul Turkey)

[SSS05-P09] Modification of computer program GOTIC2 for calculation of the ocean tidal loading effect - Application of Green's function to calculate theoretical strain at depth of borehole observation near coasts -

Osamu Kamigaichi[1,2], *Norio Matsumoto[2], Fuyuki Hirose[3] (1.Japan Meteorological Business Support Center, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3.Seismology and Tsunami Research Department, Meteorological Research Institute)

[SSS05-P10] Crustal deformation observed with Tenryu-Funagira laser strainmeter

*Takahiro Tsuyuki[1] (1.Meteorological Research Institute)

[SSS05-P11] Crustal movements due to the seismic motions observed in Kobe

*Atsushi Mukai[1] (1.Faculty of Urban Management, Fukuyama City University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.20 Zoom Room 20

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency), Chairperson:Youichi Asano(National Research Institute for Earth Science and Disaster Prevention), Yohei Yukutake(Earthquake Research Institute, University of Tokyo)

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

[SSS06-01] Aseismic process driving the earthquake swarm, revealed by the dense seismic observation

*Yohei Yukutake[1], Keisuke Yoshida[2], Ryou Honda[1] (1.Hot Springs Research Institute of Kanagawa Prefecture, 2.Tohoku University)

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

[SSS06-02] Statistical analysis and its characteristics of the earthquake activity near the border of Nagano, Gifu and Fukui prefectures

*Takao Kumazawa[1], Yosihiko Ogata[2] (1.Earthquake Research Institute, The University of Tokyo, 2.The Institute of Statistical Mathematics)

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

[SSS06-03] Seismic activity around Kamikochi, Nagano Prefecture after the M5.5 earthquake on April 23, 2020

*Takayuki Kawabe[1] (1.Ex. Faculty of Education, Arts and Sciences, Yamagata University)

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

[SSS06-04] A simple way to distinguish rather shallow PAC-intraplate events from interplate ones around Japan

*Ritsuko S. Matsu'ura[1], Takeo Ishibe[1], Koji Iwasa[1] (1.Earthquake Research Center, Association for the Development of Earthquake Prediction)

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

[SSS06-05] Hypocenter determination assuming a 1-D velocity model with station corrections and its result for the Tohoku region

*Youichi Asano[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS06-06] Seismicity distribution in the Tonankai and Nankai seismogenic zones and its spatial relationship with interplate coupling and slow earthquakes

*Yojiro Yamamoto[1], Shuichiro Yada[1], Keisuke Ariyoshi[1], Takane Hori[1], Narumi Takahashi[2] (1.JAMSTEC, 2.NIED)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.20 Zoom Room 20

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency), Chairperson:Kohei Nagata(Meteorological Research Institute), Masatoshi Miyazawa(Disaster Prevention Research Institute, Kyoto University)

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

[SSS06-07] Toward the construction of an integrated assessment method of crustal activity - characterization of “normal” seismicity in Japan-

*Kohei Nagata[1], Koji Tamaribuchi[1], Fuyuki Hirose[1], Akemi Noda[1] (1.Meteorological Research Institute)

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

[SSS06-08] A hierarchical model of earthquake asperity

*Yoshio Fukao[1] (1.Center for Earthquake and Tsunami / Japan Agency for Marine-Earth Science & Technology)

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

[SSS06-09] Radiation-corrected empirical Green's function in slip inversion

*Ritsuya Shibata[1], Genki Oikawa[1], Naofumi Aso[1], Junichi Nakajima[1], Satoshi Ide[2] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo)

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

[SSS06-10] Modeling dynamic rupture and statistical properties of earthquakes with cellular automaton models.

*Kota Fukuda[1], Takahiro Hatano[2], Kimihiro Mochizuki[1] (1.Earthquake Research Institute The University of Tokyo, 2.Department of Earth and Space Science Osaka University)

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

[SSS06-11] Dynamic earthquake triggering in Southern California in high resolution

*Masatoshi Miyazawa[1], Emily E Brodsky[2], Huiyun Guo[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.University of California, Santa Cruz)

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

[SSS06-12] Discussion

[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.10_2

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency)

[SSS06-P01] Accuracy improvement of DONET seismometer orientations estimated from seismic waveforms

*Shuichiro Yada[1], Takehiro Nishiyama[1], Keisuke Ariyoshi[1], Yojiro Yamamoto[1], Masaru Nakano[1], Kentaro Sueki[1], Takane Hori[1], Narumi Takahashi[2,1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Research Institute for Earth Science and Disaster Resilience)

[SSS06-P02] A preliminary study on data quality characterization for the DONET seismic catalogue

*Kazuyoshi Nanjo[1,2,3], Keisuke Ariyoshi[4], Narumi Takahashi[4,5], Shuichiro Yada[4], Yojiro Yamamoto[4], Takane Hori[4] (1.University of Shizuoka, 2.Shizuoka University, 3.Institute of Statistical Mathematics, 4.Japan Agency for Marine-Earth Science and Technology, 5.National Research Institute for Earth Science and Disaster Resilience)

[SSS06-P03] Aftershock activity of the 2015 M7.1 earthquake and back-arc rifting in the northern Okinawa Trough

*Hirotsugu Yanagida[1], Yukihiro Nakatani[2], Hiroshi Yakiwara[2], Shuichiro Hirano[1], Reiji Kobayashi[1], Yusuke Yamashita[3], Takeshi Matsushima[4], Hiroshi Shimizu[4], Kodo Umakoshi[5], Masanao Shinohara[6] (1.Graduate School of Science and Engineering, Kagoshima University, 2.Nansei-Toko Observatory for Earthquakes and Volcanoes, Kagoshima University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 5.Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 6.Earthquake Research Institute, the University of Tokyo)

[SSS06-P04] Microseismic Monitoring and Stress Inversion: before the 2018 Mw 6.4 Hualien earthquake and 2019 M_L 6.0 Ilan earthquake

*Wei-Jhe Wu[1], Chein-Min Su[1], Strong Wen[1], Yi-Heng Li[2], Chun-Rong Chen[2], Chau-Huei Chen[1] (1.National Chung Cheng University, 2.Industrial Technology Research Institute)

[SSS06-P05] Aftershock activity and its duration following inland earthquakes in Japan

*Taichi Honda[1], Takuji Yamada[2] (1.Ibaraki University, 2.Faculty of Science, Graduate School of Science and Technology, Ibaraki University)

[SSS06-P06] Whether the change in shear strain energy causes change in *b* value? Case study for the 2016 Kumamoto Earthquakes and the interplate coupling along the Nankai Trough

*Kohei Nagata[1], Akemi Noda[1], Koji Tamaribuchi[1], Fuyuki Hirose[1] (1.Meteorological Research Institute)

[SSS06-P07] Inter-plate aseismic slip determined from teleseismic similar earthquakes recorded by the Japanese seismic network

*Toshihiro Igarashi[1], Aitaro Kato[1] (1.Earthquake Research Institute, University of Tokyo)

[SSS06-P08] Seasonal variations in crustal seismicity and surface load

*Taku Ueda[1], Aitaro Kato[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 11:45 AM JST | 1:45 AM - 2:45 AM UTC | Ch.19 Zoom Room 19

[S-SS07] Crustal Structure

convener:Mikiya Yamashita(National Institute of Advanced Industrial Science and Technology), Chairperson:Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology)

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

[SSS07-01] Examination of applicability of seismic interferometry in exploration of underground structure under a volcanic body

*Hirofumi Kowari[1], Koji Yamada[1], Tatsuyuki Ueno[1] (1.Hanshin Consultants Co., Ltd.)

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

[SSS07-02] Deep seismic reflection profiling across the Tsugaru peninsula, northern Honshu, Japan

*Hiroshi Sato[1,2], Tatsuya Ishiyama[1], Hideo Saito[3], Mamoru Nakata[3], Naoko Kato[1], Susumu Abe[3] (1.Earthquake Research Institute, The University of Tokyo, 2.Center for integrated Research and Education of Natural Hazards, Shizuoka University, 3.JGI, Inc.)

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

[SSS07-03] Deep crustal seismic profiling from airgun-OBS surveys offshore Niigata-Yamagata: reflection imaging via reverse time migration

*Kazuya Shiraishi[1], Tetsuo No[1], Gou Fujie[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[SSS07-04] Revealing structures in the shallow crust beneath Botswana, southern Africa: considering dip and anisotropy

*Admore Phindani Mpuang[1,2], Takuo Shibutani[2] (1.Graduate School of Science, Kyoto University, 2.Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.11_1

[S-SS07] Crustal Structure

convener:Mikiya Yamashita(National Institute of Advanced Industrial Science and Technology)

[SSS07-P01] Local variations of seismic scattering-attenuation structure around the volcanic front in Hokkaido

*Kiyoshi Yomogida[1], Hidekatsu Masuda[2], Takahiro Shiina[3], Kei Katsumata[4] (1.Department of Earth and Planetary Dynamics, Graduate School of Science, Hokkaido University, 2.Earth and Planetary Dynamics, Faculty of Natural History Sciences, Graduate School of Science, Hokkaido University, 3.National Institute of Advanced Industrial Science and Technology, 4.Institute of Seismology and Volcanology, Hokkaido University)

[SSS07-P02] Study of the delamination structure at the southern end of the Hidaka collision zone- Examination using numerical calculation-

*Masahiro Shimazaki[1], Noriko Tsumura[2] (1.Graduate School of Science and Engineering, Chiba University, 2.Graduate School of Science, Chiba University)

[SSS07-P03] Three-dimensional resistivity modeling in the eastern Iburi district, Hokkaido

*Ryo Ito[1], Takeshi Hashimoto[1], Tomohiro Inoue[1], Makoto Uyeshima[2], Hiroshi Ichihara[3], Yusuke Yamaya[4] (1.Graduate School of Science, Hokkaido University, 2.Earthquake Research Institute, The University of Tokyo, 3.Graduate school of environmental studies, Nagoya University, 4.National Institute of Advanced Industrial Science and Technology)

[SSS07-P04] Measurement of seismic velocity anisotropy in the Tohoku region, NE Japan by shear wave splitting analysis (3)

*Tatsuya Mizuta[1], Tomomi Okada[1], Martha Savage[2], Ryota Takagi[1], Keisuke Yoshida[1], Shin'ichi Sakai[3], Mako Ohzono[3,9], Masahiro Kosuga[4], Yoshiko Yamanaka[5], Hiroshi Katao[6], Takeshi Matsushima[7], Hiroshi Yakiwara[8], Takashi NAKAYAMA[1], Satoshi Hirahara[1], Toshio Kono[1], Toru Matsuzawa[1], _ Group for the aftershock observations of the 2011 off the Pacific coast of Tohoku Earthquake (1.Tohoku Univ., 2.Victoria University of Wellington, 3.Tokyo Univ., 4.Hirosaki Univ., 5.Nagoya Univ., 6.kyoto univ., 7.kyushu Univ., 8.Kagoshima Univ., 9.Hokkaido Univ.)

[SSS07-P05] Velocity structure of the uppermost mantle beneath central Japan

*Akio Katsumata[1] (1.Faculty of Sustainable Design, University of Toyama)

[SSS07-P06] Seismological structure revealed by regional deep-event records beneath the Kii peninsula

*Yasunori Sawaki[1], Takuo Shibutani[2], Yihuan Ruan[1], Yoshihiro Ito[2] (1.Graduate School of Science, Kyoto University , 2.Disaster Prevention Research Institute, Kyoto University)

[SSS07-P07] Deep crustal seismicity in Hiroshima Prefecture

*Azusa Shito[1] (1.Okayama University of Science)

[SSS07-P08] Seismic imaging of the subducting Kyushu-Palau ridge in relation to the distribution of tectonic tremors

*Yanxue Ma[1], Kimihiro Mochizuki[1], Rie Nakata[1], Seiichi Miura[2], Yasuyuki Nakamura[2], Ryuta Arai[2], Gou Fujie[2], Yuka Kaiho[2], Shuichi Kodaira[2] (1.Earthquake Research Institute, University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

[SSS07-P09] Analysis of JAMSTEC Seismic Survey Database site

*Yuka Kaiho[1], Seiichi Miura[1], Ayako Nakanishi[1], Tetsuo No[1], Kaoru Takizawa[1], Yasuyuki Nakamura[1], Gou Fujie[1], Koichiro Obana[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.20 Zoom Room 20

[S-SS08] Fault Rheology and Earthquake Physics

convener:Shunya Kaneki(Disaster Prevention Research Institute, Kyoto University), Makiko Ohtani(Earthquake Research Institute, the University of Tokyo), Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Keisuke Yoshida(Tohoku University), Chairperson:Makiko Ohtani(Earthquake Research Institute, the University of Tokyo), Keisuke Yoshida(Tohoku University)

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

[SSS08-01] **Fault frictional heterogeneities can explain earthquakes with no foreshocks, accelerating foreshocks and earthquake swarms observed in central Alaska**

★Invited Papers

*Yoshihiro Kaneko[1], Nealey Sims[2], Carl Tape[2], Stephen Holtkamp[2], Andrea Perez[3] (1.Kyoto University, 2.University of Alaska - Fairbanks, 3.Victoria University of Wellington)

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

[SSS08-02] Rupture segmentation caused by fault bends in simulated earthquake sequences

*So Ozawa[1], Ryosuke Ando[1] (1.Graduate School of Science, the University of Tokyo)

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

[SSS08-03] Energy-based scenarios for the Nankai trough subduction earthquakes: Stress accumulation model taking historical earthquakes into account

*Akemi Noda[1], Tatsuhiko Saito[2] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS08-04] **Estimation of absolute shear stress in the source region of large earthquakes based on estimates of fault fracture energy**

*Nelson Pulido[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS08-05] Three-dimensional tectonic stress fields estimated from seismic data for long-term periods with direct prior information

*Toshiko Terakawa[1] (1.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

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

[SSS08-06] Spatial and temporal change of stress field in the focal area of the 2016 Kaikoura earthquake, New Zealand (2)

Miu Matsuno[1], Ayaka Tagami[1], *Tomomi Okada[1], Satoshi Matsumoto[2], Yuta Kawamura[2], Yoshihisa Iio[3], Tadashi Sato[1], Takashi NAKAYAMA[1], Satoshi Hirahara[1], Stephen Bannister[4], John Ristau[4], Martha K Savage[5], Clifford H Thurber[6], Richard H Sibson[7] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University, 4.GNS Science, New Zealand, 5.Victoria University of Wellington, New Zealand, 6.University of Wisconsin - Madison, United States of America, 7.University of Otago, New Zealand)

[E] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.23 Zoom Room 23

[S-EM12] Electric, magnetic, and electromagnetic survey technologies and the scientific achievements

convener:Kiyoshi Baba(Earthquake Research Institute, The University of Tokyo), Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China), Chairperson:Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China)

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

[SEM12-01] UNDERSTANDING MAGMATIC SYSTEM OF UNZEN VOLCANO (NAGASAKI, SOUTHWEST JAPAN) INFERRED FROM BROAD-BAND MAGNETOTELLURIC OBSERVATION

*Agnis Triahadini[1], Koki Aizawa[2], Tasuku M. Hashimoto[3], Kazunari Uchida[2], Yuto Yamamoto[1], Keita Chiba[2], Dan Muramatsu[1], Kanta Miyano[1], Yuta Kawamura[1], Satoru ANIYA[1], Ayumu Okubo[1] (1.Department of Earth and Planetary Sciences Graduate School of Sciences Kyushu University, 2.Institute of Seismology and Volcanology Faculty of Science Kyushu University, 3.Earthquake Research Institute The University of Tokyo)

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

[SEM12-02] Near-surface geothermal fluids conduit imaged by audio-frequency magnetotteluric survey in a hydrothermal area, Indonesia

*Tada-nori Goto[1], Shohei Ohba[1], Mohamad Nur Heriawan[3], Irwan Iskandar[3], Taiki Kubo[2], Koki Kashiwaya[2], Katsuaki Koike[2] (1.Graduate School of Science, University of Hyogo, 2.Graduate School of Engineering, Kyoto University, 3.Faculty of Mining and Petroleum Engineering, Bandung Institute of Technology)

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

[SEM12-03] How about using the magnetic field for the tsunami warning? Comparison of the tsunami magnetic field with the sea level change

*Zhiheng Lin[1], Hiroaki TOH[2], Takuto Minami[3] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University, 3.Department of Planetology, Faculty of Science, Kobe University)

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

[SEM12-04] **Offshore–onshore seamless resistivity imaging of freshwater using a controlled source electromagnetic method**

*Keiichi Ishizu[1], Yasuo Ogawa[1] (1.Tokyo Institute of Technology)

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

[SEM12-05] **One-dimensional Deep Learning Inversion of Marine Controlled Source Electromagnetic Data**

*Pan Li[1], Z Du[1], Yuguo Li[1,2] (1.Ocean University of China, 2.Key Lab of Submarine Geosciences and Prospecting Techniques of Ministry of Education)

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

[SEM12-06] **Applicability evaluation of non-conforming deformed hexahedral mesh for marine magnetotellurics**

*Yoshiya Usui[1] (1.Earthquake Research Institute, the University of Tokyo)

[E] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.11_2

[S-EM12] Electric, magnetic, and electromagnetic survey technologies and the scientific achievements

convener:Kiyoshi Baba(Earthquake Research Institute, The University of Tokyo), Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China)

[SEM12-P01] Characteristic features of the response functions estimated from a wide-band magnetotelluric (MT) data in the southern Tohoku area

*Dieno Diba[1], Makoto Uyeshima[1], Masahiro Ichiki[2], Shin'ya Sakanaka[3], Makoto Tamura[4], Yusuke Yamaya[5], Yoshiya Usui[1] (1.Earthquake Research Insititute, the University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.Graduate school of International Resource Sciences, Akita University, 4.Geological Survey of Hokkaido, Hokkaido Research Organization, 5.National Institute of Advanced Industrial Science and Technology)

[SEM12-P02] Three-dimensional inversion of magnetotelluric data in a geothermal area near Hakkoda volcano

*Toshihiro Uchida[1] (1.National Institute of Advanced Industrial Science and Technology)

[SEM12-P03] **On synthetic marine magnetotelluric inversion study: reproduction of error in data**

*Kiyoshi Baba[1] (1.Earthquake Research Institute, The University of Tokyo)

[SEM12-P04] Discussion

[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 | Ch.23 Zoom Room 23

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Chairperson:Takuto Minami(Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University), Maki Hata(Earthquake Research Institute, the University of Tokyo)

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

[SEM14-01] Imaging the magma plumbing system of Mt. Meakandake volcano based on broadband magnetotellurics and three-dimensional resistivity modelling

*Tomohiro Inoue[1], Takeshi Hashimoto[1], Ryo Tanaka[1], Yusuke Yamaya[2], Hiroshi Ichihara[3] (1.Graduate School of Science,Hokkaido University, 2.National Institute of Advanced Industrial Science and Technology, 3.Graduate School of environmental Studies, Nagoya University)

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

[SEM14-02] Three-dimensional resistivity structure of the Tarumae volcanic region using MT data

*Takaya Yamagiwa[1], KENTARO AOYAMA[1], Koichi Suzuki[1], Toru Mogi[2], Yusuke Yamaya[3] (1.Hokkaido University, 2.Faculty of Science, Tokyo Institute of Technology, 3.National Institute of Advanced Industrial Science and Technology)

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

[SEM14-03] 3-D resistivity models beneath Aso caldera by new and old Network-MT dipole data arranged into reticular shapes

*Maki Hata[1], Makoto Uyeshima[1], Mitsuru Utsugi[2], Nobuo Matsushima[3], Yoshikazu Tanaka, Takeshi Hashimoto[4], Ryokei Yoshimura[5], Naoto Oshiman[5] (1.Earthquake Research Institute, the University of Tokyo , 2.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 3.Geological Survey of Japan, 4.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 5.Disaster Prevention Research Institute, Kyoto University)

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

[SEM14-04] Toward joint inversion of AMT and ACTIVE data sets for better understanding of the hydrothermal system of Aso volcano

*Takuto Minami[1], Mitsuru Utsugi[2], Wataru Kanda[3], Marceau Gresse[4] (1.Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University, 2.Aso Volcanological Laboratory, Graduate School of Science, Kyoto University, 3.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 4.Earthquake Research Institute, University of Tokyo)

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

[SEM14-05] Electromagnetic field fluctuations by infrasound during the eruption of Kirishima Shinmoe-dake in 2018

*Satoru ANIYA[1], Koki Aizawa[2], Takeshi Matsushima[2] (1.Department of Earth and Planetary Sciences,Graduate School of Sciences,Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University)

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

[SEM14-06] Time Series Analyses of EM-ACROSS Data

*Sohei Serita[1], Yasuo Ogawa[1], Kuo Hsuan Tseng[1], Keiichi Ishizu[1], Takahiro Kunitomo[2], Takuto Minami[3], Hiroshi Ichihara[2], T Grant Caldwell[4] (1.Tokyo Institute of Technology, 2.Nagoya University, 3.Kobe University, 4.GNS Science)

[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 | Ch.23 Zoom Room 23

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Chairperson:Ken'ichi Yamazaki(Disaster Prevention Research Institute, Kyoto University), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

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

[SEM14-07] Accuracy and precision evaluation of the new method for the absolute magnetic measurements

★Invited Papers

*Hideyuki Hirahara[1], Junpei Oogi[1], Megumi Kaito[1], Seiki Asari[1] (1.Kakioka Magnetic Observatory, Japan Meteorological Agency.)

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

[SEM14-08] Piezomagnetic fields associated with a dislocation source in a layered elastic medium

*Ken'ichi Yamazaki[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[SEM14-09] Development and Application of Noise Reduction Method using two-stage MSSA (Multichannel Singular Spectrum Analysis) for MT data in Boso, Japan

*Shu Kaneko[1], Katsumi Hattori[2], Toru Mogi[2], Chie Yoshino[2] (1.Chiba University Graduate School of Science and Engineering, 2.Chiba University Graduate School of Science)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[SEM14-10] Understanding the spatial distribution characteristics of the MT response using Variogram

*Nagi Yamashita[1], Tada-nori Goto[1], Satoru Yamaguchi[2] (1.University of Hyogo, 2.Osaka City University)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[SEM14-11] Development of a 3D inversion code to consider ocean bottom magnetotelluric data including topographic distortion ~forward modeling part~

*Masamitsu Araki[1], Tetsuo Matsuno[1], Nobukazu Seama[1], Takuto Minami[1] (1.Department of Planetology, Graduate School of Science, Kobe University)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[SEM14-12] Discussion

[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 | Ch.11_3

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

[SEM14-P01] A research report on the fundamental investigations of an electrical resistivity structure beneath Chugoku and Shikoku regions, southwestern Japan(2020)

*Ichiro Shiozaki[1], Tomofumi Uto[1], Makoto Uyeshima[2], Hideki Murakami[3], Naoto Oshiman[4], Yoshihisa Iio[4] (1.Graduate School of Engineering, Tottori University, 2.Earthquake Research Institute, The University of Tokyo, 3.Research and Education Faculty, Kochi University, 4.Disaster Prevention Research Institute, Kyoto University)

[SEM14-P02] 1-D forward calculation of tidally-induced magnetic variation in the Lau Basin: Comparison of calculation and seafloor magnetic data and sensitivity analysis

*Nakaya Tokuma[1], Takuto Minami[1], Nobukazu Seama[1] (1.Kobe University)

[SEM14-P03] Detection of magnetic field variation induced by tsunami

*Ai Kataoka[1], Ikuko Fujii[1] (1.Japan Meteorological Agency)

[SEM14-P04] Repeated aeromagnetic survey of Tarumae volcano using an unmanned autonomous helicopter

*Keiichi Shibuya[1], Takeshi Hashimoto[2], Tomoya Hayakawa[3], Keitaro Yoshikawa[4] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Nippon Koei Co., Ltd., 4.Hokkaido Regional Development Bureau)

[SEM14-P05] A magnetic inversion method to recover the subsurface block structures based on L1-TV1 regularization

*Mitsuru Utsugi[1] (1.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

[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 | Ch.24 Zoom Room 24

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium), Chairperson:Hidenori Terasaki(Faculty of Science, Okayama University), Attilio Rivoldini(Royal Observatory of Belgium)

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[SIT18-01] Introduction

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[SIT18-02] New compositional insight on the formation of the Earth's core

*William F McDonough[1,2,3], Takashi Yoshizaki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University, Sendai, Miyagi 980-8578, Japan, 2.Research Center for Neutrino Science, Tohoku Uni- versity, Sendai, Miyagi 980-8578, Japan, 3.Department of Geology, University of Maryland, College Park, MD 20742, USA)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[SIT18-03] **Interstitial site occupancy of deuterium in a Fe-Si binary system at high-pressure and high-temperature conditions using a large volume press**

*Yuichiro Mori[1], Hiroyuki Kagi[1], Sho Kakizawa[2], Chikara Shito[1], Riko Iizuka-Oku[1], Katsutoshi Aoki[1], Takanori Hattori[3], Asami Sano-Furukawa[3], Ken-ichi Funakoshi[4], Hirouyki Saitoh[5] (1.The University of Tokyo, 2.Hiroshima Univ., 3.J-PARC Center, JAEA., 4.Neutron Science and Technology Center, CROSS. , 5.QST.)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SIT18-04] Effects of nickel on hydrogenation of iron: High-*PT* neutron diffraction measurements on Fe0.9Ni0.1D*x*

Chikara Shito[1], *Hiroyuki Kagi[1], Sho Kakizawa[2], Katsutoshi Aoki[1], Riko Iizuka[1], Yuichiro Mori[1], Kazuki Komatsu[1], Hiroyuki Saitoh[3], Jun Abe[4], Asami Sano-Furukawa[5], Takanori Hattori[5] (1.Geochemical Research Center, Graduate School of Science, University of Tokyo, 2.Graduate School of Advanced Science and Engineering, Hiroshima University, 3.National Institutes for Quantum and Radiological Science and Technology, 4.Comprehensive Research Organization for Science and Society, 5.Japan Atomic Energy Agency)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SIT18-05] Melting Experiments on the Fe-C-O Ternary System Under Core Pressures

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

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[SIT18-06] Existence of the two-phase mixture of HCP and B2 phases in the inner core

*Eiji Ohtani[1], Daijo Ikuta[1], Serena Dominijanni[2], Catherine McCammon[2], Naohisa Hirao[3], Hiroshi Fukui[4], Hiroshi Uchiyama[3], Alfred Q. R. Baron[4] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2.Bayerisches Geoinstitut, University of Bayreuth, 3.Japan Synchrotron Radiation Research Institute, 4.RIKEN)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

[SIT18-07] Discussion

[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 | Ch.24 Zoom Room 24

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium), Chairperson:William F McDonough(University of Maryland College Park), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

[SIT18-08] Introduction

10:50 AM - 11:05 AM JST | 1:50 AM - 2:05 AM UTC

[SIT18-09] Effect of the core structure on the nutation of Mars

*Attilio Rivoldini[1], Guillaume Morard[2], Daniele Antonangeli[3], Tim Van Hoolst[1], Sébastien Le Maistre[1], Véronique Dehant[1] (1.Royal Observatory of Belgium, 2.Université Grenoble Alpes, 3.Sorbonne Université)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[SIT18-10] Termination of a lunar dynamo inferred from compositionally-driven dynamo models

*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, Faculty of Science, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[SIT18-11] Possibility of percolation of Fe-S melts in asteroidsPossibility of percolation of Fe-S melts in asteroids

*Takumi Miura[1], Hidenori Terasaki[2], Tadashi Kondo[1], Osamu Ohtaka[1], Takashi Yoshino[3] (1.Department of Earth and Space Science, Graduate School of Science, Osaka university, 2. Department of Earth Sciences, Okayama University, 3.Institute for Planetary Materials, Okayama University)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[SIT18-12] **Wetting property of Fe-S melt in solid iron: Implication to core crystallization in planetesimals**

Daisuke Yumitori[1], *Hidenori Terasaki[1], Takashi Yoshino[2], Satoru Urakawa[1] (1.Faculty of Science, Okayama University, 2.Institute of Planetary Materials, Okayama University)

11:50 AM - 12:15 PM JST | 2:50 AM - 3:15 AM UTC

[SIT18-13] Discussion

[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 | Ch.12_1

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium)

[SIT18-P01] Sound velocity of hcp-iron at extreme pressure by inelastic x-ray scattering measurement

*Daijo Ikuta[1], Eiji Ohtani[1], Hiroshi Fukui[2,3], Daisuke Ishikawa[3], Alfred Q. R. Baron[3] (1.Department of Earth Science, Tohoku University, 2.Department of Material Science, University of Hyogo, 3.RIKEN)

[SIT18-P02] **Experimental modelling of seismic wave scattering near the inner-core boundary : preliminary results**

*Tatsuki Ohgishi[1], Ikuro Sumita[1] (1.National University Corporation Kanazawa University)

[SIT18-P03] GHz ultrasonic velocity measurement of iron beyond bcc-hcp transition III: FEM analysis on GHz-DAC ultrasonics

*Akira Yoneda[1], Ryo Tsuruoka[1], Seiji Kamada[2], Hidenori Terasaki[3], Tadashi Kondo[1], Daisuke Yamazaki[4] (1.Department of Earth and Space Science, Osaka University, 2.School of Science, Tohoku University, 3.School of Science, Okayama University, 4.Institute for Planetary Materials, Okayama University)

[SIT18-P04] GHz ultrasonic velocity measurements of iron beyond the bcc-hcp transition II : sample thickness determination using X-ray imaging method

*Ryo Tsuruoka[1], Akira Yoneda[1], Seiji Kamada[2], Hidenori Terasaki[3], Tadashi Kondo[1], Daisuke Yamazaki[4] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University, 2.Graduate School of Science, Tohoku University, 3.Faculty of Science, Okayama University, 4.Institute for Planetary Materials, Okayama University)

[J] 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 | Ch.24 Zoom Room 24

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology), Chairperson:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Ryuichi Nomura(Kyoto University)

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[SIT21-01] Introduction

1:50 PM - 2:20 PM JST | 4:50 AM - 5:20 AM UTC

[SIT21-02] Time-resolved transmission electron microscopy toward operando-measurement in geoscience

★Invited Papers

*Kuwahara Makoto[1] (1.Nagoya University)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[SIT21-03] Ab initio modeling of antigorite transported by subducting oceanic plates

*Jun Tsuchiya[1], Sayako Inoue[1] (1.Geodynamics Research Center, Ehime University)

2:35 PM - 3:05 PM JST | 5:35 AM - 6:05 AM UTC

[SIT21-04] Properties of liquid Fe mixtures under high-pressure conditions

★Invited Papers

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Institute of Technology, 2.Ehime Univ.)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[SIT21-05] Discussion

[J] 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 | Ch.24 Zoom Room 24

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology), Chairperson:Satoshi Ohmura(Hiroshima Institute of Technology), Jun Tsuchiya(Geodynamics Research Center, Ehime University)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SIT21-06] High spatial resolution electronic structure analysis by scanning transmission electron microscopy and electron energy loss spectroscopy

★Invited Papers

*Mitsutaka Haruta[1] (1.Kyoto University)

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

[SIT21-07] Molecular Dynamics Simulation of Shock-Induced Structural Transformation of Silica Using Artificial Neural Network

★Invited Papers

*Masaaki Misawa[1], Kohei Shimamura[2], Fuyuki Shimojo[2] (1.Okayama Univ., 2.Kumamoto Univ.)

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

[SIT21-08] Deformation mechanisms maps of bridgmanite based on high pressure experiments

*Noriyoshi Tsujino[1], Daisuke Yamazaki[1] (1.Institute for Planetary Materials, Okayama University)

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

[SIT21-09] Waveform inversion for the structure of Earth's deep interior: Progress and Prospects

*Kenji Kawai[1] (1.Department of Earth and Planetary Science, School of Science, University of Tokyo)

[J] 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 | Ch.12_2

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology)

[SIT21-P01] Theoretical approach to the pattern formation in spin systems via the time-dependent Ginzburg-Landau equation

*Ryoji Anzaki[1], Shin-ichi Ito[1,2], Hiromichi Nagao[1,2], Masaichiro Mizumaki[3], Masato Okada[4], Ichiro Akai[5] (1.ERI/UTokyo, 2.IST/UTokyo, 3.JASRI, 4.GSFS/UTokyo, 5.IINa, Kumamoto Univ.)

[SIT21-P02] Waveform inversion for localized 3-D transversely isotropic structure in the lowermost mantle beneath the western Pacific using Thai Seismic Array (TSAR) data

*Yuki Suzuki[1], Kenji Kawai[2], Robert J. Geller[2], Satoru Tanaka[3], Weerachai Siripunvaraporn[4], Songkhun Boonchaisuku[4], Noisagool Sutthipong[4], Yasushi Ishihara[3], Taweoon Kim[3] (1.Department of Earth and Planetary Science School of Science Tokyo Institute of Technology, 2.Department of Earth and Planetary Science School of Science University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Faculty of Science, Mahidol University)

[SIT21-P03] Measurements of local stress using TEM in-situ obserbation

*Akira Miyake[1], Satoko Motai[1], Yohei Igami[1], Ryuichi Nomura[1] (1.Kyoto University)

[SIT21-P04] Measurements of local strain in minerals using electron nanoprobe

★Invited Papers

*Yohei Igami[1], Akira Miyake[1] (1.Kyoto University)

[SIT21-P05] Elastic properties of fine-grained polycrystalline clinopyroxene under high *P-T* conditions

*Yumiko Tsubokawa[1,2], Masahiro Ishikawa[2] (1.Kyushu University, 2.Yokohama National University)

[SIT21-P06] Effect of Al on stability and crystal strucutre of superhydrous phase B

*Sho Kakizawa[1,2], Toru Inoue[1,2], Hiroto Nakano[3], Minami Kuroda[4], Takahiro Kuribayashi[5], Naoya Sakamoto[6], Hisayoshi Yurimoto[7] (1.Graduate School of Advanced Science and Engineering, Hiroshima University, 2.Hiroshima Institute of Plate Convergence Region Research (HiPeR), 3.Geodynamics Research Center, Ehime University, 4.Graduate School of Sciences, Hokkaido University, 5.Department of Earth Science, Graduate School of Science, Tohoku University, 6.Creative Research Institution, Hokkaido University, 7.Department of Natural History Sciences, Hokkaido University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.25 Zoom Room 25

[S-VC30] Volcanic and igneous activities, and these long-term forecasting

convener:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), 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:Tomohiro Tsuji(Division of Earth Science The Graduate School of Science and Technology for Innovation Yamaguchi University), Chisato Anai(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

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

[SVC30-01] Paleomagnetic evidence for polygenetic origin of Mamiyadake tephra ring, Ohachidaira maar-caldera complex, Hokkaido, Japan

*Yuki Yasuda[1] (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University)

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

[SVC30-02] Constraining residence times of plagioclase phenocrysts at the latest activity of Zao volcano

*Motohiro Sato[1], Masao Ban[1] (1.Graduate School of Science and Technology, Yamagata University)

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

[SVC30-03] Inverse crystallization order of phenocrysts in high-Mg basalt from Ryozen Formation, Fukushima prefecture

*Tsukasa Ohba[1], Tokiya Ando[1] (1.Faculty of International Resource Sciences, Akita University)

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

[SVC30-04] Discovery of new block and ash flow deposit from Azuma-kofuji volcano, Fukushima, Japan

*Takeshi Hasegawa[1], Suzuki Kazuma[1] (1.Department of Earth Sciences, College of Science, Ibaraki University)

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

[SVC30-05] Reexamination of the characteristics and eruption style of Haruna-Hakoda tephra found from the southern foot of Akagi Volcano to the eastern foot of Haruna Volcano in North Kanto, Northeast Japan

*Junichi Sato[1], Takehiko Suzuki[2] (1.Department of Geography, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 2.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University)

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

[SVC30-06] What have been erupted from the 2020 eruption of Nishinoshima?

*Yoshihiko Tamura[1], Tomoki Sato[1], Kenta Yoshida[1], Fukashi Maeno[2], Osamu Ishizuka[1,3], Yasuhiro Hirai[1], Noriko Tada[1], Kiyoshi Baba[2], Daisuke Suetsugu[1], Maiko Miyoshi[4], Shigeaki Ono[1] (1.Research Institute for Marine Geodynamics, Japan Agency for Maine-Earth Science and Technology, 2.ERI, Univ. of Tokyo, 3.GSJ/AIST, 4.NHK)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.25 Zoom Room 25

[S-VC30] Volcanic and igneous activities, and these long-term forecasting

convener:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), 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:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Yuki Yasuda(Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University)

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

[SVC30-07] Estimating magma flux from contact metamorphic aureoles

*Ken Yamaoka[1], Simon Richard Wallis[1], Akira Miyake[2], Catherine Annen[3] (1.The University of Tokyo, 2.Aichi University of Education, 3.University of Bristol)

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

[SVC30-08] Petrogenesis of Quaternary Yokota alkaline basalts, southwestern Japan

*Tetsuya Sakuyama[1], Izumi Kirishiki[1], Jun-Ichi Kimura[2] (1.Faculty of Science, Osaka City University, 2.JAMSTEC)

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

[SVC30-09] The history of 54 ka eruption of Kuju volcano

*Tomohiro Tsuji[1], Kishimoto Hiroshi[2], Koji Fujita[3], Chisato Nakamura[4], Tomohiro Nagata[4], Kazunari Kimura[4], Kozo Onishi[5], Michiharu Ikeda[6], Naoki Nishizaka[5] (1.Division of Earth Science The Graduate School of Science and Technology for Innovation Yamaguchi University, 2.kagoshima Meteorological Office, 3.Asia Air Survey Co. Ltd., 4.Naiba, 5.Shikoku Electric Power Co. Inc., 6.Shikoku Research Institute, Inc.)

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

[SVC30-10] Reappraising the Eruptive Age and Classification of Holocene Volcanic Products around Nakadake Crater, Aso Volcano Using Paleomagnetic and Rock Magnetic Methods

*Chisato Anai[1], Yasuo Miyabuchi[2], Mitsuru Utsugi[1], Shin Yoshikawa[1], Nobutatsu Mochizuki[3], Hidetoshi Shibuya[3], Takahiro Ohkura[1] (1.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2.Center for Water Cycle, Marine Environment and Disaster Management, Kumamoto University, 3.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University)

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

[SVC30-11] Petrogenesis of Nekodake magma in Aso volcano

*Soko Kado[1], Katsuya Kaneko[1] (1.Department of Planetology, Graduate school of science, Kobe university)

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

[SVC30-12] Silicic magma formations in the Aira caldera region during the last 100,000 years inferred from geochemical characteristics of plagioclase

*Ayumu Nishihara[1,2], Katsuya Kaneko[1], Qing Chang[3], Nobuo Geshi[2] (1.Department of Planetology, Graduate School of Science , Kobe University, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology., 3.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology)

[J] Poster | S (Solid Earth Sciences)：S-VC Volcanology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.13_1

[S-VC30] Volcanic and igneous activities, and these long-term forecasting

convener:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), 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)

[SVC30-P01] **Yield strength obtained from lava flow and lava tube cave of Undara volcano**

*Tsutomu Honda[1] (1.Vulcano-speleological Society)

[SVC30-P02] **Survey on Fissure Cave and Lava Tube Cave in Kansuyama Lava Flow of Mt.Fuji**

*Tsutomu Honda[1], Masaru Hatanaka[1], Takayoshi Katumata[1] (1.Vulcano-speleological Society)

[SVC30-P03] The origin of bimodal magmatism in the Okinawa Trough, Japan

*Arran Peter Murch[1], Kenichiro Tani[1], Takashi Sano[1], Shigekazu Yoneda[1] (1.National Museum of Nature and Science, Tsukuba, Ibaraki, Japan)

[SVC30-P04] Reinvestigation of Holocene eruption history of Nikko-Shirane Volcano, central Japan

*Yuki Kusano[1], Yoshihiro Ishizuka[1], Teruki Oikawa[1], Osamu Ishizuka[1] (1.Geological Survey of Japan, AIST)

[SVC30-P05] Construction of Geochemical database of Kikai Caldera magmas for understanding the magmatic evolution prior to caldera-forming eruptions

*Satoru Haraguchi[1,2], Kenta Ueki[2], Kenta Yoshida[2], Tatsu Kuwatani[2], Morihisa Hamada[2], Iona McIntosh[2], Takashi Miyazaki[2], Takeshi Hanyu[2] (1.Earthquake Research Institute, University of Tokyo, 2.JAMSTEC)

[SVC30-P06] Reconstruction of the volcanic history of Nakadake volcano in Kirishima volcano group, Kyushu, Japan (1)

*Yasuhisa Tajima[1], Atsushi Yasuda[2], Mitsuru Okuno[3] (1.Research & Development Center, Nippon Koei Co.,LTD., 2.Earthquake Research Institute, University of Tokyo, 3.Faculty of Science Department of Earth System Science, Fukuoka University)

[SVC30-P07] The effect of dissolved water induced by lithostatic pressure on lava migration

*Akio Goto[1] (1.Center for Northeast Asian Studies, Tohoku University)

[SVC30-P08] An attempt to detect volcanic materials of Ogasawara Ioto (Iwojima) Volcano from the core sample of the turbidite layers deposited in the Palace Bella Basin

*Masashi NAGAI[1], Takahiro Miwa[1] (1. Volcano Research Department, National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.23 Zoom Room 23

[S-TT34] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Shigeo Okuma(Geological Survey of Japan, AIST), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Chairperson:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Shigeo Okuma(Geological Survey of Japan, AIST), Yuji Mitsuhata(AdvancedIndustrial Science and Technology)

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

[STT34-01] Introduction

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

[STT34-02] Comparison of airborne magnetic surveys by different types of aircrafts - A case of Izu-Oshima Volcano

*Shigeo Okuma[1], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Masahiko Makino[2], Shogo Komori[3], Takao Koyama[4], Takayuki Kaneko[4], Takao Ohminato[4], Atsushi Yasuda[4], Yoshiaki Honda[5] (1.Institute of Geology and Geoinformation, AIST, 2.Geological Survey of Japan, AIST, 3.Research Institute for Geo-Resources and Environment, AIST, 4.Earthquake Research Institute, Univ. of Tokyo, 5.Center for Environmental Remote Sensing, Chiba univ)

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

[STT34-03] Aeromagnetic survey in Kusatsu-Shirane volcano by unmanned helicopter

*Takao Koyama[1], Wataru Kanda[2], Mitsuru Utsugi[3], Takayuki Kaneko[1], Takao Ohminato[1], Atsushi Watanabe[1], Hiroshi Tsuji[1], taro nishimoto[1], Yoshiaki HONDA[4] (1.Earthquake Research Institute, The University of Tokyo, 2.Tokyo Institute of Technology, 3.Kyoto University, 4.Chiba University)

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

[STT34-04] Automatic estimation of regression curves indicating average depths of causative layers from power spectrum of gravity anomaly or gravity gradient (g_{zz}) data

*Shigekazu Kusumoto[1], Motonori Higashinaka[2] (1.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2.JGI, Inc.)

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

[STT34-05] Study on the behavior of the groundwater in the slope in the heavy rain using Drone Airborne TEM

*Atsuhiko Kinoshita[1,2], Suguru Shibata[2], Takao Yamakoshi[1], Hiroaki Nakaya[1], Atsuyoshi Jomori[3], Tetsuya Toyama[3], Akira Jomori[3], Kentaro Kanayama[4], Minoru Okumura[4], Katsushi Kawato[4], Muneki Mitamura[5], Tamotsu Matsui[6] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, 3.NEOSCIENCE CO.LTD., 4.NIPPON ENGINEERING CONSULTANTS CO.,LTD., 5.Osaka City University, 6.Osaka University)

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

[STT34-06] Discussion

[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.14_1

[S-TT34] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Shigeo Okuma(Geological Survey of Japan, AIST), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology)

[STT34-P01] Geological structure survey by drone airborne electromagnetic survey method

*Youichi Yuuki[1], Akira Shinsei[1], Zenshiro Saito[1], Satoshi Tomimori[1], Akiyo Yamaguti[1], Akira Jomori[2], Atsuyoshi Jomori[2], Tatsuya Toyama[2] (1.Oyo corporation, 2.Neo Science)

[STT34-P02] Development of a Portable Infrared Camera system for Measuring Volcanic Surface Phenomena

*Tetsuya Jitsufuchi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.18 Zoom Room 18

[S-TT37] Seismic Big Data Analysis Based on the State-of-the-Art of Bayesian Statistics

convener:Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Keisuke Yano(The Institute of Statistical Mathematics), Takahiro Shiina(National Institute of Advanced Industrial Science and Technology), Chairperson:Ryo Kurihara(Earthquake Research Institute, The University of Tokyo), Takayuki Nagata(Tohoku University)

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

[STT37-01] Seismic noise reduction in MeSO-net during COVID-19 pandemic

★Invited Papers

*Suguru Yabe[1], Kazutoshi Imanishi[1], Kiwamu Nishida[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Earthquake Research Institute, University of Tokyo)

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

[STT37-02] MCMC-based joint determination of earthquake hypocenters and 1-D velocity structures around a fault zone

*Takahiro Shiina[1], Masayuki Kano[2] (1.National Institute of Advanced Industrial Science and Technology (AIST), 2.Graduate School of Science, Tohoku University)

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

[STT37-03] Application of structured regularization to seismic tomography for adaptation to discontinuities

*Sumito Kurata[1], Yohta Yamanaka[1], Keisuke Yano[2], Fumiyasu Komaki[1], Takahiro Shiina[3], Aitaro Kato[1] (1.The University of Tokyo, 2.The Institute of Statistical Mathematics, 3.National Institute of Advanced Industrial Science and Technology)

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

[STT37-04] Bayesian Dynamic Mode Decomposition

★Invited Papers

*Hideitsu Hino[1] (1.The Institute of Statistical Mathematics)

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

[STT37-05] Sensor Selection for Seismic Wavefield Reconstruction based on Sparse Observation (Part I. Proposal and Evaluation on Method based on Linearized Model of Governing Equation)

*Kumi Nakai[1], Takayuki Nagata[1], Yuji Saito[1], Taku Nonomura[1], Masayuki Kano[1], Shin-ichi Ito[2], Hiromichi Nagao[2] (1.Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

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

[STT37-06] Modeling space-time heterogeneities of hypocenter catalog

*Yosihiko Ogata[1], Koiti Katsura[1] (1.Research Organization of Information and Systems, The Institute of Statistical Mathematics)

[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.14_2

[S-TT37] Seismic Big Data Analysis Based on the State-of-the-Art of Bayesian Statistics

convener:Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Keisuke Yano(The Institute of Statistical Mathematics), Takahiro Shiina(National Institute of Advanced Industrial Science and Technology)

[STT37-P01] Clustering seismic noises using semi-supervised learning

*Kotaro Sato[1], Keisuke Yano[2], Komaki Fumiyasu[1] (1.The University of Tokyo, 2.The Institute of Statistical Mathematics)

[STT37-P02] Convolutional Neural Network to Detect Deep Low-Frequency Tremors from Seismic Waveform Images

*Ryosuke Kaneko[1,2], Hiromichi Nagao[2,1], Shin-ichi Ito[2,1], Kazushige Obara[2], Hiroshi Tsuruoka[2] (1.Graduate School of Information Science and Technology, The University of Tokyo, 2.Earthquake Research Institute, The University of Tokyo)

[STT37-P03] A Convolutional Neural Network based classification of local earthquakes and tectonic tremors in Sanriku-oki using a single station S-net data and its generalization ability

*Masayuki Kano[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Keisuke Yano[2] (1.Graduate school of science, Tohoku University, 2.The Institute of Statistical Mathematics)

[STT37-P04] Forecasting temporal variation of aftershocks immediately after a main shock using Gaussian process regression

*Kosuke Morikawa[1], Hiromichi Nagao[2,3], Shin-ichi Ito[2,3], Yoshikazu Terada[1,4], Shin'ichi Sakai[2,5], Naoshi Hirata[2,6] (1.Osaka University, 2.Earthquake Research Institute, The University of Tokyo,, 3.Graduate School of Information Science and Technology, 4.Center for Advanced Intelligence Project, 5.Interfaculty Initiative in Information Studies, The University of Tokyo, 6.National Research Institute for Earth Science and Disaster Resilience)

[STT37-P05] **Detection of deep low-frequency earthquakes based on matched filter technique using mutual information**

*Ryo Kurihara[1], Aitaro Kato[1], Hiromichi Nagao[1,2], Sumito Kurata[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Graduate School of Information Science and Technology, The University of Tokyo)

[STT37-P06] Adjoint-based uncertainty quantification of frictional inhomogeneity on slow-slipping fault

*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1] (1.The University of Tokyo, 2.Tohoku University)

[STT37-P07] Sensor selection for seismic wavefield reconstruction based on sparse observation (Part II: Preliminary study on method based on data-driven low-dimensional model)

*Takayuki Nagata[1], Kumi Nakai[1], Yuji Saito[1], Taku Nonomura[1], Masayuki Kano[1], Shin-ichi Ito[2], Hiromichi Nagao[2] (1.Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.17 Zoom Room 17

[S-CG42] Frontier of Understanding Earth's Interior and Dynamics

convener:Hiroko Watanabe(Research Center for Neutrino Science, Tohoku University), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Chairperson:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology)

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

[SCG42-01] Study of the Earth’s interior with high energy neutrinos

★Invited Papers

*Carsten Rott[1,2] (1.University of Utah, 2.Sungkyunkwan University)

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

[SCG42-02] Exploring the deep biosphere-frontier beneath the ocean: A geobiological perspective on the oceanic crust and the underlying upper mantle

★Invited Papers

*Fumio Inagaki[1] (1.Mantle Drilling Promotion Office, Institute for Marine-Earth Exploration and Engineering (MarE3), Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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

[SCG42-03] **Reference models of Earth’s bulk structure and heterogeneity from full-spectrum tomography**

★Invited Papers

*Pritwiraj Moulik[1], Göran Ekström[2] (1.Department of Geology, University of Maryland, College Park, MD, USA, 2.Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA)

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

[SCG42-04] On the long-term evolution of the geomagnetic field: A link between geodynamics and planetary habitability

★Invited Papers

*Takashi Nakagawa[1,2] (1.Kobe University, 2.Hiroshima University)

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

[SCG42-05] **Mohole to Mantle *M2M*** Drilling Project and ***951*-Full Proposal**: Drilling Mature Oceanic Crust on North Arch Off-Hawaii

★Invited Papers

*Susumu Umino[1,2], Fumio Inagaki[2], Damon A H Teagle[3], Mikiya Yamashita[2,4], Gregory F Moore[5], Benoit Ildefonse[6], Steven D'Hondt[7], Laura Crispini[8], Takeshi Hanyu[2], Michael O Garcia[5], Tomoaki Morishita[1,2] (1.Kanazawa University, Japan, 2.JAMSTEC, Japan, 3.University of Southampton, UK, 4.Geological Survey of Japan, AIST, Japan, 5.University of Hawaii, USA, 6.University of Montellier & CNRS Best B, France, 7.University of Rhode Island, USA, 8.University of Genova, Italy)

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

[SCG42-06] Discussion

[E] Poster | S (Solid Earth Sciences)：S-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.15_1

[S-CG42] Frontier of Understanding Earth's Interior and Dynamics

convener:Hiroko Watanabe(Research Center for Neutrino Science, Tohoku University), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan)

[SCG42-P01] Model for anomalies in the Love wave dispersion

*Ranjith Kunnath[1] (1.Mahindra University)

[SCG42-P02] Study of Ocean Bottom Detector for observation of geo-neutrinos from mantle

★Invited Papers

*Taichi Sakai[1], Hiroko Watanabe[1], Kunio Inoue[1], William F McDonough[1,2,3], Kenta Ueki[4], Natsue Abe[4], Noriaki Sakurai[4], Masanori Kyo[4], Eiichiro Araki[4], Takafumi Kasaya[4], Hiroshi Yoshida[4] (1.Tohoku University,Research Center for Neutrino Science, 2.Tohoku University, 3.University of Maryland, 4.JAMSTEC)

[SCG42-P03] Understanding the Earth's Interior and Dynamics : Interdisciplinary Approach

*Hiroko Watanabe[1], Kunio Inoue[1], Taichi Sakai[1], William F McDonough[1,2,4], Natsue Abe[5], Eiichiro Araki[3], Takafumi Kasaya[3], Masanori Kyo[3], Noriaki Sakurai[3], Kenta Ueki[3], Hiroshi Yoshida[3], Tamano Omata[3,6], Yasuhiro Yamada[3] (1.Research Center for Neutrino Science, Tohoku University, 2.Department of Earth Science, Tohoku University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Department of Geology, University of Maryland, 5.Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology, 6.Tohoku University Museum)

[SCG42-P04] The origin of Indian Mantle inferred from Re-Os isotopes of chrome spinel

*Yoko Yamashita[1], Susumu Umino[1], Ryoko Senda[2] (1.Kanazawa Univ., 2.Kyushu Univ.)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.21 Zoom Room 21

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University), Chairperson:Akinori Hashima(Japan Agency for Marine-Earth Science and Technology), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University)

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

[SCG50-01] 3D numerical simulation of island arc deformation due to steady plate subduction: Effects of a bend along a trench axis

*Yutaro Mori[1], Yukitoshi Fukahata[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SCG50-02] Effect of the Philippine Sea slab–overriding plate contact on the stress field in the Southwest Japan arc

*Akinori Hashima[1], Takashi Iidaka[1] (1.Earthquake Research Institute, The University of Tokyo)

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

[SCG50-03] A Framework to Understand Deformation in Japanese Islands: Inter-arc Deformation and Intra-arc Deformation

*Yukitoshi Fukahata[1], Tomohisa Okazaki[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.RIKEN)

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

[SCG50-04] Visualization of crustal deformation in a high-strain shear zone by geodetic, geomorphologic, and geologic approaches

★Invited Papers

*Masakazu Niwa[1], Koji Shimada[1], Tsuyoshi Watanabe[1], Akira Goto[1], Shinya Hiratsuka[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency)

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

[SCG50-05] Deciphering 3-dimensional crustal movements before and after the 2011 Tohoku-oki earthquake using principal component analysis

Shuntaro Fukaya[2], *Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University, 2.Graduate School of Environmental Studies, Nagoya University)

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

[SCG50-06] Effects of a crustal heterogeneity in the postseismic deformation of 2008 Iwate-Miyagi Nairiku Earthquake

*Youichiro Takada[1], Yoshiki Takei[2], James Daniel Paul Moore[3], Mako Ohzono[4] (1.Faculty of Science, Hokkaido University, 2.Graduate School of Science, Hokkaido University, 3.Nanyang Technological University, Earth Observatory of Singapore, 4.Earthquake Research Institute, 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 | Ch.21 Zoom Room 21

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University), Chairperson:Katsushi Sato(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo)

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

[SCG50-07] The evolving structure and material of normal fault in Yonaguni Island, Okinawa prefecture, Japan

*Kiyokazu Oohashi[1], Haruya Miyaki[1], Makoto Otsubo[2] (1.Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 2.Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology)

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

[SCG50-08] Tectonic development in the Median Tectonic Line and surrounding regions during the Late Cretaceous to Paleogene periods: Spatiotemporal development

★Invited Papers

*Toru Takeshita[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University)

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

[SCG50-09] Relationship between the Northern Osaka Prefecture earthquake and the Arima-Takatsuki Tectonic Line estimated from dense aftershock observations

*Yoshihisa Iio[1], Satoshi Matsumoto[2], Joint aftershock observation group of the Northern Osaka Prefecture earthquake (1.Disater Prevention Research Institute, Kyoto University, 2.Institute of Seismology and Volcanoloty, Kyushu University)

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

[SCG50-10] Fracture as an electrical conduction path under pressure

*Tohru Watanabe[1], Arina Tomioka[2] (1.Faculty of Sustainable Design, University of Toyama, 2.Graduate school of science and engineering, University of Toyama)

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

[SCG50-11] Grain-boundary diffusion creep of olivine and the rheology of the oceanic upper mantle

★Invited Papers

*Kosuke Yabe[1], Takehiko Hiraga[1] (1.Earthquake Research Institute, the University of Tokyo)

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

[SCG50-12] An inversion method of fault-slip analysis to deteremine stress tensor and friction coefficient

*Katsushi Sato[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto 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 | Ch.21 Zoom Room 21

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University), Chairperson:Keisuke Yoshida(Tohoku University), Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University)

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

[SCG50-13] Spatio-temporal patterns of inland stress field: Characteristics revealed by a new method using focal mechanisms and interseismic plate coupling, and its tectonic implication

★Invited Papers

*Kazutoshi Imanishi[1], Akemi Noda[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Meteorological Research Institute)

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

[SCG50-14] **Effects of ETS on seismicity and stress in the subducting oceanic plate**

*Saeko Kita[1], Heidi Houston[2], Suguru Yabe[3], Sachiko Tanaka[4], Youichi Asano[4], Takuo Shibutani[5], Naoki Suda[6] (1.Building Research Institute, 2.University of California, 3.AIST, 4.NIED, 5.DPRI, Kyoto University, 6.Hiroshima University)

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

[SCG50-15] Prevailing updip ruptures in small interplate earthquakes along the Japan Trench revealed from land-based and offshore observations

*Keisuke Yoshida[1], Naoki Uchida[1], Hisahiko Kubo[2], Ryota Takagi[1], Shiqing Xu[3] (1.Tohoku University, 2.National Research Institute for Earth Science and Disaster Resilience, 3. Southern University of Science and Technology)

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

[SCG50-16] Spatiotemporal change in the inelastic strain rate due to aftershock activity of the 2016 Kumamoto earthquake sequence, in central Kyushu, Japan

*Ayaho Mitsuoka[1], Satoshi Matsumoto[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University)

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

[SCG50-17] **Toward understanding earthquake mechanism based on theories of strain energy**

★Invited Papers

*Tatsuhiko Saito[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SCG50-18] Reconsideration of the energy balance in earthquake faulting - I: The origin of the background stress field

*Mitsuhiro Matsuura[1] (1.Institute of Statistical Mathematics)

[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.15_2

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University)

[SCG50-P01] Seismic anisotropy of the dipping Pacific slab and adjacent mantle

*Dapeng Zhao[1], Zewei Wang[1] (1.Department of Geophysics, Tohoku University)

[SCG50-P02] Magnitude of east-west contraction forces acting to Japanese Islands since 3Ma estimated from altitude changes

*Ryohei Sasajima[1], Yukitoshi Fukahata[1] (1.Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

[SCG50-P03] Earthquake simulation based on Coulomb stress change on inland faults during megathrust earthquake cycles in southwest Japan

*Tsukasa MITOGAWA[1], Takuya NISHIMURA[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

[SCG50-P04] GNSS observation around the shear zone in southern Kyushu, southwest Japan (5)

*Tsuyoshi Watanabe[1], Koichi Asamori[1], Akiomi Shimada[1], Atsushi Saiga[1], Hiroki Ogawa[1], Umeda Koji[2], Akira Goto[1], Koji Shimada[1], Tsuneari Ishimaru[1] (1.Japan Atomic Energy Agency, 2.Graduate School of Science and Technology, Hirosaki University)

[SCG50-P05] Classification of faults using vertical gravity gradient data by machine learning

*Yuya Honda[1], Kohei Hotta[1] (1.University of Toyama)

[SCG50-P06] Hierarchical clustering of reduced stress tensors based on angular stress distance

*Noriaki Abe[1], Katsushi Sato[1] (1.Kyoto University)

[SCG50-P07] Characteristic of fault geometry and the subducting plate boundary in the focal area of the 2016 Mw7.8 Kaikoura earthquake, New Zealand inferred from high precision aftershock distribution

*Yuta Kawamura[1], Satoshi Matsumoto[1], Tomomi Okada[2], Miu Matsuno[2], Yoshihisa Iio[3], Tadashi Sato[2], Stephen Bannister[4], John Ristau[4], Martha Savage[5], Richard Sibson[6] (1.Kyushu University, 2.Tohoku University, 3.Kyoto University, 4.GNS Science, 5.Victoria University of Wellington, 6.University of Otago)

[SCG50-P08] Analysis of fault kinematics and internal structure of fracture zone at ISTL

*HIBIKI CHIBA[1], Kenta Kobayashi[1], Keita Takahashi[1] (1.Gradate School of Science and Technology Niigata University)

[SCG50-P09] Non-double-couple earthquake in the focal area of the 2000 Western Tottori earthquake by “0.1 manten” hyperdense seismic observation

*Takumi Motokoshi[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Shin'ichi Sakai[4], Aitaro Kato[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Earthquake Research Institute , the University of Tokyo)

[SCG50-P10] Transition from radial to parallel dike swarm in Amakusa, Japan and their paleostress analyses

*Kentaro Ushimaru[1], Atsushi Yamaji[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

[SCG50-P11] **Electrical conductivity in a brine-saturated granite under uni-axial compression**

*Yui Aikawa[1], Tohru Watanabe[1] (1.University of Toyama)

[SCG50-P12] Lithologic and thermal controls of seismicity in the northwestern Kii Peninsula, southern Honshu, Japan

*Sumire Maeda[1], Shinji Toda[2], Toru Matsuzawa[3], Makoto Otsubo[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

[SCG50-P13] On approximations of EASY%R_o model to estimate maximum experienced temperature from vitrinite reflectance in rocks

*Shunya Kaneki[1], Hiroyuki Noda[1] (1.Disaster Prevention Research Institute, Kyoto 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 | Ch.19 Zoom Room 19

[S-CG51] New perspectives of subduction zone earthquake dynamics through experiments across-scales

convener:Masataka Kinoshita(Earthquake Research Institute, University of Tokyo), Chairperson:Masataka Kinoshita(Earthquake Research Institute, University of Tokyo), Toshinori Kimura(Japan Agency for Marine-Earth Science and Technology)

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

[SCG51-01] Current status and future plan of deformation and fracture experiments at SPring-8/BL04B1

★Invited Papers

*Yuji Higo[1] (1.Japan Synchrotron Radiation Research Institute)

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

[SCG51-02] Ultrasonic elastic wave velocity measurement of antigorite at high pressures to 10 GPa

*Yoshio Kono[1], Riseno Nose[1], Nozomi Kondo[1], Ken-ichi Hirauchi[2] (1.Geodynamics Research Center, Ehime University, 2.Shizuoka University)

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

[SCG51-03] Depth-dependent frictional properties of mud gouge in the Nankai Trough accretionary prism

*Kyuichi Kanagawa[1], Tomohiro Ishii[2], Tomoya Funaki[2], Junya Fujimori[3], Michiyo Sawai[1] (1.Graduate School of Science, Chiba University, 2.Faculty of Science, Chiba University, 3.Graduate School of Science and Engineering, Chiba University)

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

[SCG51-04] Seafloor fiber optic strainmeter performance with different cable laying condition.

*Eiichiro Araki[1], Shuhei Nishida[1], Takashi Yokobiki[1], Matthew James Cook[1], Mark Zumberge[2], Toshinori Kimura[1], Yuya Machida[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.IGPP, Scripps Institution of Oceanography)

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

[SCG51-05] Real-time SSE monitoring by optical borehole tiltmeter in the Nankai Trough, Japan

*Toshinori Kimura[1], Eiichiro Araki[1], Takashi Yokobiki[1], Shuhei Nishida[1], Matthew J Cook[1], Mark Zumberge[2], Keisuke Takahashi[3], Takane Hori[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Scripps Institution of Oceanography, 3.UBE Industries, Ltd.)

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

[SCG51-06] **Thermal maturity observations depend on the structural history of the wedge**

*Utsav Mannu[1], David Fernández-Blanco[2], Ayumu Miyakawa[3], Taras Gerya[4], Masataka Kinoshita[5] (1.Indian Institute of Science Education and Research Pune, 2.Barcelona Center of Subsurface Imaging, Institut de Ciències del Mar (ICM-CSIC), Barcelona, 3.Geological Survey of Japan, AIST, 4.Institute of Geophysics, ETHZ Zurich, 5.Earthquake and Volcano Information, Earthquake Research Institute, Tokyo-U)

[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.12_3

[S-CG51] New perspectives of subduction zone earthquake dynamics through experiments across-scales

convener:Masataka Kinoshita(Earthquake Research Institute, University of Tokyo)

[SCG51-P01] For examining steady-state solution for pore pressure distribution in a plate-subduction zone incorporating fluid release by chemical reaction

*Shunya Kaneki[1], Hiroyuki Noda[1] (1.Disaster Prevention Research Institute, Kyoto University)

[SCG51-P02] A new method for large number of core sample CT scanning and preliminary results of Nankai Trough DSDP and ODP core samples

*Satoshi Tonai[1], Yusuke Kubo[2], Masataka Kinoshita[3], Keishi Okazaki[2] (1.Faculty of Science and Technology, Kochi University, 2.Kochi Institute for Core Sample Research, JAMSTEC, 3.Earthquake Research Institute, 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 | Ch.18 Zoom Room 18

[S-CG52] Driving Solid Earth Science through Machine Learning

convener:Hisahiko Kubo(National Research Institute for Earth Science and Disaster Resilience), Yuki Kodera(Meteorological Research Institute, Japan Meteorological Agency), Makoto Naoi(Kyoto University), Keisuke Yano(The Institute of Statistical Mathematics), Chairperson:Yuki Kodera(Meteorological Research Institute, Japan Meteorological Agency)

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

[SCG52-01] Crustal stress inferred from focal mechanism solutions based on P wave first-motion polarities picked using deep learning

*Takahiko Uchide[1], Takahiro Shiina[1], Kazutoshi Imanishi[1] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

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

[SCG52-02] Automatic seismic arrival-time picking of seismogram sampled at 250 Hz using Deep Learning

*Shinya Kato[1], Yoshihisa Iio[2], Hiroshi Katao[2], Masayo Sawada[2], Kazuhide Tomisaka[2], Rie Mizushima[2] (1.Graduate School of Science, Kyoto University., 2.Disater Prevention Research Institute, Kyoto University)

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

[SCG52-03] Deep-neural-network-based arrival-time picking and earthquake location: application to S-net

*Rintaroh Suzuki[1], Naoki Uchida[1], Weiqiang Zhu[2], Takashi NAKAYAMA[1], Genti Toyokuni[1], Ryota Takagi[1], Ryosuke Azuma[1], Gregory C Beroza[2] (1.Graduate School of Science, Tohoku University, 2.Department of Geophysics, Stanford University)

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

[SCG52-04] Induced Earthquakes Before and After Cessation of Longterm Injections in Rongchang Gas Field, Sichuan, China

*Zhiwei Wang[1], Xinglin Lei[2], Jinrong Su[3], Shengli Ma[1], Yusuke Mukuhira[4] (1.Institute of Geology, China Earthquake Administration, 2.Geological Survey of Japan, AIST, 3.Earthquake Monitoring Centre, Sichuan Earthquake Administration, 4.Institute of Fluid Science, Tohoku University)

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

[SCG52-05] **Site Generalization Performance of Ground Motion Models: Application of Monotonic Neural Networks**

*Tomohisa Okazaki[1], Nobuyuki Morikawa[2], Hiroyuki Fujiwara[2], Naonori Ueda[1] (1.RIKEN Center for Advanced Intelligence Project, 2.National Research Institute for Earth Science and Disaster Resilience)

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

[SCG52-06] Prediction of natural disasters based on a hybrid approach of physics-driven and data-driven method

★Invited Papers

*Takashi Miyamoto[1] (1.University of Yamanashi)

[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.14_3

[S-CG52] Driving Solid Earth Science through Machine Learning

convener:Hisahiko Kubo(National Research Institute for Earth Science and Disaster Resilience), Yuki Kodera(Meteorological Research Institute, Japan Meteorological Agency), Makoto Naoi(Kyoto University), Keisuke Yano(The Institute of Statistical Mathematics)

[SCG52-P01] Automatic hypocenter determination by deep learning for microseismic networks in geothermal areas

*Kyosuke Okamoto[1], Yusuke Mukuhira[2], Hiroshi Asanuma[1], Markus Häring[3] (1.National Institute of Advanced Industrial Science and Technology, 2.Tohoku University, 3.Häring GeoProject)

[SCG52-P02] Toward development of dense low cost citizen seismic network: Performance comparison of different types of neural network architectures

*Ahyi KIM[1], Hiroki Uematsu[1], Yuji Nakamura[1], Yuta Takahashi[1], Momoko Nakamura[1] (1.Yokohama City University)

[SCG52-P03] Unsupervised automatic classification of seismic records based on a hierarchical clustering

*Yuki Kodera[1], Shin'ichi Sakai[2] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Earthquake Research Institute, the University of Tokyo)

[SCG52-P04] Hierarchical cluster analysis of F-net moment-tensor-solution catalogue in Japan

*Hisahiko Kubo[1], Takeshi Kimura[1], Katsuhiko Shiomi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[E] Oral | B (Biogeosciences)：B-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.26 Zoom Room 26

[B-CG03] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Shingo Kato(RIKEN), Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Yohey Suzuki(Graduate School of Science, The University of Tokyo)

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

[BCG03-01] **Hunting mineral-centered life from deep rocky biosphere**

*Yohey Suzuki[1] (1.Graduate School of Science, The University of Tokyo)

9:15 AM - 9:37 AM JST | 12:15 AM - 12:37 AM UTC

[BCG03-02] Investigation of “Martian nitrogen cycle” and its evolution: The case of a young meteorite, Tissint

★Invited Papers

*Mizuho Koike[1], Ryoichi Nakada[2], Iori Kajitani[3,4], Haruna Sugahara[3], Tomohiro Usui[3] (1.Hiroshima Univ., 2.JAMSTEC, 3.JAXA, 4.Univ. Tokyo)

9:37 AM - 10:00 AM JST | 12:37 AM - 1:00 AM UTC

[BCG03-03] Metabolite analysis and machine learning-assisted discrimination of archaea and bacteria using minimally invasive single-cell Raman microspectroscopy

★Invited Papers

*Shinsuke Shigeto[1], Nanako Kanno[1], Shingo Kato[2], Motomu Matsui[3] (1.Kwansei Gakuin Univ., 2.RIKEN, 3.Univ. of Tokyo)

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

[BCG03-04] Ongoing archaeal methanogenesis in an organic- and iodine-rich deep aquifer: molecular evidence from coenzyme factor 430 and methane-specific radiocarbon measurements

*Atsushi Urai[1,2], Yoshinori Takano[1], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Shinshu University)

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

[BCG03-05] **Microbial community and its functions on methane metabolism in the wetland ecosystems**

*Wipoo Prasitwuttisak[1], Katsunori Yanagawa[1] (1.The University of Kitakyushu)

[E] Oral | B (Biogeosciences)：B-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.26 Zoom Room 26

[B-CG03] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Shingo Kato(RIKEN), Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Shingo Kato(RIKEN)

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

[BCG03-06] Microbial protein synthetic activities in deep underground granites revealed by meta-proteomic analysis

*Nao Masuda[1], Akito Ishikawa[2], Yohey Suzuki[2], Kazuyoshi Endo[2] (1.Department of Biological Sciences, Graduate School of Science, The University of Tokyo, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:00 AM - 11:22 AM JST | 2:00 AM - 2:22 AM UTC

[BCG03-07] Mineral-catalyzed hydrothermal CO_2 reduction that generated primordial autotrophic metabolisms

★Invited Papers

*Kensuke Igarashi[1] (1.National Institute of Advanced Industrial Science & Technology)

11:22 AM - 11:45 AM JST | 2:22 AM - 2:45 AM UTC

[BCG03-08] The unique metabolism of hyperthermophilic archaea

★Invited Papers

*Haruyuki Atomi[1] (1.Department of Synthetic Chemistry and Biological Chemistry, Graduate School of Engineering, Kyoto University)

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

[BCG03-09] Investigating Environmental Controls on Cyanobacterial Primary Productivity: Laboratory, Genomic, and Environmental Studies.

*Shawn E McGlynn[1], Lucia Gastoldi[2], Fatima Li Hau[1], Paula Prondzinsky[1], Lewis M Ward[1,3] (1.Tokyo Institute of Technology, 2.Università Politecnica delle Marche , 3.Harvard University)

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

[BCG03-10] New clues on the Atlantic eels spawning behavior and area: The Mid-Atlantic Ridge Hypothesis

*Yu-Lin Eda Chang[1], Eric Feunteun[2], Yasumasa Miyazawa[1], Katsumi Tsukamoto[3] (1.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan, 2.Museum National d'Histoire Naturelle, BOREA, Center of research on coastal ecosystems (CRESCO), France, 3.Department of Aquatic Bioscience, The University of Tokyo, Japan)

[E] Poster | B (Biogeosciences)：B-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.16_1

[B-CG03] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Shingo Kato(RIKEN), Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University)

[BCG03-P01] Desorption behavior of heavy metals from contaminated soils:A surface complexation modeling

*Natsumi Takeda[1], Keisuke Fukushi[2], Baasansuren Gankhurel[1], Akihiro Okuyama[1] (1.Kanazawa University, 2.Institute of Nature and Environmental Technology Kanazawa University)

[BCG03-P02] Formation conditions of calcium carbonate hemihydrate

*Suyama Mai[1], Keisuke Fukushi[2] (1.kanazawa University, 2.Institute of Nature and Environmental Technology Kanazawa University)

[BCG03-P03] **Recent development of seamless procedures on wet chemistry, cation-exchange chromatography and ion-pair chromatography with high-precision mass spectrometry for short-chain peptide molecules.**

*Yoshinori Takano[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

[BCG03-P04] New procedures to inactivate microorganisms for Martian life detection

*Mariko Kouduka[1], Yuri Sueoka[1], Yohey Suzuki[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan.)

[BCG03-P05] Oxidation and reduction of iron by a single *Rhodoferax* isolate at circumneutral pH

*Shingo Kato[1], Takashi Itoh[1], Moriya Ohkuma[1] (1.RIKEN)

[BCG03-P06] Physiological Response to the Extraordinary Iron Stress in the Unicellular Red Alga *Galdieria sulphuraria*

*Yukihiro Fukuta[1], Yuu Hirose[3], Ayumi Minoda[2] (1.University of Tsukuba, School of Life and Environmental Science, College of Biological Sciences, 2.Faculty of Life and Environmental sciences, University of Tsukuba, 3.Toyohashi University of Technology, Department of Applied Chemistry and Life Science)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.26 Zoom Room 26

[M-IS02] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Misato Fukagawa(National Astronomical Observatory of Japan), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science)

1:45 PM - 2:10 PM JST | 4:45 AM - 5:10 AM UTC

[MIS02-01] Organics in Extraterrestrial Samples

★Invited Papers

*Scott Alan Sandford[1] (1.NASA - Ames Research Center)

2:10 PM - 2:35 PM JST | 5:10 AM - 5:35 AM UTC

[MIS02-02] Astrochemistry and molecular composition in protoplanetary disks

★Invited Papers

*Shota Notsu[1] (1.Star and Planet Formation Laboratory, RIKEN Cluster for Pioneering Research)

2:35 PM - 3:00 PM JST | 5:35 AM - 6:00 AM UTC

[MIS02-03] Linking geochemistry to biochemistry: enzyme-mimetic catalysis

★Invited Papers

*LI Yamei[1] (1.Earth-Life science Institute, Tokyo Institute of Technology)

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

[MIS02-04] **Thioesters as primordial energy currency: kinetics, thermodynamics, their use by enzymes during evolution**

*Shawn E McGlynn[1,2], Liam M Longo[1,2], Sebastian A Sanden[1], Ruiqin Yi[1] (1.Tokyo Institute of Technology, 2.Blue Marble Space Institute of Science)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.26 Zoom Room 26

[M-IS02] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Misato Fukagawa(National Astronomical Observatory of Japan), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science)

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

[MIS02-05] Effects of borate on sugar phosphorylation in the evaporitic environment on early Earth.

*Yuta Hirakawa[1], Takeshi Kakegawa[1], Yoshihiro Furukawa[1] (1.Tohoku University)

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

[MIS02-06] Abiotic synthesis of metal-sulfur clusters containing iron and molybdenum and evaluation of their catalytic functions

*Shunjiro Sodei[1], Sebastian Adrian Sanden[1], Daisuke Ishikawa[1], Shawn E McGlynn[2], Masahiko Hara[1] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

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

[MIS02-07] The role of ferrous saponite in the formation of sulfur-bearing organic matter, carbon cycles, and climate on early Mars

*Natsumi Noda[1,2], Yasuhito Sekine[1], Yoshio Takahashi[2], Hiroshi Sakuma[3], Takahiro Kawai[2], Nakagawa Mayuko[1], Norio Kitadai[4], Kristin N Johnson-Finn[1], Shawn E McGlynn[1] (1.ELSI, Tokyo Tech., 2.Grad. School Sci., Univ. Tokyo, 3.National Institute for Materials Science, 4.Japan Agency for Marine-Earth Science and Technology)

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

[MIS02-08] Relationship among evolutions of continental crust, marine ecosystem, and atmosphere

*Yasuto Watanabe[1], Eiichi Tajika[1] (1.The University of Tokyo)

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

[MIS02-09] A mechanism for non-linear amplification of methane flux in the early Earth system with primitive biosphere

*Aika Akahori[1], Yasuto Watanabe[1], Eiichi Tajika[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

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

[MIS02-10] Space experiments on a terrestrial cyanobacterium, *Nostoc* sp.HK-01

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.17_1

[M-IS02] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute)

[MIS02-P01] Deep genetic link between banded iron formation and non-photoautotrophic microbial community on the early Earth

*Takeshi Kakegawa[1] (1.Graduate School of Science, Tohoku University)

[MIS02-P02] Possible roles of solar energetic particles in the formation of amino acids and their enantiomeric excesses in early Earth atmosphere

*Kensei Kobayashi[1], Koki Naito[1], Toshiki Sakamoto[1], Yoko Kebukawa[1], Jun-ichi Takahashi[1], Hiromi Shibata[2], Kenya Kubo[3], Hitoshi Fukuda[4], Yoshiyuki Oguri[4], Vladimir Airapetian[5] (1.Yokohama National University, 2.Osaka University, 3.International Christian University, 4.Tokyo Institute of Technology, 5.NASA Goddard Flight Center)

[MIS02-P03] Circular polarization induced by aligned dust grains at UV wavelength

*Hajime Fukushima[1], Hidenobu Yajima[1], Masayuki Umemura[1] (1.University of Tsukuba)

[MIS02-P04] Evaluation of cosmic ray from nearby supernova

*shintaro taira[1] (1.The Open University of Japan)

[MIS02-P05] Amino acid production by heating and gamma-ray irradiation experiments simulating aqueous alteration in small bodies

*Akari Ishikawa[1], Yoko Kebukawa[1], Isao Yoda[2], Kensei Kobayashi[1] (1.Yokohama National University, 2.Tokyo Institute of Technology)

[MIS02-P06] Abiotic synthesis of sugars by heating or gamma irradiation simulating aqueous alteration in meteorite parent bodies

*Shunpei Abe[1], Yoko Kebukawa[1], Isao Yoda[2], Kensei Kobayashi[1] (1.Yokohama National University, 2.Tokyo Institute of Technology)

[MIS02-P07] Track Image Clustering for Tanpopo Mission

*Yunosuke Miyamoto[1], Hirohide Demura[1], Hajime Yano[2,3], Kyoko Okudaira[1], Akihiko Yamagishi[2,4] (1.University of Aizu, 2.Japan Aerospace Exploration Agency, 3.Institute of Space and Astronautical Science, 4.Tokyo University of Pharmacy and Life Sciences)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.17 Zoom Room 17

[M-IS03] Developments and applications of XRF-core scanning techniques in natural archives

convener:Steven Jyh-Jaan Huang, Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), A Ludvig Lowemark(National Taiwan University), Chairperson:Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), Ludvig A Lowemark(National Taiwan University), Jyh-Jaan Steven Huang

3:30 PM - 3:31 PM JST | 6:30 AM - 6:31 AM UTC

[MIS03-01] Introduction

3:31 PM - 3:48 PM JST | 6:31 AM - 6:48 AM UTC

[MIS03-02] Paleoceanographic interpretation of environmental magnetic and XRF core scanning data from sediment cores in the Western Pacific Warm Pool

★Invited Papers

*Toshitsugu Yamazaki[1], Futoshi Nanayama[2], Kosuke Inoue[1], Kazuho Horiuchi[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Geological Survey of Japan, AIST, 3.Graduate School of Science and Technology, Hirosaki University)

3:48 PM - 4:05 PM JST | 6:48 AM - 7:05 AM UTC

[MIS03-03] Artificial intelligence for facies classification based on high-resolution data from sediments of the Wadden Sea,Germany

★Invited Papers

*An-Sheng Lee[1], Dirk Enters[2], Bernd Zolitschka[1], Sofia Ya Hsuan Liou[3] (1.University of Bremen, Institute of Geography, Bremen, Germany, 2.Lower Saxony Institute for Historical Coastal Research, Wilhelmshaven, Germany, 3.National Taiwan University, Department of Geosciences, Taipei, Taiwan)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MIS03-04] A new sample holder for XRF scanning of ion exchange resin samples

*Ludvig A Lowemark[1] (1.National Taiwan University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MIS03-05] Implication of a black fine thin layer in the sediment cores from Lake Tazawa, Akita Prefecture, Northeast Japan

*Yoko Ishiyama[1], Daizo Ishiyama[1], Takuya Ishiguro[1], Kazuyoshi Yamada[2], Masafumi MURAYAMA[3], Takeshi Hayashi[4], Yasumasa Ogawa[1] (1.Department of Earth Resource Engineering and Environmental Science, Graduate School of International Resource Sciences, Akita University, 2.Faculty of Human Sciences, School of Human Sciences, Waseda University, 3.Department of Marine Resource Sciences, Faculty of Agriculture and Marine Science, Kochi University, 4.Department of Regional Studies and Humanities, Faculty of Education and Human Studies, Akita University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MIS03-06] Corascope: Software assisted XRF scan merging

*GEORGE KONTSEVICH[1] (1.National Taiwan University)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[MIS03-07] Discussion

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.20_1

[M-IS03] Developments and applications of XRF-core scanning techniques in natural archives

convener:Steven Jyh-Jaan Huang, Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), A Ludvig Lowemark(National Taiwan University)

[MIS03-P01] Reconstruction of variations in South Pacific westerly jet path during the last glacial and calibration for the water content influence of ITRAX intensity

★Invited Papers

*Hitoshi Hasegawa[1], Fuyu Nagaya[1], Kana Nagashima[2], Nagayoshi Katsuta[3], Masafumi MURAYAMA[4], Naomi Harada[2] (1.Faculty of Science and Technology, Kochi University, 2.JAMSTEC, 3.Faculty of Education, Gifu University, 4.Faculty of Agriculture and Marine Science, Kochi University)

[MIS03-P02] Preliminary investigation on geochemical distribution of heavy metals in Uranouchi Inlet Bay sediments during the the Anthropocene Epoch

*Masafumi MURAYAMA[1], Wataru Tanikawa[2], Tatsuhiko Hoshino[2], Akira Ijiri[2], Takehiro Hirose[2], Kazuno Arai[3], Go-Ichiro Uramoto[3], Kondo Yasuo[4] (1.Faculty of Agriculture and Marine Science, Kochi University, 2. Institute for Extra-cutting-edge Science and Technology Avant-garde Research, Kochi Institute for Core Sample Research, JAMSTEC, 3.Center for Advanced Marine Core Research, Kochi University, 4.Faculty of Science and Technology, Kochi University)

[MIS03-P03] Marine environmental changes affected by anthropogenic impacts based on XRF core scanner results in Tokyo Bay

*Atsuko Amano[1], Naohisa Nishida[2], Seishiro Furuyama[3] (1.National institute of Advanced Industrial Science and Technology, 2.Tokyo Gakugei University, 3.Tokyo University of Marine Science and Technology)

[MIS03-P04] Late Holocene vegetation dynamics in the Yangmingshan National Park, northern Taiwan

*Liang-Chi Wang[1] (1.National Chung Cheng University)

[MIS03-P05] A comprehensive 3-steps workflow of evaluation, transformation, and recognition towards automatic XRF-core scanning data processing

*Jyh-Jaan Steven Huang[1], Arata Kioka[2], Christoph Daxer[1], Jasper Moernaut[1], Michael Strasser[1] (1.Institute of Geology, University of Innsbruck, Austria., 2.Department of Earth Resources Engineering, Kyushu University, Japan.)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.25 Zoom Room 25

[M-IS21] Chemosynthetic community and mud volcano: biology, geochemistry, and geophysics of fluid discharge

convener:Yusuke Miyajima(Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Kayama Hiromi WATANABE(Japan Agency for Marine-Earth Science and Technology), Akira Ijiri(Japan Agency for Marine-Earth Science and Technology), Tomohiro Toki(Faculty of Science, University of the Ryukyus), Chairperson:Yusuke Miyajima(Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Hiromi Kayama WATANABE(Japan Agency for Marine-Earth Science and Technology)

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

[MIS21-01] **Characteristic and Origin of erupted sediments in submarine mud volcanoes, off Tanegashima Island**

*Ryoma Setoguchi[1], Akira Ijiri[2], Takeyasu Yamagata[3], Hiroyuki Matsuzaki[3], Kyoko Hagino[1], Juichiro Ashi[4], Masafumi MURAYAMA[1] (1.Kochi University, 2.Japan Agency for Marine-Earth Science and Technology, 3.The University Museum, The University of Tokyo, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[MIS21-02] Methanogenesis in deep subseafloor sediments −living methanogen diversity, distribution, physiology and activity−

★Invited Papers

*Taiki Katayama[1], Hideyoshi Yoshioka[1], Masanori Kaneko[1], Susumu Sakata[1], Miki Amo[2], Tetsuya Fujii[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Japan Oil, Gas and Metals National Corporation)

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

[MIS21-03] Aerobic and anaerobic methanotrophs and their activity in methane-seep sediments of the northeastern Japan Sea offshore Sakata assessed by ^{13}C-labelling experiments

*Yusuke Miyajima[1], Hideyoshi Yoshioka[1], Tomo Aoyagi[2], Tomoyuki Hori[2], Hiroshi A Takahashi[3], Masahiro Suzumura[2] (1.Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Environmental Management Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Japan, 3.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Japan)

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

[MIS21-04] Could listening underwater sounds reveal the dynamics of chemosynthetic ecosystems?

★Invited Papers

*Tzu-Hao Lin[1], Chong Chen[2], Hiromi Kayama Watanabe[2], Shinsuke Kawagucci[2], Yung-Che Tseng[3] (1.Biodiversity Research Center, Academia Sinica, 2.X-STAR, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 3.Marine Research Station, Institute of Cellular and organismic Biology, Academia Sinica)

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

[MIS21-05] The minor-yet-crucial roles of gut microbiomes in a deep-sea hydrothermal vent snail

*Yi YANG[1,2], Jin SUN[1,3], Chong CHEN[4], Yadong ZHOU[5], Cindy Lee Van Dover[6], Chunsheng WANG[5,7], Jian-Wen QIU[2,8], Pei-Yuan QIAN[1,2] (1.Department of Ocean Science and Hong Kong Branch of the Southern Marine Science and Engineering Guangdong Laboratory (Guangzhou), The Hong Kong University of Science and Technology, Hong Kong, China, 2.Southern Marine Science and Engineering Guangdong Laboratory (Guangzhou), Guangzhou, China, 3.Institute of Evolution & Marine Biodiversity, Ocean University of China, Qingdao 266003, China, 4.X-STAR, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2-15 Natsushima-cho, Yokosuka, Kanagawa 237-0061, Japan, 5.Laboratory of Marine Ecosystem and Biogeochemistry, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China, 6.Division of Marine Science and Conservation, Nicholas School of the Environment, Duke University, Beaufort, NC, United States, 7.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China, 8.Department of Biology, Hong Kong Baptist University, Hong Kong, China)

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

[MIS21-06] Dual symbiosis in the deep-sea hydrothermal vent snail *Gigantopelta aegis* revealed by its hologenome

*Yi Lan[1], Jin Sun[1,2], Chong Chen[3], Jian-Wen Qiu[4], Pei-Yuan Qian[1] (1.Hong Kong University of Science and Technology, 2.Ocean University of China, 3.Japan Agency for Marine-Earth Science and Technology , 4.Hong Kong Baptist University)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.17_2

[M-IS21] Chemosynthetic community and mud volcano: biology, geochemistry, and geophysics of fluid discharge

convener:Yusuke Miyajima(Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Kayama Hiromi WATANABE(Japan Agency for Marine-Earth Science and Technology), Akira Ijiri(Japan Agency for Marine-Earth Science and Technology), Tomohiro Toki(Faculty of Science, University of the Ryukyus)

[MIS21-P01] Origin of noble gases in surface sediments from submarine mud volcanoes off Tanegashima

*Yuki Mitsutome[1], Tomohiro Toki[2], Takanori Kagoshima[3], Naoto Takahata[4], Yuji Sano[5], Yama Tomonaga[6] (1.University of the Ryukyus Graduate School of Science and Engineering, 2.Faculty of Science, University of the Ryukyus, 3.University of Toyama, 4.Atmosphere and Ocean Research Institute, the University of Tokyo, 5.Division Ocean and Earth Systems, Atmosphere and Ocean Research Institute, the University of Tokyo, 6.Eawag, Swiss Federal Institute of Aquatic Science and Technology)

[MIS21-P02] Subsurface structures and fluid transportation visualization by acoustic mapping in a shallow methane hydrate area off Sakata, eastern margin of the Sea of Japan

*Miho Asada[1], Mikio Satoh[1], Toshiyuki Yokota[1], Shusaku Goto[1] (1.NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST))

[MIS21-P03] Chemosynthesis, surface ruptures and possible methane eruption on the Kuroshima Knoll: a review from previous studies

*Takeshi Matsumoto[1] (1.Faculty of Science, University of the Ryukyus)

[MIS21-P04] Community composition and connectivity of hot vent endemic animals on the Izu-Bonin-Mariana Arc

*Hiromi Kayama WATANABE[1], Chong Chen[1], Shigeaki Kojima[2], Hiroyuki Yamamoto[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, the University of Tokyo)

[MIS21-P05] Population Genetic Structure and Gene Expression Plasticity of the Deep-Sea Vent and Seep Squat Lobster *Shinkaia crosnieri*

*Yao Xiao[1] (1.Hong Kong University of Science and Technology)

[MIS21-P06] A Decade to Study Deep-Sea Science

*Hiromi Kayama WATANABE[1], Kerry Howell[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.University of Plymouth)

[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 | Ch.09 Zoom Room 09

[M-GI29] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Chairperson:Shin ya Nakano(The Institute of Statistical Mathematics), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University)

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

[MGI29-01] A machine learning approach to the observation operator for satellite radiance data assimilation

*RIKEN Jianyu Liang[1], Koji Terasaki[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

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

[MGI29-02] Enhancement in Assimilation of Doppler Radar Radial Winds

★Invited Papers

*Tadashi Fujita[1], Hiromu Seko[1], Takuya Kawabata[1], Ken Sawada[1], Daisuke Hotta[1], Yasutaka Ikuta[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

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

[MGI29-03] **Optimizing the localization scale for a convective-scale ensemble radar data assimilation system**

★Invited Papers

*James David Taylor[1], Takumi Honda[1], Arata Amemiya[1], Takemasa Miyoshi[1] (1.RIKEN Research center for computational science)

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

[MGI29-04] Improving the Stability of the Local Particle Filter and Its Gaussian Mixture Extension: Experiments with an Intermediate AGCM

*Shunji Kotsuki[1,3], Ken Oishi[2], Takemasa Miyoshi[3] (1.Center for Environmental Remote Sensing, Chiba University, 2.Department of Information Engineering, Chiba University, 3.RIKEN Center for Computational Science)

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

[MGI29-05] Non-Gaussian measure in Gaussian filtering problems

*Tianfeng Hou[1,2,3], Hideyuki Sakamoto[1], Toshiki Teramura[4], Takemasa Miyoshi[1,2,3] (1.Data Assimilation Research Team, RIKEN Center for Computational Science, Kobe, Japan, 2.RIKEN Prediction Science Laboratory, Kobe, Japan, 3.RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program, Kobe, Japan, 4.Research Institute for Computational Science Co. Ltd, Tokyo, Japan)

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

[MGI29-06] Development of a coupled atmosphere-ocean data assimilation system in the Japan Meteorological Agency: evaluation and future plan

*Yosuke Fujii[1,2], Chiaki Kobayashi[1], Ichiro Ishikawa[1], Yuhei Takaya[1], Toshiyuki Ishibashi[1], takuma yoshida[3] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.The Institute of Statistical Mathematics, 3.Japan Meteorological Agency)

[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 | Ch.09 Zoom Room 09

[M-GI29] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Chairperson:Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN)

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

[MGI29-07] Inverse analysis of atmospheric CO_2 for elucidating seasonal and interannual variations of natural carbon fluxes

★Invited Papers

*Yosuke Niwa[1,2], Akihiko Ito[1], Yosuke Iida[3] (1.National Institute for Environmental Studies, 2.Meteorological Research Institute, 3.Japan Meteorological Agency)

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

[MGI29-08] Wave assimilation system of JMA and its improvement plan

★Invited Papers

*Nadao Kohno[1], Yosuke Fujii[1] (1.Meteorological Research Institute, JMA)

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

[MGI29-09] Improving the salinity structure by AOEI in an EnKF-based ocean data assimilation system

*Shun Ohishi[1], Tsutomu Hihara[2], Hidenori AIKI[3], Joji Ishizaka[3], Yasumasa Miyazawa[4], Misako Kachi[5], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science, 2.JAFIC, 3.Nagoya Univ., 4.JAMSTEC, 5.JAXA)

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

[MGI29-10] An iterative ensemble-based variational method with ensemble generation in random subspaces

*Shin ya Nakano[1,2] (1.The Institute of Statistical Mathematics, 2.Center for Data Assimilation Research and Applications, Joint-Support Center for Data Science Research)

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

[MGI29-11] **Feasibility study of the global MHD simulation code toward reanalysis of the space weather phenomena**

*Shigeru Fujita[1], Shin ya Nakano[2], Akira Kadokura[3], Yoshimasa Tanaka[3], Ryuho Kataoka[3], Aoi Nakamizo[4], Yasubumi Kubota[4], Keisuke Hosokawa[5], Satoko Saita[6] (1.Meteorological College, Japan Meteorological Agency/ National Institute of Polar Research, 2.The Institute of Statistical Mathematics, 3.National Institute of Polar Research, 4.National Institute of Information and Communications Technology, 5.The University of Electro-Communications, 6.National Institute of Technology, Kitakyushu College)

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

[MGI29-12] Data assimilation of electron radiation belts using the Arase high energy electron data

★Invited Papers

*Yoshizumi Miyoshi[1], Genta Ueno[2], Shinji Saito[3], Satoshi Kurita[4], Tomoaki Hori[1], Shun Imajo[1], Takefumi Mitani[5], Iku Shinohara[5], Takeshi Takashima[5], Nana Higashio[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.The Institute of Statistical Mathematics, 3.National Institute of Information and Communications Technology, 4.Research Institute for Sustainable Humanosphere, Kyoto University, 5.JAXA)

[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 | Ch.19_1

[M-GI29] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University)

[MGI29-P01] Local Particle Filter Experiments with Chaotic Cellular Automata

★Invited Papers

*Ken Furukawa[1], Hideyuki Sakamoto[1], Marimo Ohhigashi, Shin-ichiro Shima[2], Travis Sluka, Takemasa Miyoshi[1] (1.Institute of Physical and Chemical Research, 2.Graduate School of Simulation Studies, University of Hyogo)

[MGI29-P02] Improving Inflation and Resampling Methods To Stabilize Local Particle Filter

*Ken Oishi[1], Shunji Kotsuki[2,3] (1.Department of Information Engineering, Chiba University, Chiba, Japan, 2.Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3.RIKEN Center for Computational Science, Kobe, Japan)

[MGI29-P03] Local Ensemble Transform Kalman Filter Experiments with Hybrid Background Error Covariance

*Takaya Otaki[1], Shunji Kotsuki[2,3], Craig Bishop[4], Takemasa Miyoshi[3] (1.Department of Information Engineering, Chiba University, Chiba, Japan, 2.Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3. RIKEN Center for Computational Science, Kobe, Japan, 4. School of Earth Sciences, University of Melbourne, Melbourne, Australia)

[MGI29-P04] Toward assimilation of high-precision 3-D lightning location data for severe thunderstorm forecast

*Yasumitsu Maejima[1], Futo Tomizawa[2,1], Tomoo Ushio[3], Takemasa Miyoshi[1,4,5] (1.RIKEN Center for Computational Science, 2.Graduate School of Engineering, the University of Tokyo, 3.Graduate School of Engineering, Osaka University, 4.University of Maryland, College Park, 5.Japan Agency for Marine-Earth Science and Technology)

[E] 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 | Ch.03 Zoom Room 03

[M-GI31] Open and FAIR Science: Data Sharing, e-Infrastructure, Data Citation and Reproducibility

convener:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), 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), Chairperson:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Yasuhisa Kondo(Research Institute for Humanity and Nature)

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

[MGI31-01] Open Science and Open Data: Definitive Steps Institutions and Researchers Can Take to Make Research Output More Discoverable, Accessible, and Transparent.

*Shelley Stall[1] (1.American Geophysical Union)

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

[MGI31-02] Landscape of Community Development for Open Science and Data Sharing in Japan

*Yasuhiro Murayama[1], Takashi Watanabe[2], Toshihiko Iyemori[3], Yasuhisa Kondo[4] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology, 2.World Data System International Programme Office, 3.Kyoto University, 4.Research Institute for Humanity and Nature)

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

[MGI31-03] Data and metadata sharing among Antarctic science community

*Masaki Kanao[1] (1.National Institute of Polar Research)

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

[MGI31-04] **The connected sample - IGSN's contribution to making samples FAIR**

★Invited Papers

*Jens F Klump[1], Kerstin Lehnert[2], Lesley Wyborn[3], Sarah Ramdeen[2] (1.CSIRO Mineral Resources, 2.Lamont-Doherty Earth Observatory, Columbia University, 3.Australian National University)

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

[MGI31-05] Japanese efforts of archiving the primary samples for the promotion of the open science.

*Gaku Kimura[1] (1.Tokyo University of Marine Science and Technology)

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

[MGI31-06] A big data system in Deep-time Digital Earth Science Program

★Invited Papers

*Juanle Wang[1] (1.Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences)

[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 | Ch.03 Zoom Room 03

[M-GI31] Open and FAIR Science: Data Sharing, e-Infrastructure, Data Citation and Reproducibility

convener:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), 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), Chairperson:Shelley Stall(American Geophysical Union), Yasuhiro Murayama(NICT Knowldge Hub, National Institute of Information and Communications Technology)

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

[MGI31-07] A Rubric for Research Data Management in Earth and Space Science

*Toshihiko Iyemori[1], Janice Smith[2,1], Shoji Kajita[1], Masahito Nose[3] (1.Kyoto University, 2.Karuta Project, 3.Nagoya University)

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

[MGI31-08] **Improve data discovery and metadata interoperability via publishing structured data on the Web**

★Invited Papers

*Mingfang Wu[1], Leyla Jael Castro[2], Adam Shepherd[3] (1.Australian Research Data Commons, Australia, 2.ZB MED Information Centre for Life Sciences, Germany, 3.Woods Hole Oceanographic Institution, US)

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

[MGI31-09] Publishing FAIR Data for Solar System Radio Astronomy

*Baptiste Cecconi[1], Cyril Chauvin[1] (1.Observatoire de Paris, CNRS, PSL Research University)

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

[MGI31-10] NASA Planetary Data System and Data Object Identifiers (DOIs).

*Jordan Padams[1], Ann Raugh[2], Dan Crichton[1], Emily Law[1], Steve Hughes[1], R Joyner[1] (1.Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 2.University of Maryland)

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

[MGI31-11] Involving Citizen Scientists in Open-Science oriented Activity

*Takashi Watanabe[1] (1.National Institute of Information and Communications Technology)

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

[MGI31-12] **Lessons learned from interdisciplinary research between social and natural sciences**

*Yasuhisa Kondo[1] (1.Research Institute for Humanity and Nature)

[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 | Ch.18_1

[M-GI31] Open and FAIR Science: Data Sharing, e-Infrastructure, Data Citation and Reproducibility

convener:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), 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)

[MGI31-P01] Update of the Global Heat Flow Database led by International Heat Flow Commission

*Akiko Tanaka[1], Sven Fuchs[2], Graeme Beardsmore[3], Paolo Chiozzi[4], Orlando Miguel Espinoza-Ojeda[5], Gianluca Gola[6], Will Gosnold[7], Robert Harris[8], Sam Jennings[9], Shaowen Liu[10], Raquel Negrete-Aranda[11], Florian Neumann[11], Ben Norden[2], Jeffrey Poort[12], Dušan Rajver[13], Labani Ray[14], Maria Richards[15], Jared Smith[16], Massimo Verdoya[17]
(1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.GFZ German Research Centre for Geosciences, 3.School of Earth Sciences, University of Melbourne, 4.Department of Earth, Environment and Life Sciences, Università di Genova, 5.Instituto de Investigaciones en Ciencias de la Tierra, Universidad Michoacana de San Nicolás de Hidalgo, 6.Institute of Geosciences and Earth Resources, National Research Council of Italy, 7.Harold Hamm School of Geology and Geological Engineering, University of North Dakota, 8.College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 9.Mawson Geocenter, University of Adelaide, 10.School of Geography and Ocean Science, Nanjing University, 11.Laboratory of Tectonophysics and Heat Flow, Department of Geology, CICESE, 12.Institut des Sciences de la Terre de Paris (ISTeP), Sorbonne Université, 13.Geological Survey of Slovenia, 14.CSIR-National Geophysical Research Institute, 15.SMU Geothermal Laboratory, Huffington Department of Earth Sciences, 16.Department of Engineering Systems and Environment, University of Virginia, 17.Department of Earth, Environment and Life Sciences, University of Genoa)

[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 | Ch.18 Zoom Room 18

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Shin-ichi Ito(The University of Tokyo), Chairperson:Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology)

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

[MGI33-01] Data-driven low-dimensional model/sparse sensing of fluid dynamics and its application to seismic waves

★Invited Papers

*Taku Nonomura[1], Yuji Saito[1], Takayuki Nagata[1], Kumi Nakai[1], Keigo Yamada[1], Sayumi Kaneko[1] (1.Tohoku University)

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

[MGI33-02] Reclassification of oceanic intraplate basalts using trace element compositions of hotspots and petit-spots

*Yosuke Shimbo[1], Taku Yutani[1], Naoto Hirano[1] (1.Tohoku University)

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

[MGI33-03] Spatial distributions of source components for REY-rich mud based on independent component analysis on major- and trace-element composition

*Masahiro Hirako[1], Kazutaka Yasukawa[1,2], Erika Tanaka[1], Koichiro Fujinaga[2,1], Kentaro Nakamura[1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology)

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

[MGI33-04] Independent Component Analysis of bulk chemical compositions of submarine hydrothermal deposits in the Okinawa Trough

*Akito Aichi[1], Kazutaka Yasukawa[1,2], Tatsuo Nozaki[3,1,4,2], Yutaro Takaya[5,3,2], Mizuki Ishida[1], Erika Tanaka[1], Kentaro Nakamura[1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC, 4.Kobe University, 5.Waseda University)

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

[MGI33-05] Spatial resolution of Bayesian sensing

*Tatsu Kuwatani[1], Hideitsu Hino[2], Nagata Kenji[3], Takahiro Kawashima[4], mitsuhiro toriumi[1], Masato Okada[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.The Institute of Statistical Mathematics, 3.National Institute for Materials Science, 4.Graduate University for Advanced Studies, 5.The University of Tokyo)

[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 | Ch.18 Zoom Room 18

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Shin-ichi Ito(The University of Tokyo), Chairperson:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MGI33-06] Sedimentology as a science of reconstruction

★Invited Papers

*Hajime Naruse[1], Rimali Mitra[1], Zhirong Cai[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

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

[MGI33-07] Data-driven Analysis of Nonlinear Heterogeneous Reactions through Sparse Modeling and Bayesian Statistical Approaches

*Masaki Ito[1], Tatsu Kuwatani[2], Ryosuke Oyanagi[2], Toshiaki Omori[1] (1.Kobe University, 2.Japan Agency for Marine-Earth Science and Technology)

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

[MGI33-08] Development of a deep learning approach to estimate numerical simulation parameters of a hydrothermal system: Evaluation using a two-dimensional model

*Akihiro Shima[1], Kazuya Ishitsuka[1], Elvar Karl Bjarkason[2], Anna Suzuki[2], Weiren Lin[1] (1.Kyoto University, 2.Tohoku University)

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

[MGI33-09] Testing on Earthquake Prediction by Deep CNN-Labeling Model

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

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

[MGI33-10] Discussion

*Tatsu Kuwatani[1] (1.Japan Agency for Marine-Earth Science and Technology)

[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 | Ch.20_2

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Shin-ichi Ito(The University of Tokyo)

[MGI33-P01] Numerical modeling of mantle melting degree based on major element composition of melt

*Kenta Ueki[1], Satoru Haraguchi[2,1], Hikaru Iwamori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo)

[MGI33-P02] Bayesian modeling of the equation-of-state by integration of various data sets for liquid iron in Earth's outer core

*Taroujirou Matumura[1], Yasuhiro Kuwayama[2], Kenta Ueki[3], Tatsu Kuwatani[3], Ando Yasunobu[1], Kenji Nagata[4], Shin-ichi Ito[5], Hiromichi Nagao[5] (1.Research center for computational design of advanced functional materials, AIST, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology, 4.Research Center for Advanced Measurement and Characterization, National Institute for Materials Science (NIMS), 5.Earthquake Research Institute, The University of Tokyo)

[MGI33-P03] Superresolution of X-ray CT images of rock core samples and applications to serpentinite in the Oman ophiolite

*Shoui Suzuki[1], Atsushi Okamoto[2], Katsuyoshi Michibayashi[3], Toshiaki Omori[1] (1.Kobe University, 2.Tohoku University, 3.Nagoya University)

[J] 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 | Ch.03 Zoom Room 03

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Chairperson:Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Ken T. Murata(National Institute of Information and Communications Technology)

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

[MGI34-01] Development of snow detection techniques by using visual IoT

*Yuki MURAKAMI[1], Ken T. Murata[1], Shigeto Watanabe[2] (1.National Institute of Information and Communications Technology, 2.Hokkaido Information University)

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

[MGI34-02] Environment Monitoring Using a Technology of Visual Internet of Things

*Tsutomu Nagatsuma[1], Ken T. Murata[1], Junji Tokairin[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1], Takamichi Mizuhara[2] (1.National Institute of Information and Communications Technology, 2.CLEALINK TECHNOLOGY Co. Ltd.)

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

[MGI34-03] Release of three-dimensional geological map of central Tokyo

*Susumu Nonogaki[1], Tsutomu Nakazawa[1], Tomonori Naya[1], Junko Komatsubara[1], Yoshinori Miyachi[1], Masanori Ozaki[1], Toshio Nakayama[2] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Civil Engineering Support and Training Center, Tokyo Metropolitan Government)

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

[MGI34-04] Introduction of Ultra-large-scale Visualization Method for 3D Geographical Information Using a Web Browser-based Scalable Display System

Tomohiro Kawanabe[1], Kenji Ono[2], *Ken T. Murata[3], Atsushi Higuchi[4] (1.Institute of Physical and Chemical Research, 2.Kyushu University, 3.National Institute of Information and Communications Technology, 4.Chiba University)

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

[MGI34-05] Environmental Monitoring Experiment with the Sensor Network in Chikuma City

*Kohei Mizuani[1], Ken T. Murata[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1], Kazuya Muranaga[2], Takamichi Mizuhara[3] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants Co., LTD., 3.CLEALINKTECHNOLOGY Co.,Ltd.)

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

[MGI34-06] Data Quality Control and Data Disclosure of Phased Array Weather Radar

*Shinsuke Satoh[1], Fusako Isoda[1], Hiroshi HANADO[1], Katsuhiro Nakagawa[1], Susumu Uchino[2], Kohei Yamashita[2], Kazuya Muranaga[2] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants (SEC))

[J] 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 | Ch.03 Zoom Room 03

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Chairperson:Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University)

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

[MGI34-07] Efforts of Aizu Research Center for Space Informatics, Univ. of Aizu as a Joint Usage / Research Center

★Invited Papers

*Hirohide Demura[1] (1.The University of Aizu)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[MGI34-08] Development of a Data Analysis Environment for Small Irregular-Shaped Bodies Centered on a 3D-GIS

*Naru Hirata[1,2], Takuma Furudate[1], Hiroshi Kikuchi[3], Hirohide Demura[1,2], Hiroyuki Sato[3], Koji Matsumoto[4], Naoto Nakasato[1], Fumiya Kono[1] (1.Dep. of Computer Science and Engineering, Univ. of Aizu, 2.ARC-Space, Univ. of Aizu, 3.Japan Aerospace Exploration Agency, 4.RISE Project, National Astronomical Observatory of Japan)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[MGI34-09] Practice, Application and Future Potential of High-Capacity Space Data Processing

*Junya Terazono[1], Ken T. Murata[1], Tomohiro Sato[1], YASUKO KASAI[1] (1.National Institute of Information and Communication Technology)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[MGI34-10] **Construction of hot spring database over Japan for clarifying thermal and fluid flow structures in the upper crust**

*Jacek Scibek[1], Katsuaki Koike[1], Koki Kashiwaya[1] (1.Kyoto University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[MGI34-11] Detection of geothermal fluids paths in highly vegetated area through a vegetation stress index using hyperspectral satellite imagery

*Taiki Kubo[1], Hiroaki Gonnokami[1], Mohamad Nur Heriawan[2], Katsuaki Koike[1] (1.Graduate School of Engineering, Kyoto University, 2.Institut Teknologi Bandung)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

[MGI34-12] Discussion

[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 | Ch.18_2

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University)

[MGI34-P01] An attempt of local government disaster prevention WebGIS

*Ken T. Murata[1], Asanobu Kitamoto[2], Tomohiro Kawanabe[3], Keiichiro Fukazawa[4], Kazuya Muranaga[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1] (1.National Institute of Information and Communications Technology, 2.National Institute of Informatics, 3.Institute of Physical and Chemical Research, 4.Kyoto University)

[MGI34-P02] Development of interface for PTZ Camera to use image processing technique

*Yuki MURAKAMI[1], Ken T. Murata[1], Michiharu Niimi[2], Yoshihide Kagatani[3], Minehito Ageno[3], Kazunori Yamamoto[1], Tomohiro Kawanabe[4] (1.National Institute of Information and Communications Technology, 2.Kyushu Institute of Technology, 3.GEO Solutions Co.Ltd., 4.Institute of Physical and Chemical Research)

[MGI34-P03] Development of LPWA and visual IoT techniques (2)

Mehdad Shirazi[1], *Takamichi Mizuhara[1], Toshiki Aoki[1], Yuua Kagebayashi[1], Takeshi Murata[2], Kazunori Yamamoto[2], Kazuya Muranaga[3] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Systems Engineering Consultants Co.,LTD.)

[MGI34-P04] HpFP: development of high-speed data transfer applications (2)

Yasunori Kakizawa[1], Ayahiro Takaki[1], *Takamichi Mizuhara[1], Kazuya Muranaga[3], Kazunori Yamamoto[2], Takeshi Murata[2] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Systems Engineering Consultants Co.,LTD.)

[MGI34-P05] Programming Techniques for visual IoT on Raspberry Pi (4)

Toshiki Aoki[1], *Takamichi Mizuhara[1], Takeshi Murata[2], Kazunori Yamamoto[2], Kazuya Muranaga[3] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Systems Engineering Consultants Co.,LTD.)

[MGI34-P06] A large-scale distributed cloud system for research works on Earth and Planetary sciences

Kazunori Yamamoto[1], Kazuya Muranaga[2], *Ken T. Murata[1], Keiichiro Fukazawa[3], Atsushi Higuchi[4], Takeshi Nanri[5], Tomohiro Kawanabe[6], Yoshitaka Ohyoshi[7] (1.National Institute of Information and Communications Technology, 2.SEC, 3.Kyoto University, 4.Chiba University, 5.Kyushu University, 6.Institute of Physical and Chemical Research, 7.Virtual)

[MGI34-P07] Activity of preparing training data for study of space plasma with collaboration of observation, MHD simulation and machine leaning

*Keiichiro Fukazawa[1], Tomoki Kimura[2], Terumasa Tokunaga[3], Shin ya Nakano[4] (1.Academic Center for Computing and Media Studies, Kyoto University, 2.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 3.Department of Systems Design and Informatics, Faculty of Computer Science and Systems Engineering, Kyushu Institute of Technology, 4.Department of Statistical Modeling, Institute of Statistical Mathematics)

[MGI34-P08] Development of a multi-station airglow imaging system using commercial cameras

*Shin Suzuki[1] (1.Faculty of Regional Policy, Aichi University)

[MGI34-P09] Super-resolution and colorization of small body images by Generative Adversarial Network

Rintaro Kishi[1], Ren Hashimoto[1], *Rie Honda[1], Kimikazu Tanase[1], Yasuhiro Yokota[2], Seiji Sugita[3], Tomokatsu Morota[3], Shingo Kameda[4], Naoya Sakatani[4], Eri Tatsumi[5], Yuichiro Cho[3], Toru Kouyama[6], Manabu Yamada[7], Masahiko Hayakawa[2], Hidehiko Suzuki[8], Kazuo Yoshioka[3], Chikatoshi Honda[9], Kazunori Ogawa[2], Hirotaka Sawada[2] (1.Kochi University, 2.ISAS/JAXA, 3.Univ. of Tokyo, 4.Rikkyo Univ., 5.Instituto de Astrofisica de Canarias, Univ. of La Laguna, 6.AIST, 7.Chiba Inst. Tech, 8.Meiji Univ., 9.Univ. of Aizu)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.17 Zoom Room 17

[M-TT42] Frontiers in Geochemistry

convener:Tsuyoshi Iizuka(University of Tokyo), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Chairperson:Tsuyoshi Iizuka(University of Tokyo), Aya Sakaguchi(Faculty of Pure and Applied Science)

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

[MTT42-01] High energy resolution fluorescence XAFS for the speciation of trace elements in environment

Yamaguchi Akiko[1,4], Hikaru Miura[3], Makoto Nagasawa[1], *Yoshio Takahashi[1,2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Photon Factory, 3.CRIEPI, 4.JAEA)

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

[MTT42-02] **Quantifying denitrification rate across water-sediment interface in aquatic areas by using triple oxygen isotopes as tracers**

*FEI CUIXIA[1], Fumiko Nakagawa[1], Urumu Tsunogai[1], Masanori Ito[1], Hiroka Mizuno (1.Nagoya University)

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

[MTT42-03] High-precision measurement of ^{17}O-excess in phosphate in hydrosphere

*Takashi Sambuichi[1], Urumu Tsunogai[1], Fumiko Nakagawa[1], Masanori Ito[1] (1.Graduate School of Environmental Studies, Nagoya university)

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

[MTT42-04] Development of iron stable isotope measurement for biological tissue and its application to the marine organisms

*Nanako Hasegawa[1], TAKAAKI ITAI[1], Yoshio Takahashi[1], Tatsuya Kunisue[2], Shinsuke Tanabe[2] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.CMES, Ehime Univ.)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[MTT42-05] Interaction between Cerium and H_2O in Hydrous Rhyolitic Melts

★Invited Papers

*Nozomi Kondo[1], Yoshio Kono[1], Koji Ohara[2], Ryoichi Nakada[3], Toshiaki Ina[2], Etienne Skrzypek[4,7], Akihiro Yamada[5], Satoshi SAITO[6] (1.Geodynamics Research Center, Ehime University, 2.Center for Synchrotron Radiation Research, Japan Synchrotron Radiation Institute, 3.Kochi Institute for Core Sample Research, Japan Agency for Marin-Earth Science and Technology, 4.Graduate School of Science, Kyoto University, 5.Center of Glass Science and Technology, The University of Shiga Prefecture, 6.Department of Earth Science, Graduate School of Science and Engineering, Ehime University, 7.Institute of Earth Science, University of Graz)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.17 Zoom Room 17

[M-TT42] Frontiers in Geochemistry

convener:Tsuyoshi Iizuka(University of Tokyo), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Chairperson:Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

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

[MTT42-06] High resolution mass spectrometry analysis of alkaline copper oxide degradation products from insoluble organic matter in carbonaceous chondrite

*Miho Shigenaka[1], Tomoko Amimoto[1], Hikaru Yabuta[1] (1.Hiroshima University)

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

[MTT42-07] Analysis of single platinum nanoparticles using high-time resolution multiple collector ICP-MS (HTR-MC-ICP-MS) and application to cosmochemical samples

*Norika Numa[1], Shuji Yamashita[1], Takafumi Hirata[1] (1.School of science, The University of Tokyo)

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

[MTT42-08] **On-site Magnetic Separation of Heterogeneous Geological Particles**

*Chiaki Uyeda[1] (1.Institute of earth and Space Science Graduate School of Science Osaka University)

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

[MTT42-09] **Towards quantitative evaluation of the chondritic Earth model: A combined geo-neutrino, -physics, and -chemistry study**

*Tsuyoshi Iizuka[1], Nozomu Takeuchi[1], Kenta Ueki[2], Akiko Tanaka[3], Sanshiro Enomoto[4], Hiroko Watanabe[5], Satoru Haraguchi[1] (1.University of Tokyo, 2.JAMSTEC, 3.AIST, 4.University of Washington, 5.Tohoku University)

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

[MTT42-10] Element abundance modeling method with the gamma distribution for quantitative balance calculations

*Sanshiro Enomoto[1,2], Kenta Ueki[3], Tsuyoshi Iizuka[4], Nozomu Takeuchi[5], Akiko Tanaka[6], Hiroko Watanabe[7], Satoru Haraguchi[5] (1.Kavli Institute for the Physics and Mathematics of the Universe, University of Tokyo, 2.University of Washington, 3.Japan Agency for Marine-Earth Science and Technology, 4.University of Tokyo, 5.Earthquake Research Institute, University of Tokyo, 6.National Institute of Advanced Industrial Science and Technology, 7.Research Center for Neutrino Science, Tohoku University)

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

[MTT42-11] Prospects of Ocean Bottom Geoneutrino Detector for direct observation of mantle radioactive element distribution

*Kenta Ueki[1], Natsue Abe[1], Hiroko Watanabe[2], Kunio Inoue[2], Taichi Sakai[2], William F McDonough[2,3,4], Eiichiro Araki[1], Takafumi Kasaya[1], Kyo Masanori[1], Noriaki Sakurai[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Tohoku University Research Center for Neutrino Science, 3.Graduate School of Science, Tohoku University, 4.University of Maryland)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.20_3

[M-TT42] Frontiers in Geochemistry

convener:Tsuyoshi Iizuka(University of Tokyo), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University)

[MTT42-P01] High-precision La isotope measurements to apply early Solar System chronology and nuclear cosmochronology

*Mitsuru Suzuki[1], Tsuyoshi Iizuka[1], Kota Yamamoto[1], Takafumi Hirata[1] (1.The University of Tokyo)

[MTT42-P02] **Factors limiting the accuracy and precision of peak positions and intensity ratios in Raman spectra: Optimisation of optics and measurement environment for carbon isotope ratio measurements of CO_2**

*Yuuki Hagiwara[1], Junji Yamamoto[1] (1.Hokkaido University)

[MTT42-P03] Development and evaluation of wet-flow type isotope analyses for fluid-inclusions in speleothems

*Ryu Uemura[1] (1.Nagoya University)

[MTT42-P04] Sub-microgram sulfur isotope analysis for the biological, geological, and extraterrestrial samples by sensitivity-improved EA/IRMS

*Nanako O. Ogawa[1], Toshihiro Yoshimura[1], Takeru Kochi[2,1], Junichiro Kuroda[2,1], Yoshinori Takano[1], Naohiko Ohkouchi[1] (1.JAMSTEC, 2.AORI, Univ. Tokyo)

[J] Poster | M (Multidisciplinary and Interdisciplinary) : M-ZZ Others

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Ch.19_2

[M-ZZ46] Marine Manganese Deposits: Origin, Exploration, and Development

convener:Akira Usui(Marine Core Research Center, Kochi University), Katsuhiko Suzuki(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Takashi Ito(Faculty of Education, Ibaraki University)

[MZZ46-P01] Detrital minerals in hydrogenetic ferromanganese crusts as an alternative tool for archiving marine geological environments

*Akira Usui[1], Takashi Ito[2], Hirokuni Oda[3], Hitoshi Hasegawa[4] (1.Marine Core Research Center, Kochi University, 2.Ibaraki University, 3.AIST, 4.Kochi University)

[MZZ46-P02] Fluxes of sinking particles in the exploration area for cobalt-rich ferromanganese crusts in the Northwest Pacific

*Kyoko Yamaoka[1], Atsushi Suzuki[1], Yuichiro Tanaka[1], Masahiro Suzumura[2], Ayumi Tsukasaki[2], Tatsuo Fukuhara[3], Takeshi Fujii[3], Junpei Minatoya[4], Nobuyuki Okamoto[4], Yoshiaki Igarashi[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Environmental Management Research Institute, National Institute of Advanced Industrial Science and Technology, 3.KANSO Co., Ltd., 4.Japan Oil, Gas and Metals National Corporation)

[MZZ46-P03] Submarine erosion of basement sedimentary rocks around ferro-manganese crust fields

*Takashi Ito[1], Masaki Saito[1], Eri Shimizu[2], Takashi Miyazaki[3], Bogdan S. Vaglarov[3], Katsuhiko Suzuki[3], Akira Usui[4] (1.Faculty of Education, Ibaraki University, 2.JOGMEC, 3.JAMSTEC, 4.Center for Advanced Marine Core Research, Kochi University)

[MZZ46-P04] Local structure of rare earth elements in marine ferromanganese oxides by extended X-ray absorption fine structure analysis

*Makoto Nagasawa[1], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

[MZZ46-P05] Reconstruction of rotation by paleomagnetic analysis of manganese nodules collected in the South Pacific

*Wataru Katanoda[1,2], Hirokuni Oda[2], Masafumi MURAYAMA[3], Akira Usui[3] (1. Kochi university Graduate school of Integrated Arts and Science, 2.National Institute of Advanced Industrial Science and Technology, 3.Kochi university)

[MZZ46-P06] Lamina-scale analysis of chemical composition of the mid-Cretaceous northern Shimanto belt, Kochi, Japan: implications for formative processes of bedded ferromanganese deposits

*Go-Ichiro Uramoto[1], Takaumi Nagata[1], Yoshiro Nishio[1] (1.Kochi University)

[MZZ46-P07] Biodiversity and connectivity of deep-sea amphipods at seamounts with cobalt-rich ferromanganese crusts in the Northwest Pacific

*Akira Iguchi[1], Eri Ikeuchi[1], Hiroyuki Yokooka[2], Hideki Sugishima[2], Kazumasa Ikeda[3], Ryuichi Miwa[4], Miyuki Nishijima[1], Nozomu Iwasaki[5], Yuichiro Tanaka[1], Taiga Kunishima[6], Shogo Kato[7], Junpei Minatoya[7], Yoshiaki Igarashi[7], Nobuyuki Okamoto[7], Atsushi Suzuki[1] (1.National Institute of Advanced Industrial Science and Technology, 2.IDEA Consultants, Inc., 3.Okamoto Glass Co., Ltd., 4.Kaiyo Engineering Co., Ltd., 5.Faculty of Geo-Environmental Science, Rissho University, 6.Wakayama Prefectural Museum of Natural History, 7. Japan Oil, Gas and Metals National Corporation)

[E] Oral | EVENT : EVENT

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC | Ch.01 Zoom Room 01

[EV-11] Lunchtime Special Lecture

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC

[E-11-14] The Earth's coda correlation wavefield: Rise of the new paradigm and recent advances

[E] Oral | EVENT：EVENT

9:00 AM - 9:45 AM JST | 12:00 AM - 12:45 AM UTC | Ch.12 Zoom Room 12

[EV-12] Exhibitors' Seminar

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

[E-11-11] NASA Earth and Planetary Science

[J] Oral | EVENT：EVENT

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.16 Zoom Room 16

[EV-13] Exhibitors' Pop-Up

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

[E-11-15] Exhibitors' Pop-Up

[E] Oral | EVENT：EVENT

9:45 AM - 10:30 AM JST | 12:45 AM - 1:30 AM UTC | Ch.19 Zoom Room 19

[EV-14] Exhibitors' Seminar

9:45 AM - 10:30 AM JST | 12:45 AM - 1:30 AM UTC

[E-11-12] MATLAB for Analyzing and Visualizing Geospatial Data

[E] Oral | EVENT：EVENT

10:45 AM - 11:30 AM JST | 1:45 AM - 2:30 AM UTC | Ch.22 Zoom Room 22

[EV-15] Exhibitors' Seminar

10:45 AM - 11:30 AM JST | 1:45 AM - 2:30 AM UTC

[E-11-13] "Digital Petrology": How automation and digitalization is revolutionizing microscopy based petrographic studies

[E] Oral | U (Union)：Union

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.01 Zoom Room 01

[U-05] Special session for a borderless World of Geoscience (GEOethics)

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Brooks Hanson(American Geophysical Union), Takashi Furumura(Earthquake Research Institute The University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Brooks Hanson(American Geophysical Union), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Takashi Furumura(Earthquake Research Institute The University of Tokyo)

This symposium will present the viewpoint of leaders from the major geoscience societies (JpGU, AGU, EGU, AOGS and CGU), which are partner unions, who are also leading scientists representing exciting geoscience fields. The Earth and space science is essential the well-being of the humankind and sustainable environments. Some of the discussion topics will include: How shall we establish more reliance between Earth and planetary science and society ? A joint action plan/communique' is a desired outcome of this symposium.

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

[U05-01] The AGU GeoHealth and Thriving Earth Exchange Programs: Engaging our Geoscience Community for a Sustainable Future

★Invited Papers

Brooks Hanson[1], Janice Lachance[1], Mark Shimamoto[1], Raj Pandya[1], *Billy M Williams[1] (1.American Geophysical Union)

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

[U05-02] Climate science and social values

★Invited Papers

*Seita Emori[1] (1.National Institute for Environmental Studies)

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

[U05-03] Transdisciplinary research on geoscience in society

★Invited Papers

*Makoto Taniguchi[1] (1.Research Institute for Humanity and Nature)

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

[U05-04] How can we effectively utilize atmospheric forecasts that include uncertainties?

★Invited Papers

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

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

[U05-05] Geodiversity and its conservation as a framing guideline for Geoethics in the 21st Century

★Invited Papers

*Abhik Chakraborty[1] (1.Wakayama University)

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

[U05-06] Communicating uncertainty of geoscience for the disaster risk reduction -Geoscience, the ambiguous, and ourselves-

★Invited Papers

*Satoko Oki[1] (1.Faculty of Environment and information Studies)

The AGU GeoHealth and Thriving Earth Exchange Programs: Engaging our Geoscience Community for a Sustainable Future

Brooks Hanson[1], Janice Lachance[1], Mark Shimamoto[1], Raj Pandya[1], *Billy M Williams[1]

1. American Geophysical Union

The American Geophysical Union, a scientific society of more than 60,000 members worldwide, has undertaken important strategic initiatives to help address important GeoEthics related concerns and opportunities. AGU efforts such as its GeoHealth program and the Thriving Earth Exchange are two such critical initiatives designed to help promote GeoEthics-related needs, and specifically to help promote the well-being of humankind and sustainable environments. This presentation will discuss the progress, impacts and future opportunities in these two AGU programs, and other means to engage and promote Earth and space sciences and society.

Keywords: Health, Sustanability, Environment, GeoHealth, Thriving Earth Exchange, Community science

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Climate science and social values

*Seita Emori[1]

1. National Institute for Environmental Studies

The Future Earth, a currently operating international platform of sustainability science, calls for trans-disciplinarity, meaning co-designing and co-producing science with various non-academic stakeholders in the society. The need of trans-disciplinarity is justified from three perspectives: the logic of accountability, the logic of impact and the logic of humility (van der Hel, 2016). The logic of humility, which is often overlooked, essentially means that scientists should reflect on their own perceptions and values, which may be biased in various ways, and should appreciate diverse values of various stakeholders in the society.

For example, when we observe climate debates in the society, different opinions based on different values over risk perceptions of climate change or various mitigation options can be identified. The climate issue is inevitably value-laden and climate science cannot be free from values as well. Observational research might look relatively value free, but what to measure and where to measure, for example, already involve some kind of value judgment. Also, continuous measurement needs stable fund, which leads to a situation that research might be influenced by the values of funders.

Typologies and recommendations on how scientists behave in such value-laden research environment have been discussed by social scientists (e.g., Honest Broker, Pielke, 2003). Here I present the idea of Reflective Advocacy (Asayama et al., 2017), which is characterized by transparency, anticipation, reflection, deliberation and responsiveness.

Keywords: climate science, social values

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Transdisciplinary research on geoscience in society

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1. Research Institute for Humanity and Nature

Global environmental issues such as global warming, decrease of biodiversity, global nitrogen contamination are wicked problems with involvement of many stakeholders, wide difference of interests, and some degrees of scientific uncertainties. To solve these wicked problems, global research communities such as Future Earth realize the importance of co-design/co-production/co-delivery with stakeholders in society as transdisciplinary research. As co-design with stakeholders including governors, media, industry, and citizen, Japanese Strategic Research Agenda (JSRA) for global environmental issues had been made, and identified 108 agendas which are important not only for scientists but also for society. These 108 agendas are categorized into ten groups, and prioritization of JSRA has been made in terms of necessity of trasdisciplinary research and character of Japanese research. Recursive and mutual learning with stakeholders are important for science in society. This JSRA are used in some Japanese associations on geoscience under JpGU for making a decision of future research directions.

Keywords: transdiciplinary, wicked problem, co-design, Japan Strategic Research Agenda

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How can we effectively utilize atmospheric forecasts that include uncertainties?

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1. Research Center for Advanced Science and Technology, University of Tokyo

Today weather forecasts provide useful information for our daily life. The numerical weather forecast was one of the first applications of a computer invented more than 70 years ago. Since then, in addition to the rapid advance of computing resources, expansion of global satellite measurements and advance of data assimilation methods have contributed to the great improvement of the forecast skill. Today, operational centers offer not only daily weather forecasts but also weekly, monthly and seasonal forecasts, and a weather forecast system has thus become a fundamental infrastructure for the modern society.

The atmospheric circulation system is a highly nonlinear complex system with super high dimensions, and its behavior is therefore essentially chaotic. Thus, tiny observational errors in the initial field can gradually amplify, which will severely degrade the forecast skill within 10 days or so. For the extended or seasonal forecast the ensemble forecast method therefore becomes essential, where parallel forecasts are performed from a number of slightly different initial fields into which tiny errors have been introduced artificially. The ensemble forecast is therefore probabilistic, and inter-member forecast spread as a measure of uncertainties of the forecast offers quite useful information to the users. The ensemble method is now being introduced even into daily forecasts, which today have high prediction skill but are by no means perfect in a deterministic sense. Furthermore, production of reanalysis data by assimilating observational data accumulated until today into a state-of-the-art forecast system can reproduce the atmospheric state four-dimensionally over the last several decades and thus provide useful data for assessing predictability of extreme weather events in the past.

For the effective risk reduction in case of an imminent disaster by a typhoon/hurricane, torrential rainfall or a snow storm, not only further improvement of forecast skill but also appropriate information of forecast uncertainty is necessary. It should be noted that prediction of behavior of pollutants once emitted into the atmosphere by volcanic eruption or a nuclear plant accident is basically a matter of atmospheric forecast. So, it becomes necessary for the society to understand the meaning and significance of forecasts that always include a certain level of uncertainties for their effective utilization. For this purpose, it is inappropriate to regard a forecast as perfect information by ignoring its uncertainties. It is also absolutely inappropriate to dismiss any forecasts simply because they contain uncertainties. With observations alone one cannot foresee what will happen in the future. Effective combination between observations and forecasts is of essential significance.

Keywords: forecast error, weather forecast, nonlinear

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Geodiversity and its conservation as a framing guideline for Geoethics in the 21st Century

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1. Wakayama University

Geodiversity refers to the collective abiotic diversity of our planet. It is defined as the natural range (diversity) of geological and geomorphological features, including their assemblages, structures, and interactions that contribute to the heterogeneity of landscapes and sustain the evolution of life. However, geodiversity has been typically undervalued in existing sustainability literature as well as in conservation policy frameworks. This issue deserves urgent consideration because there is ample evidence of recent pervasive anthropogenic change of key surface processes of our planet, and this phenomenon of humans as earth-movers will leave indelible marks on the fossil record. It therefore becomes imperative to understand that the heterogeneity of abiotic landforms/processes and their integrity across geological time are fundamental factors underpinning all biodiversity and ecosystem services, and therefore are crucial for the sustenance of our civilization. This insight can be connected to the intrinsic value of geodiversity, which in turn should underpin any ethical framework for conserving the abiotic diversity of our planet. This paper posits the important argument for understanding, appreciating, and conserving the spatial and temporal integrity of geodiversity as the backbone for geoethics, and analyzes major challenges for conservation of dynamic earth processes through insights derived from natural heritage landscapes (such as UNESCO World Natural Heritage Sites and UNESCO Geoparks).

Keywords: Geodiversity, Abiotic nature, Intrinsic value, Geoethics, World Natural Heritage

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Communicating uncertainty of geoscience for the disaster risk reduction -Geoscience, the ambiguous, and ourselves-

*Satoko Oki[1]

1. Faculty of Environment and information Studies

In Japan, a large earthquake causing casualties occurs once every few years. The 2016 Kumamoto Earthquake, the 2018 Northern Osaka Earthquake, and the 2018 Eastern Iburi Earthquake occurred one after another, even after the 2011 Tohoku Earthquake caused more than 20,000 deaths and missing. In such a situation, geosciences are expected from society for disaster risk reduction, and geosciences have also tried to meet this expectation. For example, seismology has been making efforts to publish the National Seismic Hazard Maps announced by the government every year after the 1995 Kobe Earthquake.

Here I would like to report the results of a survey on how this information from geoscience is perceived by the public, taking the National Seismic Hazard Map as an example.
We calculate the probability of a certain place to be affected by a ground motion of seismic intensity 6 or more within the next 30 years, then color it from yellow to brown on the Japan map to overview the earthquake occurrence risk. We investigated how the public perceives this map (Nagamatsu et.al., 2017), and the results showed that people seeing the map had reduced their risk perception. Earthquakes will occur everywhere in Japan, and in fact, some of the damaging earthquakes have occurred in the low probability area. It is an ironic result that the map prepared by the government to encourage earthquake countermeasures reduce the public awareness of disaster prevention at least to those who live in areas with low probabilities.

When geoscience gives out useful information to society, it is always accompanied by uncertainty. To express this uncertainty, we introduce probability, but it does not seem to be a good communication to the public. How should we communicate uncertainty? I would like to introduce an activity called "disaster prevention novel" which is being conducted at a junior high school.

The "disaster prevention novel" was introduced into the Shimizu Junior High School in Kochi prefecture. It is the only junior high school in this city of Tosashimizu, which is facing the Pacific Ocean and told to face devastating tsunamis in the forthcoming Nankai-trough Earthquake. The "disaster prevention narratives" are written by the students provided the detailed date and time of the Nankai-trough Earthquake occurrence in about a month by the school teachers. The main characters are themselves, living in their actual neighborhood. Other characters are real people too. One important requirement is that the stories end with hope.

Let us review this "disaster prevention novel" in terms of communicating the uncertainty of an earthquake. The present earthquake science cannot accurately predict when an earthquake occurs. And, if "When" cannot be designated, the accompanied damage anticipation can also be ambiguous. For example, the degree of fire disaster depends on the time of the earthquake. The uncertainty of earthquake occurrence leads to the uncertainty of damage anticipation.

In the activity of "disaster prevention novel", the school designates the date and time of earthquake occurrence. Nobody thinks this is a true earthquake prediction. It is one of the educational considerations that one can think about his/her own evacuation behavior with the detailed occurrence time. In the

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novels, the way tsunamis inundate the town is depicted in different ways by students. Some students describe fires, and others write about landslides. The 90 students anticipate and express the damage in 90 ways. This expresses the uncertainty and ambiguity of the forthcoming Nankai-trough Earthquake.

In the following year, students wrote the "disaster prevention novel" in different seasons, different times, and different weather settings. This led students, parents, and locals to come up with various assumptions. The unavoidable uncertainties from geosciences can be expressed in this way without introducing probabilities.

Keywords: uncertainty, communication, risk

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[E] Oral | U (Union)：Union

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.01 Zoom Room 01

[U-05] Special session for a borderless World of Geoscience (GEOethics)

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Brooks Hanson(American Geophysical Union), Takashi Furumura(Earthquake Research Institute The University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Brooks Hanson(American Geophysical Union), Kiyoshi Suyehiro(Japan Agency for Marine-Earth Science and Technology), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo)

This symposium will present the viewpoint of leaders from the major geoscience societies (JpGU, AGU, EGU, AOGS and CGU), which are partner unions, who are also leading scientists representing exciting geoscience fields. The Earth and space science is essential the well-being of the humankind and sustainable environments. Some of the discussion topics will include: How shall we establish more reliance between Earth and planetary science and society ? A joint action plan/communique' is a desired outcome of this symposium.

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

[U05-07] Promoting equality, diversity and inclusion (EDI) in a global forum: benefits of joint borderless actions

★Invited Papers

*Claudia Jesus-Rydin[1], Helen Glaves (1.European Research Council)

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

[U05-08] The Key Role of Scientific Societies

★Invited Papers

*Brooks Hanson[1] (1.American Geophysical Union)

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

[U05-09] Promotion of Earth and Planetary Science by valuing diversity, equality, equity, and inclusion after CONVID-19

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

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

[U05-10] Discussion

Promoting equality, diversity and inclusion (EDI) in a global forum: benefits of joint borderless actions

*Claudia Jesus-Rydin[1], Helen Glaves

1. European Research Council

In the past years scientific societies working in geosciences have stimulated several initiatives to promote equality, diversity and inclusion (EDI). Although significant improvements have been achieved, there is still a lot to do before achieving a fully inclusive environment. Moreover, data shows that COVID pandemic increased inequalities and the future is uncertain in many ways. An essential ingredient is the coordination and synchronisation of our activities and the setting up of a global forum among us. As EDI movements are gaining momentum we must not miss this opportunity.

The goal is to strengthen relations, learn about on-going activities and priorities at our organisations. It is likely that we will identify common challenges and thus benefit from discussing together possible solutions –some of which may benefit from joint actions. Our communities (and ultimately our society) could only benefit from a global initiative jointly promoted by our organisations -- led by a positive and active attitude towards a more inclusive future.

This talk will address the importance of creating a joint EDI forum across partner organisations and benefits of joint borderless actions.

Keywords: Equality, Diversity, Inclusion

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The Key Role of Scientific Societies

*Brooks Hanson[1]

1. American Geophysical Union

Forming a borderless world of geoscience is critical for benefiting humanity and forming a vibrant sustainable future. Earth, environmental, and space science are critical for many societal challenges and for guiding decisions on these issues. AGU has recently developed a new strategic plan that includes recognition of the need for deeper engagement with society and the public for a sustainable future and expanded partnerships worldwide. We’ll discuss the implications for scientific societies and the broader scientific community and new responsibilities for societies in working with each other and global stakeholders.

Keywords: Scholarly societies

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Promotion of Earth and Planetary Science by valuing diversity, equality, equity, and inclusion after CONVID-19

*Hodaka Kawahata[1]

1. Atmosphere Ocean Research Institute, the University of Tokyo

We established code of Geoethics in Japan Geoscience Union in 2020. We recognize responsibility and promote fair research. We must not conduct unfair practices such as fabrication, falsification, plagiarism, or concealment/obstruction in research activities. We establish a healthy, sound and sustainable research environment, aiming for an ideal research society without harassment. We do active dissemination and reliable storage of research results in order to promote open science and open data. We disseminate correct knowledge and deep understanding of "Earth and Planetary Science" in order to transmit correct knowledge about earth science and natural disasters to societies. We construct a solid and continuous relationship between nature and science/human society and use specialized knowledge and technology and make much efforts to prevent natural disasters and preserve the global environment. Many problematic phenomena are accelerated by the effects of CONVID-19. 1) Globalization reaction, Blocking movement of people and goods: The movements of people and things are limited, production and consumption are stagnant, and scientific research in the field becomes impossible. 2) Racial disparity, Economic disparity (=Poverty), Obesity: Low income people cannot access health services. Race and income are the biggest drivers of the difference between the most and least affected areas of the New Corona. “Food Desert” is a super-absent area in a metropolis that produces obesity. 3) Fragile Western-style "liberal democracy: Is the strict curfew policy balanced with human rights? 4) Authoritarianism, Home country priority: However, we can overcome these negative sides by promoting diversity, equality, equity, & inclusion. They will be more promoted in research environments. 1) Active Dissemination of correct knowledge: Citizens are provided with sufficient information and knowledge so that they will be conscious of responding as much as possible. 2) Voluntary action: New technologies should be actively used and explored to enable citizens to make more judgments and exercise their power by themselves. 3) Open science & open data: International collaboration should be promoted based upon transparent international cooperation and multiculturalism. 4) Mutual trust and respect.

Keywords: Diversity, Equality, Equity , inclusion, Geoethics

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[E] Oral | U (Union) | Union

[U-05] Special session for a borderless World of Geoscience (GEOethics)

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Brooks Hanson(American Geophysical Union), Takashi Furumura(Earthquake Research Institute The University of Tokyo), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Brooks Hanson(American Geophysical Union), Kiyoshi Suyehiro(Japan Agency for Marine-Earth Science and Technology), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.01 (Zoom Room 01)

This symposium will present the viewpoint of leaders from the major geoscience societies (JpGU, AGU, EGU, AOGS and CGU), which are partner unions, who are also leading scientists representing exciting geoscience fields. The Earth and space science is essential the well-being of the humankind and sustainable environments. Some of the discussion topics will include: How shall we establish more reliance between Earth and planetary science and society ? A joint action plan/communique' is a desired outcome of this symposium.

11:30 AM - 12:15 PM

[U05-10]Discussion

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[J] Oral | U (Union)：Union

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.01 Zoom Room 01

[U-06] Science Council of Japan in one hour: How it supports international organizations

convener:Nobuko Saigusa(National Institute for Environmental Studies), Takuji Nakamura(National Institute of Polar Research), Shigeko Haruyama(Mie University .Emeritus Prof.), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Takuji Nakamura(National Institute of Polar Research), Nobuko Saigusa(National Institute for Environmental Studies)

The Science Council of Japan (SCJ) joins 46 international scientific organizations, including the International Science Council (ISC), as the representative organization of Japan for the promotion of science in cooperation with the global academic community. The SCJ supports 12 organizations in the field of earth and planetary sciences by providing financial contributions and dispatching representatives to the scientific steering committee, where long-term visions and research plans are discussed with the aim of pursuing the truth and realizing global sustainability. The SCJ also supports promotion of young scientists and international research exchanges. This session covers the 12 international organizations with the latest achievements and prospects in one hour and discusses the promotion of future international activities through the SCJ.

(*) in alphabetical order
Committee on Space Research (COSPAR); International Arctic Science Committee (IASC); International Cartographic Association (ICA); International Geographical Union (IGU); International Mineralogical Association (IMA); International Union for Quaternary Research (INQUA); International Union of Geodesy and Geophysics (IUGG); International Union of Geological Sciences (IUGS); Scientific Committee on Antarctic Research (SCAR); Scientific Committee on Oceanic Research (SCOR); Scientific Committee on Solar-Terrestial Physics (SCOSTEP); World Climate Research Programme (WCRP)

1:45 PM - 1:55 PM JST | 4:45 AM - 4:55 AM UTC

[U06-01] Introduction

1:55 PM - 2:00 PM JST | 4:55 AM - 5:00 AM UTC

[U06-02] Achievements and Prospects of the Committee on Space Research (COSPAR): Promoting International Activities through the Science Council of Japan (SCJ)

*Takuji Nakamura[1], Masaki Fujimoto[2], Akiko Nakamura[3], Hajime Yano[2] (1.National Institute of Polar Research, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Graduate School of Science, Kobe University)

2:00 PM - 2:05 PM JST | 5:00 AM - 5:05 AM UTC

[U06-03] Achievements and Prospects of the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP): Promoting International Activities through the Science Council of Japan (SCJ)

*Kazuo Shiokawa[1], Yoshizumi Miyoshi[1], Akimasa Yoshikawa[2], Takuji Nakamura[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.International Center for Space Weather Science and Education, Kyusyu University, 3.National Institute of Polar Research)

2:05 PM - 2:10 PM JST | 5:05 AM - 5:10 AM UTC

[U06-04] Achievements and Prospects of the Scientific Committee on Antarctic Research (SCAR): Promoting International Activities through the Science Council of Japan (SCJ)

*Takuji Nakamura[1,2], Satoshi Imura[1,2], Gen Hashida[1,2] (1.National Institute of Polar Research, 2.SOKENDAI, the Graduate University for Advanced Studies)

2:10 PM - 2:15 PM JST | 5:10 AM - 5:15 AM UTC

[U06-05] Achievements and Prospects of the International Arctic Science Committee (IASC): Promoting International Activities through the Science Council of Japan (SCJ)

*Hiroyuki Enomoto[1] (1.National Institute of Polar Research)

2:15 PM - 2:20 PM JST | 5:15 AM - 5:20 AM UTC

[U06-06] Elucidating mechanisms of the ocean and its variations and changes-Activities of the Scientific Committee on Oceanic Research (SCOR) and Japan's contribution-

*Yukio Masumoto[1], Naomi Harada[2] (1.Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

2:20 PM - 2:25 PM JST | 5:20 AM - 5:25 AM UTC

[U06-07] Achievements and Prospects of the World Climate Research Programme (WCRP): Promoting International Activities through the SCJ

*Nobuko Saigusa[1] (1.National Institute for Environmental Studies)

2:25 PM - 2:30 PM JST | 5:25 AM - 5:30 AM UTC

[U06-08] Achievements and Prospects of the International Cartographic Association (ICA): Promoting International Activities through the Science Council of Japan (SCJ)

*Kaori Ito[1], Takashi Morita[2] (1.Tokyo University of Science, 2.Hosei University)

2:30 PM - 2:35 PM JST | 5:30 AM - 5:35 AM UTC

[U06-09] Achievements and Prospects of the International Geographical Union (IGU): Promoting International Activities through the Science Council of Japan (SCJ)

*Yasuhiro Suzuki[1] (1.Nagoya University)

2:35 PM - 2:40 PM JST | 5:35 AM - 5:40 AM UTC

[U06-10] Activities of INQUA (International Union for Quaternary Research) and Contributions from Japan

*Yoshiki Saito[1] (1.Estuary Research Center, Shimane University)

2:40 PM - 2:45 PM JST | 5:40 AM - 5:45 AM UTC

[U06-11] Achievements and Prospects of the International Mineralogical Association (IMA): Promoting International Activities through the Science Council of Japan (SCJ)

*Eiji Ohtani[1] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

2:45 PM - 2:50 PM JST | 5:45 AM - 5:50 AM UTC

[U06-12] Activities and Roles of International Union of Geodesy and Geophysics (IUGG): Standardization of Earth Observation and Models

*Kenji Satake[1], Kumiko Goto-Azuma[2], Masato Furuya[3], Takuji Nakamura[2], Toshio Koike[4], Maki Tsujimura[5], Hisashi Nakamura[6], Toshiyuki Hibiya[7], Keiko Kuge[8], Setsuya Nakada[9] (1.Earthquake Research Institute, University of Tokyo, 2.National Institute of Polar Research & SOKENDAI, 3.Earth and Planetary Science, Hokkaido University, 4.ICHARM, Public Works Research Institute, 5.Faculty of Life and Environmental Sciences, University of Tsukuba, 6.RCAST, University of Tokyo, 7.Earth and Planetary Science, The University of Tokyo , 8.Dept. of Geophysics, Kyoto University, 9.National Research Institute for Earth Science and Disaster Resilience)

2:50 PM - 2:55 PM JST | 5:50 AM - 5:55 AM UTC

[U06-13] International Union of Geological Sciences: its activities and social contributions

*Hiroshi Kitazato[1], Hiroshi Nishi[2] (1.Tokyo University of Marine Science and Technology (TUMSAT), 2.Fukui Prefectural University, Institute of Dinosaur Research)

2:55 PM - 3:15 PM JST | 5:55 AM - 6:15 AM UTC

[U06-14] Discussion

[J] Oral | U (Union) | Union

[U-06] Science Council of Japan in one hour: How it supports international organizations

convener:Nobuko Saigusa(National Institute for Environmental Studies), Takuji Nakamura(National Institute of Polar Research), Shigeko Haruyama(Mie University .Emeritus Prof.), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Takuji Nakamura(National Institute of Polar Research), Nobuko Saigusa(National Institute for Environmental Studies)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.01 (Zoom Room 01)

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1:45 PM - 1:55 PM

[U06-01]Introduction

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Achievements and Prospects of the Committee on Space Research (COSPAR): Promoting International Activities through the Science Council of Japan (SCJ)

*Takuji Nakamura[1], Masaki Fujimoto[2], Akiko Nakamura[3], Hajime Yano[2]

1. National Institute of Polar Research, 2. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3. Graduate School of Science, Kobe University

The Commitee on Space Research (COSPAR) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan. The SCJ has sent Japanese representatives to the delegate meetings, the bureau meetings, and commission/panel business meetings to contribute to the promotion of science using space craft such as satellites, sounding rockets and balloons through discussing international standard, fostering young researchers, and supporting research exchanges.

The achievements and a prospects of the COSPAR will be introduced in a five-minute presentation. The session will be concluded by a discussion on the future promotion of international activities through the SCJ.

Keywords: SCJ, International Promotion, Antarctic Research

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Achievements and Prospects of the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP): Promoting International Activities through the Science Council of Japan (SCJ)

*Kazuo Shiokawa[1], Yoshizumi Miyoshi[1], Akimasa Yoshikawa[2], Takuji Nakamura[3]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. International Center for Space Weather Science and Education, Kyusyu University, 3. National Institute of Polar Research

The Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan. SCOSTEP is a thematic organization under the International Science Council (ISC). SCOSTEP runs international interdisciplinary scientific programs and promotes solar-terrestrial physics research by providing the necessary scientific framework for international collaboration and dissemination of the derived scientific knowledge in collaboration with other ISC bodies. Scientists participating in the activities of SCOSTEP have contributed to the development of a sustainable global society by dispatching representatives to science steering committees, planning international research programs, fostering young researchers, and supporting research exchanges. The achievements and a prospects of the SCOSTEP will be introduced in a five-minute presentation, and the session will conclude with a discussion on the future promotion of international activities through the SCJ.

Keywords: SCJ, International Promotion, SCOSTEP

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Achievements and Prospects of the Scientific Committee on Antarctic Research (SCAR): Promoting International Activities through the Science Council of Japan (SCJ)

*Takuji Nakamura[1,2], Satoshi Imura[1,2], Gen Hashida[1,2]

1. National Institute of Polar Research, 2. SOKENDAI, the Graduate University for Advanced Studies

The Scientific Commitee on Antarctic Research (WCRP) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan. The SCJ has sent Japanese representatives to the delegate meetings and science group business meetings to help planning international research programs, fostering young researchers, and supporting research exchanges. The achievements and prospects of the SCAR includes the contribution to the knowledge on the future of mankind, through the international scientific research in the Antarctic region, and on the role of the Antarctic region in the Earth system.

The presentation introduces the SCAR in five minutes. The session will be concluded by a discussion on the future promotion of international activities through the SCJ.

Keywords: Antarctic Research, Science Council of Japan, International Promotion

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Achievements and Prospects of the International Arctic Science Committee (IASC): Promoting International Activities through the Science Council of Japan (SCJ)

*Hiroyuki Enomoto[1]

1. National Institute of Polar Research

The International Arctic Scientific Committee (IASC) is one of the international academic societies to which the Science Council of Japan is a member. So far, representatives of Japan have been dispatched to scientific management conferences, etc. to discuss scientific issues in the Arctic, propose research implementation through international cooperation, train young researchers, collaborate with indigenous people, and respond to social demands. Has contributed to the pursuit of science and the efforts of sustainable Arctic society and international cooperation. In this talk, we will introduce the recent activities of the International Accounting Standards Committee (IASC) on the rapidly changing environment and social changes in the Arctic. In the general discussion at the end of the session, we will discuss the promotion of future international activities through the Science Council of Japan (SCJ).

Keywords: SCJ, International Promotion, IASC



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Elucidating mechanisms of the ocean and its variations and changes-Activities of the Scientific Committee on Oceanic Research (SCOR) and Japan's contribution-

*Yukio Masumoto[1], Naomi Harada[2]

1. Graduate School of Science, The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology

The Scientific Committee on Oceanic Research (SCOR) has been working under the International Council of Scientific Unions (ICSU; the current ISC) since its establishment in 1957 to promote the development of all the desciplines in ocean science through international cooperation. Until September 2005, the Ocean Science Research Liaison Committee of the Science Council of Japan made a strong commitment to SCOR activities as the national representative in Japan. The SCOR small committee of the International Response Subcommittee (the 20th term) and the Subcommittee for SCOR (from the 21st term on) under the Committee on Earth and Planetary Science took over this important role. The aims of the Subcommittee for SCOR is to embody the international response in line with the philosophy of the new Science Council of Japan so that related academic societies and researchers in Japan can contribute globaly to the promotion of ocean science and the development of human society through the activities of SCOR. In this session, we will introduce SCOR's activities and achievements, as well as future prospects. In the general discussion at the end of the session, we will discuss the promotion of future international activities through the Science Council.

Keywords: SCJ, International Promotion, SCOR

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Achievements and Prospects of the World Climate Research Programme (WCRP): Promoting International Activities through the SCJ

*Nobuko Saigusa[1]

1. National Institute for Environmental Studies

The World Climate Research Programme (WCRP) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan. Scientists participating in the activities of WCRP have contributed to the development of climate science and a sustainable global society by dispatching representatives to science steering committees, planning international research programs, fostering young researchers, and supporting research exchanges. The achievements and a prospects of the WCRP will be introduced in a five-minute presentation, and the session will conclude with a discussion on the future promotion of international activities through the SCJ.

Keywords: SCJ, International Promotion, WCRP

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Achievements and Prospects of the International Cartographic Association (ICA): Promoting International Activities through the Science Council of Japan (SCJ)

*Kaori Ito[1], Takashi Morita[2]

1. Tokyo University of Science, 2. Hosei University

The International Cartographic Association (ICA) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan. ICA has a mission to promote the disciplines and professions of cartography and GIScience in an international context, and has co-published a book “Mapping for a Sustainpable World” with the United Nations. Scientists and professionals participating in the activities of ICA have dispatched representatives to general assemblies and international conferences, proposed and managed new committees, fostered young researchers, and supported research exchanges. They also successfully hosted the 29th International Cartographic Conference in Tokyo in 2019. The achievements and a prospects of the ICA will be introduced in a five-minute presentation, and the session will conclude with a discussion on the future promotion of international activities through the SCJ.

Keywords: SCJ, International Promotion, ICA

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Achievements and Prospects of the International Geographical Union (IGU): Promoting International Activities through the Science Council of Japan (SCJ)

*Yasuhiro Suzuki[1]

1. Nagoya University

The International Geographical Union (IGU) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan, and one of the GeoUnions in the International Science Council (ISC). Scientists participating in the activities of IGU have contributed to the development of a sustainable global society by dispatching representatives to science steering committees, planning international research programs, fostering young researchers, and supporting research exchanges. The achievements and a prospects of the IGU will be introduced in a five-minute presentation.

The IGU homepage states as follows. https://igu-online.org/

About IGU:
The International Geographical Union (IGU) is an international, non-governmental, professional organization devoted to the development of the discipline of Geography. The purposes of the IGU are primarily to promote Geography through initiating and coordinating geographical research and teaching in all countries of the world. Its work is conducted through the instruments of its National Committees, Commissions and Task Forces. The IGU hosts the International Geographical Congress every four years and also promotes regional conferences and other meetings that further of the objectives of the Union. The IGU also facilitates the participation of geographers in the global community of scientists through its formal affiliation as a Member Union within the International Science Council (ISC) and the International Council for Philosophy and the Human Sciences (CIPSH)

History of the IGU:
The IGU was formally established in Brussels in 1922. However, the history of international meetings of geographers is much longer. The first of a series of congresses met in 1871 in Antwerp. Since its early days the Union has consisted of three major components: General Assembly of the delegates appointed by the member countries which meets at the time of the Congress and is the highest authority of the Union; an Executive Committee which consists of a President, eight Vice-Presidents and a Secretary-General and Treasurer; Commissions and Study Groups which continue their work between General Assembly meetings. The working languages of the Union are English and French.

Keywords: SCJ, International Promotion, IGU

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Activities of INQUA (International Union for Quaternary Research) and Contributions from Japan

*Yoshiki Saito[1]

1. Estuary Research Center, Shimane University

INQUA (International Union for Quaternary Research) was established in 1928 by a group of scientists seeking to improve understanding of environmental change during the glacial ages through interdisciplinary research. Currently, INQUA is the representative body for Quaternary science world-wide. The basic goal of INQUA is to promote improved communication and international collaboration in basic and applied aspects of Quaternary research. An in-depth knowledge of global developments during the past 2.58 million years (the Quaternary geological period) provides the essential template for assessing the significance of current and predicted global environmental changes and natural disasters. INQUA's goal is achieved mainly through the activities of the five Commissions: CMP: Coastal & Marine Processes, HABCOM: Humans & Biosphere, PALCOM: Paleoclimates, SACCOM: Stratigraphy & Chronology, TERPRO: Terrestrial Processes, Deposits & History. INQUA also encourages Early Career Research (ECR) activities, which provide an information gateway between young (early-career) and the senior scientists and scientific networks. INQUA supports projects contributing to the development of Quaternary science worldwide through Commissions and ECR activities. INQUA Congress is held every four years. The next Congress will be held in Rome in 2023.
Japan National Committee for INQUA was established in 1955, under the Science Council of Japan. The representative from Japan participated in INQUA Congress since 1957. Japan has been contributing key members to Executive Committee and Commissions since then. The 19th INQUA Congress was successfully held in Nagoya in 2015, hosted by the Science Council of Japan, with 1789 participants from 68 countries. One of most prominent achievements from Japan to INQUA and Quaternary science is the Middle Pleistocene "Chibanian" of GSSPs, resulting from long-lasting Quaternary research in Japan for the last several decades.

Keywords: INQUA, Chibanian, Anthropocene, Global Change

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Achievements and Prospects of the International Mineralogical Association (IMA): Promoting International Activities through the Science Council of Japan (SCJ)

*Eiji Ohtani[1]

1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University

The International Mineralogical Association (IMA) is one of the international scientific organizations that the Science Council of Japan (SCJ) has joined on behalf of Japan. IMA contributed to naming and classification of newly discovered minerals, advance in mineralogical sciences such as environmental and resource mineralogy for a sustainable global society, planning international research collaborations, fostering young researchers, and supporting research exchanges. SCJ contributed to the activity of IMA by dispatching representatives to science steering committees. Achievements and prospects of IMA will be introduced in a five-minute presentation, and the session will conclude with discussions on the future promotion of international activities through the SCJ.

Keywords: SCJ, International Promotion, IMA

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Activities and Roles of International Union of Geodesy and Geophysics (IUGG): Standardization of Earth Observation and Models

*Kenji Satake[1], Kumiko Goto-Azuma[2], Masato Furuya[3], Takuji Nakamura[2], Toshio Koike[4], Maki Tsujimura[5], Hisashi Nakamura[6], Toshiyuki Hibiya[7], Keiko Kuge[8], Setsuya Nakada[9]

1. Earthquake Research Institute, University of Tokyo, 2. National Institute of Polar Research & SOKENDAI, 3. Earth and Planetary Science, Hokkaido University, 4. ICHARM, Public Works Research Institute, 5. Faculty of Life and Environmental Sciences, University of Tsukuba, 6. RCAST, University of Tokyo, 7. Earth and Planetary Science, The University of Tokyo , 8. Dept. of Geophysics, Kyoto University, 9. National Research Institute for Earth Science and Disaster Resilience

IUGG (International Union of Geodesy and Geophysics) is one of the 40 scientific unions that belong to International Science Council. Currently, IUGG has 73 member countries. IUGG consists of eight International Associations. They are

International Association of Cryospheric Sciences (IACS)

International Association of Geodesy (IAG)

International Association of Geomagnetism and Aeronomy (IAGA)

International Association of Hydrological Sciences (IAHS)

International Association of Meteorology and Atmospheric Sciences (IAMAS)

International Association for the Physical Sciences of the Oceans (IAPSO)

International Association of Seismology and Physics of the Earth's Interior (IASPEI)

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI)

IUGG was established in 1919 as one of the four scientific unions under International Research Council, together with Astronomical Union, Mathematical Union, and Chemical Union. The first nine member countries of IUGG were Australia, Belgium, Canada, France, Italy, Japan, Portugal, the United Kingdom, and the United States. The most famous and productive scientific program that IUGG led may be the International Geophysical Year (1957-8). During the cold war period, international collaborations were made under IGY, including launching Soviet Union's Sputnik 1 and USA’s Explorer 1. Japan established Showa station and started scientific measurements in Antarctica.

IUGG leads international collaboration in studies of snow and ice, geodesy, geomagnetism and aeronomy, hydrology, meteorology, physical oceanography, seismology and volcanology, through the above eight International associations. These associations proposed standard models for earth’s shape, geomagnetic field, or global climate. They are essential for everyday life such as location by using GPS signal, or weather forecast. The international collaborations are also made for global issues such as climate change,

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global warming or water issues, or natural hazards such as earthquakes or volcanic eruptions.

In Japan, the Science Council of Japan (SCJ) is the adhering organization for IUGG, and the IUGG committee and eight subcommittees for each association of SCJ serve as national committees for the IUGG and each International Association, and work as liaison with national scientific societies. Japan also sends many officers of IUGG and International Associations and contributes their managements.

Keywords: IUGG, SCJ, International Coordination

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International Union of Geological Sciences: its activities and social contributions

*Hiroshi Kitazato[1], Hiroshi Nishi[2]

1. Tokyo University of Marine Science and Technology (TUMSAT), 2. Fukui Prefectural University, Institute of Dinosaur Research

International Union of Geological Sciences is the NGO of US Department of Treasury. The union was established on 1961 at Paris for promotion and development of geological sciences. We not only promote top level geological sciences, but also standardization of time scales of the history of the Earth. We also contribute to our society with various ways such as forenthic geology and give chances to younger generations through workshops or field courses.

Keywords: Geological Sciences, Problems of the Earth, Promotion of Sciences

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[J] Oral | U (Union) | Union

[U-06] Science Council of Japan in one hour: How it supports international organizations

convener:Nobuko Saigusa(National Institute for Environmental Studies), Takuji Nakamura(National Institute of Polar Research), Shigeko Haruyama(Mie University .Emeritus Prof.), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Takuji Nakamura(National Institute of Polar Research), Nobuko Saigusa(National Institute for Environmental Studies)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.01 (Zoom Room 01)

The Science Council of Japan (SCJ) joins 46 international scientific organizations, including the International Science Council (ISC), as the representative organization of Japan for the promotion of science in cooperation with the global academic community. The SCJ supports 12 organizations in the field of earth and planetary sciences by providing financial contributions and dispatching representatives to the scientific steering committee, where long-term visions and research plans are discussed with the aim of pursuing the truth and realizing global sustainability. The SCJ also supports promotion of young scientists and international research exchanges. This session covers the 12 international organizations with the latest achievements and prospects in one hour and discusses the promotion of future international activities through the SCJ.

(*) in alphabetical order
Committee on Space Research (COSPAR); International Arctic Science Committee (IASC); International Cartographic Association (ICA); International Geographical Union (IGU); International Mineralogical Association (IMA); International Union for Quaternary Research (INQUA); International Union of Geodesy and Geophysics (IUGG); International Union of Geological Sciences (IUGS); Scientific Committee on Antarctic Research (SCAR); Scientific Committee on Oceanic Research (SCOR); Scientific Committee on Solar-Terrestial Physics (SCOSTEP); World Climate Research Programme (WCRP)

2:55 PM - 3:15 PM

[U06-14]Discussion

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[J] Oral | U (Union)：Union

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.01 Zoom Room 01

[U-07] Open Science and Open Data in Academic Publishing from Japan

convener:Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo),
Chairperson:Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo)

Scientific products including journal publications, reports and data are invaluable resour
ces for human beings. These days, open science, open data, and FAIR data policies are
becoming more and more important for sustainable society and research development
s. In the proposed session, we invite presenters representative of academic journal publications from Japanese societies and institutions as well as key organizations.

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

[U07-01] Advanced publication of scientific journals by JpGU and the related academic societies

★Invited Papers

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

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

[U07-02] Current status and issues of PEPS journal

★Invited Papers

*Eiji Ohtani[1] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

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

[U07-03] ”Earth, Planets and Space": The current status

★Invited Papers

*Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University)

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

[U07-04] STAM and STAM-M : Open Data and Open Science with Open Access Journal from Japan

★Invited Papers

*Masanobu NAITO[1] (1.National Institute for Materials Science)

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

[U07-05] Research data repository for journals “J-STAGE Data” launching

★Invited Papers

*Ritsuko Nakajima[1] (1.Japan Science and Technology Agency)

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

[U07-06] Norms in scholarly communication: changes brought by open science

★Invited Papers

*Nobuko Miyairi

Advanced publication of scientific journals by JpGU and the related academic societies

*Hodaka Kawahata[1]

1. Atmosphere Ocean Research Institute, the University of Tokyo

We have been publishing PEPS, an English-language peer-reviewed open access e-journal, by the Japan Geoscience Union (JpGU) under collaboration with 50 society members by partnership with Springer since 2014. It is intended to serve as a platform for the publication of high-quality articles covering a wider field than the usual specialist journals, thus attracting students and research scientists globally. We have been promote review papers printed in PEPS, which will contribute in order to help beginners and young scientists to learn the hot topics in this research field like several chapters in text books. Therefore we have made an effort to collect excellent review articles at 20% and good original research articles at >80%. However, the relative contribution of review articles was unfortunately reduced in 2020. We have already established the publication category of “Paper with Full Data Attached”, which contains big data with a hot scientific topic. This kind of the publication will be strongly promoted in near future because it will be related to the activity of OPEN SCIENCE.
We have been getting get some Grants-in-Aid for Scientific Research to promote scientific publication by JpGU and JpGU participating societies. With the cooperation of academic societies, we will work to promote advertising by effectively introducing published papers and requesting review paper submissions to PEPS. We are currently considering the establishment of new facilities such as "The Most Cited Paper Prize” in PEPS and widely advertizing award-winning treatises.
PEPS got the first impact factor of 2.481 for 2017 publication. Based upon the latest data base by Clarivate Analytics (the former Thomson Reuter), we will get the first 5-year IF of >3.0 with the 2-year IF of >3.0 for 2020 PEPS publication in next June. Therefore PEPS Editorial board will ask the geoscientists to submit high quality of the manuscripts to submit PEPS and to develop and enhance the intelligent activity by global community of Earth and Planetary Science for the benefit of humanity”.

Keywords: PEPS, Impact factor, JpGU, Scientific journal

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Current status and issues of PEPS journal

*Eiji Ohtani[1]

1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University

Here, we will introduce the current status of PEPS, which is in its 7th year of publication, and issues to be improved. The 2019 Impact Factor and CiteScore of PEPS were 2.058 and 3.8, respectively. The estimated values for 2020 were 3.0 and 4.6 respectively, showing steady development. During this time. PEPS introduced the Most cited paper award, Most downloaded paper award, and introduction of SPEPS to promote submission. PEPS also introduced Rules for Dealing with Suspected Malpractice Associated with Papers Submitted to PEPS. PEPS needs to deal with several unachieved issues such as publication of more than 20% review articles and to promote further submission. We are considering to introduce several procedures such as encouraging academic societies to submit review articles, improving the article category to promote the submission of synthesis articles, and introducing PEPS most citation prize. There are issues that need to be considered in the future, such as operational problems of Rules for Dealing with Suspected Malpractice and data repository for submitted articles.

Keywords: PEPS, Impact Factor, CiteScore

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"Earth, Planets and Space": The current status

*Takeshi Sagiya[1]

1. Disaster Mitigation Research Center, Nagoya University

EPS (Earth, Planets and Space) is a peer-reviewed open access journal published on behalf of the five societies; Society of Geomagnetism and Earth, Planetary and Space Sciences, The Seismological Society of Japan, The Volcanological Society of Japan, The Geodetic Society of Japan, and The Japanese Society for Planetary Sciences, all of which are society members of the Japan Geoscience Union. EPS covers broad area in earth and planetary sciences with particular foci on geomagnetism, aeronomy, space science, seismology, volcanology, geodesy, and planetary science.

EPS was remodeled in 2014 as an open access journal under the SpringerOpen platform. Since then, EPS has published average of 173 papers per year. About half of the authors are from overseas. 2-year impact factor (IF) of EPS is 2.075. The editorial board of EPS is international. Among 59 members of the editorial board, 29 members are from overseas.

EPS publishes the following article types: (1) "Full paper", (2) “Express Letter” which aims at fast publications, (3) “Frontier Letter” for leading edge researches only with the invitation from the editor in chief, and (4) “Technical report" which describes technical developments for scientific researches. In addition to regular publication, EPS promotes topical article collections called special issues about various geoscientific events (earthquakes and volcanic eruptions) or scientific missions (satellite missions).

As part of the promotion of the journal we have four annual awards to recognize authors and reviewers: (1) EPS Excellent paper awards, (2) EPS Young researcher award, (3) Highlighted Paper Awards and (4) Excellent Paper Awards.

Recently we have been trying to increase the publication speed. On average, it takes 46 days for the first decision and 141 days for acceptance from the submission. We are trying to promote EPS as an important scientific contribution from Japan to the global geoscience community. We expect to receive more submissions of important science results from JpGU members.

Keywords: Earth, Planets and Space, geoscience, scientific publication

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STAM and STAM-M : Open Data and Open Science with Open Access Journal from Japan

*Masanobu NAITO[1]

1. National Institute for Materials Science

Materials science and technology has been rapidly growing, especially, since the emergence of data-driven approach, so called, materials informatics (MI) and as more databases that include variety of materials property emerged, some of which allowed researchers to freely reuse the data to obtain further dataset, the idea of MI brought a new paradigm in designing new materials science. Just like Bioinformatics has won its standing point in the sub discipline in life sciences, use of big data has led materials science to find its new discipline. However to this moment, there has been no appropriate journal for submitting articles from this emerging field. One reason being it as the field is still in its early days, and secondly this field is an interdisciplinary one between materials science, engineering and informatics which prevented new journals to be launched in the old disciplinary hierarchy. On this account, NIMS proposes to launch a brand new journal solely dedicated in advancement of MI in the purpose of systematizing this new scientific knowledge.
NIMS has been publishing Science and Technology of Advanced Materials (STAM) since 2000. It has introduced a new article category on MI in 2016 and the number of submissions on MI has been increasing since then. However, since STAM’ s aims and scope focuses on broad term of materials science and not specifically on informatics (methodology, database, instrumentation, and programming), STAM has been struggling to receive more papers on MI even though the Editors are aware that there are many unpublished good methodology and datasets stored in each laboratory of materials scientists. The new journal will be a platform to provide opportunity for these unsung papers to be read and to be reused by third parties in hope to design the future courses of materials science.

Keywords: Science and technology of advanced materials (STAM), Science and technology of advanced materials: Methods (STAM-M)



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Research data repository for journals “J-STAGE Data” launching

*Ritsuko Nakajima[1]

1. Japan Science and Technology Agency

The J-STAGE is an electronic journal platform operated by the Japan Science and Technology Agency (JST). With the aim of disseminating and promptly distributing research results from science and technology (including humanities and social sciences) published in Japan, J-STAGE supports the publishing of scientific and technological publications by academic societies, research institutes, and other publishing organizations to strengthen international information dissemination and promote open access.

In regard to J-STAGE, JST is responsible for the planning and policy-making of the service, development, and operation of the system and various support with respect to the publishing organizations. The system has the function to register and publish articles, and the service is made possible by the publishing organizations using this system to publish their articles.

Currently, more than 3,000 journals, conference proceedings, and other publications have been published on J-STAGE by more than 1,700 domestic organizations and the number of articles exceeds 5 million. Of these, more than 85% are journals freely accessible to anyone, contributing greatly to the openness of research results from Japan.

On the other hand, when we look at the world, we can see that the nature of academic publishing and the various information provision services surrounding it are changing rapidly with the recent changes in academic communication and research workflows. These changes include, for example, the diversification of publication forms and contracts relating to open access, the increase of preprints, the emergence of new publication forms such as post-publication peer review and open peer review, and the movement to publish research data associated with papers. At the root of all these movements is the trend toward open science.

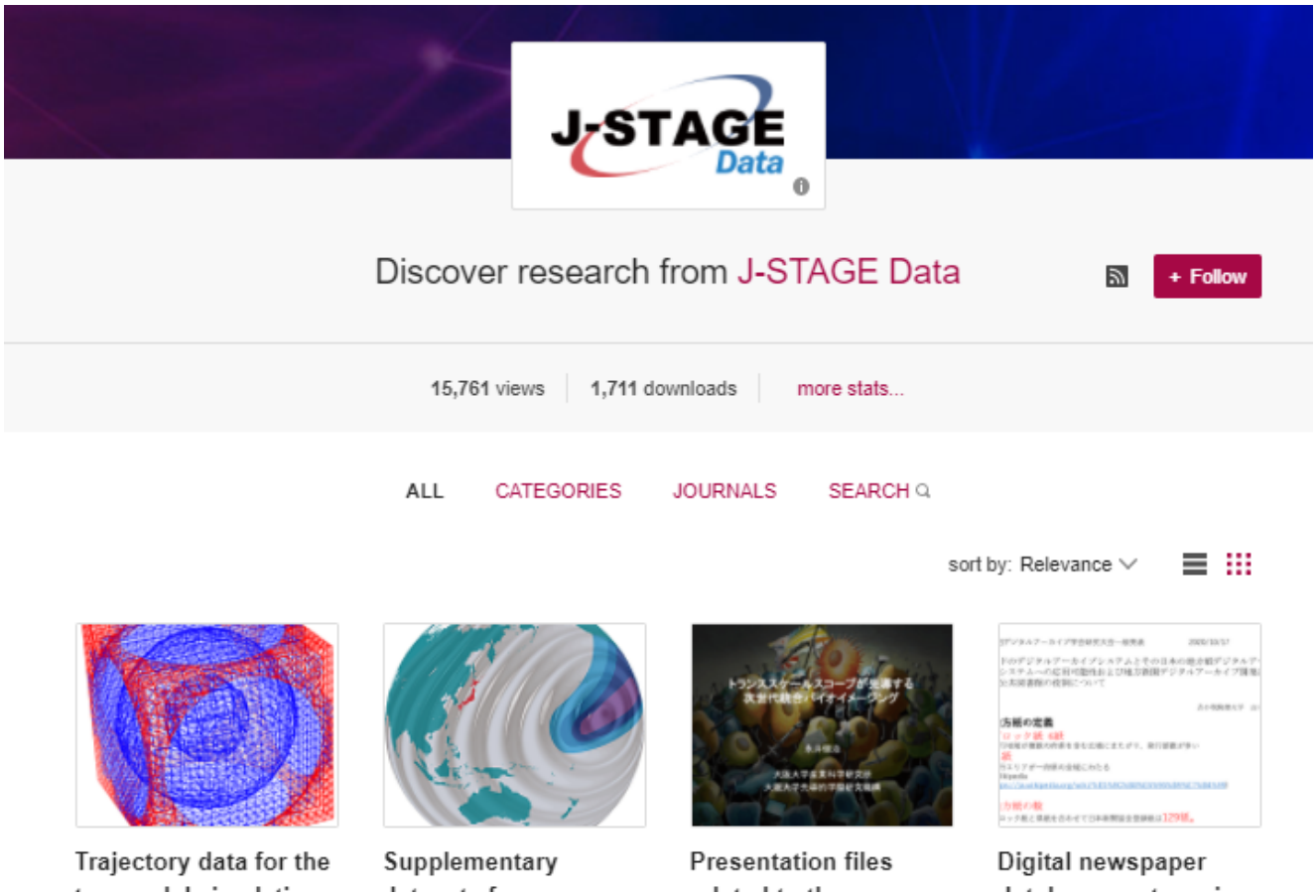
Many universities, research institutes, and research funding agencies have formulated policies for data management and disclosure in order to meet the expectations for creating new value through data sharing and utilization that accompany the development of open science, and the demands for preventing research misconduct and improving transparency. In addition, policies on open data and sharing are being developed in the field of academic publishing as well, and researchers are increasingly required to provide the data on which their research results are based when they submit their papers. Major international commercial publishers have opened their policies on research data related to their journals on their websites. They indicate the recommended and mandatory levels of data availability, repositories, data citation and linking from articles, peer review of data, licensing for reuse, etc. The journals from these publishers have guides for authors that comply with these policies.

In response to this situation, JST started the pilot operation of the publication platform "J-STAGE Data" in

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March 2020. DOI (Digital Object Identifier)s are registered for the data, and it is possible to link the data from the papers such as those on J-STAGE, and it also facilitates to distribute the research data its own. All the data on J-STAGE Data is open access, and the user organizations which publish the data grant a license that defines the scope of secondary use.
As of the end of January 2021, 37 data have been published by 3 journals, and the number of participating journals is expected to increase in the future. During this pilot period, JST is developing the operation system with the cooperation of the participating journals and aims to start the full-scale operation at the end of this fiscal year.

Keywords: open science, journal, research data, J-STAGE



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Norms in scholarly communication: changes brought by open science

*Nobuko Miyairi

Michael Nielsen, the author of *Reinventing Discovery: The New Era of Networked Science*[(1)], defined open science as the idea where “scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process.” [(2)] This overly simple statement is equivocal and troublesome for those seeking to practice open science. Scientific knowledge can be available in a variety of formats, including publications, data sets, audio-visual materials, methods, software, and so forth. They may already have established ways for sharing; or they may have not been traditionally shared at all. The idea to share “as early as is practical” depends on the technical and organizational constraints that one might face. In addition, Nielsen leaves it indistinct whether “openly shared” means either simply putting on the public web or with some additional procedures required.

The public consultation conducted by the European Commission in 2014 denotes that open science is an umbrella term for a series of movements in research and related practices, referring to a system of related changes that must be considered in relation to one another. Three essential aspects of open science are: (1) its relation to digital technology, (2) changing research practices and their impact on the research system as a whole, and (3) a certain vision of science as a community of practice. The objective of this public consultation was to receive feedback from community stakeholders on ‘science 2.0’, which the majority of respondents agreed that ‘open science’ was a more appropriate term to describe. [(3)]

If we regard the scholarly community as a social group, its members share more or less mutual values, which in turn guide their behaviors as social norms. Such norms could influence not only members’ behaviors but also define goals and the means of achieving them. Scholarly publishing, or more broadly, scholarly communication is thus governed by social norms set by the research community as a whole. The visions distilled in Nielsen’s simplistic statement demand a reform of the shared values in the traditional scholarly community and the practices cultivated therein.

There are new infrastructures allowing scholarly outputs other than VoR or the version of record, such as preprints and conference presentations, to be openly shared. OA mega-journals, which simplify peer-review process and speed up the publication process only if scientific validity is met, are increasing by number and exceeding the volume produced by traditional peer-reviewed journals. Prevailing social media made it possible to quantify the online behavior of readers, leading to the wide adoption of altmetrics. These new forms of outputs and indicators have brought new perspectives to research performance evaluation.

In this presentation, we will discuss the various changes brought about by science 2.0 or open science in contrast to the perceived norms in scholarly communications.

References:

(1) Nielsen, Michael. *Reinventing Discovery: The New Era of Networked Science*. Princeton University Press, 2011, 280p.

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(2) Gezelter, Dan. (2011, July 28). *An informal definition of OpenScience | The OpenScience Project*. Openscience.org. http://openscience.org/an-informal-definition-of-openscience/

(3) European Commission. (2015, February). Validation of the results of the public consultation on Science 2.0: Science in Transition. http://ec.europa.eu/research/consultations/science-2.0/science_2_0_final_report.pdf

Keywords: scholarly publishing, scholarly communication, open science

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

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.02 Zoom Room 02

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Kevin McGouldrick(University of Colorado Boulder)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[PPS02-01] Introduction

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[PPS02-02] Mission Concept Study for Japan’s Next Venus Exploration

*Ryoma Yamashiro[1], Masato Nakamura[1], Chikako Hirose[1], Nobuaki Ishii[1], Ryoh Nakamura[1], Takehiro Matsumoto[1], Yuuki Akiyama[1], Junichi Nakatsuka[1], Kenta Goto[1], Hiroyuki Toyota[1], Tomoaki Toda[1], Atsushi Yamazaki[1], Takehiko Satoh[1], Takumi Abe[1], Toru Kouyama[2], Masataka Imai[2], Hideo Sagawa[3], Mitsuteru Sato[4], Yukihiro Takahashi[4], Makoto Taguchi[5], Tetsuya Fukuhara[5], Takao M. Sato[6], Shin-ya Murakami[7], Yoshi-Yuki Hayashi[8], Takeshi Imamura[9] (1.Japan Aerospace eXploration Agency, 2.National Institute of Advanced Industrial Science and Technology, 3.Kyoto Sangyo Univ., 4.Hokkaido Univ., 5.Rikkyo Univ., 6.Hokkaido Information Univ., 7.Keio Univ., 8.Kobe Univ., 9.Tokyo Univ.)

9:20 AM - 9:45 AM JST | 12:20 AM - 12:45 AM UTC

[PPS02-03] Venus Atmospheric Structure Investigation (VASI) on the Proposed DAVINCI+ Probe

★Invited Papers

*Ralph Lorenz[1], James Garvin[2], Natasha Johnson[2], Stephanie Getty[2], Giada Arney[2], Francois Forget[4], Sebastien Lebonnois[4], Noam Izenberg[1], David Atkinson[3], David Crisp[3] (1.Johns Hopkins University Applied Physics Laboratory, 2.NASA Goddard SpaceFlight Center, 3.Jet Propulsion Laboratory, 4.LMD, Universite de Paris)

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

[PPS02-04] Venus cloud-aerosol observation using Life-signature Detection Microscope (Venus LDM)

*Satoshi Sasaki[1], Akihiko Yamagishi[2], Yoshitaka Yoshimura[3], Keigo Enya[4], Atsuo Miyakawa[2], Sosuke Ohno[5], Kazuhisa Fujita[4], Tomohiro Usui[4], Sanjay Limaye[6] (1.Tokyo University of Technology, 2.Tokyo University of Pharmacy and Life Sciences, 3.Tamagawa University, 4.JAXA, 5.Chiba Institute of Technology, 6.University of Wisconsin)

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

[PPS02-05] Venus, an astrobiology target

*Sanjay S Limaye[1] (1.University of Wisconsin Madison)

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

[PPS02-06] Discussion

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

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Kevin McGouldrick(University of Colorado Boulder)
Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.02 (Zoom Room 02)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

9:00 AM - 9:05 AM

[PPS02-01]Introduction

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Mission Concept Study for Japan’s Next Venus Exploration

*Ryoma Yamashiro[1], Masato Nakamura[1], Chikako Hirose[1], Nobuaki Ishii[1], Ryoh Nakamura[1], Takehiro Matsumoto[1], Yuuki Akiyama[1], Junichi Nakatsuka[1], Kenta Goto[1], Hiroyuki Toyota[1], Tomoaki Toda[1], Atsushi Yamazaki[1], Takehiko Satoh[1], Takumi Abe[1], Toru Kouyama[2], Masataka Imai[2], Hideo Sagawa[3], Mitsuteru Sato[4], Yukihiro Takahashi[4], Makoto Taguchi[5], Tetsuya Fukuhara[5], Takao M. Sato[6], Shin-ya Murakami[7], Yoshi-Yuki Hayashi[8], Takeshi Imamura[9]

1. Japan Aerospace eXploration Agency, 2. National Institute of Advanced Industrial Science and Technology, 3. Kyoto Sangyo Univ., 4. Hokkaido Univ., 5. Rikkyo Univ., 6. Hokkaido Information Univ., 7. Keio Univ., 8. Kobe Univ., 9. Tokyo Univ.

Japan's Venus Climate Orbiter, AKATSUKI has been observing Venus since its orbital injection in 2015, and has made significant achievements in elucidating phenomena in the Venusian atmosphere, such as super-rotation and gravity wave. Recently, a mysterious flash has been detected which could be a promising sign of lightning strike. On the other hand, AKATSUKI is already in the late operation phase and the end of its operation is in sight. We are considering the next generation of Venus missions to continue to investigate this interesting and enigmatic neighboring planet and to understand its unknown phenomena.

As one such mission, we are considering a project to put small probes into orbit around the Lagrange points L1 and L2 of Venus, respectively, to observe both the day and night sides of Venus continuously and simultaneously. This project was named PLANET-D after PLANET-C, the name of AKATSUKI when it was planned, and the two probes were named PLANET-D1 and PLANET-D2 respectively. Under the plan, the two spacecraft will initially be carried as a single unit on the launcher, launched, and once in LEO, will be injected into the Earth-Venus transiting orbit on a kick stage located between the launcher and the spacecraft. The spacecraft will then be controlled by the propulsion system in the vicinity of Venus and will first enter the L1 Lissajous orbit of Venus. After that, PLANET-D1 and PLANET-D2 will separate on the Venus L1 Lissajous orbit, PLANET-D1 will keep the same orbit, and PLANET-D2 will transfer to the Venus L2 Lissajous orbit. Each spacecraft will control its own orbit to maintain its orbit, and continue observations of Venus from two directions via X-band using different stations or in the manner to halve a visibility for each spacecraft.

The Epsilon rocket, Japan's small solid rocket, was tentatively set as the launch vehicle, and the system design of the spacecraft was carried out using the technical results of AKATSUKI and HAYABUSA2, and the results of the subsystem study of the future mission, DESTINY+. The Orbital Maneuver Engine (OME) for planetary transit is mounted only on PLANET-D1, while PLANET-D2 has only a small propulsion system, the Reaction Control System (RCS), for transfer between Venus L1 and L2 and for maintaining and controlling its own orbit, Venus L2 Lissajous. Due to the difference of the propulsion system, the mass of PLANET-D1 and PLANET-D2 are different, 145 kg and 55 kg respectively. The timing of the launch is better in 2031 than in the Earth-Venus meeting cycle.

Currently, the science community is discussing what should be observed on Venus from the viewpoint of planetary science. In addition to the Venusian meteorology targeted by AKATSUKI, many new themes are proposed, such as atmospheric chemistry, atmospheric escape, and geologic processes. The detail design of PLANET-D will be revised and updated in response to a demand from the science community.

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Keywords: Venus, Exploration, Lagrange point

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Venus Atmospheric Structure Investigation (VASI) on the Proposed DAVINCI+ Probe

*Ralph Lorenz[1], James Garvin[2], Natasha Johnson[2], Stephanie Getty[2], Giada Arney[2], Francois Forget[4], Sebastien Lebonnois[4], Noam Izenberg[1], David Atkinson[3], David Crisp[3]

1. Johns Hopkins University Applied Physics Laboratory, 2. NASA Goddard SpaceFlight Center, 3. Jet Propulsion Laboratory, 4. LMD, Universite de Paris

Only a single near-surface profile exists of the atmosphere of our twin planet, that obtained in 1985 by the VEGA-2 lander. The handful of other probe missions have very limited vertical resolution, or sensor failures. Unlike altitudes above 40km, which have been relatively well-surveyed by radio occultation profiles from orbiter missions, the fine temperature structure of lowest part of the Venus atmosphere must be interrogated by direct measurement. This structure is important in several respects. First, the structure and composition reflects the interactions between surface and atmosphere of an ‘exoplanet in our back yard’ which may be much more typical than are those of Earth. Secondly, there are indications that particularly interesting phenomena may occur on Venus, not seen in the atmospheres of Earth, Mars or Titan (but analogous to aspects of ocean stratification on Earth) : the VEGA-2 profile is impossible to reconcile with a profile that is both convectively stable and compositionally uniform. A favored hypothesis is that the lowest few kilometers are compositionally denser (lower N2). The supercritical thermodynamics of carbon dioxide add to the rich possibilities in this region.

The exchange of angular momentum between the retrograde, slowly-rotating Venus and its dense atmosphere is reflected in the wind profile, which can now be interpreted by global circulation models. Again, while cloud-top (60-70km) winds are now well-known from Akatsuki and preceding missions, very little data exist on winds in the hidden lowest 40km. Doppler tracking, turbulence measurements, and trajectory reconstruction from descent imaging will shed unprecedented light on the lower atmospheric dynamics.

DAVINCI+ is presently concluding a Phase A study in NASA’s Discovery program, with possible selection in summer 2021 for flight in the latter half of this decade. This presentation will review how the VASI’s measurements of pressure, temperature and wind, far superior in resolution and/or quantity to those of previous missions, may improve our understanding of Venus and complement DAVINCI+’s composition measurements and imaging.

Keywords: Atmosphere, Venus, Convection, Wind, Turbulence

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DAVINCI+

Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging Plus



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Venus cloud-aerosol observation using Life-signature Detection Microscope (Venus LDM)

*Satoshi Sasaki[1], Akihiko Yamagishi[2], Yoshitaka Yoshimura[3], Keigo Enya[4], Atsuo Miyakawa[2], Sosuke Ohno[5], Kazuhisa Fujita[4], Tomohiro Usui[4], Sanjay Limaye[6]

1. Tokyo University of Technology, 2. Tokyo University of Pharmacy and Life Sciences, 3. Tamagawa University, 4. JAXA, 5. Chiba Institute of Technology, 6. University of Wisconsin

Much of the size and shape information about of Venus aerosols forming the haze and the cloud layer is obtained from indirect inferences from analysis of variation of polarization with phase angle and the glory feature from Venus images, together from nephelometers and particle spectrometers on descent probes. The particles are inferred to be spherical and it desirable to obtain the size/shape information about the particles, particularly the large particles (> 3 μm) whose shape is uncertain.

Microscopic imaging of Venus aerosols can be an attractive measure for the *in situ* particle characterization of Venus' cloud layer. Direct measurements with a fluorescence microscope can provide information on the biochemical characteristics, as well as morphology, density of the particles.

Recently, a fluorescence microscope system for life-signature detection on Mars surface (Mars LDM) has been designed and under development. Application of this system is promising to observe Venus cloud particles, upon overcoming several challenges including strong acidity and the corrosive effects of the sulfuric acid (~75%) of the aerosol.

Various aerial platforms for long duration sampling of the Venus clouds have been proposed or considered, and further technical development is needed. In addition, an aerosol collection system is needed for microscopic imaging. In this context, a fluorescence imaging approach is proposed in combination with a collector based on impactors for the Venus clouds. For the preparation of the system, we identify the following main challenges:

(1) What kind of microorganisms can be used as models for the instrument performance evaluation?

(2) What fluorescent stains can be used in the strong acidic condition?

(3) How can we interpret the fluorescence microscope images of the particles?

Discussions on these questions and proposal for approaches will be performed for an *in situ* bio/chemical and physical characterization system for Venus cloud particles based on fluorescence microscopy. We also identify the challenges and describe our approach to overcoming them for a fluorescence microscope based on an *in situ* bio/chemical and physical characterization instrument for use in the Venus clouds, using suitable aerial platform.

Keywords: life signature detection microscope, Venus cloud

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Venus, an astrobiology target

*Sanjay S Limaye[1]

1. University of Wisconsin Madison

The interest in the possibility of life on Venus is driven not just by curiosity about life originating in another Earth-like environment, but because of the possibility that life may be playing a critical role in the planet's present, and possibly its past, atmospheric state. The brilliance of Venus in the night sky (as viewed from Earth) is due to its highly reflective cloud cover, about 28 km thick at the equator. Its spectral albedo is about 90% at wavelengths > 500 nm, but it drops gradually to about 40% around 370 nm before rising slightly at shorter wavelengths. This albedo drop is due to the presence of several absorbers in the atmosphere and the cloud cover. A very large fraction of the energy absorbed by Venus is at ultraviolet wavelengths with sulfur dioxide above the clouds contributing to the absorption below 330 nm; however, the identities of the other absorbers remain unknown. The inability to identify the absorbers that are responsible for determining the radiative energy balance of Venus over the last century is a major impediment to understanding how the planet "works", a major component of NASA's efforts in planetary exploration. Limaye et al. (*1*) presented a hypothesis suggesting that cloud-based microbial life could be contributors to the spectral signatures of Venus' clouds, building upon previous suggestions of the possibility of life in the clouds of Venus (*2-5*).

We suggest a set of four interconnected themes for the exploration of Venus as an astrobiology target –(i) investigations focused on the likelihood that liquid water existed on the surface in the past leading to the potential for the origin and evolution of life, (ii) investigations into the potential for habitable zones within Venus' clouds and Venus-like atmospheres, (iii) theoretical investigations into how active aerobiology may impact the radiative energy balance of Venus' clouds and Venus-like atmospheres, and (iv) application of these investigative themes towards better understanding the atmospheric dynamics and habitability of exoplanets. These themes can serve as a basis for proposed Venus Astrobiology Objectives and suggestions for measurements for future missions, as per the goals and objectives developed by the Venus Exploration Analysis Group (VEXAG), which is sponsored by NASA to plan for the future exploration of Venus. Similarly, they can inform laboratory work that can begin now in support of potential mission approaches and instruments and their required technical development. The scientific investigation of Venus has also been discussed in two recent reports - Search for Life across Space and Time (National Academies of Sciences and Medicine 2017) and "An Astrobiology Strategy for the Search for Life in the Universe" (National Academies of Sciences and Medicine 2019).

Additional information about the astrobiology interest in future exploration of Venus can be found in the Venus Collection to be published in Astrobiology in the coming months. This collection will include papers prepared following the first workshop, "Habitability of the Venus Cloud Layer" held in Moscow in October 2019 with support from the Russian Academy of Science and NASA.

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Keywords: Venus, Clouds, Habitability, Future exploration

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

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Kevin McGouldrick(University of Colorado Boulder)
Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.02 (Zoom Room 02)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

10:15 AM - 10:30 AM

[PPS02-06]Discussion

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

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.02 Zoom Room 02

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

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

[PPS02-07] Microphysics Implications of the Venus Bow Wave seen by LIR on Akatsuki

*Kevin McGouldrick[1] (1.Laboratory for Atmospheric and Space Physics, University of Colorado Boulder)

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

[PPS02-08] Barotropic instability and traveling linear features detected in the near-infrared images from Akatsuki

*Takeshi Horinouchi[1], Takehiko Satoh[2], Choon Wei Vun[2], Eliot F. Young[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.ISAS, 3.Southwest Research Institute)

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

[PPS02-09] Statistical analysis of the morphology of Venusian clouds

*Tomoya Suda[1], Takeshi Imamura[1] (1.Graduate School of Frontier Sciences, The University of Tokyo)

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

[PPS02-10] Simulation of sulfuric acid cloud distributions by a Venus GCM for the comparison with observations

*Hiroki Karyu[1], Takeshi Kuroda[1], Naoki Terada[1], Yasumasa Kasaba[1], Masaru Yamamoto[2], Masaaki Takahashi[3], Kohei Ikeda[4] (1.Tohoku University, 2.Kyushu University, 3.University of Tokyo, 4.National Institute for Environmental Studies)

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

[PPS02-11] A development of a broadband radiative transfer model "Mstrn-Venus" for Venus atmosphere

*Miho Sekiguchi[1], Reiko Kurihara[1], Naohiro Manago[2], Masahiro Takagi[3], Hideo Sagawa[3], Yoshihisa Matsuda[4] (1.Tokyo University of Marine Science and Technology, 2.Chiba University, 3.Kyoto Sangyo University, 4.Tokyo Gakugei University)

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

[PPS02-12] Discussion

Microphysics Implications of the Venus Bow Wave seen by LIR on Akatsuki

*Kevin McGouldrick[1]

1. Laboratory for Atmospheric and Space Physics, University of Colorado Boulder

The first scientific discovery by Akatsuki following its successful Venus Orbit Insertion in Decmber, 2015 was of a global-scale "bow wave" feature seen in data from the Longwave Infrared Bolometer. This instrument senses the region of the cloud tops at about 65 km altitude in thermal infrared in a 4 micron wide band centered at 10 microns. This feature (and others like it subsequently observed) was found to be stationary with respect to the surface topography. Work by others has demonstrated that the wave is likely very large orographically-launched buoyancy wave (sometimes referred to as planetary gravity wave). Here, we present a microphysics modelling analysis of the long-term and short-term influence that such a wave would have as it propagates through the deeper cloud decks between 50 km and 65 km.

Keywords: Venus, Clouds, Microphysics, Atmospheric Dynamics

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Barotropic instability and traveling linear features detected in the near-infrared images from Akatsuki

*Takeshi Horinouchi[1], Takehiko Satoh[2], Choon Wei Vun[2], Eliot F. Young[3]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. ISAS, 3. Southwest Research Institute

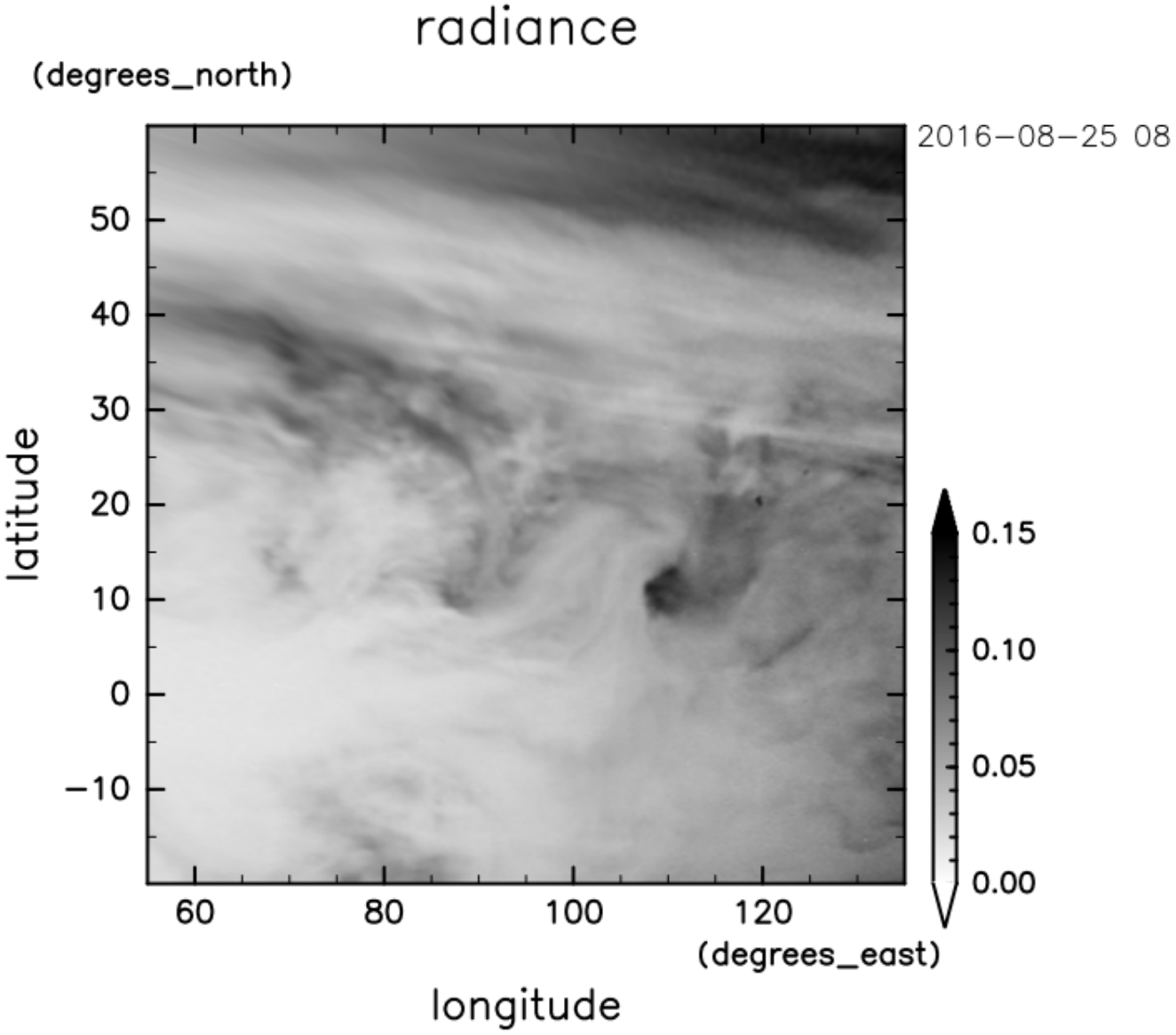
The Akatsuki IR2 camera provided images of the nightside of Venus, which captures cloud morphology illuminated by the near-infrared (NIR) thermal radiation from the lower part of the Venusian atmosphere. The nightside NIR features reveal the optical thicknesses of mid- and lower-level clouds as back-lit silhouettes. Previous studies using the nightside IR2 images reported rich features including those like barotropically unstable vortices [1] and sharp boundaries which are part of long-lasting planetary-scale waves [2]. Here, we report further morphologies indicative of dynamical processes in the cloud layer of Venus. We used data obtained on August 25, 2016. The data on this day have been difficult to treat, since the planetary limb in the images are particularly obscure, hindering the navigation-data correction needed for geographical mapping. In this study, we used a cloud tracking program to detect the apparent wind variation caused by the inaccurate mapping and corrected the navigation data to compensate it. It enabled us to study time evolutions in depth. We found gigantic (~2000 km) barotropic instability-like billows that actually exhibited rotation consistent with the shape. We also found many linear features that propagate westward relative to the motion of other features such as the billows. The linear features may be due to waves that potentially reside at relatively high altitudes.

[1] Peralta, J. et al. (2019) Icarus, 333, 177-182.

[2] Peralta, J., et al. (2020) Geophys. Res. Lett., 47, e2020GL087221.

Keywords: Venus, Cloud, Barotropic instability, Wave

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Statistical analysis of the morphology of Venusian clouds

*Tomoya Suda[1], Takeshi Imamura[1]

1. Graduate School of Frontier Sciences, The University of Tokyo

In order to understand the mechanism by which Venus' s cloud is maintained, it is necessary to clarify the transport of atmospheric constituents at various temporal and spatial scales. In the ultraviolet images of Venus, various small-scale patterns indicative of convention and waves are seen at the cloud top. Though their relation to material transport has been drawing attention, their dynamical properties and contribution to transport are not known. These patterns will evolve over time while being advected by the high-speed easterly wind called the superrotation. To obtain clues to the processes, we analyzed ultraviolet images at the wavelength of 283 nm taken continuously by UVI onboard the Venus probe Akatsuki. SO_2 is the dominant absorber at the wavelength of 283 nm on Venus, and the horizonal distributions of SO_2 and clouds near the altitude of 65 km can be observed. By analyzing the images separately for each local time, we extracted convective patterns dependent on the local time. The complexity of the pattern was evaluated quantitatively with Fractal dimension, thereby examining the statistical tendency of the local time variation. We also performed the same analysis using IR images at the wavelength of 2.02 μm taken by IR2 onboard Akatsuki. CO_2 is the dominant absorber at 2.02 μm on Venus, and the cloud top altitude can be observed at this wavelength. The comparison between the wavelengths would lead to the elucidation of the processes controlling small-scale patterns such as convection.

Keywords: Venus, clouds, Akatsuki

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Simulation of sulfuric acid cloud distributions by a Venus GCM for the comparison with observations

*Hiroki Karyu[1], Takeshi Kuroda[1], Naoki Terada[1], Yasumasa Kasaba[1], Masaru Yamamoto[2], Masaaki Takahashi[3], Kohei Ikeda[4]

1. Tohoku University, 2. Kyushu University, 3. University of Tokyo, 4. National Institute for Environmental Studies

The coupling between the mode distributions of sulfuric acid clouds and atmospheric dynamics is a key to understand Venusian cloud structures, but has not well been investigated. Haus et al. (2014) detected the meridional distributions of the total cloud opacity observed by the Visible and InfraRed Thermal Imaging Spectrometer (VIRTIS) aboard Venus Express (VEX), and showed that the cloud optical thickness reached the maximum in both equatorial and polar region.

Previously we have implemented the scheme of condensation, evaporation, and sedimentation processes of sulfuric acid clouds (cloud droplets are assumed to be composed of 75 % sulfuric acid, and supersaturation is not considered) together with the atmospheric chemistry for the formation of H_2SO_4 vapor into a Venus general circulation model (VGCM) for the investigation of the cloud formation and circulation systems, and showed that the total cloud thickness became the largest in the equatorial region and decreased towards the pole (Kasaba et al., 2016 AGU Fall Meeting, https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/140404). On the other hand, a recent study by Ando et al. (2020) using a different VGCM showed that the cloud mass loading was significantly larger in the polar region than in the equatorial region. The difference of the cloud implementation method between those two studies is the treatment of cloud particle distributions. Crisp (1986) defined four modes of cloud particle sizes from the Pioneer Venus observation, as mode 1 (effective radius of 0.49 μm, mode 2 (1.18 μm), mode 2' (1.40 μm) and mode 3 (3.65 μm). Kasaba et al. (2016) considered the formations of all four modes, while Ando et al. (2020) considered only modes 1 and 2, which resulted in the difference of sedimentation velocity. As both results were partly consistent with the VIRTIS observations, so the combination of the two studies would produce better fits.

In this study, we have improved the cloud formation scheme from our previous study (Kasaba et al., 2016) for a better reproduction of observed cloud distributions. In Kasaba et al. (2016) the cloud particle formation ratios in the middle and lower altitude (~50-60 km) are uniform in all latitudes, but in this study we decreased the formation of mode 3 clouds in higher latitudes. The newly implemented mass formation ratio of mode 3 was defined to be a half of Kasaba et al. (2016) in the latitudes of >70 degrees, and replaced to mode 2' for another half, to mimic the particle size of formed clouds defined in Ando et al. (2020) in the polar region. Also, a linear interpolation of the ratio from the original one was implemented between 50 and 70 degrees, and the vertical eddy diffusion coefficient in the cloud layer is set to be lower than Kasaba et al. (2016).

In comparison with Kasaba et al. (2016), this study produced improved latitudinal distribution of cloud opacity at 1 μm wavelength, which was qualitatively consistent with the VIRTIS observation (Haus et al., 2014). Also, the latitudinal distributions of cloud mode factors seen in Fig. 18 of Haus et al. (2014) are also well reproduced. The thickness of mode 3 clouds are the highest in poles, nevertheless of the lower production rate than in low-latitudes.

For the investigations of the cloud formation process, we are analyzing cloud production and loss rates

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due to advection, sedimentation, and vertical eddy diffusion. Because of the low vertical eddy diffusion coefficient, more H_2SO_4 vapor remains in the upper cloud. Consequently, the H_2SO_4 vapor is transported to the polar region by the downwelling of the Hadley circulation, and the thickness of polar clouds increases. Cloud formation around 40 km also increases slightly. This may be the result of coupling between the increase of polar clouds and equatorward advection by the return branch of the Hadley cell extended from the pole to the equator.

In addition, we are conducting spectrum analyses on temperature, wind, and cloud mode distributions to investigate the relationship between waves and cloud fluctuation. Equatorial Kelvin-wave-like structures are found in the lower cloud layer, and cloud fluctuation is synchronized with the waves. It could be useful to understand cloud morphology observed by Akatsuki, such as disruption in the lower cloud layer interpreted as a Kelvin wavefront (Peralta et al., 2020). Although other types of waves exist and seem to be correlated with cloud fluctuation, further investigation is needed to interpret the causality between them.

Keywords: Venus, Sulfuric acid cloud , General Circulation Model

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A development of a broadband radiative transfer model "Mstrn-Venus" for Venus atmosphere

*Miho Sekiguchi[1], Reiko Kurihara[1], Naohiro Manago[2], Masahiro Takagi[3], Hideo Sagawa[3], Yoshihisa Matsuda[4]

1. Tokyo University of Marine Science and Technology, 2. Chiba University, 3. Kyoto Sangyo University, 4. Tokyo Gakugei University

Venus has a dense atmosphere entirely covered by a thick cloud layer (ranging over 50 –70 km altitude). Due to the high opacity of the atmosphere, there is almost no remote-observational access to the lower atmosphere below the cloud. Past (only a few, though) in-situ measurements suggest that a convective layer appears 18 to 32 km, but the nature of such a thermal structure is still not understood clearly.

To better knowledge on the thermal structure (radiative transfer of the thermal flux), we developed a newly developed 1-D radiative transfer model “MSTRN-Venus”. The absorption coefficients of the molecular gases in the Venus atmosphere (CO_2, H_2O, CO, SO_2, HF, HCl, and OCS) are calculated in each 0.005cm^{-1} wavenumber, and correlated k-distribution are calculated and applied. The settings of radiative parameters for gas absorption and scattering processes are mainly based on Haus et al. [2015] for shortwave and Lee et al. [2016] for longwave region. The spectroscopic parameters such as the transition position and line strength are taken from the recent compilations of HITRAN 2012, HITEMP, and UCL08 catalogs. In addition, the collision-induced absorption of CO_2 is also included. We prepared the absorption coefficients under several pressure and temperature conditions within the ranges of 0.01 - 100 bar and 100 - 800 K, respectively. The results are kept in a look-up table of (p, T) domain so that we can interpolate the absorption coefficient for any pressure and temperature condition without repeating computational burdens. The sulfuric acid clouds, Rayleigh scattering, and UV unknown absorber are also considered. The upward and downward flux density is calculated for a given atmospheric profile using the MSTRN code. This code has been successfully applied in several studies of our terrestrial atmosphere, and also adopted as the radiation calculation module of several global circulation models.

The presentation will discuss the sensitivity of the radiative-convective temperature profile concerning the abundance of minor species, incoming solar heating, and cloud opacities.

Keywords: Venus, radiative transfer model

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

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.02 (Zoom Room 02)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

12:00 PM - 12:15 PM

[PPS02-12]Discussion

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

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.02 Zoom Room 02

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Hideo Sagawa(Kyoto Sangyo University)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[PPS02-13] Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[PPS02-14] Spatial distribution of HCl abundance at the cloud top of Venus retrieved from IRTF/iSHELL spectra

*Takao M. Sato[1], Hideo Sagawa[2] (1.Hokkaido Information University, 2.Kyoto Sangyo University)

2:05 PM - 2:30 PM JST | 5:05 AM - 5:30 AM UTC

[PPS02-15] Day-night contrast of the atmospheric circulation at the cloud top of Venus revealed by Akatsuki LIR

★Invited Papers

Kiichi Fukuya[1], *Takeshi Imamura[2], Makoto Taguchi[3], Tetsuya Fukuhara[3], Toru Kouyama[4], Takeshi Horinouchi[5], Javier Peralta[6], Masahiko Futaguchi[11], Takeru Yamada[3], Takao M. Sato[7], Atsushi Yamazaki[8], Shin-ya Murakami[10], Takehiko Satoh[8], Masahiro Takagi[9], Masato Nakamura[8] (1.Department of Earth and Planetary Science, The University of Tokyo, Japan, 2.Graduate School of Frontier Sciences, The University of Tokyo, Japan, 3.Rikkyo University, Japan, 4.Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, Japan, 5.Faculty of Environmental Earth Science, Hokkaido University, Japan, 6.Instituto de Astrofísica e Ciências do Espaço, Portugal, 7.Space Information Center, Hokkaido Information University, Japan, 8.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan, 9.Faculty of Science, Kyoto Sangyo University, Japan, 10.Research and Education Center for Natural Sciences, Keio University, 11.Omori Medical Center, Toho University, Japan)

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

[PPS02-16] Identification and characterization of quiescent cloud region "CALM" in the Akatsuki and Venus Express data

*Takehiko Satoh[1,2], Choon Wei Vun[3,2], Takeshi Horinouchi[4], Kevin McGouldrick[5], Takao M. Sato[6] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Dept of Space and Astronautical Science, SOKENDAI, 3.ZMP Inc., 4.Hokkaido University, 5.University of Colorado, Boulder, 6.Hokkaido Information University)

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

[PPS02-17] EnVision: Understanding why Earth's closest neighbour is so different

*Thomas Widemann[1], Richard Ghail[2], Colin Wilson[3], Dmitri Titov[4] (1.Observatoire de Paris, France, 2.Royal Holloway, U. of London, UK, 3.U. of Oxford, UK, 4.ESA-ESTEC, Noordwijk, Netherlands)

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

[PPS02-18] Discussion

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

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Hideo Sagawa(Kyoto Sangyo University)
Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.02 (Zoom Room 02)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

1:45 PM - 1:50 PM

[PPS02-13]Introduction

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Spatial distribution of HCl abundance at the cloud top of Venus retrieved from IRTF/iSHELL spectra

*Takao M. Sato[1], Hideo Sagawa[2]

1. Hokkaido Information University, 2. Kyoto Sangyo University

The atmosphere of Venus can be divided into three altitudinal regions with different chemical conditions. High temperature and pressure and the absence of effective photolysis processes are dominant in the lower atmosphere up to 60 km where solar radiation longer than UV can reach. The middle atmosphere between 60 and 110 km is controlled by photochemistry driven by solar UV radiation. In the upper atmosphere above 110 km, dissociation, ionization, and ionospheric reactions are important processes. HCl is the primary chlorine reservoir in the Venus atmosphere bellow 110 km. Highly reactive chlorine species (ClO_x) is produced by solar UV photolysis of HCl and has been proposed to play an important role in catalysis of CO and O recombination to CO_2, thereby stabilizing the CO_2 atmosphere. Chlorine chemistry is also linked to sulfur chemistry and its understanding is necessary to explain the observed vertical distribution of SO_2.
Interestingly, there is a large inconsistency between the HCl abundances measured by spacecraft and ground-based telescopes. The SOIR instrument onboard Venus Express measured its abundance as less than ~50 ppb at the cloud top (~70 km) increasing to 1 ppm in the upper atmosphere (~110 km). Such a vertical trend conflicts with the vertically constant profile (up to ~80 km) reported by sub-mm ground-based observations. Near-infrared ground-based observations also showed the HCl abundance at the cloud top as ~500 ppb, which are nearly one order of magnitude larger than the SOIR results. The reason for this inconsistency has not been understood yet.
In order to re-examine HCl abundance at the cloud top, we carried out a high-resolution spectroscopy of Venus' dayside at wavelengths of 3.580-3.934 μm with IRTF/iSHELL on August 5-7, 2018 and August 18-20, 2020 (UT). Taking the full advantages of its high spectral resolution of R ~ 75,000, iSHELL resolved individual HCl lines with sufficient separation from terrestrial lines. In this presentation, we will show spatial distribution of HCl abundance at the cloud top, retrieved from processed spectra and compare them with previous studies.

Keywords: Venus, atmosphere, HCl, ground-based observation, radiative transfer

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Day-night contrast of the atmospheric circulation at the cloud top of Venus revealed by Akatsuki LIR

Kiichi Fukuya[1], *Takeshi Imamura[2], Makoto Taguchi[3], Tetsuya Fukuhara[3], Toru Kouyama[4], Takeshi Horinouchi[5], Javier Peralta[6], Masahiko Futaguchi[11], Takeru Yamada[3], Takao M. Sato[7], Atsushi Yamazaki[8], Shin-ya Murakami[10], Takehiko Satoh[8], Masahiro Takagi[9], Masato Nakamura[8]

1. Department of Earth and Planetary Science, The University of Tokyo, Japan, 2. Graduate School of Frontier Sciences, The University of Tokyo, Japan, 3. Rikkyo University, Japan, 4. Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, Japan, 5. Faculty of Environmental Earth Science, Hokkaido University, Japan, 6. Instituto de Astrofísica e Ciências do Espaço, Portugal, 7. Space Information Center, Hokkaido Information University, Japan, 8. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan, 9. Faculty of Science, Kyoto Sangyo University, Japan, 10. Research and Education Center for Natural Sciences, Keio University, 11. Omori Medical Center, Toho University, Japan

In spite of the importance of elucidating the atmospheric circulation of Venus from the viewpoint of planetary meteorology, winds at the cloud top of Venus have been measured predominantly on the dayside. Prominent poleward drifts have been observed with dayside cloud tracking and interpreted to be caused by thermal tides and a Hadley circulation; however, the lack of nightside measurements over broad latitudes has prevented the unambiguous characterization of these components. Here, we obtain cloud-tracked winds at all local times for the first time using thermal infrared images taken by LIR onboard the Venus orbiter Akatsuki. To suppress the random noise and topography-related stationary features present in the original images, we applied a moving average in the time domain in a coordinate system that rotates with the superrotating background atmosphere, thereby highlighting drifting cloud patterns. The occurrence of prominent equatorward flows was found on the nightside, resulting in null meridional velocities when these are zonally averaged. The velocity structure of the thermal tides were unambiguously determined for the first time. The semidiurnal tide was found to have an amplitude large enough to contribute to the maintenance of the atmospheric superrotation. The weakness of the mean meridional flow at the cloud top implies that the poleward branch of the Hadley circulation exists above the cloud top and the equatorward branch in the clouds. The LIR data, combined with the analysis method developed in this paper, would enable characterization of various types of atmospheric motions including waves and the mean flow with emphasis on the localtime dependence.

Keywords: Venus, Akatsuki, atmosphere

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Identification and characterization of quiescent cloud region "CALM" in the Akatsuki and Venus Express data

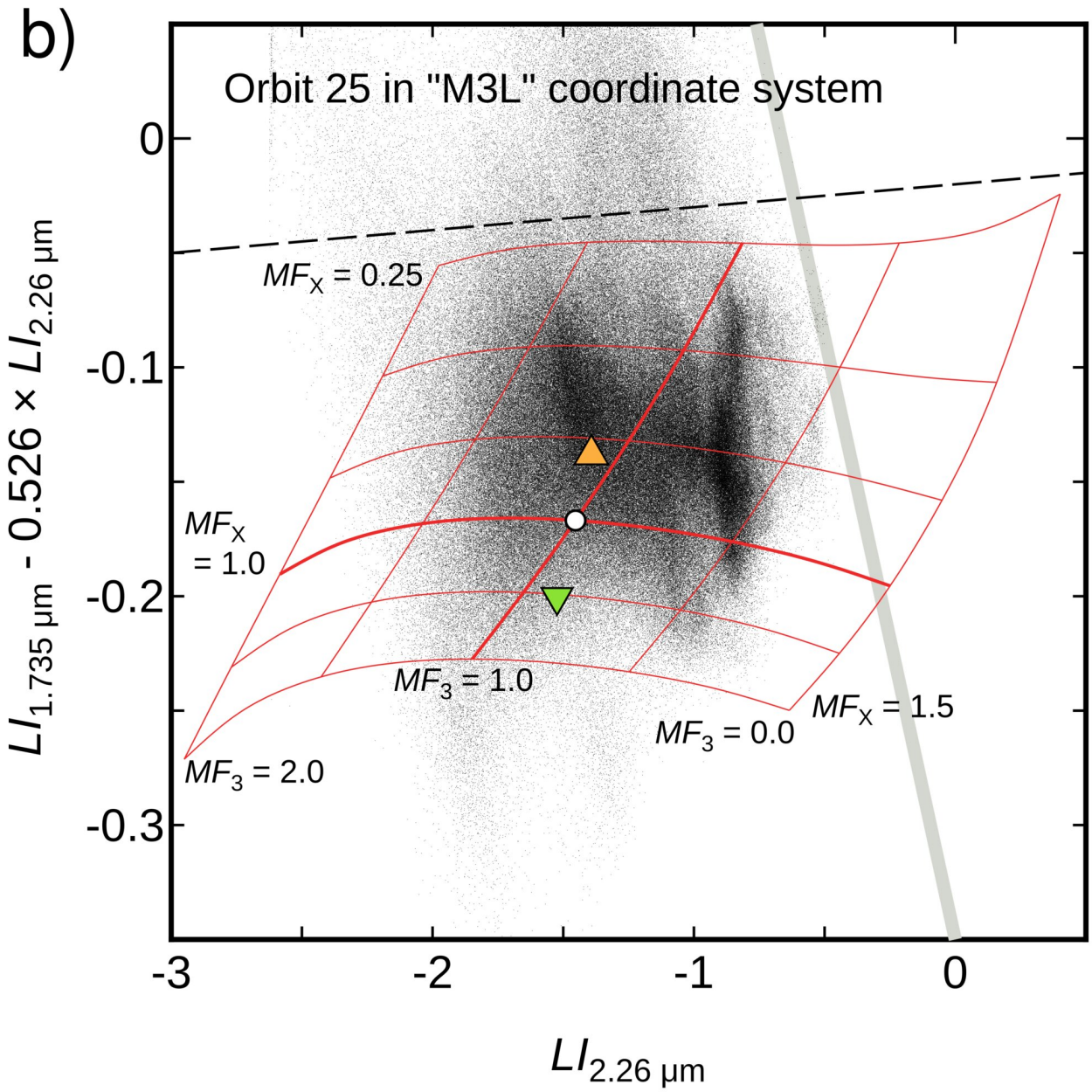
*Takehiko Satoh[1,2], Choon Wei Vun[3,2], Takeshi Horinouchi[4], Kevin McGouldrick[5], Takao M. Sato[6]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Dept of Space and Astronautical Science, SOKENDAI, 3. ZMP Inc., 4. Hokkaido University, 5. University of Colorado, Boulder, 6. Hokkaido Information University

"CALM" was identified in the Akatsuki IR2 data acquired during Orbits 24 and 25 (August 2016) once data (in 2.26- and 1.735-um filters) were plotted in a special coordinates: the horizontal axis is logarithm of radiance at 2.26 um while vertical axis (basically logarithm of radiance at 1.735 um) has been sheared such that the curve corresponding to varying amount of Mode 3 particles becomes almost level (M3L = Mode 3 Leveled). CALM appears as a concentration of data points in this correlation plot (Clouds Aligned Linearly in M3L coordinates) and is interpreted as relatively quiescent region in which aerosol sizes are determined by equilibrium. Because IR2 stopped working in December 2016, the available data set is limited. To identify more CALM-like regions and to characterize them, we have examined the data acquired by VIRTIS-M onboard Venus Express. Examples of CALM-like regions in VEx/VIRTIS-M data will be presented along with physical insights obtained through comparison with Akatsuki/IR2 data.

Keywords: cloud, microphysics, sulfuric acid, Akatsuki, Venus Express

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EnVision: Understanding why Earth's closest neighbour is so different

*Thomas Widemann[1], Richard Ghail[2], Colin Wilson[3], Dmitri Titov[4]

1. Observatoire de Paris, France, 2. Royal Holloway, U. of London, UK, 3. U. of Oxford, UK, 4. ESA-ESTEC, Noordwijk, Netherlands

EnVision is a proposed orbiter mission aiming at determining the nature and current state of Venus' geological evolution and its relationship with the atmosphere, to understand how and why Venus and Earth evolved so differently. It is is one of two M5 mission concepts in Phase A study with a final down-selection expected in June 2021. EnVision’ s overall science goals are

- to **characterise** the sequence of events that generated the regional and global surface features of Venus, and characterize the geodynamics framework that controls the release of internal heat over Venus history;

- to **search** for ongoing geological processes and determine whether the planet is active in the present era;

- to **characterise** regional and local geological units, to better assess whether Venus once had condensed liquid water on its surface and was thus perhaps hospitable for life in its early history.

EnVision will deliver new insights into geological history through complementary imagery, polarimetry, radiometry and spectroscopy of the surface coupled with subsurface sounding and gravity mapping; it will search for thermal, morphological, and gaseous signs of volcanic and other geological activity; and it will trace the fate of key volatile species from their sources and sinks at the surface through the clouds up to the mesosphere.

EnVision’ s science payload consists of VenSAR, a dual polarization S-band radar also operating as microwave radiometer, three spectrometers VenSpec-M, VenSpec-U and VenSpec-H designed to observe the surface and atmosphere of Venus, and the Subsurface Radar Sounder (SRS), a High Frequency (HF) sounding radar to probe the subsurface. These are complemented by a radio science investigation which achieves gravity mapping and radio occultation of the atmosphere, for a comprehensive investigation of the Venusian surface, interior and atmosphere and their interactions.

Keywords: Venus, Planetary surface, Planetary Interior, Planetary Atmosphere

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

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University), Chairperson:Hideo Sagawa(Kyoto Sangyo University)
Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.02 (Zoom Room 02)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

3:00 PM - 3:15 PM

[PPS02-18]Discussion

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

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.01_1

[P-PS02] Recent advances of Venus science and coming decades

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Thomas Widemann(Observatoire de Paris), Kevin McGouldrick(University of Colorado Boulder), Hideo Sagawa(Kyoto Sangyo University)

Akatsuki, Japan's Venus Climate Orbiter, has been operational in the Venus orbit for more than 5 Earth years, advancing our knowledge mostly about the atmospheric dynamics by feature tracking in the high-resolution imagery. Together with 8 years of coverage made by ESA's Venus Express (2006 - 2014), including spectroscopic information plus plasma measurements, we are in another golden age of Venus science decades after the landing missions of the USA and the former USSR in the 1970's. In addition, the Venus community has been eager to realize next generation missions to Venus. This session will cover all aspects of science related to Venus, either by observationally (including future missions) or by theoretically, about the planet itself or its surrounding environment or even implications to the exoplanets. Contributions by experts and by early-career researchers are all welcome.

[PPS02-P01] Observation and analysis of planetary lightning flashes using the ground-based telescope with Photomultiplier tube

*Tatsuharu Ono[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Shigeto Watanabe[1], Seiko Takagi[1], Masataka Imai[2] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 2.The National Institute of Advanced Industrial Science and Technology)

[PPS02-P02] Light curve recorded in Venus by LAC onboard Akatsuki

★Invited Papers

*Yukihiro Takahashi[1,4], Mitsuteru Sato[1,4], Masataka Imai[2], Ralph Lorenz[3], Tatsuharu Ono[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 2.The National Institute of Advanced Industrial Science and Technology (AIST), 3.Johns Hopkins Applied Physics Lab., 4.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

[PPS02-P03] Updates on the point-spread function of Akatsuki IR2 for improvement of night-side photometry

*Takehiko Satoh[1,2], Choon Wei Vun[3,2], Masafumi Kimata[4], Takao M. Sato[5] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Dept of Space and Astronautical Science, SOKENDAI, 3.ZMP Inc., 4.Ritsumeikan University, 5.Hokkaido Information University)

[PPS02-P04] Development of a Radiative Transfer Code of Venus Atmosphere in UV Region

*Tatsuro Iwanaka[1], Takeshi Imamura[1] (1.Graduate School of Science, The University of Tokyo)

[PPS02-P05] Topographic feature extraction from Akatsuki/LIR image using Conditional Generative Adversarial Network (CGAN) and Deep learning

*Masataka Imai[1], Toru Kouyama[1], Makoto Taguchi[2], Hiroki Ando[3], Masahiro Takagi[3] (1.Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, 2.Graduate School of Science, Rikkyo University, 3.Faculty of Science, Kyoto Sangyo University)

[PPS02-P06] Data assimilation of horizontal wind obtained from Akatsuki UVI observations focusing on thermal tides and attempts to produce Venus first analysis

*Yukiko Fujisawa[1], Shin-ya Murakami[1], Norihiko Sugimoto[1], Masahiro Takagi[2], Takeshi Imamura[3], Takeshi Horinouchi[4], George HASHIMOTO[5], Masaki Ishiwatari[4], Takeshi Enomoto[6], Takemasa Miyoshi[7], Yoshi-Yuki Hayashi[8] (1.Keio University, 2.Kyoto Sangyo University, 3.Tokyo University, 4.Hokkaido University, 5.Okayama University, 6.Disaster prevention Research Institute, Kyoto University, 7.RIKEN, 8.Kobe University)

[PPS02-P07] Revisiting Venus Doppler-wind maps obtained by ALMA: Impact of missing short-baseline data and uncertainty in the flux calibration

*Hideo Sagawa[1] (1.Kyoto Sangyo University)

Observation and analysis of planetary lightning flashes using the ground-based telescope with Photomultiplier tube

*Tatsuharu Ono[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Shigeto Watanabe[1], Seiko Takagi[1], Masataka Imai[2]

1. Department of Cosmosciences, Graduate School of Science, Hokkaido University, 2. The National Institute of Advanced Industrial Science and Technology

Lightning has been detected not only on Earth but also on Jupiter by spacecraft through night-side optical imaging and radio wave observations. Although there is still no critical evidence of the detection of lightning on Venus, it has discussed that lightning exists for 40 years. Detecting lightning is useful to observe the distribution of moist convection if the lightning generating process on Jupiter and Venus is the same mechanism as on Earth because the lightning activity would be correlated with moist convection activity. The moist convection generates terrestrial lightning in the convective water clouds through a charge-separation between liquid water droplets and water-ice particles by collision. The distribution of moist convection is important for understanding the general circulation, energy transport, and composition of Jupiter, Venus, and other Planets. In Venus, the generation mechanisms other than convection are volcanic, or aeolian triboelectric activity. In the previous study, there are radio wave observations and optical observations with CCD. One of them, the ground-based telescope observation has detected Venusian lightning (Hansell et al., 1995). However, no clear lightning flash has been detected by LAC (Lightning and Airglow Camera) onboard the AKATSUKI Venus Climate orbiter (Lorenz et al., 2019). There is no robust evidence of existence of Venusian lightning because it is difficult to distinguish between the lightning signal and the electrical noise, the observation area and period by spacecraft are limited, and the CCD's sensitivity is not enough to detect the lightning.

We have developed the Planetary Lightning Detector (PLD) to observe the Venusian and Jovian lightning optical flashes to obtain a longer observation period and cover the larger area, which is the high-speed and high-sensitive lightning detector mounted on a 1.6-m ground-based telescope by using a photomultiplier tube. PLD equips a narrowband filter (FWHM = 1 nm) of 777 nm for Venusian lightning which wavelength is the strongest emission line in the Venus lightning spectra (Borucki et al. 1996). PLD observe the light curve by using a photomultiplier tube. The minimum exposure time is 50 microseconds. The maximum time resolution is about $2x10^4$ points/s. The FOV of PLD can be changed to 5", 10", 30", 60" pinhole, and 2"x11" slit by using field stops to reduce the light from the dayside of the Venus. The signal is extracted from the background signal by applying a low-pass filter to the time series data to remove the shot noise and large time scale variation by Earth’s atmosphere. We have begun to observe Venus and Jupiter by using PLD from 2020. In our Venus observation, we could find several possible flashes that peak is 4 standard deviations above the background level. However, it is possible that these signals were formed by noise, and we haven’t yet been able to compare it with the noise. Also, our total observation period is not enough to compare with the previous study. We need to improve the noise reduction technique and increase the total observation time longer than 3 hours.

In this time, we will introduce the developed lightning observation instrument PLD, analysis method, and present our observation results obtained from May 2020. We will also make a presentation on the improvement plan of PLD.

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Keywords: Venus, Telescope, Photomultiplier tube, Lightning

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Light curve recorded in Venus by LAC onboard Akatsuki

*Yukihiro Takahashi[1,4], Mitsuteru Sato[1,4], Masataka Imai[2], Ralph Lorenz[3], Tatsuharu Ono[1]

1. Department of Cosmosciences, Graduate School of Science, Hokkaido University, 2. The National Institute of Advanced Industrial Science and Technology (AIST), 3. Johns Hopkins Applied Physics Lab., 4. Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

The existence of lightning discharge in Venus has been controversial for about four decades. In order to conclude this subject, we developed a lightning and airglow camera, LAC, onboard Akatsuki spacecraft, a Venus orbiter. LAC has a high-speed sampling rate at 20 kHz with 32 pixels of Avalanche Photo Diode (APD) matrix, and 777 nm narrow-band filter to detect lightning emission line of OI, which is expected by laboratory experiment in the CO2-dominant atmosphere. We have been conducting a lightning search in over 40 passes of AKATSUKI around Venus with triggering parameter sets optimized for the light curve similar to the normal lightning and also to sprite type with a longer time constant in the Earth. On March 1, 2020, LAC recorded a signal, which seems like a kind of optical flash. The total coverage of the LAC lightning hunt up to now was about 100 [million km2-hr]. If the flash is originated from lightning discharge, the occurrence rate could be equivalent to that with a ground-based telescope reported by Hansell et al. (1995). On the other hand, we are also examining the possibility of a bolide. If it’ s bolide, the magnitude observed on the ground might be 10 times brighter than a full moon on the ground of Earth. Here we discuss the possibilities of both cases based on the latest knowledge on the small object near the Venus orbit. Also, we explore the possibility and strategy for the investigation of small objects around Venus and other solar system planets.

Keywords: Venus, lightning, LAC, Akatsuki

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Updates on the point-spread function of Akatsuki IR2 for improvement of night-side photometry

*Takehiko Satoh[1,2], Choon Wei Vun[3,2], Masafumi Kimata[4], Takao M. Sato[5]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Dept of Space and Astronautical Science, SOKENDAI, 3. ZMP Inc., 4. Ritsumeikan University, 5. Hokkaido Information University

The 2-um infrared camera (IR2) onboard Akatsuki Venus orbiter utilizes a 1040x1040 pixels PtSi array sensor. When IR2 started imaging night-side emission of Venus (1.735, 2.26, and 2.32 um wavelengths), it was realized that intense light from the day crescent spread over a unexpectedly great extent. The cause of the large point-spread function (PSF) is thought to be multiple light reflection in the 400-um thick Si substrate of the sensor (Satoh et al., 2017). Photometric works with the IR2 night-side data were not possible, due to this PSF problem, until Satoh et al. (2021) introduced a method to remove (or reduce) the contamination from the day-side crescent. Their method is called "Restoration by Simple Subtraction (RSS)" which does NOT require precise knowledge about the PSF. Another possible method is to apply deconvolution to the night-side data so that the spread light is sucked back to the original position (the day-side) but this obviously require the knowledge about the PSF. We approximated the PSF with mathematical functions (Satoh et al., 2017; Sato et al., 2020) to successfully deconvolve the day-side data. The night-side data are more sensitive to subtle differences in PSF than the day-side data. We report updates of the IR2 PSF as obtained from the deconvolution experiments of the night-side data as well as some laboratory measurements.

Keywords: Akatsuki, sensor, point-spread function, multiple reflection

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Development of a Radiative Transfer Code of Venus Atmosphere in UV Region

*Tatsuro Iwanaka[1], Takeshi Imamura[1]

1. Graduate School of Science, The University of Tokyo

The clouds on Venus cover the entire planet and have a significant effect on the Venus system. The clouds are thought to be composed of sulfuric acid aerosols and produced photochemically from SO_2 (Mills et al., 2007), which is abundant below the cloud top (Bertaux et al., 1996). The mechanism of the transport of SO_2 to the cloud tops needs to be known to understand the atmospheric chemistry leading to cloud formation.
To obtain the spatial and temporal distribution of SO_2, Akatsuki has been taking 283-nm UV images since December 2015 at intervals of typically two hours. The wavelength of 283 nm corresponds to a strong absorption band of SO_2. From these images, we can retrieve the amount of SO_2 and its spatial and temporal variation to study the formation mechanism of clouds.
Here we would like to determine the variation of the mixing ratio of SO_2 at the cloud top from the 283-nm images with the aid of radiation transfer calculations with various sets of parameters. To calculate the radiative transfer in the UV region where scattering is dominant, we are developing a radiative transport code for a plane parallel atmosphere using the Adding-Doubling method. When discretizing the direction of radiation, the resolution in the parallel direction is much worse than that in the zenith direction on a latitude-longitude grid. In our code, we use the Lebedev quadrature to calculate the spherical integrals, which allows for a more uniform distribution of sample points on the sphere (Lebedev, 1975).
In this presentation, we show a comparison of the calculation results between several methods for solid angle integrals. We will also compare the calculation results with the observed dependences on the emission angle, incidence angle, and phase angle.

Keywords: Akatsuki, Venus atmosphere, radiative transfer

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Topographic feature extraction from Akatsuki/LIR image using Conditional Generative Adversarial Network (CGAN) and Deep learning

*Masataka Imai[1], Toru Kouyama[1], Makoto Taguchi[2], Hiroki Ando[3], Masahiro Takagi[3]

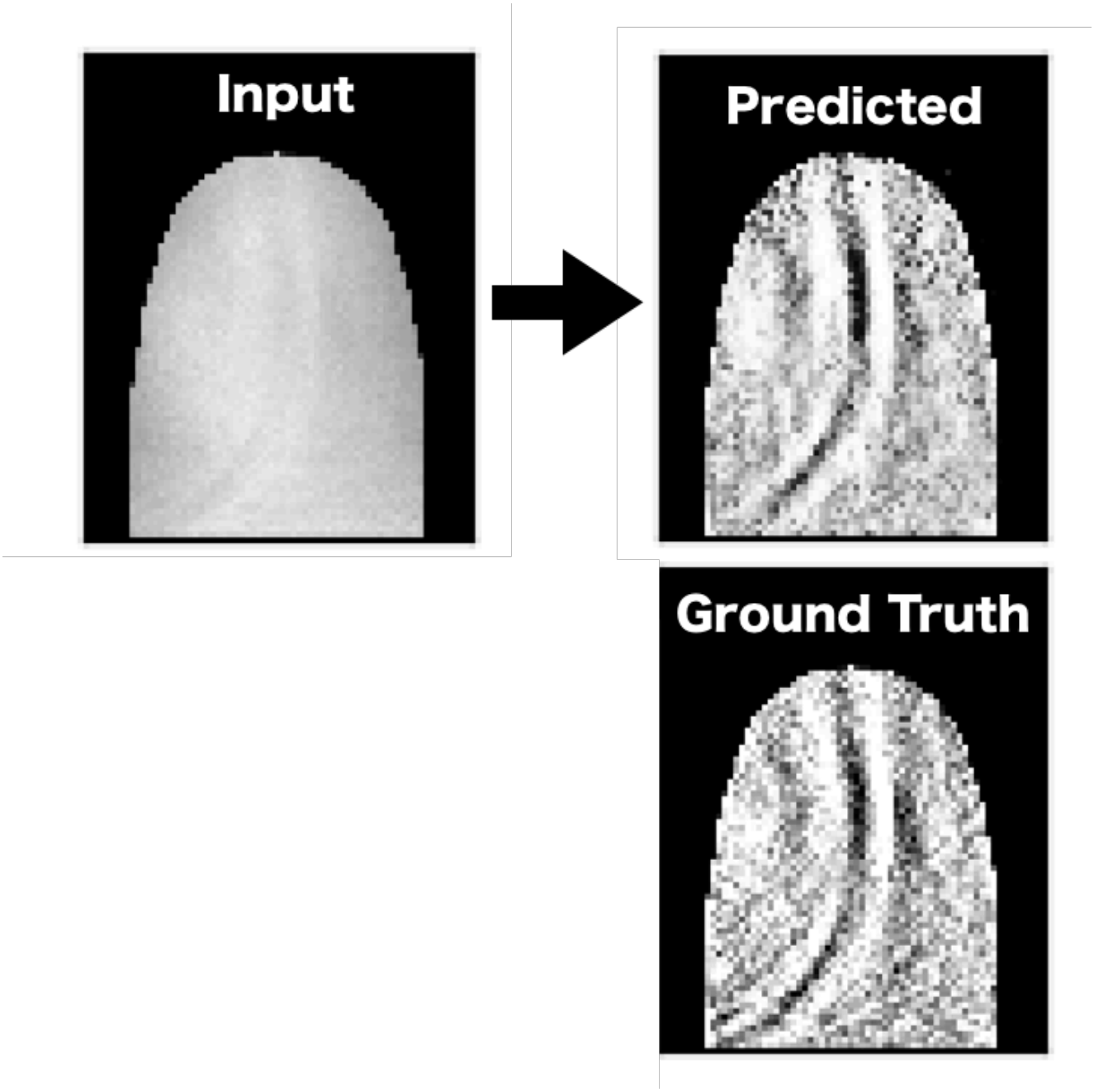
1. Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology, 2. Graduate School of Science, Rikkyo University, 3. Faculty of Science, Kyoto Sangyo University

Venus has a thick global cloud layer in an altitude range of 40–70 km, and the atmosphere rotates over 100 ms^{-1} from east to west. This mysterious fast wind is named the Super-rotation. Thermal tides are global-scale atmospheric waves excited in the cloud layer by the solar heating and are regarded as one of the mechanisms maintaining the entire Super-rotation. The LIR (Long-wave Infrared camera) onboard Akatsuki Venus orbiter observes 10 μm of global thermal emissions from ~70 km cloud-top and successfully retrieves the temperature perturbation associated with diurnal and semidiurnal tides. However, zonal and meridional wind measurements covering all local time have not been archived yet, and it is critical to evaluate the angular momentum transport by thermal tides.

The LIR mainly observes thermal perturbations due to gravity waves generated by the surface topography. While the LIR can also capture mesoscale features migrating with the Super-rotation, it was challenging to use these features for cloud tracking because of the low SN ratio. In order to distinguish such minor features from the topographic features, we conducted machine-learning-based feature extraction. We used Conditional Generative Adversarial Network (CGAN) model, which is used widely in image generation and its algorithm architectures include two neural networks the generator and the discriminator. The generator generates synthetic instances from inputs, and the discriminator evaluates the instances and facilitating the learning. In this study, we initially tested to reconstruct high-pass filtered LIR images. In the training phase, the CGAN takes as input a set of image pairs, one is a single LIR image high-pass filtering (by this we mean a low SN image hard to interpret minor features) and a corresponding high-pass filtered image where sequential 30 images were stacked in the geographic coordinate system. The CGAN then tries to 'learn' to recover the degraded image by minimizing the difference between the recovered image and the non-degraded image. In our first trial, we reduced the spatial resolution from 0.25° in longitude and latitude to 1° to accelerate the learning and success to reconstruct feature-enhanced images (Figure). Based on this result, we can distinguish major features from the original image. Our next step is applying the coordinate system that rotates with the background superrotation for stacking the ground truth image. In this presentation, we will show the results of CGAN machine learning-based temperature perturbation extraction from LIR images and discuss the future possibility of utilizing LIR images for cloud tracking.

Keywords: Venus, Akatsuki, Deep learning, Atmospheric Mountain Waves

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Data assimilation of horizontal wind obtained from Akatsuki UVI observations focusing on thermal tides and attempts to produce Venus first analysis

*Yukiko Fujisawa[1], Shin-ya Murakami[1], Norihiko Sugimoto[1], Masahiro Takagi[2], Takeshi Imamura[3], Takeshi Horinouchi[4], George HASHIMOTO[5], Masaki Ishiwatari[4], Takeshi Enomoto[6], Takemasa Miyoshi[7], Yoshi-Yuki Hayashi[8]

1. Keio University, 2. Kyoto Sangyo University, 3. Tokyo University, 4. Hokkaido University, 5. Okayama University, 6. Disaster prevention Research Institute, Kyoto University, 7. RIKEN, 8. Kobe University

Observations of the Venus Orbiter “Akatsuki” provide us with horizontal distributions of the horizontal wind derived from cloud tracking of the UVI camera and of temperature observed by the LIR camera. However, these observations are very limited with respect to the altitude, local time (day or night side), and frequency. It is difficult to elucidate the general circulation including various temporal and spatial scales only from observations. In this study, we aim to produce a Venus objective analysis that has high temporal and spatial resolutions by assimilating the Akatsuki observations into a general circulation model.

At the top of the cloud layer of Venus, there are planetary-scale atmospheric waves that are excited by solar heating and move with the sun, called the thermal tides. In the previous studies, it is pointed out that phases of thermal tides in our atmospheric general circulation model “AFES-Venus” [1] are different from those of Akatsuki observations. Sugimoto et al. (2019) [2] assimilated horizontal wind data of the Venus Express into AFES-Venus by the Venus atmospheric data assimilation system “ALEDAS-V” [3] based on the Local Ensemble Transform Kalman Filter (LETKF) and confirmed that phases of thermal tides are improved. In this presentation, we assimilate the horizontal wind obtained from the UVI (365 nm) of Akatsuki using cloud tracking (Ikegawa and Horinouchi, 2016[4]) to the altitude of 70 km of ALEDAS-V for the period from September to December 2018, and show the results of an attempt to improve phases of the thermal tides as in Sugimoto et al. (2019).

The figure shows the latitude-longitude cross sections calculated by the composite means over November 2018 at the sub-solar point (fixed at the center of each panel). Each figure is a weighted mean between altitudes of 53 km and 81 km using the LIR weighting function based on Taguchi et al. (2007) [5]. Figure (a,c,e) are the results without data assimilation (free run forecast; “frf”), and figure (b,d,f) are the results of horizontal wind assimilation.

For zonal wind, the assimilated result (b) shows a shift of the structure of the zonal wave number 2 near the equator by about 30 degrees in the direction opposite to the rotation compared to frf (a), and the phase of the thermal tide successfully improved. For temperature, the assimilated result (f) shows a shift in the structure of the zonal wavenumber 2 near the equator compared to frf (e), and the assimilation of the horizontal wind improved the phase of temperature as well as wind speed.

For the future work, we plan to release these assimilation results as the objective analysis data of Venus for the first time in the world.

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[3] Sugimoto, N., A. Yamazaki, T. Kouyama, H. Kashimura, T. Enomoto, and M. Takagi (2017), Scientific Reports, 7(1), 9321.
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[5] Taguchi, M., T. Fukuhara, T. Imamura, M. Nakamura, N. Iwagami, M. Ueno, M. Suzuki, G. L. Hashimoto, and K. Mitsuyama, (2007), Adv. Space Res., 40, 861–868.

Keywords: Akatsuki, Venus atmosphere, Data assimilation

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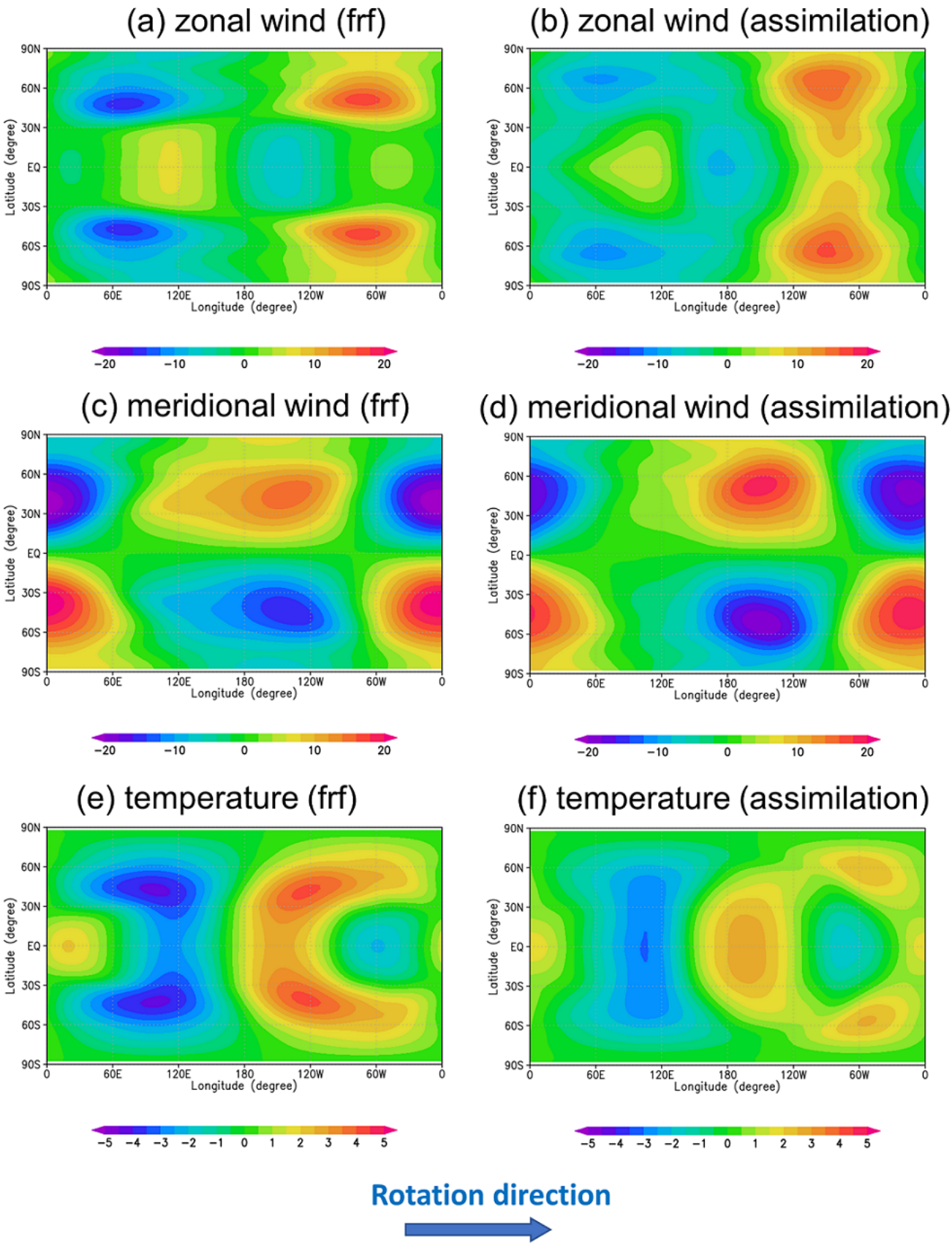


Figure: Latitude-longitude cross sections calculated by the composite means over November 2018 at the sub-solar point (fixed at the center of each panel). Each figure is a weighted mean between altitudes of 53 km and 81 km using the LIR weighting function based on Taguchi et al. (2007). Figure (a,c,e) are the results without data assimilation (free run forecast; “frf”), and figure (b,d,f) are the results of horizontal wind assimilation.

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Revisiting Venus Doppler-wind maps obtained by ALMA: Impact of missing short-baseline data and uncertainty in the flux calibration

*Hideo Sagawa[1]

1. Kyoto Sangyo University

Venus atmospheric dynamics is well known with its super-rotating circulation in the troposphere (below the cloud layer). A different circulation regime, that is, subsolar-to-antisolar (day-to-night) flow is considered to be dominant in the upper thermosphere. The dynamics in the intermediate region, i.e., middle/upper atmosphere above the cloud layer, is an important topic to understand how the global circulation changes from the super-rotation to the subsolar-to-antisolar flow. Although the observational constraints of the middle/upper atmospheric dynamics are still limited, the most widely employed observation technique is to measure a Doppler-shift of carbon monoxide (CO) absorption line at millimeter and sub-millimeter wavelengths. The derived Doppler-shift tells us a wind velocity projected along the line-of-sight of observation (a.k.a. “Doppler-wind”) at altitudes of ~95-110 km [e.g., 1-3]. ALMA (Atacama Large Millimeter/submillimeter Array) is undoubtedly one of the most essential and attractive observational facilities to obtain spatial distribution of such Doppler-winds on Venus disk. On the other hand, interferometric observations of Solar system planets, which are very bright and large, often encounter several technical problems compared to other astronomical observations. One of the shortcomings of interferometric observations of Solar system planets is the lack of short-baseline visibilities, i.e., lack of the sensitivity to large-spatial scale brightness distribution. This is known as a “resolve-out” problem and is unavoidable when observing Venus near the inferior conjunction (apparent disk diameter is ~40-60 arcsec). Another caveat of ALMA Venus CO observation is the effect of uncertainty in the flux calibration. Recently, it is reported that the current flux calibration (including the raw data acquisition) scheme in the ALMA data can introduce significant errors in the absolute flux and also in the spectral line shape for any very bright objects [4]. In fact, the presence of such errors has been confirmed with other ALMA data of Mars [5]. The unwilling (and without knowing) distortion of the spectral line shape becomes a critical issue when interpreting the Doppler-wind maps.
This presentation reviews the technical issues of observing Venus with ALMA, and evaluate the impact of those technical issues on the Doppler-wind maps by running radiative transfer and ALMA observation simulations.

[1] Lellouch et al. (2008), PSS 56, 1355–1367.
[2] Clancy et al. (2012), Icarus 217, 794–812.
[3] Moullet et al. (2012), A&A 546, id.A102, 12 pp.
[4] ALMA knowledge base:
https://help.almascience.org/kb/articles/what-errors-could-originate-from-the-correlator-spectral-normalization-and-tsys-calibration
[5] ALMA Mars data are being analyzed in collaborations with Shohei Aoki (University of Liège, Belgium), Kazi Rygl (INAF, Italy), and Eric Villard (European Southern Observatory).

Keywords: Venus atmosphere, ALMA

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

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.04 Zoom Room 04

[P-PS06] Planetary Sciences

convener:Yusuke Nakauchi(Japan Aerospace Exploration Agency), Hiroshi Kikuchi(Japan Aerospace Exploration Agency), Chairperson:Yuri Fujii(Graduate School of Human and Environmental Studies, Kyoto University), Haruka Hoshino(Department of Astronomy, Graduate School of Science, The University of Tokyo)

We call for general interest papers for Planetary Sciences. Planetary Sciences consist o f a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

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

[PPS06-01] Size evolution of close-in super-Earths: effects of giant impacts and photoevaporation

*Yuji Matsumoto[1], Eiichiro Kokubo[2], Pin-Gao Gu[1], Kenji Kurosaki[3] (1.ASIAA, 2.NAOJ, 3.Nagoya Univ.)

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

[PPS06-02] Stellar mass dependence of planetary systems formed by giant impacts: minimum-mass exstrasolar nebula model and habitable planets

*Haruka Hoshino[1,2], Eiichiro Kokubo[2,1] (1.Department of Astronomy, Graduate School of Science, The University of Tokyo, 2.Division of Science, National Astronomical Observatory of Japan)

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

[PPS06-03] Collisional Growth and Fragmentation of Dust Aggregates with Low Mass Ratios

*Yukihiko Hasegawa[1], Takeru Suzuki[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Koji Wada[4] (1.The University of Tokyo, 2.Tohoku University, 3.Nagoya University, 4.Chiba Institute of Technology)

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

[PPS06-04] The amount of cosmic rays in protoplanetary disks and their effects on ionization degrees

*Yuri I. Fujii[1], Shigeo Kimura[2] (1.Kyoto University, 2.Tohoku University)

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

[PPS06-05] Suppression of the vertical shear instability in protoplanetary disks by dust growth : Implications for disk observations

*Yuya Fukuhara[1], Satoshi Okuzumi[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

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

[PPS06-06] Constructing a model of metal accretion disks around white dwarf stars: toward understanding the evolution of remnant planetary systems

*Ayaka Okuya[1], Shigeru Ida[2], Ryuki Hyodo[3] (1.Department of Earth & Planetary Sciences, Tokyo Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.JAXA/ISAS)

Size evolution of close-in super-Earths: effects of giant impacts and photoevaporation

*Yuji Matsumoto[1], Eiichiro Kokubo[2], Pin-Gao Gu[1], Kenji Kurosaki[3]

1. ASIAA, 2. NAOJ, 3. Nagoya Univ.

To date, transit observations report more than 3000 exoplanets, and we know their orbital architecture, i.e., their size and period distribution. The size distribution of super-Earths in close-in orbits is bimodal with a radius gap (e.g., Fulton et al., 2017). Besides, planetary sizes within systems show that adjacent planet pairs have the same size and separations (peas in a pod; e.g., Weiss et al., 2018). We have investigated whether these features are explained simultaneously. The former feature, the radius gap, is considered as a result of envelope evolution through photoevaporation (e.g., Owen & Wu 2017) or other mechanisms (e.g., Gupta & Schlichting 2019). The latter feature, peas in a pod, is not well investigated. It still remains unclear whether this feature is reproduced in the formation processes of planetary systems. We consider planetary growth via giant impacts along with the envelope loss via both giant impacts and photoevaporation to study the size evolution of planets. We have developed the N-body simulation code where planetary sizes are derived by the summation of the core size and envelope size using the scaling law (Valencia et al. 2006) and analytical expression (Owen & Wu 2017). We also consider the envelope loss in giant impacts based on recent SPH simulation results (Kegerreis et al. 2020). We have performed simulations by changing initial envelope fractions and surface density profiles of protoplanets based on observations (Dai et al., 2020).
Our simulations show that impacts are not head-on but grazing encounters, which do not cause significant envelope loss. However, high-velocity collisions sometimes cause whole envelope loss events. As a result, some bare rocky planets are formed. These bare rocky planets are located at inner orbits and have larger masses, typically, since they tend to experience a larger number of collisions. Interestingly, these massive planets barely lose their whole envelope via photoevaporation, especially when the surface density profiles of protoplanets are shallow, i.e., inner protoplanets are massive. We also found that there are several planets located in the outer region where the initial envelopes can be retained. Small inner planets lose their envelopes via photoevaporation. The final size distribution of planets is bimodal due to the envelope loss via photoevaporation. The distribution of planets on the period-radius plane roughly agrees with that of observed planets. In addition, the neighboring formed planets have the same size and same separations. The combination of giant impacts and photoevaporation provides a possible explanation of the orbital architecture of observed super-Earths. However, our results produce too many large planets. This suggests that some additional envelope loss mechanisms are necessary to explain the observed size distributions of planets.

Keywords: Planet size, Super-Earth, Giant impact, Photoevaporation

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Stellar mass dependence of planetary systems formed by giant impacts: minimum-mass exstrasolar nebula model and habitable planets

*Haruka Hoshino[1,2], Eiichiro Kokubo[2,1]

1. Department of Astronomy, Graduate School of Science, The University of Tokyo, 2. Division of Science, National Astronomical Observatory of Japan

Recent exoplanet surveys revealed that for solar-type stars close-in super-Earths are ubiquitous and many of them are in multi-planet systems. These systems are more compact than the solar system’s terrestrial planets. Ongoing and future exoplanet observations will find more planets around low-mass stars. However, there are not many theoretical studies on the formation of such planets around low-mass stars. Now is the time to clarify the dependence of the stellar mass on planet formation. In the standard model, the final stage of terrestrial planet formation is the giant impact stage where protoplanets gravitationally scatter and collide with each other, to evolve into a stable planetary system. We investigate the effect of the stellar mass on the architecture of planetary systems formed by giant impacts. We perform *N*-body simulations of the giant impact stage around different stellar masses. Using the minimum-mass extrasolar nebula model, we set the isolation mass of protoplanets and distribute them in 0.05 - 0.15 au from the central star. We follow the evolution for 200 million orbital periods of the innermost planet. We find that the eccentricity and inclination of orbits, and the orbital separation of adjacent planets increase with decreasing the stellar mass. This is because that as the stellar mass decreases the relative strength of planetary scattering becomes more effective. We also discuss the properties of planets formed in the habitable zone.

Keywords: planetary system formation, terrestrial planet, giant impact, stellar mass

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Collisional Growth and Fragmentation of Dust Aggregates with Low Mass Ratios

*Yukihiko Hasegawa[1], Takeru Suzuki[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Koji Wada[4]

1. The University of Tokyo, 2. Tohoku University, 3. Nagoya University, 4. Chiba Institute of Technology

We investigated fundamental processes of collisional sticking and fragmentation of dust aggregates composed of submicron-sized icy dust monomers. We carried out N-body simulations of dust monomers. We examined the condition for collisional growth of two colliding dust aggregates in a wide range of the mass ratio, 1-64. We found that the mass transfer from a larger dust aggregate (called a target) to a smaller one (called a projectile) is a dominant process in collisions with a mass ratio of 2-30 and the impact velocity of about 30-170 m per s. As a result, the critical velocity for collisional fragmentation of the target is considerably reduced for such unequal-mass collisions; the critical fragmentation velocity of collisions with a mass ratio of 3 is about half of that obtained from equal-mass collisions. The impact velocity is generally higher for collisions between dust aggregates with higher mass ratios because of the difference between the radial drift velocities in the typical condition of protoplanetary disks. Therefore, the reduced critical fragmentation velocity for unequal-mass collisions would delay growth of dust grains in the inner region of protoplanetary disks.

Keywords: Numerical simulation, Planet formation, Protoplanetary disk

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The amount of cosmic rays in protoplanetary disks and their effects on ionization degrees

*Yuri I. Fujii[1], Shigeo Kimura[2]

1. Kyoto University, 2. Tohoku University

Protoplanetary disk gas is weakly ionized by various ionization sources, such as cosmic rays, X-rays, ultraviolet, and decay of radionuclides. Ionization fraction of the gas is essential information to study the magnetohydrodynamic evolution of the disk, because it determines the coupling between the gas and magnetic fields. Cosmic rays are also known to play an important role in chemical evolution by triggering reactions in the disk. Thus, we need to understand how deep inside of the disk cosmic rays can penetrate. Previous studies adopted interstellar cosmic-ray ionization rate at the surface of the disk and the attenuation of cosmic rays are considered based on the vertical column of the gas from the point of interest to the surface of the disk/infinity. However, the actual path of cosmic ray particles should be affected by magnetic fields, and thus so will the column density swept by them. Cosmic rays are focused towards a protoplanetary disk from a larger area by magnetic fields, but some of them are reflected due to magnetic mirrors; in total, we found that the flux arriving at a protoplanetary disk is reduced by a factor of 4. We also found that low energy cosmic rays are captured by azimuthal component of the fields in the surface area of the disk and lose their energy before entering to the inside. Thus, the cosmic-ray ionization rate is expected to be smaller than previously thought.

Keywords: Cosmic rays, Protoplanetary Disks, Ionization fraction, Magnetic fields

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Suppression of the vertical shear instability in protoplanetary disks by dust growth : Implications for disk observations

*Yuya Fukuhara[1], Satoshi Okuzumi[1]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Planet formation depends on dust evolution and distribution in protoplanetary disks. Among them, strong dust settling to the midplane in disks promotes dust growth and planetesimal formation. One of the observational evidence of this dust settling is the protoplanetary disk around HL Tau. Recent radio interferometric observations have provided us with evidence that the HL Tau disk has rings and gaps of dust. Because these gaps have well separated and showing a high degree of contrast with the rings, the dust in outer regions in the HL Tau disk settles in the vertical direction.
This dust settling to the midplane means that the vertical turbulent diffusion is weak in outer disk regions. However, the vertical shear instability (VSI), which is the most robust turbulent origin in outer disk regions, drives turbulence with efficiently preventing vertical dust settling. This is about 10 times stronger than the intensity of vertical diffusion estimated from observations of the HL Tau disk. If the VSI drives turbulence in the HL Tau, the strong settling of dust may not occur.
On the other hand, One candidate of factors that weaken the turbulence of this VSI is dust growth and settling. The VSI requires rapid gas cooling and has been suggested to operate in outer disk regions. Dust growth and settling to the midplane affect the cooling rate distribution of disks and make the cooling above the midplane inefficient.
In this study, we develop a model to estimate the diffusion coefficient of the VSI-driven turbulence based on the linear analysis, taking into account dust evolution. Furthermore, by applying this model to the HL Tau disk, we discuss whether the observed dust settling is feasible or not. The model consists of the following two steps. In the first step, we calculate the region where the VSI can be driven and the VSI growth rate by linear analysis, taking into the dust distribution with settling in the disk. In the second step, we estimate the vertical diffusion coefficient of the VSI-driven turbulence from them. We construct the model to be consistent with the hydrodynamical simulations of the VSI. Comparing the estimated diffusion coefficient and the assumed one that is necessary to calculate the dust distribution given initially, we investigate how the VSI-driven turbulence evolves.
We find that dust diffusion due to the VSI-driven turbulence is weakened and dust settling is possible consistent with the HL Tau observations. As the dust particles grow up to 1 mm, the vertical diffusion coefficient of the VSI-driven turbulence is expected to settle down to about 10^(-4), which is consistent with the maximum value of the vertical diffusion coefficient ~10^(-4) assumed from observations. Even if the dust diffuses strongly temporarily due to the VSI, the dust cannot sustain this strong diffusion and may settle on the midplane.
Our results suggest that dust evolution may suppress the VSI-driven turbulence, which causes strong dust diffusion. Given that turbulence generally prevents dust coagulation and planetesimal formation, this may promote dust growth and planetesimal formation under the VSI-driven turbulence.

Keywords: protoplanetary disks, dust evolution, turbulence, vertical shear instability, HL Tau disk

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Constructing a model of metal accretion disks around white dwarf stars: toward understanding the evolution of remnant planetary systems

*Ayaka Okuya[1], Shigeru Ida[2], Ryuki Hyodo[3]

1. Department of Earth & Planetary Sciences, Tokyo Institute of Technology, 2. Earth-Life Science Institute, Tokyo Institute of Technology, 3. JAXA/ISAS

White dwarfs are the final evolutionary state of stars with a mass less than ~8 Msun. 1/2-1/4 of all WDs exhibit metal pollution in their atmospheres (Zuckerman et al. 2010), and some of them show infrared excess from their circumstellar debris disks (Rocchetto et al. 2015). These are thought to be originated from the remnant planetary systems around WDs which evolve with their central stars. The surviving asteroids/minor planets are gravitationally scattered onto star-grazing orbits, and the subsequent tidal disruption is likely to produce compact accretion disks. Based on this scenario, an accretion disk model is essential to link a rapidly growing number of these observations around WDs to surviving planetary systems as well as their evolution.
In this study, we construct a 1-dimensional WD disk model that consistently solves key processes in such disks: advection, diffusion, sublimation, and condensation. We firstly investigated the time evolution of accretion disks composed of silicate particles and their vapor. For the particulate disk, Poynting-Robertson (PR) drag is thought to drive the metal accretion. On the other hand, observations have shown that WDs accompanied by debris disks tend to have accretion rates orders of magnitude higher than that can be explained by PR drag alone (~ 1e8 g/s). Metzger et al. (2012) demonstrated that if the aerodynamic drag due to vapor produced by the sublimation of silicate particles is effective, the accretion rate could reach such measured values. However, they neglected the back-reaction and diffusion of particles in the gas and condensation of silicate vapor. As a result of our calculation including these effects, we found that the accretion rate enhancement proposed by Metzger et al. (2012) does not occur because the vapor density determined by the saturating vapor pressure outside the sublimation line is so low that it cannot affect the particle motion. Furthermore, near the silicate sublimation line, silicate vapor advects/diffuses outward and then recondenses into the solid particles. This causes a pile-up of the particles just outside the sublimation line, resulting in a lower accretion rate than even that predicted by PR drag alone. Finally, we will discuss the possibility that the disk with vapor produced by solid components with lower sublimation points than silicates (e.g., water ice) could reproduce the observational high accretion rates.

Keywords: White dwarf stars, Debris disks, Exoplanets

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

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.04 Zoom Room 04

[P-PS06] Planetary Sciences

convener:Yusuke Nakauchi(Japan Aerospace Exploration Agency), Hiroshi Kikuchi(Japan Aerospace Exploration Agency), Chairperson:Hiroshi Kikuchi(Japan Aerospace Exploration Agency), Yusuke Nakauchi(Japan Aerospace Exploration Agency)

We call for general interest papers for Planetary Sciences. Planetary Sciences consist o f a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

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

[PPS06-07] ALMA high resolution observations of the transitional disk around SY Cha.

*Ryuta Orihara[1], Munetake Momose[1], Takayuki Muto[2], Jun Hashimoto[3], Hauyu Baobab Liu[4], Takashi Tsukagoshi[5], Tomoyuki Kudo[5], Sanemichi Takahashi[5], Yi Yang[5,6], Yasuhiro Hasegawa[7], Ruobing Dong[8], Mihoko Konisi[9], Eiji Akiyama[10], Masato Ishiduka[6] (1.Ibaraki University, 2.Kogakuin University, 3.Astrobiology Center, 4.Academia Sinica Institute of Astronomy and Astrophysics, 5.National Astronomical Observatory of Japan, 6.University of Tokyo, 7.NASA Jet Propulsion Laboratory, 8.University of Victoria, 9.Oita University, 10.Niigata institute of technology)

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

[PPS06-08] Model calculation of infrared and radio observations of the circumplanetary disks: Conditions for satellite formation

*Bochao Hu[1], Hideko Nomura[2] (1.Tokyo Institute of Technology/National Astronomical Observatory of Japan, 2.National Astronomical Observatory of Japan)

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

[PPS06-09] Development of a Hayabusa2 ONC image retrieval system with 2D/3D switchable maps in a web browser

*Hiroshi Kikuchi[1], Mitsuo Yamamoto[1], Yasuhiro Yokota[1], Hiroyuki Sato[1], Hisashi Otake[1], Rie Honda[2], Seiji Sugita[3], Tomokatsu Morota[3], Toru Ishikawa[4], Kazuya Imaki[4], Yasuyuki Watabe[4], Takeshi Konishi[5], Ryodo Hemmi[3], Hideaki Miyamoto[3], Yukio Yamamoto[1], Naru Hirata[6], Naoyuki Hirata[7], Sho Sasaki[8], Goro Komatsu[9], Hirohide Demura[6], Chikatoshi Honda[6], Manabu Yamada[10], ERI TATSUMI[11], Yuichiro Cho[3], Kazuo Yoshioka[3], Hirotaka Sawada[1], Naoya Sakatani[12], Masahiko Hayakawa[1], Moe Matsuoka[1], Toru Kouyama[13], Hidehiko Suzuki[14], Kazunori Ogawa[1] (1.JAXA, 2.Kochi Univ., 3.Univ. of Tokyo, 4.JAMSS, 5.Konniesystem, 6.Univ. of Aizu, 7.Kobe Univ., 8.Osaka Univ., 9.IRSPS, Università d'Annunzio, 10.Chiba Inst. Tech., 11.IAC, 12.Rikkyo Univ., 13.AIST, 14.Meiji Univ.)

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

[PPS06-10] Martian Moons eXploration MMX: Current Status Report 2021

*Kiyoshi Kuramoto[1,2], Yasuhiro Kawakatsu[2], Masaki Fujimoto[2], Maria Antonietta Barucci[3], Hidenori Genda[4], Naru Hirata[5], Takeshi Imamura[6], Jörn Helbert[7], Shingo Kameda[8], Masanori Kobayashi[9], Hiroki Kusano[10], David J. Lawrence[11], Koji Matsumoto[12], Patrick Michel[13], Hideaki Miyamoto[6], Hiromu Nakagawa[14], Tomoki Nakamura[14], Kazunori Ogawa[2], Hisashi Otake[2], Masanobu Ozaki[2], Sara Russell[15], Sho Sasaki[16], Hiroki Senshu[9], Naoki Terada[14], Stephan Ulamec[7], Tomohiro Usui[2], Koji Wada[9], Shoichiro Yokota[16] (1.Hokkaido University, 2.JAXA, 3.Paris Observatory, 4.Tokyo Institute of Technology, 5.Aizu University, 6.The University of Tokyo, 7.DLR, 8.Rikkyo University, 9.Chiba Institute of Technology, 10.QST, 11.Johns Hopkins University APL, 12.NAOJ, 13.Université Côte d'azur, 14.Tohoku University, 15.Natural History Museum, 16.Osaka University)

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

[PPS06-11] The orbital evolution of Phobos in the expanded atmosphere of early Mars under an intense solar EUV radiation

*Kohei Fujita[1], Naoki Terada[1], Shotaro Sakai[1], Kaori Terada[1] (1.Tohoku University)

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

[PPS06-12] Hydrodynamic escape of reduced proto-atmospheres: different consequences for surface volatile inventories between Mars and Earth

*Tatsuya Yoshida[1], Kiyoshi Kuramoto[1] (1.Hokkaido University)

ALMA high resolution observations of the transitional disk around SY Cha.

*Ryuta Orihara[1], Munetake Momose[1], Takayuki Muto[2], Jun Hashimoto[3], Hauyu Baobab Liu[4], Takashi Tsukagoshi[5], Tomoyuki Kudo[5], Sanemichi Takahashi[5], Yi Yang[5,6], Yasuhiro Hasegawa[7], Ruobing Dong[8], Mihoko Konisi[9], Eiji Akiyama[10], Masato Ishiduka[6]

1. Ibaraki University, 2. Kogakuin University, 3. Astrobiology Center, 4. Academia Sinica Institute of Astronomy and Astrophysics, 5. National Astronomical Observatory of Japan, 6. University of Tokyo, 7. NASA Jet Propulsion Laboratory, 8. University of Victoria, 9. Oita University, 10. Niigata institute of technology

Transitional disks have a cavity with weak dust emission in the central region, and they are thought to be highly evolved protoplanetary disks. The formation mechanism of such disks is still not known. Transitional disks are identified as objects with low infrared excess in the spectral energy distribution (SED). However, it is difficult to classify transitional disks only with SED. There is a class of disks so-called "pre-transitional disks", which has a small inner disk in the cavity of the outer transitional disk. These are considered to be precursors to the transitional disks and therefore are important in understanding disk evolution processes. Since the SED of a pre-transitional disk is indistinguishable from that of a transitional disk, high-resolution observations that reveal the actual structure of gas and dust at a small scale are necessary to study disk evolution and planet formation.
In this presentation, we report the results of high-resolution (0.14 arcsec) observations of the 225 GHz dust continuum and CO molecular emission lines from SY Cha (distance: 180.7 pc, mass: 0.5-0.7 Msun, age: 3 million years), which is selected from a sample of objects showing transitional disk features in their SEDs. In the dust continuum emission, a ring structure with the radius of about 100 au is detected, as well as a central point source that has not been identified before from SED analyses. Our high resolution observations clearly reveal the inner cavity and the central point source for the first time. We fit the radial profiles of dust continuum emission and find that there is a Gaussian ring of 35 au in radial width on top of another flattened ring with the radial width of 135 au. The reduced chi-square value for the best-fit model is 1.38, which is calculated for actual visibility data in the processes of MCMC fitting. We also find that there is a weak asymmetry in dust continuum emission.
In our observations, 12CO(2-1) and 13CO(2-1) emission are also detected. We estimate the surface density of gas and find that the total gas mass is comparable with that of dust, indicating that the gas is highly depleted. We also find that the gas is present inside the dust cavity. The analysis of the velocity structure of the 12CO(2-1) emission line suggests that the velocity is distorted at the location of the dust inner disk. This may be due to warp of the disk or radial gas flow within the cavity of the dust disk. In our presentation, we report the basic properties of the transitional disk system associated with SY Cha derived from the observations.

Keywords: ALMA, protoplanetary disk, transitional disk, warp

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Model calculation of infrared and radio observations of the circumplanetary disks: Conditions for satellite formation

*Bochao Hu[1], Hideko Nomura[2]

1. Tokyo Institute of Technology/National Astronomical Observatory of Japan, 2. National Astronomical Observatory of Japan

Satellites are believed to be formed from circumplanetary disks. There are various theoretical models of satellite formation, but there are few observational constraints on the physical quantity of the circumplanetary disks. It is known that the ice-rock ratio of Jupiter's moons are not uniform. In the hot regions inside the water snow line in the circumplanetary disks, ice vaporizes and rocks become the main material for satellites. Therefore, it is important to investigate the physical quantity of the circumplanetary disks, especially the temperature, when considering the conditions for satellite formation. In recent years, detailed structures of protoplanetary disks around many young stars have been observed using high-resolution ALMA telescopes. In addition, structures similar to the circumplanetary disks were discovered. It is also expected that the infrared space telescope JWST, which is scheduled to be launched in 2021, will detect more circumplanetary disks.

In this study, we aim to establish a method for investigating the temperature of the circumplanetary disks by comparing model calculations with these observations. Previous studies have predicted the intensities of the dust and gas emission at (sub)millimeter wavelengths of the turbulent viscous accretion disks (Zhu et al. 2018) and the irradiation heating disks (Rab et al. 2019), for ALMA observations. In this study, we perform model calculations of dust and gas emission from circumplanetary disks, using the viscous accretion disk model, for JWST observations, and investigate how the intensities change for the models with different physical quantities, such as the accretion rate and the viscous parameter, alpha. As a result, it was shown that the circumplanetary disks is detectable relatively easily with dust continuum emission by JWST. Furthermore, chemical reaction calculations were performed to predict the intensities of various molecular lines and investigate how the infrared and (sub)millimeter line intensities depend on the physical quantity of the disk, and their detectabilities were also investigated.

Keywords: circumplanetary disk, radiative transfer calculation, infrared observations, radio observations

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Development of a Hayabusa2 ONC image retrieval system with 2D/3D switchable maps in a web browser

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1. JAXA, 2. Kochi Univ., 3. Univ. of Tokyo, 4. JAMSS, 5. Konniesystem, 6. Univ. of Aizu, 7. Kobe Univ., 8. Osaka Univ., 9. IRSPS, Università d’ Annunzio, 10. Chiba Inst. Tech., 11. IAC, 12. Rikkyo Univ., 13. AIST, 14. Meiji Univ.

Recent asteroid missions including Hayabusa, Hayabusa2, and OSIRIS-REx, have obtained various datasets of asteroidal surfaces, which are of great value for scientific analyses and future explorations (e.g., Lucy, DESTINY+, etc.). For increasing the availability and applicability of these data, it is important to develop a user-friendly system in which image data, metadata, and individual information (e.g., image position) are linked to each other. It is desirable to develop a system that allows users to easily browse and search data according to their own requirements.
There are several two-/three-dimensional (2D/3D) visualization interfaces (both in application softwares and web-based systems) for viewing and searching datasets: for example, the PILOT (U.S. Geological Survey) [1], Small Body Mapping Tool (Johns Hopkins University) [2], JMARS (Arizona State University) [3], Solar System Trek (NASA) [4], etc. As a data retrieval system for existing small celestial bodies, a 2D-3D switchable display is the most desirable interface, which helps research activities (e.g., researchers can browse and study images overlaid on a 2D map and a 3D shape model similar to the way terrestrial geologists investigate a specific area horizontally and vertically). However, the existing systems for browsing image data of small celestial bodies are limited to either a 2D or 3D display. Therefore, this study aims to develop a web system that can switch between 2D and 3D map displays of small celestial bodies in the same system.
Here we used the ONC image datasets of the asteroid Ryugu as the case study. This is because the Hayabusa2 spacecraft has achieved the acquisition of a vast amount of ONC image data of the asteroid Ryugu, which is the highest level of quality and quantity among all the data explored thus far. Furthermore, the shape of Ryugu is relatively spherical, which is useful to validate the concept of a 2D-3D switchable map. Furthermore, the ONC image datasets are well organized, and all of these data will be publicly available widely, which is useful to demonstrate the system. In this presentation, we report the current status of the system development and its usage.

References: [1] https://pilot.wr.usgs.gov [2] Ernst, C., Barnouin, O., Daly, R., Team, S. B. M. T., 2018. The Small Body Mapping Tool (SBMT) for Accessing, Visualizing, and Analyzing Spacecraft Data in Three Dimensions. Lunar and Planetary Science Conference, Vol. 49. [3] https://jmars.mars.asu.edu/ [4] https://trek.nasa.gov/

Keywords: Hayabusa2 ONC image, Image retrieval system, 2D/3D

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Martian Moons eXploration MMX: Current Status Report 2021

*Kiyoshi Kuramoto[1,2], Yasuhiro Kawakatsu[2], Masaki Fujimoto[2], Maria Antonietta Barucci[3], Hidenori Genda[4], Naru Hirata[5], Takeshi Imamura[6], Jörn Helbert[7], Shingo Kameda[8], Masanori Kobayashi[9], Hiroki Kusano[10], David J. Lawrence[11], Koji Matsumoto[12], Patrick Michel[13], Hideaki Miyamoto[6], Hiromu Nakagawa[14], Tomoki Nakamura[14], Kazunori Ogawa[2], Hisashi Otake[2], Masanobu Ozaki[2], Sara Russell[15], Sho Sasaki[16], Hiroki Senshu[9], Naoki Terada[14], Stephan Ulamec[7], Tomohiro Usui[2], Koji Wada[9], Shoichiro Yokota[16]

1. Hokkaido University, 2. JAXA, 3. Paris Observatory, 4. Tokyo Institute of Technology, 5. Aizu University, 6. The University of Tokyo, 7. DLR, 8. Rikkyo University, 9. Chiba Institute of Technology, 10. QST, 11. Johns Hopkins University APL, 12. NAOJ, 13. Université Côte d’ azur, 14. Tohoku University, 15. Natural History Museum, 16. Osaka University

As of February 2021, the MMX project is under the final phase of preliminary design reviews (PDRs), which consist of reviews on specific instruments, subsystems, total system, operations, and integration. Tests using mechanical test models and thermal test models are being conducted. The composition of science instruments (7 sensing instruments, 2 sampler systems, a return capsule, and a rover) is maintained although the architecture of the infrared spectrometer has been changed from a hyperspectrometer to a grating array detector. The plan of observations during the stay in the Mars-moons system is being extensively studied as well as measures for possible regolith contamination onto sensing instruments during landing operations. After passed the PDRs, the MMX project will proceed to phase C or the detailed design phase. Partly due to the effect of the COVID-19 pandemic, the development schedule has been slightly revised so far but maintains the launch year 2024.

The MMX mission is a sample return mission to Phobos, a small inner moon orbiting Mars. Owing to the lack of definitive evidence, the origin of Phobos and the outer Martian moon Deimos is still under debate between two leading hypotheses: the capture of volatile-rich primordial asteroid(s) and the in-situ formation from a debris disk that generated by a giant impact onto early Mars. Whichever theory is correct, the Martian moons are expected to be associated with Mars formation and preserve key records of volatile material transport that would make the terrestrial planets habitable in the early solar system. Through close-up observations of both moons and sample return from Phobos, MMX will settle the controversy of their origin, reveal their evolution, and constrain the early solar system evolution around the region near the snow line. Monitoring of global circulation and escape of the Martian atmosphere will be also conducted to reveal basic processes that have shaped and altered the Martian surface environment.

To achieve a round-trip to the Martian system within a reasonable time, the MMX spacecraft is composed of three modules equipped with a chemical propulsion system and solar generators. By releasing used modules at appropriate timings, the spacecraft mass is reduced to allow orbital tuning to quasi-satellite orbits around Phobos, landing on Phobos surfaces, and the escape from the Martian gravity to the return cruise to the Earth.

MMX will arrive at the Martian system in 2025 and start close-up observations of Phobos after the release of the propulsion module used for Mars orbit insertion. In early 2027, Mars will approach the closest distance from the Earth which minimizes the communication delay between the spacecraft and the Earth station. Together with the timing relatively far from Sun-Mars conjunctions and the Martian equinoxes,

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this period is the most favorable for landing operations that require real-time communication with the ground station and day-time solar illumination undisturbed by an eclipse. Preceded ~1 year will be largely devoted to landing site selection that requires global and zoom-up observations of Phobos confirming operational safety and availability of Phobos-indigenous materials at landing sites. After the stay near Phobos for ~3 years, the MMX spacecraft will be transferred to Deimos-flyby orbits to conduct Deimos observations, and then only the return module will depart the Martian system leaving the exploration module in a circum-Martian orbit in 2028. The sample capsule will come back to the Earth in 2029.

Keywords: Phobos, Deimos, Mars, MMX, habitable planet, early solar system

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The orbital evolution of Phobos in the expanded atmosphere of early Mars under an intense solar EUV radiation

*Kohei Fujita[1], Naoki Terada[1], Shotaro Sakai[1], Kaori Terada[1]

1. Tohoku University

Mars has two moons, Phobos and Deimos, which have the common characteristics of small orbital inclination and eccentricity. The origin of these moons can be explained by the capture scenario, in which asteroids were captured by the Martian gravity, and the giant impact scenario, in which an object crashed into Mars, and then debris accumulated to form the moons. One of the reasons why the capture scenario is supported is that the reflectance spectra of Phobos are consistent with D- and T-type asteroids, and those of Deimos are consistent with D-type asteroids. However, it is difficult to explain the characteristics of the current orbital inclination and eccentricity in both moons. In the capture scenario, we need to consider the dissipation of orbital energy after capture, since the asteroid has velocity at infinity. An example of the orbital energy dissipation process is atmospheric drag. In a stationary atmosphere, the lifetime of the captured asteroid has been found to be short due to atmospheric drag and it cannot survive for a long time (Hunten, 1979). At that time, it is possible to make the orbit circular, but it is difficult to attenuate the orbital inclination. Therefore, in the previous study, Matsuoka and Kuramoto calculated the orbit taking into account the co-rotation of the proto-Martian atmosphere. The results showed that there is a solution with a relatively long lifetime of the prograde satellite in the vicinity of the geostationary orbit, and that eccentricity and orbital inclination attenuate on a short timescale. However, in order to track the orbital evolution of the captured asteroid after its capture, the evolution of the Martian atmosphere has to be considered. The solar EUV radiation has decreased over time, so the early Martian atmosphere would have gradually shrunk. It is possible that the atmosphere was rotating at angular velocity relatively close to that of Mars when it expanded significantly beyond the co-rotation radius. However, as the atmosphere shrunk, wind systems that deviate from the co-rotation, such as day-night flow seen in the upper atmosphere, were expected to intersect the geostationary orbit and affect the orbit of the moon.
In order to take into account for the change in the solar EUV radiation, we deviate the rotation of the atmosphere by several tens of percent from the co-rotation and perform orbit calculations around the geostationary orbit, where the asteroid is expected to have a longer lifetime. As a result, the lifetime of the captured asteroid is shortened by one order of magnitude in the vicinity of the geostationary orbit when the atmosphere is reduced by 10% from the angular velocity of Mars, and the lifetime is shortened as the deviation increases. On the other hand, in order for the captured asteroid to maintain its orbit, the atmosphere needs to shrink more rapidly than the timescale of orbital evolution. We calculate the orbit taking into account the change in the atmospheric to obtain the lifetime of the captured asteroid in different atmospheric structures of the early Mars in addition to the deviation from the co-rotation since the expanded early Martian atmosphere shrunk as the solar EUV radiation evolved. In this presentation, we will discuss the validity of the capture scenario based on the calculation results of the orbital evolution of Phobos in the above scenarios.

Keywords: Phobos, Satellite formation, Capture scenario

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Hydrodynamic escape of reduced proto-atmospheres: different consequences for surface volatile inventories between Mars and Earth

*Tatsuya Yoshida[1], Kiyoshi Kuramoto[1]

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The present Martian surface is significantly depleted in volatiles compared to the Earth's one. On the other hand, Mars may have obtained a massive proto-atmosphere because Mars was likely formed from volatile-rich building blocks due to its large distance from the Sun (Dreibus and Wanke, 1985; Saito and Kuramoto, 2018). H, C, N, and noble gases on Mars are enriched in heavier isotopes, indicating that the paucity of the volatiles on Mars may be largely due to atmospheric escape.

Hydrodynamic escape is one of the few mechanisms that can change the composition of a planetary atmosphere irreversibly (Hunten, 1990). The X-ray and extreme ultraviolet (XUV) radiation from the young Sun may have induced hydrodynamic escape of early atmospheres. Proto-atmospheres on Mars and Earth are expected to have been composed of reduced species such as H_2 and CH_4 considering the chemical reduction of volatiles by reactions with metallic iron and the gravitationally capture of surrounding solar nebula gas (Kuramoto and Matsui, 1996; Saito and Kuramoto, 2018). Such hydrogen-rich atmospheres on low-gravity rocky planets are susceptible to hydrodynamic escape with rates possibly very large compared to those of other atmospheric escape processes (Catling and Kasting, 2017).

Considering the difference in the planetary masses, the hydrodynamic escape rate on Mars is expected to be much larger than that on Earth, which may largely explain the paucity of the volatiles on the present Martian surface. The difference in the planetary gravity may lead to the difference in the atmospheric temperature, radiative cooling efficiency, and thereby atmospheric escape rate. Therefore, to clarify the difference in the hydrodynamic escape of the proto-atmosphere, it is needed to investigate the radiative and photochemical processes and the energy balance in each escaping outflow. However, previous studies simplified the radiative and photochemical processes, and therefore the difference in hydrodynamic escape rates was uncertain.

Here we carry out one-dimensional hydrodynamic escape simulations considering radiative and photochemical processes for proto-atmospheres on Mars and Earth. Then, we clarify the difference in the hydrodynamic escape and its effect on the amount of surface volatiles between Mars and Earth. In this modeling, fluid equations for a multi-component gas assuming spherical symmetry are solved by numerical integration about time until the physical quantities settle into steady profiles. We apply the XUV spectrum 100 Myr after the birth of the Sun from 0.1 to 165 nm provided by Claire et al. (2012), whose total flux is about 100 times the present. We consider radiative cooling by thermal line emissions of CH_4, CO, CH, CH_3 and H_3^+. 157 photochemical reactions are considered for 23 atmospheric components. We assume that the atmospheres at their low altitudes are composed of H_2 and CH_4 for Earth, and composed of H_2, CH_4 and CO for Mars referring to the thermodynamic analysis on accreting planets (Kuramoto, 1997).

The suppression of the hydrodynamic escape by the radiative cooling on Earth's atmospheres is more drastic than that on Mars. The difference is mainly due to the differences in the planetary mass and gravity. Under smaller gravity, adiabatic cooling of expanding atmosphere is effective on Mars, leading to the lower atmospheric temperature and inefficient radiative cooling. The total amount of carbon species

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lost by hydrodynamic escape on Mars exceeds 10 bar equivalent to 20 bar of CO_2 when the proto-Mars obtained >10 bar of H_2 assuming that carbon species equivalent to 1 bar of CO_2 was left behind. On the other hand, CH_4 on Earth escapes hardly even when the mixing ratio of H_2 is as high as ~99 % due to efficient radiative cooling by photochemical products from CH_4 and H_2. The difference in the efficiency of hydrodynamic escape may have resulted in a significant difference in the amount s on the surfaces of Mars and Earth.

Keywords: hydrodynamic escape, radiative cooling, photochemistry, proto-atmosphere, Mars, Earth

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

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Masaru Kogure(National Institute of Polar Research)

The Atmosphere-Ionosphere (A-I) system forms the so-called near-Earth space. Recent rapidly expanding use of satellite constellations in Low-Earth Orbit (LEO) drives a high demand for better understanding and accurate forecast of the global A-I system for scientific and operational purposes. This session aims to provide a forum for research advances and frontiers related to these aspects, and we invite presentations on global A-I coupling at all temporal and spatial scales. This includes but is not limited to: A-I coupling via atmospheric waves (tides, gravity waves, planetary waves) and trace gases (CO2, O3, H2O), A-I response to Space Weather events (solar flares, CMEs, CIRs), polar-equatorial or inter-hemispheric coupling via TADs/TIDs/disturbance dynamo/penetration electric field, ionospheric plasma irregularities, ionospheric currents, etc. Observations, theoretical studies, model simulations, data assimilation, instruments development are all highly welcome.

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

[PEM11-01] Forecasting Multi-scale Space Weather Phenomena in the Upper Atmosphere

★Invited Papers

*Tzu-Wei Fang[1,2], Tim Fuller-Rowell[1,2], David L Hysell[3], Valery Yudin[1], Adam Kubaryk[1,2], Raffaele Montuoro[1,2], Houjun Wang[1] (1.University of Colorado Boulder, USA, 2.NOAA Space Weather Prediction Center, USA, 3.Earth and Atmosphere Sciences, Cornell University, USA)

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

[PEM11-02] Model Simulation and Observation of Equatorial Ionospheric Response to Substorm

*Qian Wu[1,2], Wenbin Wang[1], Dong Lin[1] (1.National Center for Atmospheric Research, 2.COSMIC, UCAR)

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

[PEM11-03] High Resolution Ionosphere/Thermosphere Modeling Studies of Equatorial Plasma Bubbles

★Invited Papers

*Joseph Huba[1], Hanli Liu, Erich Becker (1.Syntek Technologies, Inc)

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

[PEM11-04] Temporal evolution of three-dimensional structures of metal ion layer around Japan simulated by mid-latitude ionospheric model

*Satoshi Andoh[1], Akinori Saito[1], Hiroyuki Shinagawa[2] (1.Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

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

[PEM11-05] Statistical behavior of large-scale ionospheric disturbances during geomagnetic storms using 20-years GNSS-TEC data

*Atsuki Shinbori[1], Yuichi Otsuka[1], Sori Takuya[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2.National Institute of Information and Communications Technology (NICT))

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

[PEM11-06] Generation mechanisms of plasma density irregularity from equatorial to midlatitude ionosphere during a geomagnetic storm on 21 and 22 December 2014

*Sori Takuya[1], Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Tsugawa[2], Michi Nishioka[2], Akimasa Yoshikawa[3]
(1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Information and Communications Technology, 3.International Center for Space Weather Science and Education, Kyushu University)

Forecasting Multi-scale Space Weather Phenomena in the Upper Atmosphere

*Tzu-Wei Fang[1,2], Tim Fuller-Rowell[1,2], David L Hysell[3], Valery Yudin[1], Adam Kubaryk[1,2], Raffaele Montuoro[1,2], Houjun Wang[1]

1. University of Colorado Boulder, USA, 2. NOAA Space Weather Prediction Center, USA, 3. Earth and Atmosphere Sciences, Cornell University, USA

The coupled Whole Atmosphere Model - Ionosphere Plasmasphere Model (WAM-IPE) is currently in the process of being transitioned into operations at the NOAA Space Weather Prediction Center (SWPC). This model calculates Earth’ s global three-dimensional, time-dependent, neutral atmosphere from the surface up to the thermosphere at 10^-7 hPa (400-600 km), coupled to a global ionosphere-plasmasphere that extends to several Earth radii. The WAM-IPE combined with the WAM Data Assimilation System (WDAS) is capable of capturing ionospheric and thermospheric changes during geomagnetic storms as well as the impact from large meteorological events. The operational products from the model aim to provide a forecast of the neutral and plasma environment that impacts the GNSS positioning, global communications, and collision avoidance for space traffic management. Based on the operational code, a high-resolution version of the WAM-IPE has recently developed, which allows us to further simulate smaller scale ionospheric features. Through ingesting neutral and plasma fields from the WAM-IPE to the plasma irregularity model established by Cornell University, we explore the possibility of forecasting the plasma irregularity a few hours in advance. In this talk, we will present the simulated neutral and plasma structures caused by the large-scale space weather event. The effort and preliminary results of high-resolution WAM-IPE simulation on forming the small-scale plasma irregularities will also be discussed.

Keywords: ionosphere and thermosphere, plasma irregularity, whole atmosphere model, atmosphere coupling

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Model Simulation and Observation of Equatorial Ionospheric Response to Substorm

*Qian Wu[1,2], Wenbin Wang[1], Dong Lin[1]

1. National Center for Atmospheric Research, 2. COSMIC, UCAR

Equatorial ionosphere can react to substorm events via direct penetrating electric field. In the past, the thermosphere and ionosphere model driven by the high empirical ion convection models lacked the dynamic high latitude input to properly simulate the penetrating electric field and equatorial response. The recently developed magnetospheric and ionospheric coupling model GTR (GAMERA-TIEGCM-RCM) aims to resolve the issue. GTR is part of the Multiscale Atmosphere-Geospace Environment (MAGE) modeling effort. We will simulate recent substorm events to examine the penetrating electric field effect. Additionally, we will use the observations from recent missions such as GOLD, COSMIC 2, and ICON to validate the simulation results. These three missions provide unprecedented coverage of the equatorial ionosphere including ion density profiles, UV images, ion drift, and neutral winds. The ion drift and neutral winds are particularly important for understanding the equatorial dynamo.

Keywords: Equatorial Ionosphere, COSMIC, GOLD

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High Resolution Ionosphere/Thermosphere Modeling Studies of Equatorial Plasma Bubbles

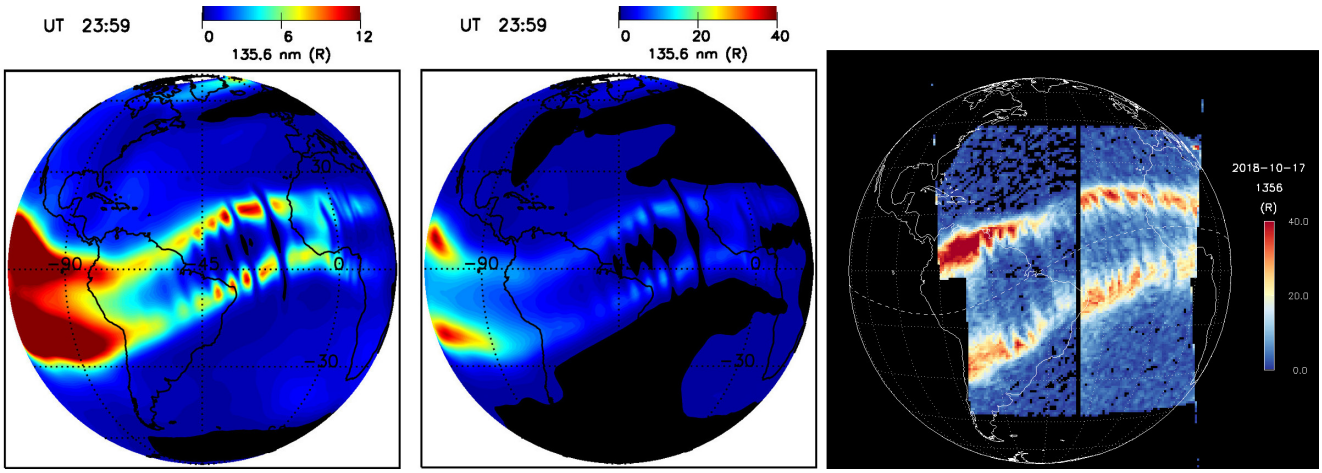
*Joseph Huba[1], Hanli Liu, Erich Becker

1. Syntek Technologies, Inc

We report results from a high resolution global simulation study of the ionosphere/thermosphere system that self-consistently generates large-scale equatorial spread F (ESF) plasma bubbles. The coupled model comprises the ionospheric code SAMI3 and the atmosphere/thermosphere codes WACCM-X and HIAMCM. An important feature of the study is that a high resolution grid is used globally with scale sizes 50 km. Several cases are studied for different seasons and solar activity. We show one case that is consistent with recent GOLD observations [Huba and Liu, 2020]. In addition to seasonal and solar activity variations in the onset of ESF, we also find a strong longitudinal and day-to-day variation. Importantly, the bubbles are initiated self-consistently by atmospheric gravity waves in the WACCM-X and HIAMCM models as opposed to artificial, numerical ionosphere perturbations.

Huba, J.D. and H.-L. Liu, Global modeling of equatorial spread F with SAMI3/WACCM-X, Geophys. Res. Lett., 47, e2020GL088258. https://doi.org/10.1029/2020GL088258 2020.

Keywords: equatorial bubbles, ionosphere/thermosphere modeling



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Temporal evolution of three-dimensional structures of metal ion layer around Japan simulated by mid-latitude ionospheric model

*Satoshi Andoh[1], Akinori Saito[1], Hiroyuki Shinagawa[2]

1. Graduate School of Science, Kyoto University, 2. National Institute of Information and Communications Technology

A numerical local ionospheric model with neutral winds of GAIA (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy) is used to investigate temporal evolutions of three-dimensional structures of metal ion layer (MIL) around Japan. The MILs appear especially in the ionospheric E region, which is called sporadic E, and show complicated structures such as multi-layer structures and intense density variation. Wind shear theory is recognized as the basic formation mechanism of the MILs, but it does not explain fully physical mechanism of the three-dimensional MIL structures, especially their sporadic behaviors. In the presentation, we present two simulation cases where the monthly averaged and the day-to-day variable wind effects on the MILs around Japan are investigated and classify temporal evolutions of complicated MIL structures in following four phases: (1) Above 110 km, MILs are generally constrained vertically and horizontally at zonal-wind shear null. (2) Below 110 km, MILs lag behind the zonal-wind shear null, and the three-dimensional MIL structures are affected not only by the wind shears but also the magnitude and direction of the horizontal winds. (3) When stagnating MILs exist below descending MILs, some ions of the stagnating MILs ascend and merge with the descending MILs, causing density enhancement of the descending MILs. (4) MILs stagnate around 100 km or descend to < 100 km depending on the strength of the vertical winds. Our result reveals that Phases (2)–(4) are crucial for the formation of the complicated MIL structures. Moreover, MIL tends to drift westward in the all phases because they tends to move with westward phase propagation of the migrating tides in Phase (1) and is embed in the westward wind regions in Phases (2)–(4).

Keywords: sporadic E, simulation, ionosphere, metal ion, mid-latitude

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Statistical behavior of large-scale ionospheric disturbances during geomagnetic storms using 20-years GNSS-TEC data

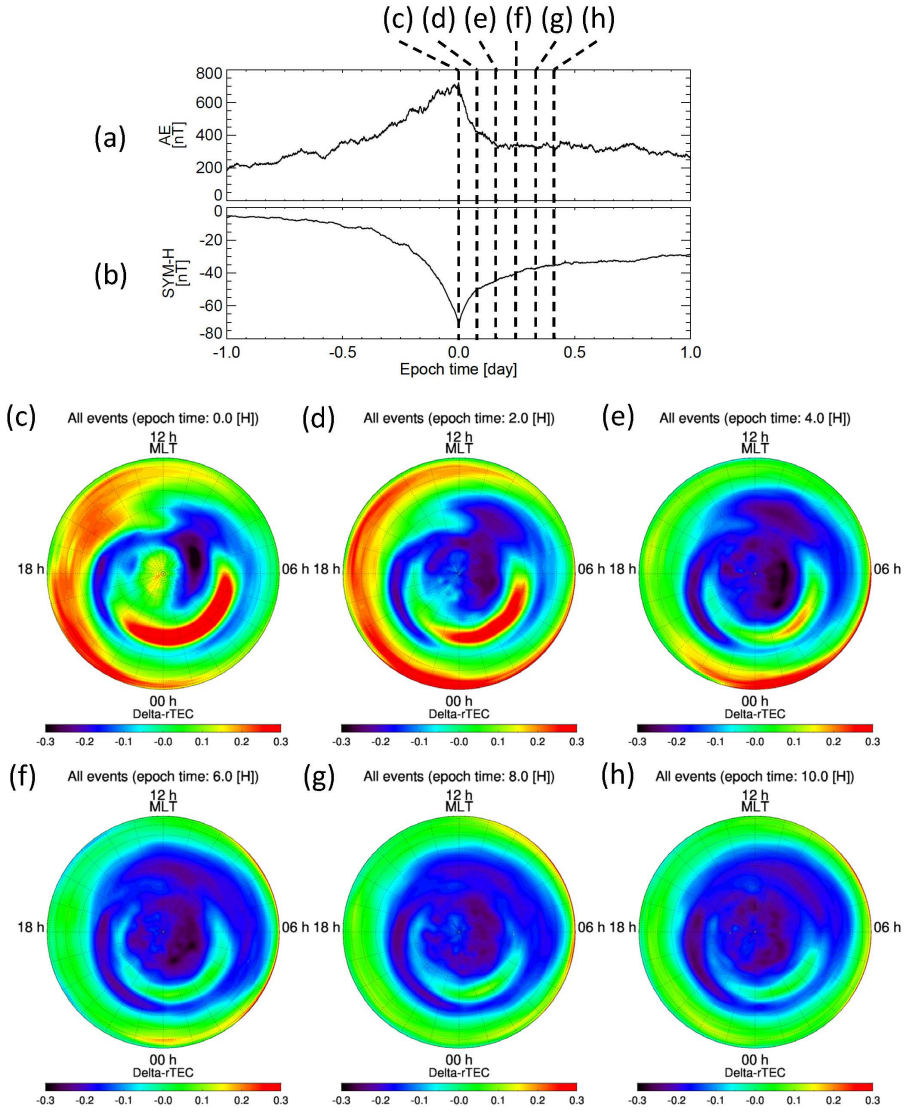
*Atsuki Shinbori[1], Yuichi Otsuka[1], Sori Takuya[1], Takuya Tsugawa[2], Michi Nishioka[2]

1. Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2. National Institute of Information and Communications Technology (NICT)

To investigate the time history of spatial variation of global electron density in the ionosphere during geomagnetic storms, we conducted a super epoch analysis of interplanetary magnetic field (IMF), solar wind, geomagnetic indexes (AE and SYM-H), and global navigation satellite system (GNSS) –total electron content (TEC) data for 20 years (2000–2019). In this study, we analyzed the ratio of the TEC difference (rTEC) for 663 geomagnetic storms with the minimum SYM-H value of less than -40 nT. The rTEC is defined as a difference between the storm-time TEC and averaged quiet-day TEC normalized by the quiet-day one. During the main phase of geomagnetic storms associated with a negative excursion of the IMF Bz, the rTEC enhancement related to the mid-latitude broad storm-enhanced density (SED) appeared with a wide latitudinal range in the daytime (9–18 h, geomagnetic local time: GMLT) mid-latitude (more than 30° in geomagnetic latitude: GMLAT) in the northern and southern hemispheres. The enhanced rTEC region expanded to the midnight with time. Around the noon, the rTEC enhancement related to the SED plume was observed at high latitudes (60–70°, GMLAT). In the low-latitude and equatorial regions (less than 30°, GMLAT), the rTEC enhancement appeared in the evening to morning sectors after -6 h epoch time. On the other hand, in the polar region, the rTEC enhancement and depression were observed in the duskside and dawnside polar cap in addition to the large rTEC enhancement in the pre-midnight to early morning sectors associated with auroral particle precipitation. The duskside rTEC enhancement had a stream-like structure along the anti-sunward convection plasma flow. This phenomenon has been named tongue of ionization (TOI). The depth and width of the dawnside rTEC depression increased as the geomagnetic storms developed. The region of rTEC depression corresponded to the downward region-1 field-aligned current (FAC) observed by the DMSP satellites. This result suggests that the rTEC depression is caused by the evacuation effect of the downward FAC. During the recovery phase, the magnitude of the rTEC enhancement from the polar cap to the mid-latitudes decreased rapidly within 4 hrs, and the rTEC depression around the morning at auroral latitudes expanded to the lower latitudes with a large MLT extent. After the epoch time of 8 h, the second weak rTEC enhancement appeared at the mid-latitudes in the afternoon –evening sectors although the geomagnetic activities as seen in the AE and SYM-H indexes remained low. Considering that the high-latitude convection electric field becomes weak, the second rTEC enhancement could be generated by the uplift of ionospheric plasmas due to the enhanced equatorward neutral wind in the thermosphere. On the other hand, the rTEC enhancement and depression were observed in the nighttime and morning equatorial (less than 10°, GMLAT) regions, respectively. Further, the rTEC value decreased slightly in the off equatorial region around 15° GMLAT after the epoch time of 2 h. The rTEC depression expanded to in the midnight within 4 hrs. Such the equatorial rTEC structures were maintained at least for 16 hrs. The equatorial rTEC signatures suggests that an over-shielding or disturbance dynamo field suppresses the equatorial fountain effect.

Keywords: Geomagnetic storm, Ionosphere, Penetration electric field, Over-shielding electric field, Ionospheric disturbance dynamo, Total electron content

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Generation mechanisms of plasma density irregularity from equatorial to midlatitude ionosphere during a geomagnetic storm on 21 and 22 December 2014

*Sori Takuya[1], Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Tsugawa[2], Michi Nishioka[2], Akimasa Yoshikawa[3]

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Plasma bubbles having a significantly sharp depletion of plasma density are one of the ionospheric irregularities in the low-latitude and equatorial regions. Within the plasma bubbles, plasma density irregularities with different spatial scales exist. The plasma bubbles are generated in the bottomside F region of the nighttime equatorial ionosphere after sunset by Rayleigh-Taylor instability (RTI) mechanism [Farley et al., 1970]. The growth rate of RTI increases with increasing eastward electric fields and increasing ionospheric altitude. During geomagnetic storms, three kinds of electric field originating from interplanetary magnetic field (IMF), region-2 field-aligned currents (FAC) and disturbance dynamo are imposed in the ionosphere from the midlatitude to equator. Especially, an over-shielding electric field generated by the enhanced region-2 FACs is dominant for 1-2 hours after northward turning of the IMF and/or the onset of substorms. However, how the over-shielding electric field contributes to generation of plasma bubbles remains unknown. In this study, we investigate temporal and spatial variations of plasma bubbles and electric fields during a geomagnetic storm on 21 and 22 December 2014 by using global navigation satellite system-rate of total electron content index (ROTI), incoherent scatter (IS) radars and magnetometers data, and discuss the origin of plasma bubble generation during the geomagnetic storm. The ROTI enhancements related to plasma bubbles were observed three times in the American sector from the low latitude to equator at 00:50, 03:10 and 05:30 UT on 22 December, respectively. Before the second ROTI enhancement appeared, the AL index showed a sudden decrease and reached the peak value of -805 nT at 02:14 UT. The equatorial electrojet (EEJ) estimated from the difference of the X component of geomagnetic field at Yap and Guam decreased from 33 nT at 02:13 UT to -28 nT at 02:50 UT. Plasma drift velocity of **E×B** (upward and northward perpendicular to the geomagnetic field) direction observed by the Arecibo IS radar increased from -9.0 m/s at 02:23 UT to 17.6 m/s at 02:37 UT. The **E×B** drift velocity over Arecibo turned into upward around 02:30 UT. Vertical drift velocity obtained from the Jicamarca IS radar also increased from -22.0 m/s at 02:22 UT to 28.8 m/s at 02:52 UT. The vertical drift velocity over Jicamarca turned into upward direction around 02:42 UT. The north-south component of the IMF showed a constant value of -15 nT during 01:56–02:58 UT. The equivalent currents derived from global magnetometer data were directed westward at 40–55˚ in geomagnetic latitude (GMLAT) and eastward at 60–70˚ in GMLAT in the dusk sector while those in the dawn sector were directed eastward at 40–50˚ in GMLAT and westward at 50–75˚ in GMLAT around 02:30 UT. The EEJ variation at the dayside equator suggests that the eastward ionospheric electric field turned into westward after the AL decrease associated with a substorm. The plasma drift velocities over Arecibo and Jicamarca on the nightside also turned into upward 20–30 min after the AL index decreased. From these observational facts, it can be inferred that the reversed convection electric field penetrates to the low-latitude and equatorial regions in both the day and night. The second ROTI enhancement appeared 30–40 min after the plasma drift velocities were directed upward. Further, a distribution of global equivalent currents suggests that the region-2 FACs were dominant after the AL decrease. These results suggest that the second plasma bubble was generated by the enhanced eastward over-shielding electric field driven by the substorm in the

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pre-midnight sector even though the IMF was directed southward. Therefore, it can be concluded that an over-shielding electric field originating from the enhanced region-2 FAC system during geomagnetic storms and substorms can be also an important factor contributing to generation of plasma bubbles in the nighttime.

Keywords: geomagnetic storm, plasma bubble, rate of TEC index (ROTI), over-shielding electric field, incoherent scatter radar, equatorial electrojet

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

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Atsuki Shinbori(Institute for Space-Earth Environment Research (ISEE), Nagoya University)

The Atmosphere-Ionosphere (A-I) system forms the so-called near-Earth space. Recent rapidly expanding use of satellite constellations in Low-Earth Orbit (LEO) drives a high demand for better understanding and accurate forecast of the global A-I system for scientific and operational purposes. This session aims to provide a forum for research advances and frontiers related to these aspects, and we invite presentations on global A-I coupling at all temporal and spatial scales. This includes but is not limited to: A-I coupling via atmospheric waves (tides, gravity waves, planetary waves) and trace gases (CO2, O3, H2O), A-I response to Space Weather events (solar flares, CMEs, CIRs), polar-equatorial or inter-hemispheric coupling via TADs/TIDs/disturbance dynamo/penetration electric field, ionospheric plasma irregularities, ionospheric currents, etc. Observations, theoretical studies, model simulations, data assimilation, instruments development are all highly welcome.

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

[PEM11-07] Ionospheric plasma irregularities and GPS scintillation/outage observed by Swarm and other LEO satellites

★Invited Papers

*Chao Xiong[1,3], Xin Wan[2], Claudia Stolle[3], Yiwen Liu[4], Jisheng Xu[1] (1.Department of Space Physics, College of Electronic and Information, Wuhan University, 430072 Wuhan, China, 2.Planetary Environmental and Astrobiological Research Laboratory (PEARL), School of Atmospheric Sciences, Sun Yat-sen Univeristy, Zhuhai, China, 3.GFZ German Research Centre for Geosciences, Telegrafenberg, 14473, Potsdam, Germany, 4.Scholl of Physics and Electronic Information, Shangrao Normal University, Shangrao, China)

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

[PEM11-08] Regional ionospheric parameter estimation by assimilating the LSTM trained results into the SAMI2 model

★Invited Papers

Jeong-Heon Kim[1], *Young-Sil Kwak[1,2], Yong Ha Kim[3], Se Heon Jeong[3], Jong Yeon Yun[4] (1.Korea Astronomy and Space Science Institute, 2.University of Science and Technology, 3.Chungnam National University, 4.Korea Space Weather Center)

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

[PEM11-09] Thermospheric variability investigation and thermospheric prediction using machine learning techniques

★Invited Papers

*Jiuhou Lei[1], Denxin Ren[1], Libing Weng[1] (1.USTC University of Science and Technology of China)

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

[PEM11-10] Ionospheric ring current system accounting for ground-level magnetic observations during the 2011 Tohoku earthquake tsunami

*Takuto Minami[1], Masashi Kamogawa[2], Tsutomu Ogawa[3], Makoto Uyeshima[3], Toru Mogi[4], Hiroshi Ichihara[4] (1.Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University, 2.University of Shizuoka, 3.Earthquake Research Institute, University of Tokyo, 4.Graduate School of Environmental Studies, Nagoya University)

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

[PEM11-11] Simultaneous measurement of ion drift and neutral wind using Ba/Sr chemical releases of CHI sounding rocket experiment

*Taro Watanabe[1], Yoshihiro Kakinami[2], Masa-yuki Yamamoto[1], Miguel F. Larsen[4], Mark Conde[3], Takao M. Sato[2], Yuuichi Kaga[2], Takako Kaga[2] (1.Kochi University of Technology, 2.Hokkaido Information University, 3.University of Alaska Fairbanks, 4.Clemson University)

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

[PEM11-12] EUV signals associated with O+ ions observed from ISS-IMAP/EUVI in the nightside ionosphere

*Shin ya Nakano[1,2], Yuta Hozumi[3], Akinori Saito[4] (1.The Institute of Statistical Mathematics, 2.Center for Data Assimilation Research and Applications, Joint-Support Center for Data Science Research, 3.University of Electro-Communications, 4.Graduate School of Science, Kyoto University)

Ionospheric plasma irregularities and GPS scintillation/outage observed by Swarm and other LEO satellites

*Chao Xiong[1,3], Xin Wan[2], Claudia Stolle[3], Yiwen Liu[4], Jisheng Xu[1]

1. Department of Space Physics, College of Electronic and Information, Wuhan University, 430072 Wuhan, China, 2. Planetary Environmental and Astrobiological Research Laboratory (PEARL), School of Atmospheric Sciences, Sun Yat-sen Univeristy, Zhuhai, China, 3. GFZ German Research Centre for Geosciences, Telegrafenberg, 14473, Potsdam, Germany, 4. Scholl of Physics and Electronic Information, Shangrao Normal University, Shangrao, China

Ionospheric plasma irregularities are an important issue for the ionospheric and Global Navigation Satellite System (GNSS) related communities. The generation as well as the global distribution of irregularities are highly related to ionospheric and ionosphere-thermosphere coupling processes. This talk will review recent results on plasma irregularities observed by ESA’ s Swarm mission. The characteristics of irregularities detected by in-situ plasma density and related GNSS measurements from Swarm are consistent with previous findings. However, with three satellites forming a constellation, Swarm provides new insights about plasma irregularities, e.g., their scale lengths, that cannot be achieved by single satellite mission. For example, when the Swarm satellites cross the plasma irregularities, the GNSS measurements show only intense carrier phase variations but almost no amplitude fades (less than 2 dB-Hz), both characterizing GNSS scintillation behaviors. These observations are different from what we learn from data of ground-based receivers. Further comparisons with GNSS data received at the GOCE satellite, which flew at about 250 km, we found that the Fresnel diffractive process is necessary to cause GPS signal amplitude fades during scintillations. Swarm observations also reveal that the absolute density gradient associated with plasma irregularities is an important parameter for causing the outage of spaceborne GNSS receiver.

Keywords: Ionospheric plasma irregularities, Scintillation, Ionosphere-Theremosphere coupling, GNSS, Swarm, LEO satellites



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Regional ionospheric parameter estimation by assimilating the LSTM trained results into the SAMI2 model

Jeong-Heon Kim[1], *Young-Sil Kwak[1,2], Yong Ha Kim[3], Se Heon Jeong[3], Jong Yeon Yun[4]

1. Korea Astronomy and Space Science Institute, 2. University of Science and Technology, 3. Chungnam National University, 4. Korea Space Weather Center

This talk presents the potential of predicting the regional ionosphere at mid-latitude by assimilating the predicted ionospheric parameters from a neural network (NN) model into the Sami2 is Another Model of the Ionosphere (SAMI2). The NN model was constructed from the dataset of Jeju ionosonde (33.43N, 126.30E) for the period of 1 Jan 2011 to 31 Dec 2015 by using the long-short term memory (LSTM) algorithm. The NN model provides 24-hour prediction of the peak density (NmF2) and peak height (hmF2) of the F2 layer over Jeju. The predicted NmF2 and hmF2 were used to compute two ionospheric drivers (total ion density and effective neutral meridional wind), which were assimilated into the SAMI2 model. The SAMI2-LSTM model estimates the ionospheric conditions over the mid-latitude region around Jeju on the same geomagnetic meridional plane. We evaluate the performance of the SAMI2-LSTM by comparing predicted NmF2 and hmF2 values with measured values during the geomagnetic quiet and storm periods. The root mean square error values of NmF2 (hmF2) from Jeju ionosonde measurements are lower by 45% and 45% (30% and 11%) than those of the SAMI2 and IRI-2016 models during the geomagnetic quiet periods. However, during the geomagnetic storm periods, the performance of the SAMI2-LSTM model does not predict positive geomagnetic storms well. Comparing the quiet and storm periods for the SAMI2-LSTM model, the RMSE of the storm period was calculated to be 2.76 (3.2) times higher at Jeju (Icheon) than in the quiet period. From these results, we demonstrated that in this study, the combination of the NN-LSTM model and physics-based model could improve the ionosphere prediction of existing theoretical and empirical models for mid-latitude regions, at least in geomagnetically quiet conditions. We strongly suggest that this attempt, which has not been reported before, could be used as one of the keys to advance the physics-based model further.

Keywords: Ionosphere, forecast model, SAMI2 model, LSTM algorithm, assimilation technique

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Thermospheric variability investigation and thermospheric prediction using machine learning techniques

*Jiuhou Lei[1], Denxin Ren[1], Libing Weng[1]

1. USTC University of Science and Technology of China

In recent years, the deep learning technology has become increasingly popular and successfully applied in space physics. In this talk, we will present long-term trend of thermospheric density by using a Machine-Learning approach. Also, we will introduce a novel methodology, which is utilized to forecast the thermosphere by specifying the uncertain parameters in a physics-based model using an intelligent optimized particle filter. This method has the capability of providing a reliable forecast with multi-days leading time for the thermospheric mass density.

Keywords: Upper atmosphere, Thermosphere prediction, machine learning technique

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Ionospheric ring current system accounting for ground-level magnetic observations during the 2011 Tohoku earthquake tsunami

*Takuto Minami[1], Masashi Kamogawa[2], Tsutomu Ogawa[3], Makoto Uyeshima[3], Toru Mogi[4], Hiroshi Ichihara[4]

1. Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University, 2. University of Shizuoka, 3. Earthquake Research Institute, University of Tokyo, 4. Graduate School of Environmental Studies, Nagoya University

Large earthquakes and tsunamis cause acoustic waves reaching the ionosphere and drive many related electromagnetic phenomena. Variations in the total electron content were reported by many papers, which include effects of acoustic waves not only from tsunamis but also from Rayleigh waves (e.g. Tsugawa et al. 2011). The associated ionospheric dynamo in the E region generated observable magnetic variation at the ground level, as implied by numerical simulations of Kherani et al. (2013). However, the form of the electric current system due to the E-region dynamo has never been revealed from the perspective of geomagnetic observations at the ground level.

To reveal the current system in the ionosphere during the 2011 Tohoku earthquake event, we analyzed 1-min sampling magnetic data at 20 on-land stations on the Japan Arc and at one seafloor magnetometer ~200 km off the Tohoku. We, first, subtracted the effects of non-seismic magnetic variation from the magnetic data, using inter-station magnetic transfer functions between the stations of interest and a reference site in China, Changchun. We further subtracted magnetic variation due to the oceanic electric currents induced by the tsunami propagation by the time-domain three-dimensional simulation of Minami et al. (2017). In the rotated coordinate system where the horizontal axes consist of radial and transverse ones in terms of the tsunami centre, we found a clear concentric propagation of magnetic variation with phase velocities of ~3.6 km/sec in the period band of 3 to 10 min and ~0.9 km/sec in the period band of 15 to 40 min. The former corresponds to the speed of Rayleigh wave, while the latter does to the speed of the acoustic wave in the ionosphere. The polarities of the radial and downward components of the radially propagating magnetic variation imply the presence of anti-clockwise electric currents in the ionosphere in the both period bands. We tried to express the corresponding electric current system in the ionosphere by fitting a steady ring current model without induction to the magnetic data. Our preliminary ring current model successfully explains the concentric propagating features and the long-lasting offset in the radial and downward components of the magnetic variation at most of the observation sites. In the presentation, we will report our analysis of the geomagnetic data at ground level and describe their concentric propagation during the 2011 Tohoku earthquake tsunami event. Furthermore, we will discuss possible ionospheric ring current system accounting for the observed magnetic variation at the ground level.

Keywords: ionosphere, 2011 Tohoku Earthquake , tsunami, magnetic field, E region, dynamo

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Simultaneous measurement of ion drift and neutral wind using Ba/Sr chemical releases of CHI sounding rocket experiment

*Taro Watanabe[1], Yoshihiro Kakinami[2], Masa-yuki Yamamoto[1], Miguel F. Larsen[4], Mark Conde[3], Takao M. Sato[2], Yuuichi Kaga[2], Takako Kaga[2]

1. Kochi University of Technology, 2. Hokkaido Information University, 3. University of Alaska Fairbanks, 4. Clemson University

The CHAMP satellite observations suggest that neutral up-welling due to Joule heating of the ionospheric E layer in the cusp region causes neutral density enhancement above 400 km [Lühr et al., 2004]. In the heating process, small-scale electric field seems to play an important role. Hurd and Larsen [2016] showed that the small-scale electric field estimated from drift of Barium ion (Ba^+) and the neutral winds contributed the heating.

To measure the Joule heating and find the neutral up-welling in the cusp region, in November 2014, the sounding rocket campaign which was a chemical release experiment of Barium (Ba) and Strontium (Sr) named Cusp Region Experiment 1 (C-REX-1) was conducted. The sounding rocket was launched from Andøya Space Center, Norway. In this experiment, we measured ion drift and neutral wind using Ba^+ as ion tracers and Sr as neutral tracers. However, no signatures of the up-welling and small-scale electric field were observed at the C-REX-1 experiment. In December 2019, the Joint Japan-U.S. Cusp Heating Investigation (CHI) rocket was launched from Svalbard Rocket Range, Norway, and released Ba/Sr from all 8 canisters. Another sounding rocket C-REX-2 was also planned at the same window of CHI; however, it was postponed due to the low magnetospheric activity and weather conditions.

We newly developed band-pass filters for Ba^+ (614.2 nm) and Sr (460.7 nm) with 6 nm bandwidth. These wavelengths correspond to the resonance scattering emissions of Ba^+/Sr, respectively. We successfully observed Ba^+/Sr separately and simultaneously with band-pass filters from Longyearbyen and Ny-Ålesund until about 25 minutes after the launch of the CHI rocket.

The measurement results of the ion drift and neutral wind are shown in Figures 1 and 2. The horizontal velocities of the ion drift were 170-1200 m/s to east-northeast direction approximately. In only one case of 3rd ion tracer, a vertical velocity of 323 m/s was obtained at 324 km altitude, although the data was only available for about one minute for analysis. Neutral tracers moved to the northwest or west direction at 100-170 m/s horizontally. We analyzed two of the eight clouds but we could not find neutral up-welling which could cause the enhancement of neutral density above 400 km.

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Hurd, L. D., and M. F. Larsen, Small-scale fluctuations in barium drifts at high latitudes and associated Joule heating effects, *J. Geophys. Res. Space Physics,* **121**, 779–789, 2016.

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Keywords: Ionosphere, Thermosphere, Chemical Release, Cusp Region, Sounding Rocket

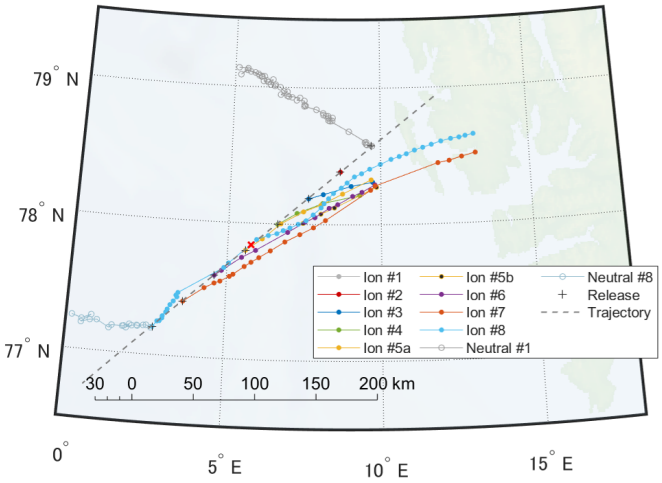


Figure 1 Horizontal tracks of Ba^+/Sr.

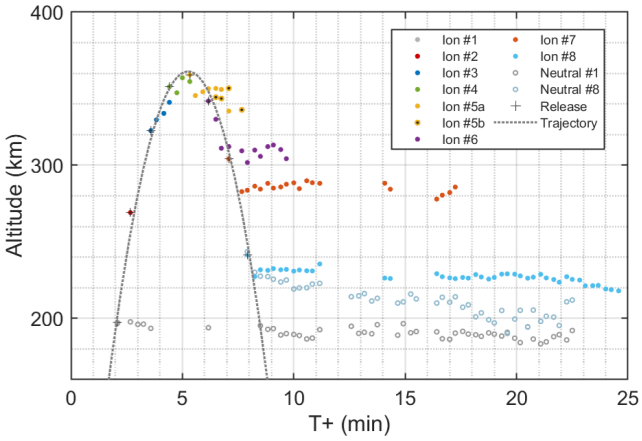


Figure 2 Vertical tracks of Ba^+/Sr.

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EUV signals associated with O+ ions observed from ISS-IMAP/EUVI in the nightside ionosphere

*Shin ya Nakano[1,2], Yuta Hozumi[3], Akinori Saito[4]

1. The Institute of Statistical Mathematics, 2. Center for Data Assimilation Research and Applications, Joint-Support Center for Data Science Research, 3. University of Electro-Communications, 4. Graduate School of Science, Kyoto University

The extreme ultraviolet (EUV) imager, EUVI-B, on board International Space Station (ISS) under the ISS-IMAP mission was designed for observing EUV emission at 83.4 nm scattered by O+ ions. During the mission, EUVI-B sometimes detected evident EUV signals in the umbra of the Earth. These nightside signals were expected to be resulted from multiple scattering of EUV by O+ ions and their source was attributed to EUV emitted by O+ ions excited by solar radiation on the dayside. However, the effect of the multiple scattering has not been assessed in the existing studies.

We simulated the nightside EUV flux at 83.4 nm using with the Monte Carlo method to compute EUV scattering process due to O+ ions. In this Monte Carlo computation, the scattering cross section was estimated from the O+ density and temperature distribution given by the IRI model. However, the simulation suggested that the multiple scattering does not explain the features of the observations from EUVI-B of ISS. We also modeled the nightside EUV at 91.1 nm as a result of recombination between O+ ions and electrons. The result showed that the recombination well explain the observations from EUVI-B morphologically and quantitatively. We therefore conclude that the EUV signals observed from EUVI-B in the umbra of the Earth were mainly attributed to 91.1 nm emission due to recombination. This result suggests that the spatial distribution of ionospheric O+ density can be estimated from the EUVI-B data.

Keywords: O+ ions in the ionosphere, resonant scattering, ion recombination

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

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Hiroyuki Nakata(Graduate School of Engineering, Chiba University), Hiroyo Ohya(Graduate School of Engineering, Chiba University)

The Atmosphere-Ionosphere (A-I) system forms the so-called near-Earth space. Recent rapidly expanding use of satellite constellations in Low-Earth Orbit (LEO) drives a high demand for better understanding and accurate forecast of the global A-I system for scientific and operational purposes. This session aims to provide a forum for research advances and frontiers related to these aspects, and we invite presentations on global A-I coupling at all temporal and spatial scales. This includes but is not limited to: A-I coupling via atmospheric waves (tides, gravity waves, planetary waves) and trace gases (CO2, O3, H2O), A-I response to Space Weather events (solar flares, CMEs, CIRs), polar-equatorial or inter-hemispheric coupling via TADs/TIDs/disturbance dynamo/penetration electric field, ionospheric plasma irregularities, ionospheric currents, etc. Observations, theoretical studies, model simulations, data assimilation, instruments development are all highly welcome.

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

[PEM11-13] Study on variations in the D-region ionosphere after the 2015 Nepal earthquake using VLF/LF transmitter signals

*Tekkna Akashi[1], Hiroyo Ohya[1], Fuminori Tsuchiya[2], Kenro Nozaki[3], Hiroyuki Nakata[1] (1.Chiba University , 2.Tohoku University , 3.The University of Electro-Communications)

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

[PEM11-14] D-region ionospheric effects for 2016 eruptions of Mt. Aso using LF transmitter signals

*Hiroyo Ohya[1], Yuhi Orito[2], Fuminori Tsuchiya[3], Masa-yuki Yamamoto[4], Hiroyuki Nakata[1], Akimasa Yoshikawa[5] (1.Graduate School of Engineering, Chiba University, 2.Faculty of Engineering, Chiba University, 3.Tohoku University, 4.Kochi University of Technology, 5.Kyushu University)

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

[PEM11-15] **Ionospheric effects caused by June 11-16, 2009 Sarychev Peak volcano eruption**

*Nikolai Shestakov[1,2], Alexander Orlykovskii[2], Natalia Perevalova[3], Nikolai Titkov[4], Danila Chebrov[4], Mako Ohzono[5,6], Hiroaki Takahashi[5], Evgenii Lialiushko[2] (1.Institute for Applied Mathematics FEB RAS, Vladivostok, Russia, 2.Far Eastern Federal University, Vladivostok, Russia, 3.Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia, 4.Kamchatka Branch of Geophysical Survey of RAS, Petropavlovsk-Kamchatsky, Russia, 5.Institute of Seismology and Volcanology, Hokkaido University, Sapporo, Japan, 6.Earthquake Research Institute, University of Tokyo, Tokyo, Japan)

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

[PEM11-16] A possible effect of rainfall on medium scale electron density fluctuations in dayside ionosphere

*Toshihiko Iyemori[1], Tadashi Aoyama[1,2], Yoshihiro Yokoyama[1] (1.Kyoto University, 2.F-Factory)

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

[PEM11-17] Pattern matching of polar mesospheric clouds with data from the meteorological satellite Himawari-8

*Yuta Hozumi[1], Takuo T. Tsuda[1], Yoshiaki Ando[1], Keisuke Hosokawa[1], Hidehiko Suzuki[2], Takuji Nakamura[3], Ken T. Murata[4] (1.University of Electro-Communications, 2.Department of physics, Meiji university, 3.National Institute of Polar Research, 4.National Institute of Information and Communications Technology)

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

[PEM11-18] Analysis of spatial distributions of Coseismic ionospheric disturbances using HFD

*Tomoaki Horikiri[1], Hiroyuki Nakata[2], Hiroyo Ohya[2], Keisuke Hosokawa[3] (1.Graduate School of Science and Engineering, Chiba University, 2.Graduate School of Engineering, Chiba University, 3.Department of Communication Engineering and Informatics, University of Electro-Communications)

Study on variations in the D-region ionosphere after the 2015 Nepal earthquake using VLF/LF transmitter signals

*Tekkna Akashi[1], Hiroyo Ohya[1], Fuminori Tsuchiya[2], Kenro Nozaki[3], Hiroyuki Nakata[1]

1. Chiba University , 2. Tohoku University , 3. The University of Electro-Communications

In the D-region ionosphere, oscillations of LF (low frequency, 30-300 kHz) transmitter signals with a period of 100 s were reported about five minutes after mainshock of the 2011 Tohoku earthquake [Ohya et al., JGR, 2018]. The reflection height of the LF waves was estimated to be 67 km at 05:46 UT on 11 March, 2011, and the LF oscillations were caused by acoustic waves excited by seismic Rayleigh waves based on simulation of neutral atmosphere. However, this is only one report for coseismic disturbances in the D-region ionosphere. In this study, we investigate the D-region ionospheric variations associated with the 2015 Nepal earthquake using VLF (very low frequency, 3-30 kHz)/LF transmitter signals that reflect in the D-region ionosphere. The mainshock of the Nepal earthquake (Mw 7.9) occurred at 06:11:26 UT on April 25, 2015. The propagation path was BPC (68.5 kHz, 34.63˚N,115.83˚E) - TKN (Takine, Fukushima, 37.34˚N, 140.67˚E). Intensity and phase were observed with a sampling time of 0.1 s. We compared between the VLF/LF transmitter signals and vertical velocity data of seismometers provided by IRIS (Incorporated Research Institutions for Seismology), USA. Based on wavelet analysis, a periodic component of about 100-300 s was seen in both the VLF/LF signals and seismic velocity at arrival time of acoustic waves excited by Rayleigh waves. The coherences between the VLF/LF variation and the seismic velocity were 0.91 and 0.85 for amplitude and phase, respectively, which were significant at the 95% confidence level. If the acoustic waves were excited at the midpoint of BPC-TKN propagation path by the Rayleigh waves that propagated horizontally from the epicenter, and propagate upward up to the D-region height 70 km, the propagation time from the ground to 70 km height would be 225 s.The propagation time of the Rayleigh wave calculated from seismograph data was 1057s, and the whole propagation time of the Rayleigh and acoustic waves was 1252 s (= 21 min and 22 s). The arrival time of the acoustic waves was in good agreement with the VLF/LF oscillations.Therefore, the acoustic waves excited by the Rayleigh waves caused the ionospheric variations. In this session, we will discuss this VLF/LF variations in more detail.

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D-region ionospheric effects for 2016 eruptions of Mt. Aso using LF transmitter signals

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Several studies for the F-region ionosphere associated with volcano eruptions based on GPS-total electron content (TEC) data have been reported so far (e.g., Heki, 2006; Dautermann et al., 2009; Heki et al., 2010). These studies reported that acoustic waves excited by volcano eruptions reach up to the F-region ionosphere and caused F-region perturbations. After eruption of the Kelud Volcano, Indonesia, in February 2014, acoustic resonance between the Earth’ s surface and lower thermosphere was reported based on TEC data and the seismic wave data (Nakashima et al., 2015). However, little studies on the D-region ionosphere associated with volcano eruptions have been reported. In this study, we investigate the D-region ionospheric effects of 2016 eruptions of Mt. Aso (32.89N, 131.08E), Japan, using intensity of low frequency (LF, 30-300 kHz) transmitter signals. The LF propagation paths used in this study were JJY (JJY60) - Sasaguri (SGR, Japan, Observatory of Kyushu University), JJY (JJY40) - SGR, and BPC (68.5 kHz) - SGR. Mt. Aso erupted at 16:46 UT on 7 October, 2016. The volcanic explosivity index (VEI) was 3 out of 8, and the eruption height was 11 km. The VLF/LF intensity on all three paths varied with frequency of 2-5 mHz based on wavelet spectra during 16:53-17:20 UT after the eruptions (16:46 UT). We compared the perturbations with atmospheric pressure data obtained by the Kochi university of Technology Infrasound Sensor Network, and seismic waves in the National Research Institute for Earth Science and Disaster Resilience (NIED) Full Range Seismograph Network of Japan (F-net) data (INN, TKD, and TMC) located close to the LF path. The atmospheric pressure and vertical velocity of the seismic waves had the similar frequencies of 3-6 mHz during 16:46-17:20 UT. These similar frequencies suggest that the perturbations would be caused by acoustic resonance between the Earth's surface and lower thermosphere, or by acoustic and atmospheric gravity waves generated by the volcanic eruptions. In the presentation, we will discuss the cause of the VLF/LF perturbations in more detail.

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Ionospheric effects caused by June 11-16, 2009 Sarychev Peak volcano eruption

*Nikolai Shestakov[1,2], Alexander Orlykovskii[2], Natalia Perevalova[3], Nikolai Titkov[4], Danila Chebrov[4], Mako Ohzono[5,6], Hiroaki Takahashi[5], Evgenii Lialiushko[2]

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According to numerous studies ionosphere is sensitive to different man-made and natural phenomena such as rocket launches, explosions (mining explosions, nuclear tests and asteroid atmospheric blasts), earthquakes, tsunami, tropical storms, volcano eruptions, etc. Ionospheric reaction to volcano eruptions is still insufficiently studied and understood. In this work we analyzed the ionosperic response to June 11-16, 2009 Sarychev Peak volcano eruption (VEI class 4) by using surrounding Russian and Japanese GPS networks.
Sarychev Peak stratovolcano (elevation 1446 m above the sea level) is situated on Matua Island. It belongs to the Kuril Islands Arc and is located as far as 400 km to the southwest from the Kamchatka Peninsula tip (Russian Federation) and 750 km to the northeast from Hokkaido Island (Japan). Strong explosive eruption of Sarychev Peak volcano occurred after 33 years of inactivity. The active phase of the eruption consisted of two series of explosions separated by 13 hours pause. More than twenty explosions of different strength and duration resulted in eruptive columns of 3-21 km height. Ash plumes propagated within a few hundred up to 800 km from the volcano. The eruption chronology was reconstructed primarily based on satellite data including observations from the International Space Station and infrasonic measurements provided by the International Monitoring System infrasound network. No seismic records of the eruption were obtained by the nearest seismic arrays due to remote location of Matua Island.
Prominent covolcanic TEC disturbances (CVIDs) with amplitudes and periods ranged between 0.03-0.15 TECU and 2.5-4.5 min were discovered for the three eruptive events occurred at 18:51 UT, June 14; at 01:15 and 09:18 UT, June 15. The estimates of apparent CVIDs velocities vary within 700-1000 m/s in the far-field zone (300-900 km to the southwest from the volcano) and 1300-1800 m/s in close proximity to Sarychev Peak. The obtained characteristics of the observed TEC variations allow us to attribute them to acoustic mode. The south-southwestward direction is preferred for CVIDs propagation. We concluded that the ionospheric response to a volcano eruption is mainly determined by a ratio between explosion strength and background ionization level. A few evidences of secondary (F2-layer) CVIDs source eccentric location were obtained. The limited observation data amount remains this question opened for the future investigations.
This work was supported by RFBR grant 20-05-00509a and grants of JSPS KAKENHI numbers 19H01984, 20KK0073, 25257204

Keywords: volcanic eruption, explosion, covolcanic ionospheric disturbances, GNSS, acoustic mode

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A possible effect of rainfall on medium scale electron density fluctuations in dayside ionosphere

*Toshihiko Iyemori[1], Tadashi Aoyama[1,2], Yoshihiro Yokoyama[1]

1. Kyoto University, 2. F-Factory

Electron density (Ne) fluctuation with spatial scale of a few tens of km - a few hundred km is observed very frequently in middle or low latitude along the orbit of the Swarm satellites. The cause of such medium scale fluctuation could be a plasma instability or atmospheric waves. On the night side, it is well known that the Rayleigh-Tayler instability or Perkins instability can cause such fluctuations. The Ne fluctuations discussed in this presentation are observed on the dayside where the above-mentioned instabilities, in general, may not develop easily. The fluctuations could be caused by the atmospheric waves, i.e., acoustic waves or gravity waves. However, the amplitudes of fluctuations tend to be larger where the gradient of Ne along the satellite orbit is large by the equatorial fountain effect. Although it is not very clear, a tendency that the global distribution of rainfall correlates with the amplitude of Ne fluctuation. In this presentation, the global distribution of Ne fluctuation under various conditions and its correlation with global map of rainfall published by the JAXA/GSMaP project will be discussed.

Keywords: electron density fluctuation, dayside ionosphere, Swarm satellites

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Pattern matching of polar mesospheric clouds with data from the meteorological satellite Himawari-8

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A cloud tracking technique is applied to polar mesospheric cloud (PMC) data from the Geostationary-Earth-Orbit (GEO) meteorological satellite Himawari-8 to examine the horizontal movement of PMCs. While previous PMC observations from the ground and Low-Earth-Orbit (LEO) satellites have a limitation on local time coverage, observations from the GEO satellite provide a great opportunity to study the PMC variability with all local time coverage and a wide field of view. The band 1 (the blue band, 0.47 μm) data of the Advanced Himawari Imager (AHI) onboard Himawari-8 is resampled to the horizontal versus vertical grids data on the Earth-s limb. A pattern matching technique is applied to the PMC peak radiance of the resampling data, and the horizontal movement of PMC along the transverse direction to the line of sight is derived. The tracking velocity approximates the zonal movement of PMCs around the latitude of 81.3ºN and the longitude of 140.7ºE. The horizontal movement shows a large oscillation with an amplitude of order 10–30 m/s and the spectral peaks at periods of 12, 14.76, and 24 hours. The mean velocity for the northern summer season of 2018 is about 7 m/s in the westward direction. The westerly mean movement is consistent with the horizontal wind derived from PMC images taken with the Cloud Imaging and Particle Size instrument (CIPS) on the Aeronomy of Ice in the Mesosphere (AIM) satellite, and the wind of HWM14. The horizontal movement of PMC observed by Himawari-8 is likely to be subjected to wind advection.

Keywords: Polar mesospheric clouds, Himawari-8

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Analysis of spatial distributions of Coseismic ionospheric disturbances using HFD

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The propagation characteristics of ionospheric disturbances associated with earthquakes have been studied by using GPS observations. Althogh the horizontal propagations of coseismic ionospheric disturbances, are extensively examined . Their vertical propagations are not reported much. Since HF Doppler observation(HFD), which is operated by the University at Electro-Communications(UEC), is enable to receive the four radio waves simultaneously, three-dimentional distributions of various ionospheric disturbances can be examined by this system. In this study, we examined the 3-dimentional distribution of ionospheric disturbances associated with earthquakes using the HFD observation.

The HFD observation used in this study enables us to observe variations at maximumly four altitudes using different transmission frequencies (5.006, 6.055, 8.006 and 9.595 MHz). The two transmitting stations were used; Chofu (UEC) and Radio Nikkei Nagara Transmitting Station, and the data from four receiving stations were used: Iitate, Sugadaira, Kakioka, and Kiso. For the seismometer data, we used the vertical velocity data obtained by the seismometer closest to each HFD reflection points. We examined the coseismic ionospheric disturbances associated with the earthquake occurred at Hamadori, Fukushima Prefecture on April 11, 2011.

HFD observations showed that all the four receiving points used in the analysis showed fluctuations with the periods of 2 to 4 minutes about 10 minutes after the earthquake. We also examined the arrival times of the fluctuations at each HFD reflection points. It is found that the fluctuations observed by the HFD were caused by the Rayleigh wave, not the direct wave from the epicenter. By comparing the vertical velocity of the waves obtained by HFD with those obtained by the seismometers, it was confirmed that the magnitude of the ionospheric disturbance decreased with the distance from the epicenter. However, the height variations of the amplitude of the disturbance were different each other. From this fact, we have to examine them in view of the disturbances in propagation upward.

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

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.05 Zoom Room 05

[P-EM11] Coupling Processes in the Atmosphere-Ionosphere System

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Yue Deng(University of Texas at Arlington), Chairperson:Loren Chang(Institute of Space Science, National Central University), Yuta Hozumi(University of Electro-Communications)

The Atmosphere-Ionosphere (A-I) system forms the so-called near-Earth space. Recent rapidly expanding use of satellite constellations in Low-Earth Orbit (LEO) drives a high demand for better understanding and accurate forecast of the global A-I system for scientific and operational purposes. This session aims to provide a forum for research advances and frontiers related to these aspects, and we invite presentations on global A-I coupling at all temporal and spatial scales. This includes but is not limited to: A-I coupling via atmospheric waves (tides, gravity waves, planetary waves) and trace gases (CO2, O3, H2O), A-I response to Space Weather events (solar flares, CMEs, CIRs), polar-equatorial or inter-hemispheric coupling via TADs/TIDs/disturbance dynamo/penetration electric field, ionospheric plasma irregularities, ionospheric currents, etc. Observations, theoretical studies, model simulations, data assimilation, instruments development are all highly welcome.

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

[PEM11-19] Ionospheric Quai-6-Day Oscillation generated by the Secondary Waves During the 2019 Antarctic Sudden Stratosphere Warming

*Jia-Ting Lin[1], Charles Lin[1], Loren Chang[2,3], Nicholas M Pedatella[4,5], P. K. Rajesh[1], CHIYEN LIN[2,3] (1.Department of Earth Science, National Cheng Kung University, Tainan, Taiwan, 2.Department of Space Science & Engineering, National Central University, Taoyuan, Taiwan, 3.Center for Astronautical Physics and Engineering, National Central University, Taoyuan, Taiwan, 4.High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO, USA, 5.COSMIC Program Office, University Corporation for Atmospheric Research, Boulder, CO, USA)

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

[PEM11-20] Southern hemisphere response to northern hemisphere stratospheric warming events

*Patrick J Espy[1,2], Kristina Shizuka Yamase Skarvang[1,2], Willem van Caspel[1,2], Robert Hibbins[1,2], Andrew Kavanagh[3] (1.Norwegian University of Science and Technology, 2.Birkeland Centre for Space Science, 3.The British Antarctic Survey)

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

[PEM11-21] The 2019 Antarctic Stratospheric Sudden Warming effect on Gravity Wave in the Middle Atmosphere

★Invited Papers

*Masaru Kogure[1], Yue Jia[2,3], Huixin Liu[1] (1.Kyushu University, 2.NASA Goddard Space Flight Center, 3.Catholic University of America)

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

[PEM11-22] Nonlinear interactions of planetary-scale MLT waves using multi-radar techniques

★Invited Papers

*Maosheng He[1], Jorge L. Chau[1], Jeffrey M. Forbes[2], Guozhu Li[3,4] (1.Leibniz Institute of Atmospheric Physics at the Rostock University, Kühlungsborn, Germany,, 2.Ann and H.J. SmeadDepartment of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA,, 3.Beijing National Observatory of Space Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China,, 4.College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China)

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

[PEM11-23] Seasonal Dependence of the Quasi-6-Day Oscillation in the Sq-EEJ current system

*Takayama Kumi[1], Akimasa Yoshikawa[1], Yasunobu Miyoshi[1] (1.Kyushu University)

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

[PEM11-24] Turbulent signatures in the Auroral Cusp Ionosphere based on sounding rocket observations

*Francesca Di Mare[1], Andres Spicher[2], Lasse Boy Novock Clausen[1], Wojciech Jacek Miloch[1], Joran Idar Moen[3] (1.Dep. of Physics, University of Oslo, Norway, 2.Dep. of Physics and Technology, University of Tromso, Norway, 3.University Centre in Svalbard, Longyearbyen, Norway)

Ionospheric Quai-6-Day Oscillation generated by the Secondary Waves During the 2019 Antarctic Sudden Stratosphere Warming

*Jia-Ting Lin[1], Charles Lin[1], Loren Chang[2,3], Nicholas M Pedatella[4,5], P. K. Rajesh[1], CHIYEN LIN[2,3]

1. Department of Earth Science, National Cheng Kung University, Tainan, Taiwan, 2. Department of Space Science & Engineering, National Central University, Taoyuan, Taiwan, 3. Center for Astronautical Physics and Engineering, National Central University, Taoyuan, Taiwan, 4. High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO, USA, 5. COSMIC Program Office, University Corporation for Atmospheric Research, Boulder, CO, USA

During the rare Antarctic sudden stratospheric warming (SSW) in September 2019, the quasi-6-day wave (Q6DW) was dramatically enhanced in the mesosphere and lower thermosphere (MLT) region, and strong quasi-6-day oscillations (Q6DO) are observed in ionospheric equatorial electrojet and electron density. However, model simulations demonstrated that the Q6DO in the ionosphere is not driven directly by the Q6DW during the September 2019 SSW. Instead of the secondary waves generated by nonlinear interaction between the Q6DW and semi-diurnal migrating tide. In this study, we examine the amplitude variations of Q6DO and shorter period child waves by using data-assimilation analysis of electron density from three-dimensional Global Ionosphere Specification (GIS). We focus on the behaviors of W1_13h and W3_11h, which are the largest in the secondary waves and are the possible contributors to the ionospheric Q6DO. The day-to-day variabilities of child waves show that both the W1_13h and W3_11h are dramatically enhanced after the SSW peak, growing in amplitude at the EIA region with poleward extension from negligible amplitude. The amplitudes reach maximum and contribute about 6 % to the zonal and diurnal mean background, which coincides with the day of maximum amplitude of Q6DO. The amplitude distributions of two child waves are also overlapped with comparable amplitude. These results suggest that the two child waves might interfere with each other at the EIA regions, resulting in the change of the amplitudes and phases of Q6DO at the different local times if their contributions are not uniform in local time. Additionally, child waves activity during the same period in the non-SSW year of 2020 is also examined for comparison.

Keywords: Sudden Stratospheric Warming, Ionospheric Variabilities, Quasi-6-day Wave, Secondary Waves, Vertical Coupling

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Southern hemisphere response to northern hemisphere stratospheric warming events

*Patrick J Espy[1,2], Kristina Shizuka Yamase Skarvang[1,2], Willem van Caspel[1,2], Robert Hibbins[1,2], Andrew Kavanagh[3]

1. Norwegian University of Science and Technology, 2. Birkeland Centre for Space Science, 3. The British Antarctic Survey

The British Antarctic Survey meteor radar located at Rothera station on the Antarctic Peninsula (68S, 68W), has been used to measure hourly winds from 82 km to 98 km with 2 km vertical resolution from February 2005 to August 2019. The mean winds, as well as the 24- 12- and 8-hour tidal amplitudes were fitted to these winds using a 4-day running window. To remove seasonal effects, an individual, smoothed climatology for each of the tidal components and the mean wind was constructed and used to calculate wind anomalies. A superposed-epoch analysis quantified the behaviour of the wind and tidal amplitude anomalies during the 5, northern hemisphere stratospheric warming events that were accompanied by an elevated stratopause occurring between 2005-2013. The results of that analysis showed that the northern hemisphere events did not cause any significant change in the mean winds or the 24- and 8-hour tidal amplitudes. However, the 12-hour tidal amplitude showed a decrease of between 1 m/s at 84km, and 11 m/s at 92 km, significant between 2 and 8 sigma, 12 to 15 days after the event. Preliminary results using the WACCM-X-SD model show similar southern hemisphere behaviour, and the cause of these anomalies is investigated using a primitive-equation tidal model incorporating mean wind fields derived from the NAVGEM-HA reanalysis. We will present the data, analysis, and model results showing the response of southern hemisphere winds to northern hemisphere stratospheric warming events.

Keywords: tide, SSW, interhemispheric

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The 2019 Antarctic Stratospheric Sudden Warming effect on Gravity Wave in the Middle Atmosphere

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A Stratospheric sudden warming (SSW) drastically change the meteorological fields in the middle atmosphere. The polar night jet disappears after an onset of a SSW, and zonal wind becomes weak and occasionally reverses from a westerly wind to an easterly wind. This wind variation suppresses gravity wave (GW) activity.

In late August 2019, an Antarctic stratospheric sudden warming (SSW) occurred. Antarctic SSW events are rare and have occurred only twice in the 21st century (2002 and 2019). Although this 2019 SSW event was classified as a minor warming event, the zero zonal wind layer reached a 40 km altitude. An Antarctic stratospheric sudden warming (SSW) occurred on August 30, 2019, and was a vortex displacement minor warming event. We investigated variations in GW activity before and after this rare Antarctic SSW event using two satellite measurements (AIRS and CIPS) and reanalysis data (GEOS-5 FP). The observations and GEOS-5 FP showed that the GW activity in whole southern high latitudes decreased after the SSW onset, with a weakening of zonal wind. The zonal mean GW activity further decreased coincided with a reversal of the zonal mean zonal wind around September 8. The decline in the zonal mean GW activity was probably caused by wind filtering and polar night jet breaking. The GW activity in the Andes also decreased after the onset, although the westerly wind was 40–60 ms^{-1} and stronger than the zonal mean one. This decline in GW activity was probably caused by wave saturation.

Keywords: stratospheric sudden warming, Gravity wave, Antarctic

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Nonlinear interactions of planetary-scale MLT waves using multi-radar techniques

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The mesosphere and lower thermosphere (MLT) region is populated by a variety of planetary-scale waves. These waves have been investigated using ground- and space-based observations. Most of these studies were based on single-spacecraft or single-station techniques and therefore were subject to inherent spatiotemporal ambiguities. To overcome the spatiotemporal ambiguity, we collected MLT winds detected by specular meteor radars from multi-longitudinal sectors to resolve the horizontal scale of MLT waves. With the constraints of both frequency and zonal wavenumber, we detected, in different cases, migrating solar tides (at periods of 24hr, 12hr, ⋯, 4hr), lunar tides (12.4hr), planetary wave (PW) normal modes (at periods of 28, 16, 10, 6 days), Gravity-Rossby waves (quasi-2-day waves, Q2DWs) and varieties of secondary waves of nonlinear interactions between tides and PWs. Specifically, the interactions occur between the 12hr migrating tide and PW normal modes, between four migrating tides and Q2DWs, and between PW normal modes and stationary PWs, which increase the variety of MLT waves significantly.

Keywords: the mesosphere and lower thermosphere region, planetary wave (PW) , tide, Gravity-Rossby waves, nonlinear interactions, meteor radar

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Seasonal Dependence of the Quasi-6-Day Oscillation in the Sq-EEJ current system

*Takayama Kumi[1], Akimasa Yoshikawa[1], Yasunobu Miyoshi[1]

1. Kyushu University

Day-to-day variations in the Sq-EEJ current system using dense geomagnetic field observational sites along 210°geomagnetic longitude chain composed of MAGDAS (Global Geomagnetic Observation Network) and observational sites operated by Geospatial Information Authority of Japan (GSI) and INTERMAGNET were analyzed for a comprehensive understanding of coupling processes in the atmosphere-ionosphere system. In this study, we focus on the quasi-6-day oscillation excited by atmospheric waves from lower atmosphere.

The quasi-6-day wave (Q6DW), one of the atmospheric waves, is excited in the lower atmosphere and propagates into thermosphere. Using CHAMP, Swarm and Aura satellites, Yamazaki et al. showed that the quasi-6-dayoscillation in the EEJ occurs when the Q6DW in the mesosphere is enhanced. This suggests that the quasi-6-day oscillation in the EEJ is caused by the Q6DW propagated from below. However, the seasonal dependences and global characteristics of the quasi-6-day oscillation in the Sq-EEJ current system are not well known.

To understand the global distribution of the quasi-6-day oscillation in the Sq-EEJ current system, we analyzed magnetic field data of MAGDAS, GSI, and INTERMAGNET during 2007-2011. We used Principal component analysis to eliminate disturbance components and to extract the magnetic field variation caused by the Sq-EEJ current system more clearly. In this case, we used the first to fifth order components added together as the basic components. In addition, to ensure that the quasi-6-day oscillations are not affected by the amplitude of the background magnetic field, we expressed them in terms of relative amplitudes as used in [Yamazaki et al. 2018].

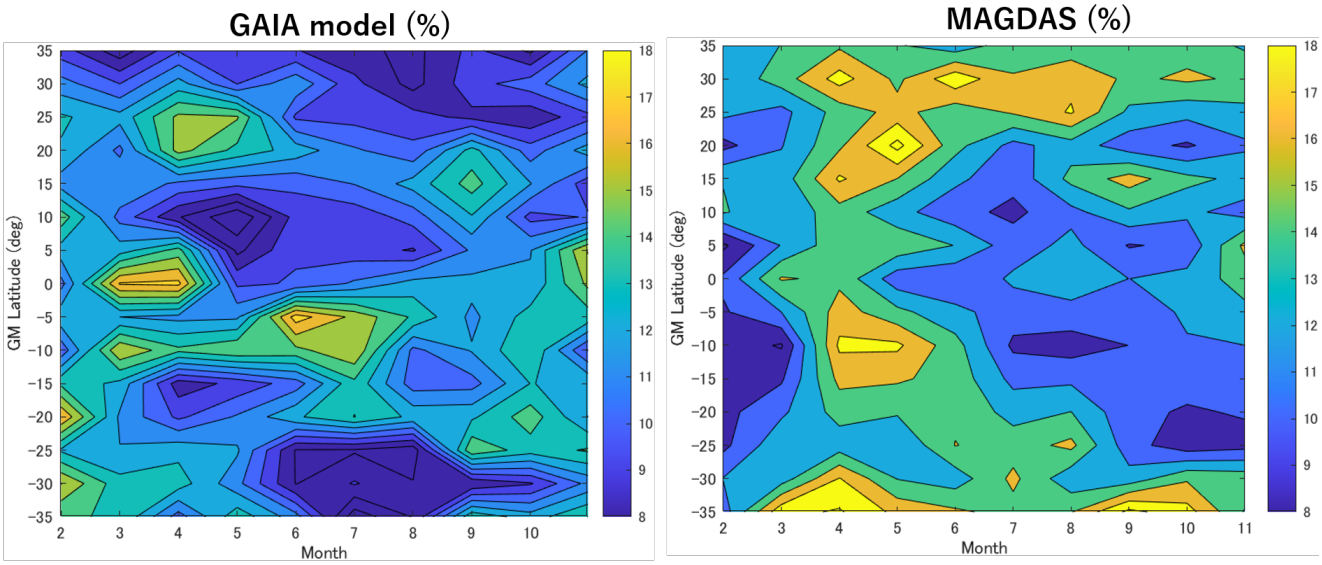
Our results indicate that the quasi-6-day oscillation in the Sq-EEJ current system more strongly developed in the mid-latitude Sq current system than in the EEJ, and more strongly developed in the day side. The quasi-6-day oscillation in the magnetic field data of the GAIA model and MAGDAS have similar seasonal variation and global characteristics. This result indicates the usefulness of the relative amplitude. The quasi-6-day oscillation is strongly developed in equinoxes, which is consistent with the seasonal dependence of the excitation source, the Q6DW.

In the future, we will analyze how the Q6DW effects on the electrical conductivity and generates the electric field with the GAIA model. That leads to understand coupling processes in the atmosphere-ionosphere system.

Keywords: the Quasi-6-Day Wave, the Quasi-6-Day Oscillation, Sq-EEJ current system, Principal component analysis, GAIA model, Seasonal dependence

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2007年磁場$\sqrt{H^2+D^2}$における準6日振動の相対振幅の時間-緯度分布



モデルと観測データを比較すると3月と9月のピークが一致している。

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Turbulent signatures in the Auroral Cusp Ionosphere based on sounding rocket observations

*Francesca Di Mare[1], Andres Spicher[2], Lasse Boy Novock Clausen[1], Wojciech Jacek Miloch[1], Joran Idar Moen[3]

1. Dep. of Physics, University of Oslo, Norway, 2. Dep. of Physics and Technology, University of Tromso, Norway, 3. University Centre in Svalbard, Longyearbyen, Norway

Space plasmas display fluctuations and nonlinear behavior at a broad range of scales, being in most cases in a turbulent state. The majority of these plasmas are also considered to be heated, with dissipation of turbulence as a possible explanation. Despite of many studies and advances in research, many aspects of the turbulence, heating and their interaction with several space plasma phenomena (e.g., shocks, reconnection, instabilities, waves), remain to be fully understood and many questions are still open. Plasma irregularities and turbulence are believed common in the F-region ionosphere and because of their impact on the GNSS and the human activity [1, 2, 3] in the polar regions, a detailed understanding is required. This study provides a characterization of the turbulence developed inside the polar-cusp ionosphere, including features as intermittency, not extensively addressed so far.
The electron density of ICI-2 and ICI-3 missions have been analyzed using advanced time-series analysis techniques and a standard diagnostics for intermittent turbulence. The following parameters have been obtained: the autocorrelation function, that gives useful information about the correlation scale of the field [4]; the energy power spectra, which show the average spectral indexes ~−1.7, not far from the Kolmogorov value observed at MHD scales [5], while a steeper power law is suggested below kinetic scales [6]. In addition, the PDFs of the scale-dependent increments display a typical deviation from Gaussian that increase towards small scales due to intense field fluctuations, indication of the presence of intermittency and coherent structures [7, 8, 9]. Finally, the kurtosis-scaling exponent [10, 11] reveals an efficient intermittency, usually related to the occurrence of structures.

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Keywords: Sounding rocket observations, Turbulence, Ionospheric Irregularities

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[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.02 Zoom Room 02

[P-CG17] Future missions and instrumentation for space and planetary science

convener:Kazunori Ogawa(Japan Aerospace Exploration Agency), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Naoya Sakatani(Department of Physics, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, 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 (e.g. ultra-small satellite). 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 astronomy 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.

3:30 PM - 4:15 PM JST | 6:30 AM - 7:15 AM UTC

[PCG17-01] JAXA's Strategic Mars Exploration Program (JSMEP) for Understanding the Origin, Evolution, Inventory of Water on Mars

★Invited Papers

*Tomohiro Usui[1] (1.Japan Aerospace Exploration Agency)

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

[PCG17-02] Constraints on the origin of Phobos using multivariate element data obtained by MMX MEGANE

*Kaori Hirata[1,2], Tomohiro Usui[2], Ryuki Hyodo[2], Hidenori Genda[3], Ryota Fukai[2], David J. Lawrence[4], Nancy L. Chabot[4], Patrick N. Peplowski[4], Hiroki Kusano[5] (1.University of Tokyo, 2.Institute of Space and Astronautical Science, 3.Earth-Life Science Institute, Tokyo Institute of Technology, 4.Johns Hopkins University Applied Physics Laboratory, 5.National Institute for Quantum and Radiological Science and Technology)

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

[PCG17-03] Development of the Autofocusing Subsystem for the Raman Spectrometer on the MMX Rover

*Shoki Mori[1], Tomàs Belenguer[2], Ute Böttger[3], Maximilian Buder[3], Yuichiro Cho[1], Enrico Dietz[3], Till Hagelschuer[3], Heinz-Wilhelm Hübers[3], Shingo Kameda[4], Emanuel Kopp[3], Guillermo Lopez-Reyes[5], Andoni Gaizka Moral Inza[2], Akinojo Ogura[1], Olga Prieto-Ballesteros[6], Steve Rockstein[3], Selene Rodd-Routley[3], Fernando Rull[5], Conor Ryan[3], Thomas Säuberlich[3], Friedrich Schrandt[3], Susanne Schröder[3], Stephan Ulamec[7], Tomohiro Usui[8], Koki Yumoto[1] (1.Department of Earth and Planetary Science, The

University of Tokyo, 2.Instituto Nacional de Técnica Aerospacial (INTA), 3.Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Optical Sensor Systems, 4.School of Science, Rikkyo University, 5.Universidad de Valladolid – GIR ERICA, 6.Centro de Astrobiología (CAB-INTA-CSIC), 7.Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), 8.Japan Aerospace Exploration Agency (JAXA), Institute of Space and Astronautical Science, Department of Solar System Sciences)

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

[PCG17-04] Discussion

JAXA’s Strategic Mars Exploration Program (JSMEP) for Understanding the Origin, Evolution, Inventory of Water on Mars

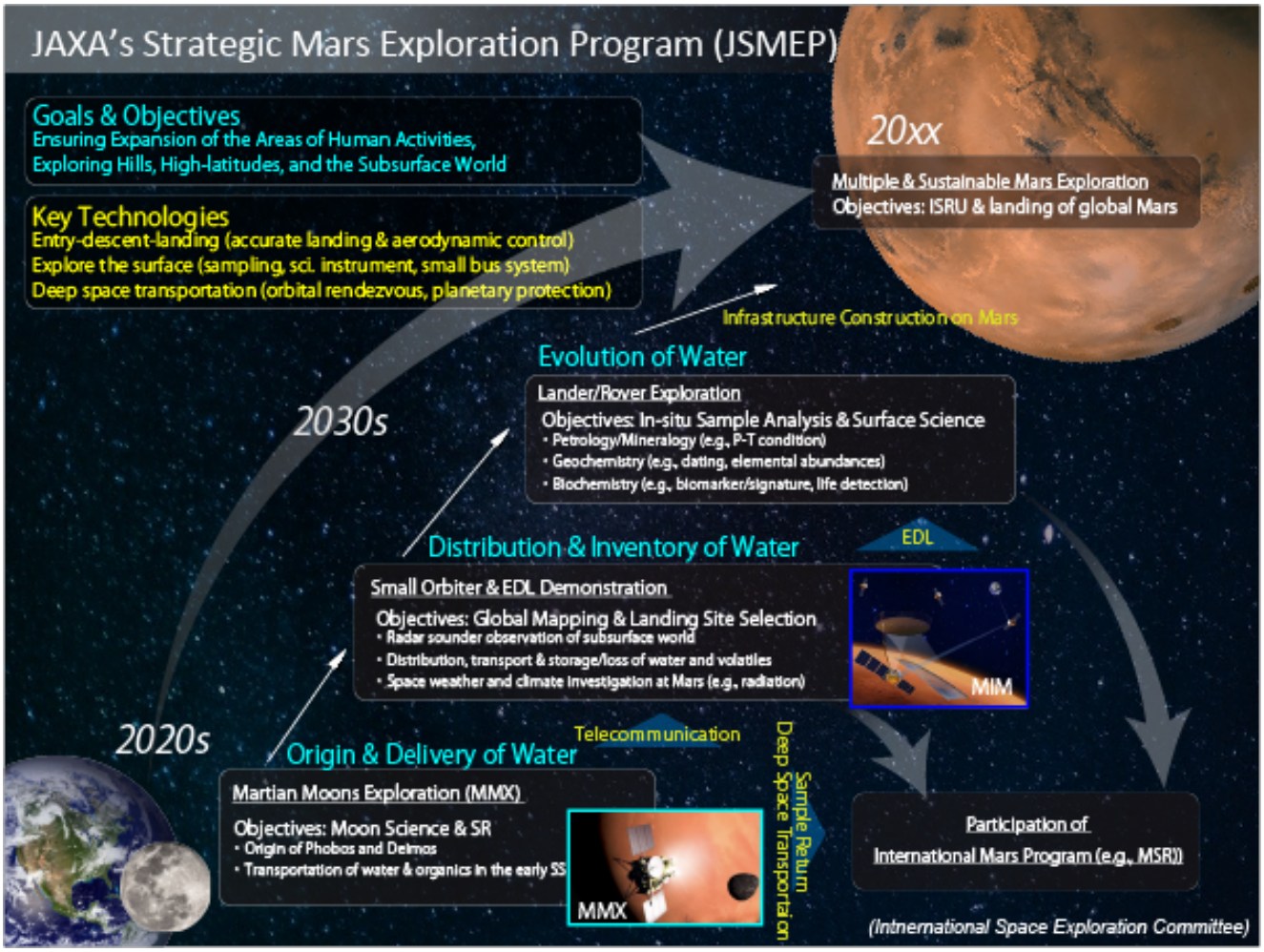
*Tomohiro Usui[1]

1. Japan Aerospace Exploration Agency

The Mars-moon system is a promising target for exploration in the broad field of planetary science: e.g., geology, geochemistry, astrobiology, and comparative planetology. The international Mars science community has set a long-term goal toward achieving Mars sample return (MSR) and human exploration. MSR will address questions on the origin (e.g., source of building blocks), interior evolution (e.g., crust-mantle differentiation and mantle dynamics), the potential biological history (e.g., nature and extent of habitability and preservation of biosignature), and geologic history of Mars with an emphasis on the role of water. Previous Mars exploration missions have provided compelling evidence for the presence of liquid water during the earliest geologic era (Noachian: >~3.9 Ga) of Mars. Observations of dense valley networks, evaporites (e.g., gypsum) and hydrous minerals (e.g., clays) that are commonly formed by aqueous processes imply that, at some time in the past, Mars had an Earth-like active hydrological cycle with lakes, oceans, possibly also aquifers and groundwater, and had the potential for life.
According to the international trend for Mars exploration and potential significance for understanding the current and past surface/subsurface aqueous environments, JAXA plans a strategic Mars exploration program (JSMEP). JSMEP starts with a Martian moon’s sample return mission (MMX: Martian Moons Explorer) in 2024-2029, followed by a Mars orbiter (MO) in later 2020s and a Mars lander/rover (ML/R) mission in early 2030s. JSMEP’s goals are 1) to address questions of water on Mars [origin and delivery (MMX), distribution and inventory (MO), and chemical evolution (ML/R)], 2) to ensure the expansion of the areas of human activities by exploring the habitable subsurface world, and 3) to acquire key technologies including EDL (entry-descent-landing) with aerodynamic control, drilling and sampling on the surface, deep space telecommunication, transportation to/from the Mars orbit, and planetary protection.

Keywords: Mars, JAXA’s strategic Mars exploration program, water

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Constraints on the origin of Phobos using multivariate element data obtained by MMX MEGANE

*Kaori Hirata[1,2], Tomohiro Usui[2], Ryuki Hyodo[2], Hidenori Genda[3], Ryota Fukai[2], David J. Lawrence[4], Nancy L. Chabot[4], Patrick N. Peplowski[4], Hiroki Kusano[5]

1. University of Tokyo, 2. Institute of Space and Astronautical Science, 3. Earth-Life Science Institute, Tokyo Institute of Technology, 4. Johns Hopkins University Applied Physics Laboratory, 5. National Institute for Quantum and Radiological Science and Technology

Two leading hypotheses for the origin of Phobos and Deimos have been proposed: the asteroid capture [e.g., Burns et al., 1992; Murchie et al., 1991] and the giant impact [e.g., Rosenblatt et al., 2016; Hyodo et al., 2017] hypotheses. The orbital properties of Phobos and Deimos suggest the giant impact scenario, whereas their reflectance spectra, similar to D-type asteroids, support the capture origin. This controversy partly arises from the surface reflectance spectra that would have been modified by space weathering and late accretions. In order to constrain Phobos' origin, we focus on the bulk elemental composition of Phobos which is expected to preserve the original building blocks, either a captured asteroid or a mixture of the impactor and the Martian crustal materials [Usui et al., 2020].

The Mars-moon Exploration with GAmma rays and NEutrons (MEGANE), which is a science payload of Martian Moons eXploration (MMX) mission, enables measurement of the bulk elemental abundances of Phobos using gamma-ray and neutron spectroscopy [Lawrence et al., 2019]. In this study, we constructed a multivariate mixing model of Phobos' bulk elemental composition and examined the model's performance to discriminate the Phobos' origin hypotheses.

Our mixing model assumes that Phobos consists of a mixture of materials from Mars and chondrite parent bodies. We employed a set of variables that consists of elemental abundances of O, Mg, Si, Ca, Fe, and Th and assumed 13 types of compositions as end-components of the starting building blocks. The Phobos' composition (P) including a relative error (E_P) of 0, 10, and 20%, and the matrix of the Mars and chondrite compositions (M) yield the mixing ratio (R) as a solution of the mixing equation, $P=MR$. R ranges from 50% in the impact scenario or 100% in the capture scenario. Based on the acquired R, we classified the P into 4 cases; (1) only the capture origin, (2) only the impact origin, (3) both origins, or (4) neither origins reasonably explain the P. Cases-1 and -2 yield the unique solution for the possible origin of Phobos, whereas the cases-3 and -4 do not. Conducting the mixing calculation with the 13 end-member compositions, we determined the case at all P in 6-dimension compositional space. We evaluate our model's performance to determine the origin of Phobos using the discrimination performance (D), a ratio of data points relating to the unique origin (cases -1 and -2) to all data points (cases -1, -2, and -3).

Discrimination performances calculated with 0, 10, and 20% of E_P are 96, 87, and 74%, respectively, suggesting that reducing the observation error of MEGANE improves our model's performance to determine the Phobos' origin only from the elemental composition. Also, discrimination performances vary depending on the measured Fe-Si composition of Phobos. For example, some end-components (e.g., L, EL, R) have similar Fe-Si compositions to those of the mixture of Mars and other end-components (e.g., H, EH). These overlaps result in 80, 60, and 40% of the smallest discrimination performances on Fe-Si diagrams calculated with 0, 10, and 20% of E_P. If Phobos has a bulk composition similar to these types of chondrites (e.g., L, EL, R), these six elements data from MEGANE may not provide unique constraints on Phobos' origin without additional MEGANE element measurements and the mineralogical and petrologic

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information obtained by other onboard instruments and the analysis of the returned sample [Usui et al., 2020].

The relative precision of MEGANE is strongly dependent on the total acquired measurement time and the altitude of the measurements [Peplowski, 2016]. If the MMX mission is able to obtain MEGANE measurements beyond 10 days of accumulated time at an altitude lower than 1 body radius used to provide the current sensitivity estimates [Lawrence et al., 2019], the relative precision of MEGANE’s measurements can be improved.

Keywords: Elemental Abundance, MMX, Giant-impact origin, Asteroid-capture origin

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Development of the Autofocusing Subsystem for the Raman Spectrometer on the MMX Rover

*Shoki Mori[1], Tomàs Belenguer[2], Ute Böttger[3], Maximilian Buder[3], Yuichiro Cho[1], Enrico Dietz[3], Till Hagelschuer[3], Heinz-Wilhelm Hübers[3], Shingo Kameda[4], Emanuel Kopp[3], Guillermo Lopez-Reyes[5], Andoni Gaizka Moral Inza[2], Akinojo Ogura[1], Olga Prieto-Ballesteros[6], Steve Rockstein[3], Selene Rodd-Routley[3], Fernando Rull[5], Conor Ryan[3], Thomas Säuberlich[3], Friedrich Schrandt[3], Susanne Schröder[3], Stephan Ulamec[7], Tomohiro Usui[8], Koki Yumoto[1]

1. Department of Earth and Planetary Science, The University of Tokyo, 2. Instituto Nacional de Técnica Aerospacial (INTA), 3. Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Optical Sensor Systems, 4. School of Science, Rikkyo University, 5. Universidad de Valladolid –GIR ERICA, 6. Centro de Astrobiología (CAB-INTA-CSIC), 7. Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), 8. Japan Aerospace Exploration Agency (JAXA), Institute of Space and Astronautical Science, Department of Solar System Sciences

Raman spectroscopy is a useful approach for the identification of minerals. Raman spectrometers have been developed or are under development for planetary missions. For example, NASA’s Perseverance rover has two Raman spectrometers, SuperCam [1] and Sherloc [2]. The Rosalind Franklin rover of ESA’s ExoMars mission incorporates the Raman Laser Spectrometer (RLS) [3] on board as well, where elements have been inherited for RAX. The rover of JAXA’s Martian Moons Exploration (MMX) has a Raman Spectrometer (RAX) an instrument to determine the surface composition and the formation conditions of Phobos. It also plays a critical role in the selection of the samples to be returned to the Earth [4]. RAX is much more compact as compared to those aboard the Mars rovers because of the requirements to fit in the volume of the much smaller MMX rover; the volume of the RAX main box is 81×98×125 mm^3 [5, 6]. Its weight is only 1.4 kg.

In-situ Raman measurements require the high transmission of the optical path and precise focusing in order to acquire high-quality Raman spectra, since the intensity of Raman scattering is very low (10^{-4} of Rayleigh scattering). Thus, a small, lightweight, robust, and power-saving focusing system (the Autofocusing Subsystem, AFS) is designed as a part of the RAX instrument. The AFS is primarily made of two parts, Light Shuttle Objective (LSO) and actuator system [7]. The LSO moves up and down for focusing the laser spot onto the surface of Phobos and to collect the Raman scattered light from the sample. It is attached to the lead screw and driven by a stepping motor. Because of the small volume, no encoder was implemented into the system; the position of the LSO is estimated by counting the pulses transmitted to the motor.

To verify the capability of this design, the development model (DM) of the AFS was manufactured for the first integrated performance test. The DM has the same design as the engineering/qualification model (EQM), but is not subject to the qualification tests. For the DM, we conducted three test campaigns: functional test to verify the design and function of the AFS, performance test using a breadboard laser/spectrometer to acquire Raman spectra of actual samples, and vibration test to detect any workmanship errors during its assembly. These test campaigns were all successful [8].

Then the EQM was manufactured and a thermal vacuum test was conducted. The EQM was subject to a bakeout for more than 72 hours at a temperature of 70℃. Then it was cooled down to 15℃ at a rate of 10℃ per hour. When the temperature was stabilized at 15℃, the pressure was 2.0×10^{-4} Pa. Under this condition, the LSO was moved for 200 up-and-down cycles. During the movement, no stuttering or

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sudden temperature rise was observed. We also observed that the LSO moved smoothly at the temperature of -20℃ and the pressure of 1.6×10^{-4} Pa. These results proof the capability of the AFS to function under a cold representative thermal environment consistent with the environment aboard the rover on Phobos.

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Keywords: Martian Moons Exploration (MMX), Phobos, Raman Spectroscopy

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[E] Oral | P (Space and Planetary Sciences) | P-CG Complex & General

[P-CG17] Future missions and instrumentation for space and planetary science

convener:Kazunori Ogawa(Japan Aerospace Exploration Agency), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Naoya Sakatani(Department of Physics, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University)

Thu. Jun 3, 2021 3:30 PM - 5:00 PM Ch.02 (Zoom Room 02)

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 (e.g. ultra-small satellite). 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 astronomy 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.

4:45 PM - 5:00 PM

[PCG17-04]Discussion

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.04 Zoom Room 04

[P-CG18] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Tomoki Kimura(Tokyo University of Science), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Kanako Seki(Graduate School of Science, University of Tokyo)

Exploration of Mercury, Venus, Moon, Mars, Jupiter, Saturn, and beyond together with rapid developments of numerical simulations provides us new view of planetary environment. This session collects general contributions of new findings about planetary magnetosphere, ionosphere, and atmosphere. New methodology and technology development studies for future explorations are also welcome. In order to put the common knowledge at different planets into perspective, this session aims to facilitate discussions on comparative planetary environments.

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

[PCG18-01] Current status, initial results, and upcoming observation plans during cruise of BepiColombo

*Go Murakami[1], Johannes Benkhoff[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.European Space Agency)

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

[PCG18-02] Revisiting Mariner-10 and MESSENGER observations: Anticipation for BepiColombo's Mercury flybys

*Sae Aizawa[1,2], Nicolas André[1], Ronan Modolo[3], James A. Slavin[4], Scott A. Boardsen[5] (1.Institute de Recherche en Astrophysique et Planetologie, 2.Graduate School of Science, Tohoku University, 3.LATMOS, 4.University of Michigan, 5.NASA/GSFC)

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

[PCG18-03] A belt-like distribution of gaseous hydrogen cyanide on Neptune's equatorial stratosphere detected by ALMA

*Takahiro IINO[1], Hideo Sagawa[2], Takashi Tsukagoshi[3], Satonori Nozawa[4] (1.Information Technology Center, the University of Tokyo, 2.Department of Science, Kyoto Sangyo University, 3.NAOJ, 4.ISEE, Nagoya University)

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

[PCG18-04] Estimation of the drift rate and intensity of Neptune's storm in 2018-2020 with Pirka Telescope

*Yuuki Sato[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Seiko Takagi[1], Masataka Imai[2], Tatsuharu Ono[1] (1.Graduate School of Science, Hokkaido University, 2.National Institute of Advanced Industrial Science and Technology)

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

[PCG18-05] Ion escape mechanism from a Mars-like planet under weak intrinsic magnetic field conditions: Dependence of IMF clock angle

*Shotaro Sakai[1,2], Kanako Seki[3], Naoki Terada[1], Hiroyuki Shinagawa[4], Ryoya Sakata[3], Takashi Tanaka[4,5], Yusuke Ebihara[6] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 3.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 4.National Institute of Information and Communications Technology, 5.International Center for Space Weather

Science and Education, Kyushu University, 6.Research Institute for Sustainable Humanosphere, Kyoto University)

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

[PCG18-06] Dependences of ion escape from Mars on the intrinsic magnetic field strength under CME-like solar conditions at 3.5 Ga

*Ryoya Sakata[1], Kanako Seki[1], Shotaro Sakai[2], Naoki Terada[2], Hiroyuki Shinagawa[3], Takashi Tanaka[3,4] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Department of Geophysics, Graduate School of Science, Tohoku University, 3.National Institute of Information and Communications Technology, 4.International Center for Space Weather Science and Education, Kyushu University)

Current status, initial results, and upcoming observation plans during cruise of BepiColombo

*Go Murakami[1], Johannes Benkhoff[2]

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The ESA-JAXA joint mission BepiColombo is now on the track to Mercury. After the successful launch of the two spacecraft for BepiColombo, Mio (Mercury Magnetospheric Orbiter: MMO) and Mercury Planetary Orbiter (MPO), commissioning operations of the spacecraft and their science payloads were completed. BepiColombo will arrive at Mercury in the end of 2025, and it has 7-years cruise with the heliocentric distance range of 0.3-1.2 AU. The long cruise phase also includes 9 planetary flybys: once at the Earth, twice at Venus, and 6 times at Mercury. Even during the interplanetary cruise phase, the BepiColombo mission can contribute to the heliospheric physics and planetary space weather in the inner solar system. In addition, NASA’s Parker Solar Probe was launched in 2018 and it is orbiting around Sun (~0.05 AU at perihelion). ESA’s Solar Orbiter was launched in February 2020 and will have a highly elliptic orbit between 1.2 AU at aphelion and 0.28AU at perihelion. These multi spacecraft observations provide us great opportunities to investigate the inner heliosphere. The Earth flyby and the first Venus flyby were successfully completed on 10 April 2020 and on 15 October 2020, respectively. Planetary flybys are great opportunities not only for scientific motivation but also for instrument calibrations. Especially ion sensors onboard MPO (SERENA/MIPA and PICAM) and Mio (MPPE/MIA and MSA) can detect ions only during the planetary flybys because of constraints on spacecraft attitude and field of views. During the two flybys in 2020 science observations are performed and plasma instruments successfully measured both the Earth’s magnetosphere and Venus’s induced magnetosphere. The second Venus flyby and the first Mercury flyby will happen on 10 August 2021 and on 1 October 2021, respectively. Here we present the updated status of BepiColombo mission, initial results of the science observations during the interplanetary cruise and planetary flybys, and the upcoming observation plans.

Keywords: Mercury, Venus, Heliosphere

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Revisiting Mariner-10 and MESSENGER observations: Anticipation for BepiColombo's Mercury flybys

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BepiColombo is en route to Mercury and will conduct its first Mercury flyby in October 2021. The trajectories of BepiColombo during these flybys are unique and will bring new insights into Mercury's plasma environment. Although their field of view is limited, some instruments within the Mercury Plasma Particle Experiment (MPPE) consortium onboard Mio/BepiColombo will be operated during these flybys. Unlike Mariner-10 ion measurements will be obtained, and unlike MESSENGER, low energy electrons and ions will be measured simultaneously. Thus we have revisited Mariner-10 and MESSENGER observations with the help of the hybrid model LatHys in order to constraint the plasma environment that will be encountered by BepiColombo during its forthcoming Mercury flybys.

Keywords: BepiColombo, Mercury, MESSENGER, Mariner-10, Global simulation

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A belt-like distribution of gaseous hydrogen cyanide on Neptune's equatorial stratosphere detected by ALMA

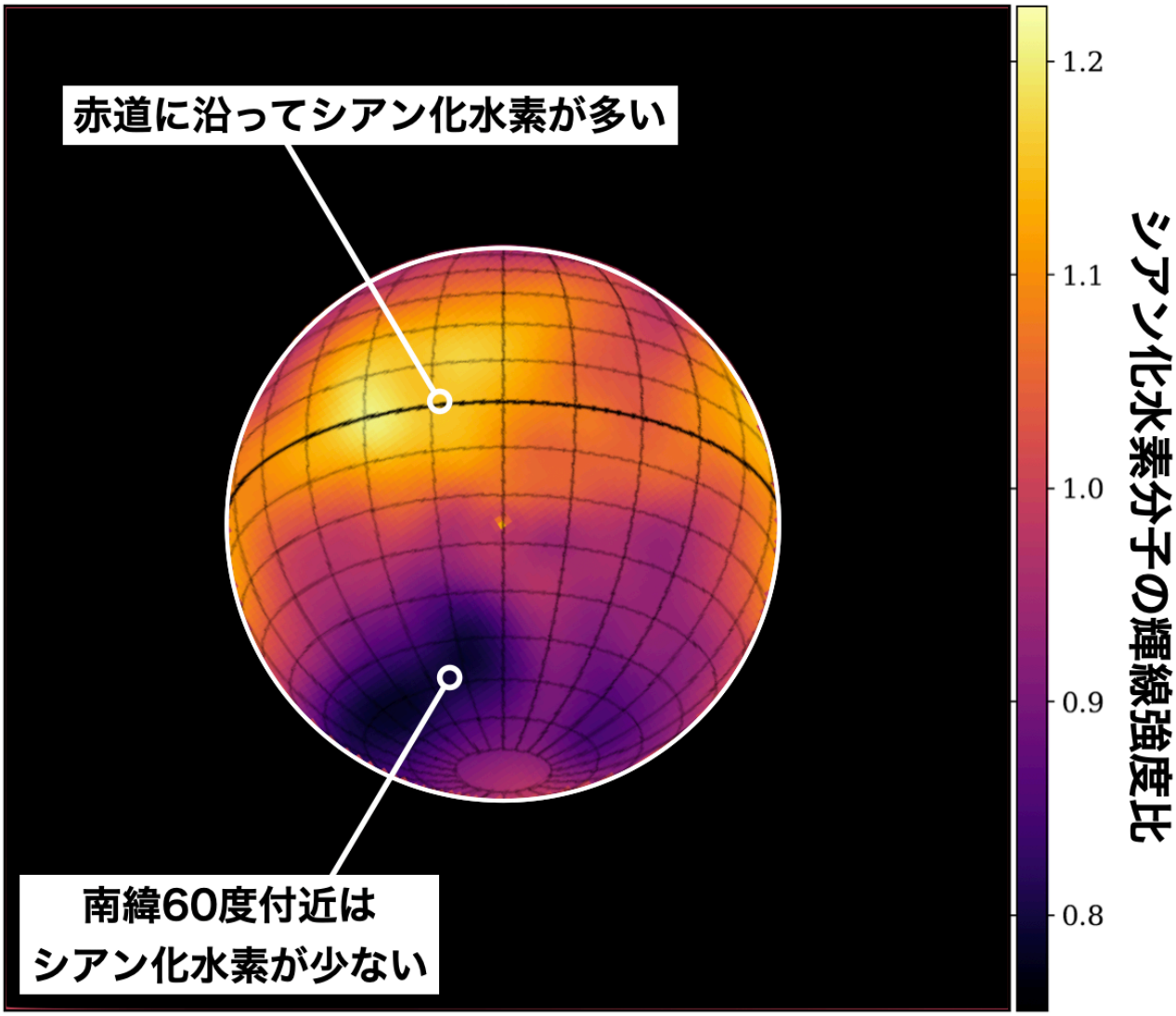
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We present a spatially resolved map of integrated- intensity and abundance of Neptune's stratospheric hydrogen cyanide (HCN).
The analyzed data were obtained from the archived 2016 observation of the Atacama Large Millimeter/submillimeter Array.
A 0.42 x 0.39 arcsec synthesized beam, which is equivalent to a latitudinal resolution of ~20 degrees at the disk center, was fine enough to resolve Neptune's 2.24 arcsec diameter disk.
After correcting the effect of different optical path lengths, a spatial distribution of HCN emissions is derived over Neptune's disk, and it clearly shows a band-like HCN enhancement at the equator.
Radiative transfer analysis indicates that the HCN volume mixing ratio measured at the equator was 1.92 ppb above the 10^{-3} bar pressure level, which is 40% higher than that measured at the southern middle and high latitudes.
The spatial distribution of HCN can be interpreted as either the effect of the transportation of N_2 from the troposphere by meridional atmospheric circulation, or an external supply such as cometary collisions (or both of these reasons).
From the meridional circulation point of view, the observed HCN enhancement on both the equator and the pole can be explained by the production and accumulation of HCN at the downward branches of the previously suggested two-cell meridional circulation models.
However, the HCN-depleted latitude of 60 degrees south does not match with the location of the upward branch of the two-cell circulation models.

Keywords: ALMA, Neptune, Atmospheric Chemistry

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Estimation of the drift rate and intensity of Neptune’s storm in 2018-2020 with Pirka Telescope

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A storm more than 4,000 km in diameter occasionally occurs in Neptune. Since Neptune is a great distance away from the Earth, storms in Neptune can be resolved only by using large telescopes such as the Keck Observatory and the Hubble Space Telescope. However, it isn't easy to always use those telescopes for Neptune observation. Therefore Neptune is not observed for the long term on a short time scale. We developed the technique to estimate the drift rate and intensity of storms by observing Neptune's whole spectrum in this study. When seeing is bad, it's possible to observe and acquire Neptune's observation data for the long term on a short time scale. The purpose is to deepen the understanding of Neptune's atmosphere convection structure by chasing the detailed change of storms. In this study, we observed Neptune by using a 1.6 m Pirka telescope that Hokkaido University owns. The observation time is from October 22, 2018, to November 26, 2018, from July 8 to November 12, 2019, and we started observation on July 20 in 2020. The wavelengths are 890, 855 nm. The apparent size of storms from the observation point changes by the rotation of Neptune, so an 890 nm flux changes by the rotation. We took the ratio of an 890 nm flux and an 855 nm flux to correct the atmosphere's effect on the earth and calculated the theoretical values of the relative intensity by the rotation. We assumed the storm's size and fit the observed values with the theoretical values in the method of least squares to estimate the drift rate and 890 nm reflectance inside storms. We estimated that the drift rate and the 890 nm reflectance are 24.6˚/ day and 0.166 in 2018, respectively. In 2019, since there are multiple storms and this analysis method assumes that there is only one storm, it is necessary to consider an analysis method when there are multiple storms from HST and amateur observation images. In 2020, we estimated that the drift rate and the 890 nm reflectance are 20.0˚/ day and 0.234 respectively. In 2018, Simon et al. (2019) discovered a new northern Great Dark Spot (NDS-2018) located at 23˚N. NDS2018 drifted westward at 2.46˚/hr in November 2018. However, NDS-2018 could not be seen because it was located on the night side during our observation, and it is considered that we observed a different storm. We will continue the observations in 2021 and compare them with other researchers and amateur observations to have a discussion in the future.

Keywords: Neptune, Ground-based telescope

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Ion escape mechanism from a Mars-like planet under weak intrinsic magnetic field conditions: Dependence of IMF clock angle

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The ion escape mechanism from planets is mainly determined by the presence of an intrinsic magnetic field, the orientation of the interplanetary magnetic field (IMF), and the solar X ray and extreme ultraviolet (XUV) irradiances. It is believed that ancient Mars had a global intrinsic magnetic field of interior origin and the magnetic field decayed by ~3.9 billion years ago (Acuña et al., 1999). One of the pieces of evidence that ancient Mars had an intrinsic field is the existence of a "crustal magnetic field" (Acuña et al., 1999). Sakai et al. (2018) investigated the effect of a weak intrinsic magnetic field at the Martian equatorial surface on the escape mechanism. It was shown that the existence of the weak field results in an enhancement of the ion escape rate. A parker-spiral IMF was however used in order to obtain the escape rate in this earlier study. The orientation of IMF also changes the escape rate and mechanism. Sakai et al. (2021) suggested that the escape rate is the lowest in the case of IMF parallel to the dipole at subsolar and comparable in the Parker-spiral and antiparallel IMF case. The parallel IMF case is dominated by the ion escape from the high-latitude lobe reconnection region, where ionospheric ions are transported upward along open field lines, while in the antiparallel IMF case, the escape flux of heavy ions increases significantly due to the mass loading of ionospheric ions, with peaks around the equatorial dawn and dusk flanks. Previous studies have investigated the ion escape rate and its mechanism for only three IMF orientations, e.g., the northward (parallel), Parker-spiral, and southward (antiparallel) IMF cases, but the factors responsible for the enhancement of escape rate have not yet been elucidated.

This paper investigates the dependence of the escape mechanism on the IMF clock angle under a weak intrinsic magnetic field of 100 nT at the surface and the present-day XUV irradiances using a multispecies magnetohydrodynamic simulation. The simulation is conducted under the condition that the IMF makes a round in twenty-four hours, which is comparable to the time scale of coronal mass ejection, after starting the northward IMF. The ion escape rate drastically increases when the clock angle is above 45° from the due north. The reconnections occur in the lobe region of the magnetosphere in the northward IMF, its location gradually moving to the flank region during the transition of the clock angle to 45°. The reconnections in the flank region also occur in the Parker-spiral IMF case (Sakai et al., 2018; 2021), leading to the enhancement of the ion escape rate. The escape rate gradually increases over time after the clock angle of 60°, reaching a maximum around the clock angle of 180° - 210° in the southward IMF.

This paper also studies the escape mechanism under the different magnetic field strengths and XUV irradiances influencing the escape mechanism, and the results are compared with those under the magnetic field strength of 100 nT and the present-day XUV irradiances.

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Keywords: Mars, Atmospheric escape, Intrinsic magnetic field, Interplanetary magnetic field, Numerical modeling

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Dependences of ion escape from Mars on the intrinsic magnetic field strength under CME-like solar conditions at 3.5 Ga

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Mars experienced drastic climate change during its early period. Atmospheric escape to space played an important role in the removal of the atmosphere and climate change on ancient Mars. In particular, escape of the ionized atmosphere, i.e., ion escape was a key process of atmospheric loss. Stronger solar X-ray and extreme ultraviolet (XUV) radiation and solar wind from the young Sun facilitate ion escape. Past studies pointed out that ion escape on ancient Mars was stronger by several orders of magnitude and contributed to the atmospheric loss. A planetary magnetic field is another important parameter controlling ion escape. Mars has crustal remnant magnetic field, which implies that ancient Mars once had a global intrinsic magnetic field. Existence of an intrinsic magnetic field affects the magnetic configuration and thus processes and rates of ion escape. Although previous studies suggested both inducing and reducing effects of an intrinsic magnetic field on ion escape, the details are not fully understood. Based on multispecies magnetohydrodynamics (MHD) simulations, Sakata et al. (2020) investigated how the strength of an intrinsic magnetic field affects ion escape from Mars under the solar XUV and solar wind conditions at 4.5 Ga. They revealed that the effects of an intrinsic magnetic field depend on the relationship between the solar wind dynamic pressure and the magnetic pressure of the intrinsic magnetic field and showed that the effects are more pronounced on molecular ions (O_2^+ and CO_2^+). Escape rates of molecular ions increase by a factor of six if Mars has a weak intrinsic magnetic field whose magnetic pressure is lower than the solar wind dynamic pressure, while they decrease by two orders of magnitude if the intrinsic magnetic field is strong enough to sustain the solar wind dynamic pressure. Effects on O^+ are milder than those on molecular ions because of the contribution of ion pickup on the extended neutral oxygen corona.

We investigated dependences of ion escape processes and rates on the intrinsic magnetic field strength under solar XUV and solar wind conditions during coronal mass ejection (CME)-like events at 3.5 Ga. As solar events such as CMEs occurred more frequently during the early period of the Sun, enhanced ion escape during CMEs is expected to play a role in atmospheric loss from ancient Mars. The solar XUV flux was set to be 50 times higher than the present value. The solar wind number density, velocity, and the interplanetary magnetic field (IMF) strength were set to be 700 cm^{-3}, 1400 km s^{-1}, and 20 nT, respectively. The intrinsic magnetic field was assumed to be a dipole field and northward at the equator. We conducted multiple simulations cases with different strength of the dipole field.

As expected, escape rates of molecular ions increase in the weak dipole field case, while they decreased strongly under the existence of a strong dipole field enough to sustain the solar wind dynamic pressure. In the intermediate case, the escape rates decrease despite the dipole field strength is lower than the threshold defined so that the dipolar magnetic pressure at the equatorial surface equals the solar wind dynamic pressure. It suggests that the relationship between the intrinsic magnetic field and the solar wind should be evaluated more carefully based on the ion escape mechanism. The effects on O^+ are seen more clearly than those in Sakata et al. (2020). The contribution of ion pickup on the neutral oxygen corona is

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smaller due to weaker solar XUV flux.

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Keywords: atmospheric escape, intrinsic magnetic field, MHD simulation, ancient Mars

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.04 Zoom Room 04

[P-CG18] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Yuki Harada(Kyoto University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University)

Exploration of Mercury, Venus, Moon, Mars, Jupiter, Saturn, and beyond together with rapid developments of numerical simulations provides us new view of planetary environment. This session collects general contributions of new findings about planetary magnetosphere, ionosphere, and atmosphere. New methodology and technology development studies for future explorations are also welcome. In order to put the common knowledge at different planets into perspective, this session aims to facilitate discussions on comparative planetary environments.

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

[PCG18-07] Investigation of periodic electron injection observed in Martian crustal magnetic fields with MAVEN and MGS

*Michio Kato[1], Yuki Harada[1], David L Mitchell[2], Christian Mazelle[3], Gina A DiBraccio[4], Jasper S Halekas[5], Suranga Ruhunusiri[5] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Space Sciences Laboratory, University of California, Berkeley, 3.RAP, University of Toulouse, CNRS, UPS, CNES , 4.NASA Goddard Space Flight Center, 5.Department of Physics and Astronomy, University of Iowa)

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

[PCG18-08] Modeling diffuse auroral emissions at Mars: Contribution of precipitating protons and mirror effects of crustal fields

*Yuki Nakamura[1,2], Naoki Terada[1], Francois Leblanc[2], Hiromu Nakagawa[1], Shotaro Sakai[1], Sayano Hiruba[1], Ryuho Kataoka[3], Kiyoka Murase[4] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.LATMOS, Sorbonne University, 3.National Institute of Polar Research, 4.The Graduate University for Advanced Studies)

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

[PCG18-09] Effects of the magnetic field orientation on the vertical emission profile of Martian diffuse aurora: A Monte Carlo model development

*Taishin Okiyama[1], Kanako Seki[1], Nicholas M. Schneider[2], Sonal K. Jain[2] (1.Graduate School of Science, University of Tokyo, 2.LASP, University of Colorado, Boulder)

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

[PCG18-10] Extraction of Martian atmospheric fine structures by analyzing Mars Global Surveyor radio occultation data

*Ryutaro Sakurai[1], Takeshi Imamura[1] (1.Graduate School of Frontier Sciences, The University of Tokyo)

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

[PCG18-11] Variation of CO/CO_2 profile in the Martian middle atmosphere observed by TGO/NOMAD

*Nao Yoshida[1], Hiromu Nakagawa[1], Shohei Aoki[2,3], Justin Erwin[2], Ann Carine Vandaele[2], Isao Murata[1], Ian Thomas[2], Frank Daerden[2], Lori Neary[2], Shungo Koyama[1], Naoki Terada[1], Yasumasa Kasaba[1], Bojan Ristic[2], Manish R Patel[4], Giancarlo Bellucci[5], Jose-Juan Lopez-Moreno[6] (1.Dep. Geophysics Graduate School of Science Tohoku University, 2.Royal Belgian Institute for Space Aeronomy, BIRA-IASB, 3.LPAP,

STAR Institute, Université de Liège, 4.School of Physical Sciences, The Open University, 5.Instituto di Astrofisica e Planetologia Spaziali (IAPS/INAF), 6.Instituto de Astrofisica de Andalucia (IAA/CSIC))

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

[PCG18-12] Periodic variations of hydrogen and oxygen airglow in the Martian upper atmosphere during a rapid growth of a regional dust storm

*Kei Masunaga[1], Naoki Terada[2], Nao Yoshida[2], Takeshi Kuroda[2], Kazuo Yoshioka[3], Tomoki Kimura[2], Fuminori Tsuchiya[2], Go Murakami[4], Atsushi Yamazaki[4], Ichiro Yoshikawa[3] (1.University of Colorado Boulder, 2.Tohoku University, 3.University of Tokyo, 4.Institute of Space and Astronautical Science)

Investigation of periodic electron injection observed in Martian crustal magnetic fields with MAVEN and MGS

*Michio Kato[1], Yuki Harada[1], David L Mitchell[2], Christian Mazelle[3], Gina A DiBraccio[4], Jasper S Halekas[5], Suranga Ruhunusiri[5]

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Mars has no global intrinsic magnetic field, but it has relatively strong crustal remanent magnetic fields. The solar wind interacts with these localized crustal magnetic fields and with the upper atmosphere of Mars, forming a complex magnetosphere. Provided that electrons get injected impulsively from the adjacent plasma into closed magnetic field lines formed above the strongly magnetized areas, they drift in an energy-dependent manner in the direction perpendicular to the magnetic field while bouncing between the mirror points, producing energy-time dispersion at a fixed observing point on the closed filed line. These energy-time dispersed electron signatures were measured by the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission. It has been reported that the energy-time dispersed electron signatures sometimes occur periodically for multiple times in succession, but the generation mechanism of this periodicity has not been clarified yet. In this study, we investigate characteristics of these periodic electron energy-time dispersion observed in the crustal magnetic fields of Mars using the solar wind electron analyzer (SWEA) and magnetometer (MAG) onboard MAVEN, and the electron reflectometer (ER) and magnetometer (MAG) onboard the Mars Global Surveyor (MGS). First, we conducted a survey of the periodic events from the MAVEN data obtained from September 2014 to September 2020 at altitudes from 200 km to 1000 km. As a result, we identified 211 cases in which electron energy-time dispersion was observed for multiple times in succession. In addition, we analyze the MGS data obtained from March 1999 to November 2006. Although no cases of the periodic electron energy-time dispersion have been reported from the MGS data, we have identified such cases by utilizing the methodology originally developed for the MAVEN data analysis. We will discuss long-term trends of these events based on statistical results derived from a large amount of the MGS data.

Keywords: Mars, Martian crustal magnetic fields, the energy-time dispersed signatures, MAVEN, MGS

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Modeling diffuse auroral emissions at Mars: Contribution of precipitating protons and mirror effects of crustal fields

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Solar Energetic Particle (SEP) and the Imaging UltraViolet Spectrograph (IUVS) instruments aboard the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft have discovered new type of diffuse aurora that spans across nightside Mars, which resulted from the interaction of Solar Energetic Particles (SEPs) with the Martian atmosphere [Schneider et al., 2015]. Previous models suggested that 100 keV monoenergetic electron precipitation should be the origin of the low altitude (~ 60 km) peak of the limb emission, however, no models were able to reproduce the observed emission profiles by using the observed electron energy spectrum [e.g., Haider et al., 2019]. Previous auroral emission models did not take into account the contribution of MeV proton precipitation, although MeV proton can penetrate down to ~ 70 km altitude as well [e.g., Jolitz et al., 2017]. This study aims to model SEP-induced diffuse auroral emissions by both electrons and protons. In order to constrain the possible sources of the diffuse auroral emissions, we focus on the different magnetic mirror behaviors of the precipitating electrons and protons in the presence of crustal magnetic fields.

We have developed a Monte-Carlo collision and transport model of precipitating electrons and protons with magnetic fields on Mars. We calculated limb intensity profile of CO2+ ultraviolet doublet (UVD) excited by precipitating electrons and protons with energies ranging 100 eV - 100 keV and 100 eV - 5 MeV, respectively, during December 2014 SEP event and September 2017 SEP event by using electron and proton fluxes observed by MAVEN/SEP, SWEA and SWIA.

At the SEP event in December 2014, we found that calculated intensity at peak altitude of the CO2+ UVD due to proton precipitation is comparable to those by electron precipitation. On the other hand, inferred peak altitudes of the CO2+ UVD limb intensities are 80 km for protons and 110 km for electrons, respectively. In this event, we concluded that the MeV protons mainly contribute to reproduce the proton-induced CO2+ UVD emission, while the few keV electrons contribute to the electron-induced CO2+ UVD emission. At the SEP event in September 2017, the calculated peak limb intensity of CO2+ UVD due to proton precipitation is four times larger than that due to electron precipitation. Peak altitudes of the CO2+ UVD limb intensities are 60 km and 70 km for protons and electrons, respectively. In this event, 5 MeV protons contribute the most to the proton-induced CO2+ UVD emission and 100 keV electrons contribute the most to the electron-induced CO2+ UVD emission.

We compared our model results with the observations of CO2+ UVD limb intensity obtained in Schneider et al. (2015) and Schneider et al. (2018) for December 2014 SEP event and September 2017 SEP event, respectively. At the SEP event in December 2014, our result of total CO2+ UVD limb intensity of electron and proton contributions is 3 times larger than the observation. As for the peak altitude, our result is 80 km, which is 10 km higher than the observed peak at 70 km. In the SEP event in September 2017, our result of total CO2+ UVD limb intensity of electron and proton contributions is 1.5 times larger than the observation. As for the peak altitude, our result is 60km, which is almost identical to the observation. We concluded that our model results are almost consistent with observations.

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We have also investigated the effect of crustal field on the emission of CO2+ UVD. The CO2+ UVD emissions due to precipitating electrons are depleted by a factor of 10 in the region of open crustal field and disappeared in the region of closed and parallel crustal field, whereas the emissions due to precipitating protons do not change significantly due to the difference in their gyro radii and their relations to the crustal field spatial scale. Further observations of diffuse aurora in the crustal field region are needed to constrain the origin of diffuse aurora on Mars.

Keywords: Mars, Diffuse aurora, Solar energetic particles

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Effects of the magnetic field orientation on the vertical emission profile of Martian diffuse aurora: A Monte Carlo model development

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The Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft first observed the diffuse aurora at Mars (Schneider et al. 2015). The aurora is thought to be caused by solar energetic particles penetrating into the Martian atmosphere along the interplanetary magnetic field lines draped around the planet. The aurora was observed over a wide area in the northern hemisphere where the crustal magnetic fields are absent or weak. The energy of these solar energetic particles, measured by SEP instrument onboard MAVEN, did not show rapid variation and changed slowly over several days. On the other hand, observations by the Imaging Ultraviolet Spectrograph (IUVS) onboard MAVEN show rapid changes in the peak altitude of the diffuse aurora emission intensity. The cause of the rapid changes of the vertical auroral emission profile is far from understood. One of the possibilities is that the change in the magnetic field orientation around Mars affects the auroral altitude profile. The purpose of this study is to investigate effects of the magnetic field orientation on the vertical emission profile of Martian diffuse aurora based on a Monte Carlo simulation.

We have developed a one-dimensional (1-D) model that calculates the vertical emission profile of CO_2^+ UVD and the CO Cameron bands, which are typical emission lines of the diffuse aurora. The methods used are similar to that of the Monte Carlo model of Bhardwaj et al. (2009), which describes the interaction between CO_2 neutral atmosphere and electrons up to 1000 eV. Our model includes elastic scattering, excitation, and ionization between electrons and CO_2, and extended the upper energy up to hundreds of keV to include high-energy electrons that cause the diffuse aurora. In addition, the effect of the draped magnetic field structure was introduced by changing the incident angle of electrons through coordinate transformation. The results of our model showed that decreasing elevation angle of the magnetic field from the horizontal direction increased the peak altitude of the emission intensity. The result might indicate that the magnetic field orientation in the vicinity of the planet is one of the important factors to change the vertical emission profile of the diffuse aurora.

Keywords: Mars, aurora, Solar Energetic particle, Monte Carlo, induced magnetosphere

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Extraction of Martian atmospheric fine structures by analyzing Mars Global Surveyor radio occultation data

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Radio occultation observation is one of the most effective methods to study fine structures in planetary atmospheres. In order to derive the vertical structure of an atmosphere from the data of radio waves transmitted from the spacecraft and recorded at the ground station after passing through the planet's atmosphere, the geometric optics method has been used to calculate the ray path at each moment and then determine the atmospheric structure sequentially. In contrast, the recently developed radio holographic method derives the atmospheric structure from the entire signal time series at once, thereby significantly improving the vertical resolution compared to the geometric optics. One of the radio holographic methods, Full Spectrum Inversion (FSI) proposed by Jensen et al. (2003), was applied to the Venusian atmosphere by Imamura et al. (2018) to reveal fine vertical structures in the atmosphere that could not be captured by previous analysis.On Mars, the temperature structure of the Martian atmosphere has been obtained by radio occultation observations by Mars Global Surveyor (MGS). Various microstructures such as atmospheric gravity waves, convective boundary layers, and thin stable layers of ice clouds that occur at night have been revealed. Such fluid dynamical processes are thought to play important roles in the transport of energy and momentum. However, conventional analysis has an altitude resolution of about 1 km, which is not sufficient to fully resolve the vertical structures of these phenomena. The purpose of this study is to apply the new analysis method, FSI, to Martian radio occultation data in order to analyze the fine structures of the Martian atmosphere at a higher resolution than before, and to reveal the details of these small-scale processes.In this study, we analyzed the MGS radio occultation data by both the geometrical optics method and FSI, and compared the results. MGS conducted many radio occultations during its mission period from 1997 to 2006, and here we report results from a portion of the data. The atmospheric profiles obtained from MGS occultation data by geometrical optics method has already been released as an official product by the MGS project. However, since the geometrical optics analysis performed in this study shows finer structures, we will also report on the comparison between the two.

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Variation of CO/CO_2 profile in the Martian middle atmosphere observed by TGO/NOMAD

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The upper atmosphere is the reservoir for atmospheric escape to space. The composition in the Martian upper atmosphere is mainly controlled by the solar Extreme-Ultraviolet (EUV) irradiance [e.g., Fox et al., 1996; Bougher et al., 2015; Krasnopolsky et al., 2002] but also varies with the altitude of homopause [Yoshida et al., 2020]. Homopause is the compositional boundary above which the molecular diffusion coefficient becomes larger than the eddy diffusion coefficient. On Mars, it is inferred that homopause altitude varies between 60 and 140 km altitudes with season, latitude, and local time [Jakosky et al., 2017; Slipski et al., 2018; Yoshida et al., 2020]. The substantial variation of homopause altitude suggests the influence of the lower atmospheric processes on the upper atmosphere. The inflation and contraction of the lower atmosphere are suggested as the main source of variations of homopause altitude. Besides, the gravity waves, planetary-scale waves, thermal tides, and global circulation are suggested to affect the homopause location [Imamura et al., 2016; Leovy et al., 1982; González-Galindo et al., 2009]. Since the variability of atmospheric composition study has been conducted by Mars Volatile Evolution spacecraft which measures the atmospheric composition in the upper atmosphere, variability of the lower-middle atmospheric composition has not acquired. To understand the dynamical coupling between the lower and the upper atmospheres, we use the Nadir and Occultation for MArs Discovery (NOMAD) instrument aboard Trace Gas Orbiter (TGO). NOMAD solar occultation is designed the combination of the Acousto Optical Turnable Filter and echelle grating [Neefs et al., 2015; Thomas et al., 2016]. NOMAD solar occultation operates in the wavelength range of 2.2 - 4.3 μm with a high-resolution (0.15 –0.22 cm^{-1}) [Vandaele et al., 2018]. It provides us CO and CO_2 spectrum below 100 km and 180 km altitudes, respectively.

The retrieved column mixing ratio of CO has the seasonal variation, which increases at the wintertime polar regions and decreases at the summertime polar regions [Smith et al., 2009; 2018; Krasnopolsky, 2007]. Seasonal variation of CO mixing ratio is controlled by CO_2 sublimation and condensation. The general circulation model including atmospheric chemistry has suggested that the vertical structure of CO mixing ratio increases along with altitude above 60 km [Daerden et al., 2018; Lefevre et al., 2008]. The CO mixing ratio is constant in the lower atmosphere because time of vertical mixing is shorter than the CO lifetime of ~6 years [Krasnopolsky, 2007]. However, the lifetime of CO becomes comparable to the time of vertical mixing around 60 km due to the production by CO_2photodissociation when a linear decrease in the eddy diffusion coefficient (e.g., Izakov, 1978) is assumed. These studies suggest that both photochemistry and eddy diffusion are important in determining the CO/CO_2 ratio profiles.

In this study, we applied the equivalent width technique [Chamberlain and Hunten, 1987; Krasnopolsky, 1986] to derive a new set of the column densities of CO and CO_2, respectively, with the observed atmospheric transmittance spectra by NOMAD solar occultation. The CO (2-0) band and the CO_2 (21102 –00001) band are carefully selected for retrievals due to the contribution of nearby and central orders [cf.

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Liuzzi et al., 2019]. It is noted that CO_2 absorption cross sections, we use, have high sensitivity to the background temperature. We found that the retrieved CO/CO_2 ratio between 60 and 90 km increases with altitudes as predicted by the models. The seasonal variation of observed CO/CO_2 profile will be discussed. For interpretation, 1D photochemical model is compared newly obtained CO/CO_2 profiles, especially in order to infer the eddy diffusion coefficient in the lower atmosphere on Mars.

Keywords: Trace Gas, Mars, IR observation, CO, Eddy diffusion, Photochemistry

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Periodic variations of hydrogen and oxygen airglow in the Martian upper atmosphere during a rapid growth of a regional dust storm

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Analyzing extreme ultraviolet (EUV) spectra of the Martian upper atmosphere obtained from the Hisaki space telescope, we study variations of hydrogen (HI Ly-β) and oxygen (OI 135.6 nm) airglow during a rapid expansion of a regional dust storm that occurred in Mars Year 33. We find that Ly-β brightness did not vary with the solar EUV flux but significantly increased over the observation period (L_S=213°-232°), while OI 135.6 mainly varied with the solar EUV flux. After subtracting the seasonal and solar effects from Ly-β and OI 135.6 nm brightness, respectively, it was found that their residual brightness varied with a ~6-8-day periodicity and that the OI 135.6 nm residual brightness approximately varied in quadrature with that of Ly-β. The variation level for both emissions was ~20-40% for the whole disk. This indicates that when hydrogen atoms are globally produced by water vapor transported from the lower atmosphere during the dust storm expansion, the amount of oxygen atoms significantly decreases in the upper atmosphere of Mars. In this presentation, we discuss a role of atmospheric waves such as baroclinic waves that usually present in the northern hemispheric lower atmosphere in this season as a possible candidate to cause the periodic airglow variations in the upper atmosphere. We also discuss a cause of the anti-correlation between the hydrogen and oxygen airglow emissions, by analyzing variations of other emission lines such as OII 83.4 nm and ArI 106.6 nm, and CO bands as well as the hydrogen and oxygen emissions.

Keywords: Mars, Hisaki space telescope, Airglow, Dust storm

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[J] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.01_2

[P-CG18] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Naoki Terada(Graduate School of Science, Tohoku University)

Exploration of Mercury, Venus, Moon, Mars, Jupiter, Saturn, and beyond together with rapid developments of numerical simulations provides us new view of planetary environment. This session collects general contributions of new findings about planetary magnetosphere, ionosphere, and atmosphere. New methodology and technology development studies for future explorations are also welcome. In order to put the common knowledge at different planets into perspective, this session aims to facilitate discussions on comparative planetary environments.

[PCG18-P01] Hybrid particle simulation on Mercury's dayside magnetopause

*Hideyuki Usui[1], Yohei Miyake[2], Naoshi Motoda[1], Masaharu Matsumoto[3] (1.Graduate school of system informatics Kobe University, 2.Education Center for Computational and Engineering Science, 3.Graduate school of information science and technology, The University of Tokyo)

[PCG18-P02] Numerical calculation of moist convection in Jupiter's atmosphere - A case study with an average cooling vertical profile based on a radiative transfer calculation -

Taro Sekiguchi[1], *Ko-ichiro SUGIYAMA[2], Masaki Ishiwatari[1], Kensuke Nakajima[3], Kiyoshi Kuramoto[1], Yoshi-Yuki Hayashi[4] (1.Department of Cosmoscience, Graduate School of Science, Hokkaido University, 2.National Institute of Technology, Matsue College, 3.Department of Earth and Planetary Sciences,Flculty of Sciences,Kyushu University, 4.Department of Planetology, Graduate School of Science, Kobe University / Center for Planetary Science (CPS))

[PCG18-P03] High dynamic range observation using a 1.8-m off-axis telescope PLANETS: feasibility study and telescope assembly

*Masato Kagitani[1], Takeshi Sakanoi[1], Kazuya Nagta[1], Yasumasa Kasaba[1], Yasuhiro Hirahara[2], Mikio Kurita[3], Jeffry Kuhn[4], Svetlana Berdyugina[5], Emilio Marcelo[6] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Science, Kyoto University, 4.Institute for Astronomy, Univesity of Hawaii, USA, 5.Kiepenheuer Institute for Solar Physics, Germany, 6.Universidade Estadual de Ponta Grossa, Brazil)

[PCG18-P04] A search for atomic sodium and calcium in the atmosphere of the icy Galilean moons of Jupiter with ground-based telescope

*Seiko Takagi[1], Taro Matsuo[2], Jun Kimura[3], Kazuo Yoshioka[4] (1.Hokkaido University, Graduate School of Science, 2.Nagoya University, 3.Osaka University, 4.The University of Tokyo)

[PCG18-P05] Development of PLANETS telescope: An attempt to reduce polishing volume in final polishing process by using an active mirror support

*Kazuya Nagata[1], Masato Kagitani[1], Yasumasa Kasaba[1], Takeshi Sakanoi[1], Yasuhiro Hirahara[2], Mikio Kurita[3] (1.Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Science, Kyoto University)

[PCG18-P06] Numerical simulations of 500eV-50keV electron elastic collisions with neutral H_2O around Enceladus ~estimation of electron loss rate and auroral brightness~

*Hiroyasu Tadokoro[1], Yuto Katoh[2] (1.Surugadai University, 2.Tohoku University)

[PCG18-P07] Development of the near-infrared camera TOPICS and the Echelle spectrograph ESPRIT for planetary observations

Ayumu Kambara[1], *Takeshi Sakanoi[1], Yasuhiro Hirahara[2], Takashi Ichikawa[3], Masato Kagitani[1], Yasumasa Kasaba[1], Aya Otomo[1], Kazuya Nagata[1] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Astronomical Institute, Graduate School of Science, Tohoku University)

[PCG18-P08] Effects of the magnetic field configuration in the ionosphere on solar energetic electron precipitation into the Martian upper atmosphere observed by MAVEN

*Kanako Seki[1], Takuya Hara[2], Dave A Brain[3], Robert J Lillis[2], Darvin E Larson[2], Dave L Mitchell[2], Gina A Dibraccio[4], Janet G Luhmann[2], Bruce M Jakosky[3] (1.Graduate School of Science, University of Tokyo, 2.Space Sciences Laboratory, University of California, Berkeley, 3.Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder., 4.Goddard Space Flight Center, NASA)

[PCG18-P09] Observations of minor constituents in the Venusian atmosphere, CO and SOx using the millimeter/submillimeter-wave band radio telescopes, SPART/ALMA

Ayaka Tomihara[1], Teppei Yonetsu[1], Yuki Hamaguchi[1], Hideo Sagawa[2], *Hiroyuki Maezawa[1] (1.Department of Physical Science Osaka Prefecture University, 2.Kyoto Sangyo University)

[PCG18-P10] Influences of solar energetic particles on the Martian ozone layer

*Sayano Hiruba[1], Yuki Nakamura[1], Hiromu Nakagawa[1], Naoki Terada[1], Shotaro Sakai[1], Isao Murata[1], Yoshifumi Futaana[2] (1.Dept. of Geophysics, Graduate school of science, Tohoku University, 2.Swedish Institute of Space Physics)

[PCG18-P11] Simultaneous remote and in-situ observations of ionospheric irregularities at Mars

*Hina Bando[1], Yuki Harada[1], Naoki Terada[2], Hiromu Nakagawa[2] (1.Kyoto University, 2.Tohoku University)

[PCG18-P12] Annual variability in the thermospheric wave perturbations at Mars

*Hiromu Nakagawa[1], Nao Yoshida[1], Kaori Terada[1], Naoki Terada[1], Yuki Harada[2], Shotaro Sakai[1], Takeshi Imamura[3], Hitoshi Fujiwara[4], Kanako Seki[5] (1.Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2.Kyoto University, 3.Graduate School of Frontier Scienfes, The University of Tokyo, 4.Faculty of Science and Technology, Seikei University, 5.Graduate School of Science, University of Tokyo)

[PCG18-P13] **Study of atmospheric ion escape from exoplanet TOI-700 d**

*Tomoaki Nishioka[1], Kanako Seki[1], Ryoya Sakata[1], Kazuhiro Yamamoto[1], Naoki Terada[2], Hiroyuki Shinagawa[3] (1.Graduate School of Science, University of Tokyo , 2.Graduate School of Science, Tohoku University , 3.NICT)

[PCG18-P14] DSMC simulations of slow hydrodynamic escape from Earth-like and Mars-like planets

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Hybrid particle simulation on Mercury’s dayside magnetopause

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The purpose of the present study is to investigate the ion dynamics at the dayside magnetopause of Mercury's magnetosphere and the magnetopause location's dependence on the solar wind dynamic pressure by performing hybrid particle simulations. In the simulation model, a small planetary body that has an intrinsic dipole magnetic field is placed at the center, and the solar wind with the Southward or Northward IMF is injected from the simulation boundary. A magnetosphere is created in the simulation due to the interaction between the solar wind and planetary magnetic dipole field. Bow shock, magnetosheath, magnetopause, and cusp are formed in the magnetosphere. In this study, we focus on the ions' trajectories at the dayside magnetopause in the Southward IMF case and analyze the meandering motion and ExB drift motion of the ions at the magnetopause. We also performed simulations to study the magnetopause location in the extreme case of the solar wind condition. When the solar wind dynamics pressure is very high, the previous observations suggest that the possibility that the dayside magnetopause disappears and the solar wind bombard directly to Mercury's surface, called Disappearing Dayside Magnetopause (DDM). We simulate DDM and investigate the structure of the magnetosphere in terms of density and current profiles and the solar wind flux to the surface.

Keywords: Mercury, magnetosphere, hybrid particle simulation

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Numerical calculation of moist convection in Jupiter's atmosphere - A case study with an average cooling vertical profile based on a radiative transfer calculation -

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Active moist convections associated with condensation of H_2O and NH_3 and chemical reaction of NH_4SH are considered to occur in Jupiter's atmosphere. Since it is difficult to observe Jupiter's atmosphere covered with thick clouds by remote sensing, the structure of moist convection remains unclear. We have developed a cloud resolving model that includes cloud microphysical processes of condensation and chemical reactions of multiple components, and have investigated the structure of moist convection realized under Jupiter's atmospheric conditions (Sugiyama et al., 2009, 2011, 2014). Our calculations showed that periods of intense convective activity (active periods) and periods of weak convective activity (quiet periods) appear quasi-periodically. However, the settings of our previous studies were highly idealized. The purpose of this study is to examine the structure of moist convection in Jupiter's atmosphere that are established through a large number of life cycles of convective cloud elements by using the temperature and thermal forcing profiles based on the result of a one-dimensional vertical radiative-convective equilibrium calculation (Takahashi, Hokkaido University Ph. D. thesis, 2018).

The cloud resolving model developed by Sugiyama et al. (2009) is used. The temperature and pressure conditions and the abundances of condensible gases used in our calculation are based on the one-dimensional vertical radiative-convective equilibrium calculation (Takahashi, Hokkaido University Ph. D. thesis, 2018). The computational domain is two-dimensional, 1024 km in the horizontal direction and 300 km in the vertical direction. The resolution is set to 2 km in both the horizontal and vertical directions. One of the major differences between the settings of our calculation and those of Sugiyama et al. (2014) is the temperature profile of the basic state. The temperature profile used in our calculation is stable between 0.4 bar level and the tropopause (0.1 bar level). Another difference is the pressure range in which the model atmosphere is subject to an externally given body cooling that is a substitute for radiative cooling. The body cooling is applied below 0.4 bar level.

In our poster, we will present the characteristics of the structure of moist convection that emerge under more realistic conditions that are based on the one-dimensional vertical radiative-convective equilibrium calculation.

Keywords: planetary atmosphere, moist convection, cloud resolution model

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High dynamic range observation using a 1.8-m off-axis telescope PLANETS: feasibility study and telescope assembly

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High dynamic-range observation is one of the key techniques to reveal composition, distribution and dynamics of plasma and neutrals in the vicinity of planets and their moons in our solar system, e.g. water plumes on Europa and Enceladus, volcanic plumes on Io, escaping plasma and neutrals from Venus and Mars, and so on. A low-scattered light telescope PLANETS (Polarized Light from Atmospheres of Nearby Extra-Terrestrial Systems) will be a 1.8-m off-axis telescope atop Haleakala observatory in Hawaii in collaboration with Japan, USA, Germany and Brazil. Combined with contrast enhancement techniques such as coronagraphy, adaptive optics and high-resolution spectroscopy, the off-axis optical system enables us to achieve high dynamic range measurements without diffraction by support structure of secondary mirror. We present feasibility study of monitoring water plumes on Europa, neutral torus close to Enceladus, and ionosphere on Mars using PLANETS telescope and latest telescope design and assembly in Japan.

This “high dynamic-range” capability is largely dependent upon precision of telescope optics as well as atmospheric distortion. To test feasibility of high dynamic-range observation under actual conditions of wavefront error, we modeled propagation of light though the system based on Fraunhofer calculation taking into account for wavefront error made by atmospheric distortion and by primary mirror figure error. Then point spread function is calculated for several cases of figure errors under use of adaptive optics. The modeling result predicts that using moderate or high-precision primary mirror M1, a contrast level < 10^{-4} at 5 λ /D would be accomplished. We also derived signal-to-noise ratio expected for three observing targets in the vicinity of Saturn, Mars and Europa. The moderate or high-precision M1 is mandatory to achieve the HDR observations with signal-to-noise ratio > 2 to 3.

We also present latest design of the telescope structure and M1 active support structure. The most part of the telescope structure is reuse of prototype of Kyoto 3.8-m telescope (*Kurita and Sato*, 2009) which employs commercial truss component for architecture. The structure is characterized by its light-weight (6.4 tons) and high-stiffness. The primary thin mirror (100 mm thick on edge) is supported by 36-point whiffletrees in axial and 24-point Schwesinger support in lateral direction. 33 warping harnesses equipped to the axial support whiffletrees enable to compensate low-frequency wavefront error of M1. The laboratory experiment using a third part of prototype whiffletrees shows supporting force RMS repeatability < 0.005 kgf, and drive hysteresis < 0.7% of load range, which are precise enough to control or to keep the M1 surface figure.

We aim to complete the final M1 polish and assembling the telescope structures in the year of 2021.

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A search for atomic sodium and calcium in the atmosphere of the icy Galilean moons of Jupiter with ground-based telescope

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Study of the Galilean moon atmospheres has been advanced by space missions of the last 25 years, e.g., Voyager, Hubble Space Telescope, and Galileo, and numerous ground-based observations. Thus we now know these moons have tenuous atmosphere with SO_2 for Io and oxygen for Europa as primary species. On the other hand, minor species in the atmosphere can aid in investigation of surface composition and transportation processes between moons. For Io and Europa, numerous sets of observations exist of atomic sodium and potassium [Brown and Chaffee, 1974; Trafton, 1975; Brown and Hill, 1996; Brown, 2001]. For Io, the sodium D_1 (5,895.92 Å) and D_2 (5,889.95 Å) emission lines brightness of the sodium nebula has a positive correlation with Io's volcanic activity [Mendillo et al., 2004; Yoneda et al., 2015], which strongly suggests that the sodium originates from the Io’s interior. For Europa, spectrographic evidence on the surface acquired from the Galileo spacecraft suggests that hydrated salt minerals, such as magnesium and sodium sulfates, sodium carbonate and their mixtures, are concentrated at the linear features and in the chaotic terrains [McCord et al., 1999]. Furthermore, recent visible spectroscopic observations by the Hubble Space Telescope suggests the presence of sodium chloride on Europa [Trumbo et al. 2019]. The value of [Na]/[K] for the Europa’s atmosphere, ~25+/-3 [Brown et al., 2001], is used to express that Europa’s atmospheric alkalis are endogenic because of the relatively close to the predicted value for the Europa’s ocean [Zolotov and Shock, 2001] than the meteoroid source value of ~13 [Carlson et al., 2009]. However, we have no definitive conclusions about the endogenic or exogenic origin of Europa’s alkalis at present, and the compositional relationship between the Europa’s ocean, the surface and the atmosphere is unknown. In addition, although an emission signal from magnesium atoms has been expected, no positive signal has been reported [Horst and Brown, 2013]. Further observations expect to bring better understandings for the source of these materials and interaction processes on and around Europa.

We search minor species, on the icy Galilean moons of Jupiter using the ground-based telescope of Hokkaido University (Pirka telescope, the primary mirror is 1.6 m in diameter). The Pirka telescope and its on-board observation device has started full-scale operation in 2011 with priority to observe planetary bodies in the Solar System. The multi spectral imaging device [Watanabe et al., 2012] has been installed at the Cassegrain focus of the telescope and it allow us to obtain surface spectral data with wavelength between 350 and 1050 nm. We observed the Galileo satellite in 2018-2020 and searched for sodium and calcium in the Io and Europa atmospheres. Here we will report the investigation.

Keywords: Galilean moon, atmosphere, ground-based observation

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Development of PLANETS telescope: An attempt to reduce polishing volume in final polishing process by using an active mirror support

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PLANETS (Polarized Light from Atmospheres of Nearby Extra-Terrestrial Systems) telescope is a 1.85 m off-axis telescope. It is developed with technical support from Nagoya University and Kyoto University, and in international collaboration between Tohoku University, Hawaii, Germany, and Brazil. It is going to be temporally installed in Japan late in 2021, and will be finally installed at the Haleakala observatory, one of the world’ s best astronomical observation sites. PLANETS telescope is the only medium aperture telescope in Japan located at Hawaii longitude, and can be a base for collaborative observations with small and medium aperture telescopes in Japan. The main targets of the PLANETS telescope are faint luminous phenomena around bright bodies, such as material eruptions from Io, Europa, Enceladus, and other solar system objects, and the rarefied atmospheres around Mars and Venus. To achieve these observations, it is necessary to suppress the diffraction and scattering of light from the bright bodies effectively and to increase the contrast with the faint emission spreading to the surroundings. PLANETS telescope is one of the biggest off-axis telescopes except for solar telescopes. It uses a Gregorian type with a concave elliptic secondary mirror, and there is no obstacle on the light path such as secondary mirror and its support structure, so there is no diffraction from them. Combining the off-axis design with a coronagraph and an adaptive optics enables high-contrast observations. In addition, long-term continuous observations are necessary to understand such atmospheric and plasma phenomena. PLANETS telescope can make a significant contribution to understand planetary atmospheric phenomena because it will be used for dedicated observation of own instrument and can provide a large amount of observation time. In this presentation, we report an attempt to reduce the polishing volume by using an active support mechanism in the final polishing of the primary mirror, which will start in May 2021, and the results of a test to verify the operation of the support mechanism.

The primary mirror is a Clearceram-Z HS with a diameter of 1.85 m and an edge thickness of 100 mm. As of February 2021, the primary mirror has been figured to surface error of 1.50 μm RMS, and the final polishing scheduled for May 2021 aims to achieve the surface error < 20 nm RMS for 30-cm spatial scale. Large volume of mirror material to be removed by polishing (polishing volume) leads to an increase in the time and cost required, so smaller polishing volume is desirable. We will reduce the polishing volume by using both of the following two methods. In the first method, a radius of curvature of the off-axis paraboloid, an off-axis distance, tip-tilt of the mirror surface and a rotation angle are adjusted so that the polishing volume is minimized for the mirror surface error. Changes of these parameters deform the surface figure linearly and independently when the parameter changes are small amounts. By tuning these parameters, the best-fit parameters are determined so that the polishing volume is minimized. This minimization basically reduces polishing volume by less than half for the surface figure error expressed up to the third order of Zernike polynomial with 2μm RMS amplitude. In the second method, the active support mechanism of the primary mirror is also applied to correct the surface figure error to reduce the polishing volume. PLANETS telescope uses a 36-point whiffletree for the axial support of the primary mirror. The whiffletree is combined with 33 warping harnesses consisting of leaf springs and linear motors to control the support force at each support point. This axial support is also used in the final polishing to

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reduce the polishing volume by decreasing the surface figure error on large spatial scales. We used finite element analysis to validate the second method. Combination of these two methods successfully deforms the mirror surface in shapes expressed as Zernike polynomials up to the third order and less than about 20% error. We also simulated the minimization of the polishing volume for the current figure error of the primary mirror in advance of the final polishing. As a result, it was expected that the mirror surface error could be reduced from 1.5 μm RMS to 0.28 μm RMS, and the amount of polishing could be reduced by 80.5 %.

Prior to the final polishing, we are making tests to confirm the control repeatability and stability of the active support mechanism using the primary mirror and autocollimator. We will report the latest results in this presentation.

Keywords: Off-axis optical system, Planetary atmosphere and plasma, Mirror polishing

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Numerical simulations of 500eV-50keV electron elastic collisions with neutral H_2O around Enceladus ~estimation of electron loss rate and auroral brightness~

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1. Surugadai University, 2. Tohoku University

Saturn's inner magnetosphere is dominated by water group neutrals (H_2O, OH, and O) originated from Enceladus. Previous studies suggested that the neutrals contribute to loss processes of plasma in the inner magnetosphere. However, little has been reported on a quantitative study of the electron loss process due to electron-neutral collisions. *Tadokoro and Katoh* [2014] focused on the loss process of 1 keV electron through the elastic collision with neutral H_2O. They examined the time variations of equatorial electron pitch angle distribution and electrons within loss cone through 1keV electron pitch angle scattering due to elastic collisions around Enceladus, conducting one dimensional test particle simulation. The result showed that the electrons of 11.4 % are lost in the time scale (~380 sec.) of the co-rotation of the flux tube passing through the region of the dense H_2O in the vicinity of Enceladus. The examination of elastic collisions with other electron energy is required to understand the electron loss process due to elastic collision.

We calculate the electron elastic collision in the energy range of 500 eV –50 keV. We show the electron loss rate into the atmosphere of Saturn and auroral brightness based on the loss rate.

Keywords: Saturn, Enceladus, test particle simulation, elastic collision, auroral brightness

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Development of the near-infrared camera TOPICS and the Echelle spectrograph ESPRIT for planetary observations

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We are developing a near-infrared imager TOPICS (Tohoku Planetary near-Infrared Camera System) and echelle spectrograph ESPRIT (Echelle Spectrometer for Planetary Research In Tohoku University) to carry out long-term observations of variations in planetary and satellite atmospheres at Haleakala Observatory (3,055 m) in Hawaii. In this study, we improved the electronics of the InSb 256 x 256 array by developing a proper and safe driving system of TOPICS, and conducted the vacuum and cooling tests of ESPRIT.

We summarized the results of TOPICS as follows. (1) Development of the precise ammeter: We developed the precise ammeter circuits with two specifications in the range of ±500 μA with the resolution of ~0.0209 μA, and in the range of ±10 mA with the resolution of ~0.418 μA. These ammeters were combined with the driving and readout electronics. Measuring with the science grade detector (Raytheon, SCA#108), we obtained current values as estimated for the all lines. These values are used as references in the future safe operation. (2) Development of voltage input sequence control system. We developed the electronics that control the turn on and turn off sequence of voltages to the detector using logic device and analog switches. (3) Test with the engineer grade detector (Raytheon, SCA#060): We got similar images of a halogen lamp to that in the previous tests by using a bandpass filter (a center wavelength is 2.295 μm). Therefore, we verified proper work of the new electronics. (4) Test with science-grade detector: We got the images of halogen lamp successfully. However, dark current was high (2,230 e^-/s) and the read noise was also huge (1,730 e^-_{rms}). We require the dark current less than 40 e^-/s , and the read noise less than 60 e^-_{rms} to observe Jovian thermospheric ion wind velocity with an accuracy of ±0.5 km from Doppler shift of the emission line of the Jovian H_3^+ aurora. We found that the main noise source is the pre-amplifier, and will improve it soon. For the dark current, we found that the detector temperature was 47 K of which optimal temperature is 30-35K.

We summarized the updates of ESPRIT (wavelength range 1–4 μm, wavelength resolution 20,000) as follows. (5) Vacuum test: We carried out vacuum and leak tests of ESPRIT chamber with optical system. The vacuum level reached to be 2.47×10^{-7} Torr which is sufficient for this spectrograph. (6) Development of thermal path: Thermal paths between 1st and 2nd stages of He refrigerator, radiation shield, and cold plate on which the detector is mounted. The thermal paths are made of oxygen-free copper mesh (wire diameter: ϕ0.23 mm, density: 50 mesh/inch). We found that the temperature of radiation shield and internal optical system reached to be 96 K, and cold plate to be 14 K which satisfies temperature requirements.

We will reduce the dark and read noises of TOPICS soon, and plan to install it on the T60 telescope at Haleakala. The electronics of ESPRIT is similar to that of TOPICS, and we are ready to develop the electronics for ESPRIT.

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Keywords: planetary atmosphere, spectroscopy, near infrared

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Effects of the magnetic field configuration in the ionosphere on solar energetic electron precipitation into the Martian upper atmosphere observed by MAVEN

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Discovery of the diffuse aurora at Mars in the region where the crustal magnetic field is absent, indicates precipitation of the high-energy electrons of ~100 keV down to the altitudes around 70 km along the draped IMF around the planet [Schneider et al., Science, 2015; GRL, 2018]. However, how the draped magnetic field configuration around Mars controls the SEP (solar energetic particle) electron precipitation to the atmosphere is far from understood. Moreover, global simulations of the solar wind-Mars interaction have shown that the existence of the crustal magnetic fields primarily in the southern hemisphere results in the complexed magnetic structure around entire Mars [e.g., Luhmann et al., GRL, 2015].

We here investigated SEP events observed by MAVEN from December 2014 to October 2017 in order to investigate effects of the magnetic field structure in the ionosphere, including both the crustal magnetic fields and penetrating draped IMF, on SEP pitch angle distributions (PADs) and energy dependent loss into the atmosphere. The PADs of the high-energy (30-210 keV) electrons observed in the Martian ionosphere are analyzed in details. Using the elevation angle of the local magnetic field, we also sorted the data so as to investigate the SEP electron loss below the MAVEN periapsis (~150 km altitude). The obtained PA distributions in the ionosphere are compared with the distributions of the source electrons in the magnetosheath. For some of the strong SEP events, one-to-one correspondence of the SEP distributions to the strength and dip angle of the local magnetic field was investigated.

In most of SEP events, the field-aligned component is pronounced for the precipitating electrons before entering the collisional region of the atmosphere, even if the source SEP electrons have isotropic pitch angle distributions. The highest energy of the SEP electrons lost into the Martian atmosphere depends on the magnetic field configuration draped around the planet. The SEP electron precipitation depleted in the region of the strong crustal magnetic field. Its loss into the atmosphere tend to be pronounced in the nightside, suggesting the deeper penetration of draped magnetic fields in the nightside than dayside. We will also report on the energy dependent precipitation seen in some SEP events and discuss role of the magnetic field to determine the precipitation flux of SEP electrons into the Martian atmosphere.

Keywords: Mars, Solar Energetic Particle, aurora, Induced Magnetosphere

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Observations of minor constituents in the Venusian atmosphere, CO and SOx using the millimeter/submillimeter-wave band radio telescopes, SPART/ALMA

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As exoplanets are being explored, there is an urgent theme to understand the atmospheric environment of habitable planets. In Venus, it is known that there is an unsolved absorption spectrum in the cloud region in the ultraviolet wavelength region. The temperature and pressure at this altitude are close to those at the troposphere of the Earth, and the spectrum is similar to that caused by bacteria, so that the possibility of absorption by organisms has been discussed. Atmospheric environment of the earth-type planet whose main component is CO_2 such as Venus and the past earth seems to be comparatively universal. Therefore, study how materials circulate via cloud heights in the Venusian atmosphere is also important in understanding how such circulations influence planetary habitability/organisms.

Against this background, we have observed the minor constituents of the Venusian atmosphere using the 10m single dish radio telescope, SPATR at the Nobeyama Radio Observatory of Japan, and ALMA interferometers. The millimeter/submillimeter-wave band high-resolution heterodyne spectroscopies allow us to address the molecular abundances at a higher altitude than the H2S4 clouds layer on both dayside and nightside of Venus. Since 2011, SPART has been monitoring the rotational spectral lines of carbon monoxide (CO) in the 100 and 200 GHz bands. The mixing ratio of CO at an altitude of about 80 km observed during the time appeared to be anti-correlated with the intensity of solar UV in the 11-year solar cycle. These trends were compared with the abundance of SO_2 observed by Venus Express (VEX) and the albedo observed by VEX/Akatsuki satellite. In addition, the preliminary results obtained with ALMA show the latitude/longitude and altitudinal distributions of SO and SO_2 are anti-correlated. In this conference, a brief picture of the material circulations in the Venus middle atmosphere inferred from these results will be also discussed.

Keywords: planetary atmosphere, Solar system, Venus, terrestrial planet, millimeter/submillimeter-wave band telescope, heterodyne spectroscopy

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Influences of solar energetic particles on the Martian ozone layer

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Solar energetic particles (SEPs) consist of protons, electrons and heavy ions in the energy range between a few tens of keV and GeV. SEPs are originated from solar flares, shock waves driven by coronal mass ejections.

SEPs penetrate the Earth’ s atmosphere down to tens of kilometers at high geomagnetic latitudes. The penetrating SEPs can change the composition in the middle atmosphere. During the large solar flare that occurred in October 2003, penetrating SEPs caused NO_2 enhancement by several hundred percent, accompanied by ozone depletion of tens of percent between 36 and 60 km altitudes (e.g., Seppälä et al., 2004; Rohen et al., 2005).

In the same event, Martian Radiation Environment Experiment (MARIE) onboard Mars Odyssey was disabled by SEPs (Zeitlin et al., 2010). In addition, SEPs emitted by a solar flare in September 2017 reached Mars, where global diffuse-aurora was reported on the entire Martian night side (Schneider et al., 2018). The SEP penetration imposes a critical influence on deep atmospheres and impacts on surfaces of various planets. Considering the increasing human activities in space, like planned national and international missions to the Moon and Mars, understanding the SEP behaviors in the planetary environment is critical to assess influences on the missions and human bodies. In addition, the ozone layer is vital for understanding how NOx increases in the Martian environment. The increase of NOx can have implications on the aspects of astrobiology and the past Martian greenhouse effect.

In this study, we aim to identify the response of the Martian ozone layer to SEP events. We use vertical profiles of ozone number densities observed by stellar occultation measurements by IUVS onboard MAVEN, and the energy fluxes of electrons and ions monitored by Solar Energetic Particle onboard MAVEN (MAVEN/SEP). MAVEN/IUVS has regularly conducted stellar occultation campaigns (1-2 days per campaign) once every ~2-3 months (Groller et al., 2018). MAVEN/SEP can detect electron's and ion's energy spectra from 20 keV to 1 MeV and from 20 keV to 6 MeV in the differential flux range of $3\text{-}3\times10^6$ eV/cm^2 s sr eV (Larson et al., 2015).

As the first step of this study, we focus on a SEP event at Mars measured on 3-4 November 2015. Comparing the data during this SEP event with those during another period when the quiet period of solar activity under similar seasonal and latitudinal conditions, we found no significant differences in the ozone profiles.

We then estimated the amount of ozone depletion by oxygen atoms induced by the SEP flux using a Monte-Carlo model. In this model, we assumed that SEP-induced oxygen atoms would instantaneously destroy ozone for simplicity. The model suggests only ~0.1% of depletion of ozone number density from the background for the event in 2015. The depletion is too low to be detected by IUVS. On the other hand, the model suggests that the depletion of ozone is at detectable levels (about 100 % of the background) during the large flux SEP event in the September 2017 event. Note that the used model is yet simple. For example, we have to consider the ozone depletion by the catalytic cycle of HOx. The cycle

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plays an essential role on the Earth. We will further develop a further photochemical model to assess the effect of SEPs on the photochemistry of the Martian atmosphere.

Since the MAVEN data are only available after 2014, we are analyzing the data from Mars Express (MEX). The vertical profiles of ozone number densities can be obtained from the observation by stellar occultation of SPICAM and the SEP flux is from the background counts of energetic particles observed by the Analyzer of Space Plasma and Energetic Atoms (ASPERA-3). MEX/SPICAM stellar occultations are applied to retrieve the ozone profiles since 2004. MEX/ASPERA-3 can record the penetrating energetic particles through the instrument structure as background counts (Ramstad et al., 2018). In this presentation, we will use these data for further analysis to evaluate the effect of SEPs on atmospheric chemistry on Mars.

Keywords: Mars, Solar Energetic Particles, ozone

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Simultaneous remote and in-situ observations of ionospheric irregularities at Mars

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1. Kyoto University, 2. Tohoku University

It is known that the ionosphere of Mars contains a variety of irregularities. Gurnett et al., [2008] reported that “diffuse echoes”, the traces of which appear unusually diffuse in an ionogram, are sometimes observed by topside ionospheric sounding of Mars Express. These echoes are proposed to be caused by irregularities in the Martian ionosphere. Also, in addition to vertical echoes reflected from the horizontally stratified ionosphere, “oblique echoes” sometimes appear as hyperbola-shaped traces in a radargram. These echoes are typically found in regions where the Martian crustal magnetic field is nearly vertical, and they are interpreted as echoes reflected obliquely from electron density structures deviated from horizontally stratified ionosphere. However, the spatial scale lengths and generation mechanisms of ionospheric irregularities that cause diffuse and oblique echoes are still unknown, partly because comparative studies utilizing remote and in-situ measurements of ionospheric irregularities are yet to be conducted at Mars.

In this study, we surveyed conjunction events in which Mars Express and MAVEN observed the topside ionosphere of Mars at almost the same time and the same location, searching for cases with diffuse echoes or oblique echoes apparent in the Mars Express data. We then investigated variations of the electron, ion,and neutral densities, magnetic fields, and the presence or absence of the hot electron precipitation from MAVEN data. Based on the analysis, it is suggested that the spatial scale lengths of irregularities causing diffuse echo and oblique echoes range from tens to hundreds of kilometers. Additionally, we found an event that exhibits intense diffuse echoes in ionograms, and periodic variations of neutral and ion densities in in-situ data, implying ion-neutral coupling. These observations would provide an important clue as to the unidentified drivers of ionospheric irregularities causing diffuses echoes at Mars.

Keywords: Mars ionospheric irregularities

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Annual variability in the thermospheric wave perturbations at Mars

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1. Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2. Kyoto University, 3. Graduate School of Frontier Scienfes, The University of Tokyo, 4. Faculty of Science and Technology, Seikei University, 5. Graduate School of Science, University of Tokyo

Although there have been very limited observations in the Martian thermosphere, especially on the night side, our understanding of the region has been rapidly enhanced in recent years by the MAVEN spacecraft (Bougher et al. (2015) ; Yigit et al. (2015) ; England et al; Siddle et al. (2019) ; Nakagawa et al. (2020) Recent observations have reported that wave-like perturbations are ubiquitously observed in the thermosphere, especially on the night side, with large amplitude density perturbations exceeding 50%. The anti-correlated amplitudes with the background temperature suggest the saturated atmospheric gravity wave (Terada et al., 2017). There are two possible excitation sources: (1) atmospheric gravity waves propagating upward from the lower atmosphere, and (2) energy injected from the upper atmosphere by external factors such as solar wind or energetic solar particles.

The widespread diffuse aurora on Mars (Schneider et al., 2015, 2020), recently discovered by the MAVEN spacecraft, is a luminous phenomenon that covers the entire Martian night side with the arrival of solar energetic particles (SEPs) and has an emission altitude of 60 km. This suggests that energetic particles can have a significant impact on the deep Martian atmosphere by globally injecting energy. In particular, ionization, dissociation, heating, and disturbance effects in the upper atmosphere can potentially have an impact on the escaping atmosphere, and are important for understanding the response of Mars, a non-magnetic planet, to space environment changes.

In this study, we use the MAVEN onboard mass spectrometer NGIMS to reveal the long-term interannual variation of density perturbation components in the Martian thermosphere. In particular, NGIMS has realized the multi-molecular observation since Viking, and here we focus on the difference in behavior between CO_2 and N_2 density perturbations in order to constrain the excitation source. In this study, we used the MAVEN/NGIMS data Level-2 and version-8 registered in NASA PDS.

In the evolution of the CO_2 density disturbance components over the five-year period from 2015 to 2020, we find that the amplitude of the density perturbations is significantly larger in the nighttime than in the daytime throughout the five-year period. This is consistent with the results of recent previous studies (Terada et al., 2017; Nakagawa et al., 2020). On the other hand, it should be noted that the amplitude of the density disturbance differs from year to year. In this paper, we will discuss in detail the relative importance of the lower and external factors on the interannual variation. Another important feature is the relationship between the perturbation amplitude components of CO_2 and N_2. The statistical results show that the two are basically well correlated, with CO_2 of a larger perturbation amplitude than N_2. This is consistent with the arguments of Cui et al. (2014) and England et al. (2016, 2017), because the disturbance amplitude normalized by the background density is anti-correlated to the scale height, and the amplitude ratio corresponds to the mass ratio of the molecular species. In fact, a scatter plot of the disturbance amplitudes of CO_2 and N_2 shows a distribution that follows with a mass ratio of 28/44 ~ 0.64, the mass ratio of CO_2 and N_2. Analysis of the perturbation components for each orbit shows that CO_2 and N_2 are well in phase with each other in many cases. On the other hand, we also find the N_2 perturbation

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amplitude sometimes exceeds that of CO_2, meanwhile the perturbations seen in N_2 appear to be out of phase with those in CO_2. Interestingly, according to the predictions of the full-particle Direct Simulation Monte-Carlo (DSMC) modeling of the Martian upper atmosphere (Terada et al., 2016), the atmospheric waves excited at thermospheric altitudes during the injection of energetic particles from space have different wavelengths and amplitudes at each species. It is suggested that the amplitude of N_2 perturbations exceeds that of CO_2 at the distance from the source region (Terada et al., in prep.). In this paper, we compare and discuss the predictions with this numerical model and the implications of the observations.

Keywords: Mars, thermosphere, atmospheric wave

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Study of atmospheric ion escape from exoplanet TOI-700 d

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1. Graduate School of Science, University of Tokyo , 2. Graduate School of Science, Tohoku University , 3. NICT

An important purpose of detecting and characterizing exoplanets is to find habitable planets like Earth. Liquid water is essential for planetary habitability, and it is necessary to retain the atmosphere in strong stellar wind to maintain liquid water. By the Transiting Exoplanet Survey Satellite (TESS), exoplanet TOI-700 d was discovered in January 2020 (Gilbert et al., AJ, 2020; Rodriguez et al., AJ, 2020). This is the first Earth-sized planet in the habitable zone (HZ) discovered by TESS. The host star is a M dwarf star, which has lower surface temperature, thus closer HZ to the host star, and stronger X-ray and EUV (XUV) radiation in HZ than the solar system around a G-type star. Another important difference is that direction of the interplanetary magnetic field (IMF) around the planet may be dominated by the radial component because of the proximity to the host star and planet. The IMF orientation can change the atmospheric escape rate from the exoplanet. In this study, we investigated effects of the XUV radiation and IMF orientation on the atmospheric ion escape.

In order to simulate the atmospheric ion escape from TOI-700 d, we used multi-species MHD simulations (e.g., Terada et al., JGR, 2009; Sakata et al., JGR, 2020). Our model solved three-dimensional multispecies MHD equations including continuity equations for 10 ion species (O^+, O_2^+, CO_2^+, NO^+, CO^+, N_2^+, N^+, C^+, He^+, H^+) the bottom of the ionosphere to the inter-planetary space where a constant stellar wind is assumed. The model includes photoionization, electron impact ionization, charge exchange, ion-neutral reactions, dissociative recombination, collisions (ion-electron, ion-neutral, electron-neutral). As stellar wind conditions, number density, velocity, and temperature were set to 450 cm^{-3}, 470 km s^{-1}, and 1.3×10^6 K, respectively, by referring to previous studies (Cohen et al., ApJ, 2020; Dong et al., ApJL, 2020). IMF was assumed to be a Parker spiral with an angle of 4˚ or 45˚ degrees and a magnitude of 12 nT. Also, the stellar XUV flux was set either as 30 or 50 times larger than the current value of the Earth (referred as XUV30 and XUV50 hereafter). We assumed a Venus-like atmospheric composition that depends on the stellar XUV flux as the input neutral atmosphere based on Kulikov et al. (Space Sci. Rev., 2007).

The results show that the IMF Parker spiral angle affects the structure of the induced magnetosphere. Therefore, the path of atmospheric ion escape differs greatly depending on whether IMF Parker spiral angle is 4˚ or 45˚. In the case of 45˚, the escape flux is confined to the current sheet similar to Mars and Venus in the solar system. This is because a typical induced magnetosphere is formed and the magnetic tension force of the drape magnetic field in the polar region accelerates the local ionospheric plasma. In the case of 4˚, the escape from around SZA = 65˚ in the ionosphere becomes a ring-shaped escape flux in the induced magnetotail. The stellar XUV flux has a stronger effect on the escape rate of atmospheric ions than the IMF orientation. The larger the stellar XUV flux, the more atmospheric ions escape. This is because the scale height of atmospheric ions increases due to the increase in the stellar XUV flux. In the case of XUV50 and IMF angle 45˚, the atmospheric ion escape rate obtained in this study is ~2.3×10^{27} s^{-1}, which is about an order of magnitude larger than the value to be able to retain the 1-atm CO_2 atmosphere for about 10 billion years (Dong et al., ApJL, 2020). This result suggests that even if the atmosphere of TOI-700 d is Venus-like, it will be difficult to maintain it for a long time under strong XUV condition. This study also reveals that the escape rate of atmospheric ions, especially molecular ions, can be suppressed by small IMF Parker spiral angle which can become typical as the planet and the host star

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get closer.

Keywords: exoplanet, atmospheric escape, MHD Simulation

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DSMC simulations of slow hydrodynamic escape from Earth-like and Mars-like planets

*Naoki Terada[1], Kaori Terada[1], Hitoshi Fujiwara[2], Masahiro Ikoma[3]

1. Graduate School of Science, Tohoku University, 2. Faculty of Science and Technology, Seikei University, 3. Graduate School of Science, The University of Tokyo

We have developed full-particle simulation models that solve the slow hydrodynamic escape from Earth-like and Mars-like planets based on the Direct Simulation Monte Carlo (DSMC) method to understand the long-term evolution of the atmospheres of these planets. While hydrodynamic and Jeans escape processes are relatively well understood, the transition between the two, i.e., slow hydrodynamic escape process, has been less thoroughly investigated due to difficulties in its theoretical and numerical treatment. The slow hydrodynamic escape is one of the candidate processes that would have caused the drastic climate change on early Mars and have significantly changed the amount and composition of the atmosphere. The DSMC method is able to self-consistently solve the slow hydrodynamic escape without imposing a priori assumptions on the boundary condition and molecular diffusion. We first developed a full-particle DSMC model of the upper atmosphere of an Earth-like planet and then implemented photochemistry related to atomic carbon for a Mars-like planet. Our simulation results showed that the adiabatic cooling associated with the slow hydrodynamic expansion was weakened due to infrequent intermolecular collisions around the exobase, hence higher exobase temperature and escape rates were obtained than previous fluid models. In this presentation, we will show simulation results of Earth-like and Mars-like atmospheres subject to intense EUV radiation and compare them with fluid models.

Keywords: Atmospheric escape, DSMC simulation

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.07 Zoom Room 07

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Sachie Kanada(Nagoya University)

In 2019, Typhoon Faxai (T1915) hit the Kanto District and caused a long-term shut-down by high winds. In October, Typhoon Hagibis (T1919) provided a huge amount of water vapor and contributed to the record breaking heavy rainfalls over the Japanese Islands. In 2020, Typhoon Haishen (2020) approached Japan; the typhoon exhibited unique concentric eyewall structures and underwent eyewall replacement cycle over the sea south of the Japanese Islands. Tropical cyclones (TCs) often cause tremendous disasters in the coastal regions by torrential rainfall, gale, storm surge, and high surf. A number of future projection studies have implied that higher-latitude occurrences of intense TCs will increase, because the projected future increase in sea surface temperature is larger at higher latitudes. Understanding such phenomena associated with translation, intensity change, and precipitation of TCs and their accurate forecasts are still challenging issues to be solved in the earth and planetary science.
Advances in innovative observations including meteorological aircrafts and next generation satellites, and supercomputers have led to novel development of numerical weather forecasting and understanding of the phenomena in both the forecast and long-term projection. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide new direction for future TC research activity.

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[AAS03-01] Introduction

9:05 AM - 9:35 AM JST | 12:05 AM - 12:35 AM UTC

[AAS03-02] Hurricane ocean surface wind retrieval from ALOS-2/PALSAR-2

★Invited Papers

*Osamu Isoguchi[1], Takeo Tadono[2], Masato Ohki[2], Udai Shimada[3], Munehiko Yamaguchi[3], Masahiro Hayashi[3], Wataru Yanase[3] (1.RESTEC, 2.JAXA, 3.Meteorological Research Institute)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[AAS03-03] Impact of Aeolus DWL data assimilation in the JMA's global data assimilation system on forecasting skills for typhoons

*Izumi Okabe[1], Kozo OKAMOTO[1] (1.Meteorological Research Institute of Japan Meteorological Agency)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[AAS03-04] Wind speed structure of Typhoon 201821 as seen by CYGNSS and AMSR2

*Dexin Gu[1], Kaoru Ichikawa[1], Kako Shinichiro[2], Hiroyuki Tomita[3] (1.Kyushu Univ, 2.Kagoshima Univ, 3.Nagoya Univ)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[AAS03-05] Oceanic environmental change due to Typhoon Faxai(T1915) and Hagibis(T1919)

*Koki Iida[1,2], Fudeyasu Hironori[1], Yuusuke Tanaka[2], Satoshi Iizuka[3], Yoshiaki Miyamoto[4] (1.Yokohama National University, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Keio University)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

[AAS03-06] Discussion

[E] Oral | A (Atmospheric and Hydrospheric Sciences) | A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Sachie Kanada(Nagoya University)

Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.07 (Zoom Room 07)

In 2019, Typhoon Faxai (T1915) hit the Kanto District and caused a long-term shut-down by high winds. In October, Typhoon Hagibis (T1919) provided a huge amount of water vapor and contributed to the record breaking heavy rainfalls over the Japanese Islands. In 2020, Typhoon Haishen (2020) approached Japan; the typhoon exhibited unique concentric eyewall structures and underwent eyewall replacement cycle over the sea south of the Japanese Islands. Tropical cyclones (TCs) often cause tremendous disasters in the coastal regions by torrential rainfall, gale, storm surge, and high surf. A number of future projection studies have implied that higher-latitude occurrences of intense TCs will increase, because the projected future increase in sea surface temperature is larger at higher latitudes. Understanding such phenomena associated with translation, intensity change, and precipitation of TCs and their accurate forecasts are still challenging issues to be solved in the earth and planetary science. Advances in innovative observations including meteorological aircrafts and next generation satellites, and supercomputers have led to novel development of numerical weather forecasting and understanding of the phenomena in both the forecast and long-term projection. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide new direction for future TC research activity.

9:00 AM - 9:05 AM

[AAS03-01]Introduction

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Hurricane ocean surface wind retrieval from ALOS-2/PALSAR-2

*Osamu Isoguchi[1], Takeo Tadono[2], Masato Ohki[2], Udai Shimada[3], Munehiko Yamaguchi[3], Masahiro Hayashi[3], Wataru Yanase[3]

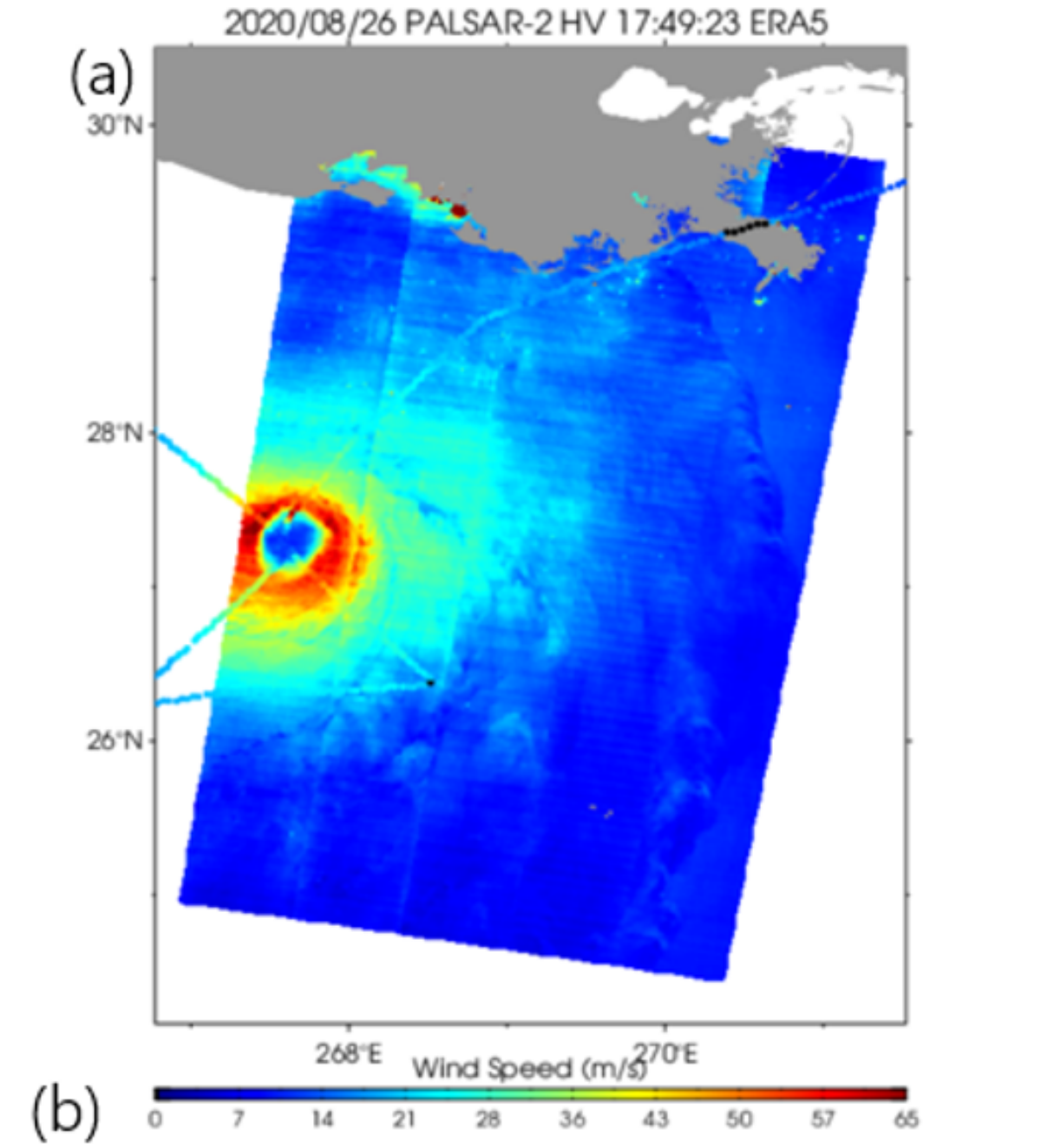
1. RESTEC, 2. JAXA, 3. Meteorological Research Institute

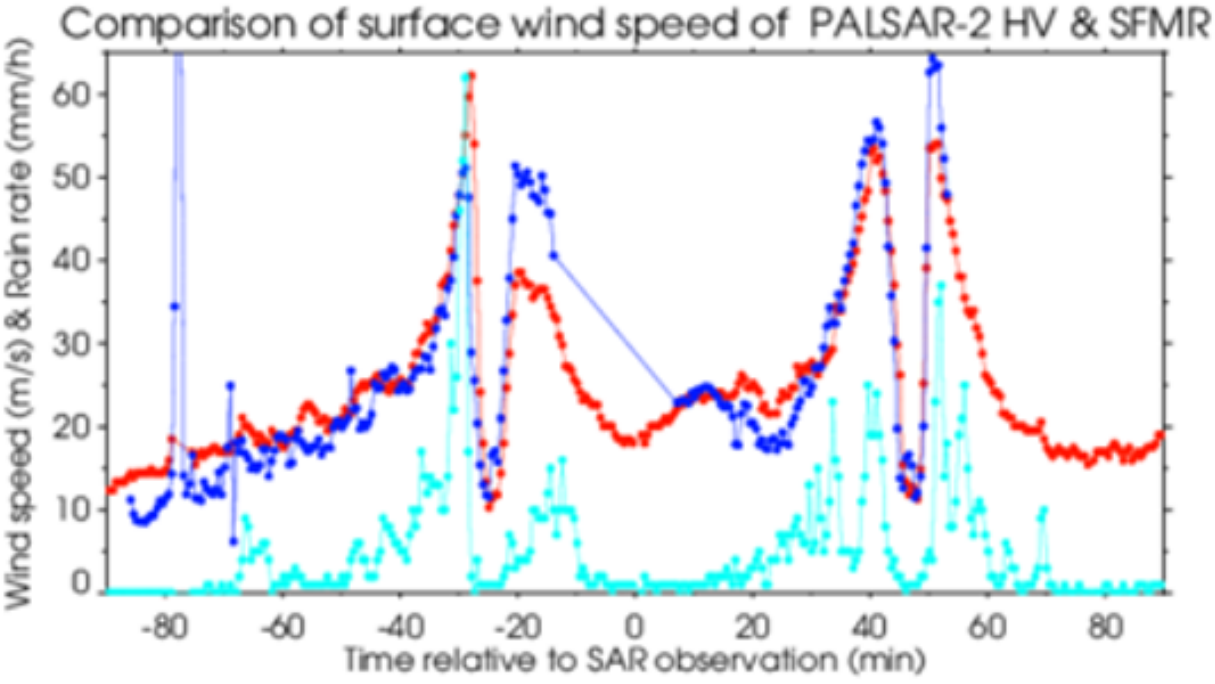
Strong winds induced by typhoons and hurricanes cause disasters and have a great impact on social activities, so there is an increasing demand for their monitoring and prediction. Synthetic aperture radar (SAR) can be the only satellite sensor capable of measuring sea surface winds with high spatial resolution O (100 m). For the purpose of wind speed detection by Japanese L-band SAR (Phased Array type L-band Synthetic Aperture Rader-2: PALSAR-2) and use for operational weather forecasting under typhoon conditions, Japan Aerospace Exploration Agency (JAXA)-Meteorological Research Institute cooperation study has launched. Typhoons/hurricanes observations were being carried out under the cooperation by programming the PALSAR-2 observations based on the predicted course of typhoons and hurricanes. So far, simultaneous observations with National Oceanic and Atmospheric Administration (NOAA)'s airborne Stepped Frequency Microwave Radiometer (SFMR) has been made for four cases of hurricanes. Based on these data, estimating the wind structure of the hurricane by PALSAR-2 was developed.
The 3 km average PALSAR-2 normalized radar cross section (NRCS) and the incidence angle were collocated with the SFMR-measured ocean surface wind speed and rain rate. It was confirmed that the incidence angle dependence was small for the cross-polarized (HV) NRCS, so we developed a model function for the strong winds for the HV polarization. In order to investigate the dependency of NRCS on wind speed and incidence angle, the match-ups were classified into “bins” of 2 m/s wind speed and 5° incidence angle. Any data of which deviation exceeded 2σ in each bin were excluded.
A relationship between the PALSAR-2 HV NRCS and ocean surface wind speeds measured by SFMR showed that NRCS increased with respect to the wind speed up to about 55 m/s. Based on the method proposed by Hwang et al. (2015), a geophysical model function (GMF) was constructed as a function of wind speed and incidence angle. The wind speed was then inversely estimated from the matchup data (HV NRCS) and compared with the wind speed of SFMR. Bias and RMSE are -0.2m/s and 4.1m/s, respectively. It indicates that the wind speed can be detected up to about 50 m/s or more without depending on the incidence angle.
The derived GMF was applied to the PASLAR-2 HV image of Hurricane Laura to calculate the ocean surface wind speed, and the comparison was performed along the SFMR observation tracks (Fig. 1). Although there are some biased differences, fluctuation trends including maximum wind speed of about 60m/s and sudden changes in wind speed near the eye wall are captured. The derived wind speed structure of the hurricane was compared with the best track data. Omnidirectional surface wind profiles as a function of distance from the hurricane center for the four geographical quadrants (NW, SW, SE, and NE) were calculated from the PALSAR-2-derived wind speed and compared with wind speed radii at three wind speed levels (34Knot, 50Knot, 64Knot) obtained from the best track data. Wind speed radius is smaller in NW and SW than in NE and SE, which indicates the same spatial asymmetry structure as the best track. In addition, the absolute value of the wind speed radius and the decreasing tendency with respect to the distance are approximately the same.
It was confirmed that the L-band HV NRCS has a relationship with wind speed up to about 55 m/s in the data used in the present study and the wind speed can be estimated. On the other hand, the stronger the wind, the lower the increasing rate of NRCS with respect to the wind speed, so the radiometric accuracy of the SAR product has a strong impact on the wind speed estimation especially under the extreme wind condition.

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Keywords: typhoons/hurricanes, wind speed retrieval, SAR, PALSAR-2

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Impact of Aeolus DWL data assimilation in the JMA's global data assimilation system on forecasting skills for typhoons

*Izumi Okabe[1], Kozo OKAMOTO[1]

1. Meteorological Research Institute of Japan Meteorological Agency

European Space Agency's (ESA's) Earth Explorer, Aeolus, was launched into space on 22 August 2018. The horizontal line of sight (HLOS) wind data from Aeolus Doppler Wind Lidar (DWL) is available from the ESA Earth Online Portal. The DWL provides wind profile observations with high vertical resolution (0.5-2.0 m) in clear air, inside thin clouds and aerosol layers and on top of thick clouds globally. Assimilation experiments of this HLOS data were conducted using JMA's global data assimilation (DA) system and the global spectral model (GSM) at a horizontal resolution of 20km and vertical layers of 100. The experiment term is from July to October 2020. The result of the assimilation experiments showed positive impacts of Aeolus HLOS wind data on forecasting scores (global average of root mean square errors, etc.) of not only wind speed but also geopotential height, temperature and specific humidity. Improvement of typhoon track forecasting after about three days was found suggesting the improved environment forecasting. During the experiment term, Aeolus observed horizontal wind shears around some typhoons. The Aeolus assimilation seemed to intensify the divergence over the top of typhoons. The details of assessment and assimilation experiments will be shown in the presentation.

Keywords: Satellite data, Data assimilation, Typhoon

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Wind speed structure of Typhoon 201821 as seen by CYGNSS and AMSR2

*Dexin Gu[1], Kaoru Ichikawa[1], Kako Shinichiro[2], Hiroyuki Tomita[3]

1. Kyushu Univ, 2. Kagoshima Univ, 3. Nagoya Univ

It is known that typhoons often have asymmetric wind speed distribution in which the wind is stronger in the right semi-circle than in the left with respect to their movement direction. However, since direct observations of synoptic wind field of a typhoon are practically difficult, satellite remote sensing data are required. In this presentation, two different types of remotely sensed wind speed data, CYGNSS and AMSR2, are compared for a case of Typhoon 201821 (JEBI).
The Advanced Microwave Scanning Radiometer 2 (AMSR2) on GCOM-W1 spacecraft measures microwave radiation. In AMSR2 All-weather Sea surface Wind speed (ASW) product provided by JAXA, 2-dimensional wind speed distribution map can be obtained every half day even under heavy wind conditions.
Meanwhile, NASA Cyclone Global Navigation Satellite System (CYGNSS) mission operates eight micro-satellites that measures the strength of GPS signals reflected at the sea surface in order to provide frequent observations of wind speeds of hurricanes. The reflected GPS signals are reversely proportional to the sea surface slope created by waves so that wind speed can be retrieved. One micro-satellite provides four 1-dimensional wind speed distribution along trails of GPS refection points during its fly-over movements. We used CYGNSS Ver.3 Level 2 product from NASA JPL PO.DAAC during a period from 27 August to 4 September, 2018 and converted its 1-dimensional data to two-dimensional typhoon coordinate data by referring the best track data from National Institute of Informatics with the assumption that wind speed structures are kept the same during 6 hours of interpolation.
In the early stage of the typhoon from 27 to 31 August, CYGNSS wind speeds show significant asymmetry with stronger winds on the right-hand (northern) side of its westward movement. On 1 September when the typhoon changed its direction to the northwestward, asymmetry of CYGNSS wind speeds became less significant. On the contrary, snapshot wind speed distributions seen by AMSR2 similarly shows asymmetric structures in August, but the asymmetry is much less significant than it seen in CYGNSS data. Reasons of discrepancy between CYGNSS and AMSR2 will be discussed in this presentation, taking account of wave spectrum variations within the typhoon due to swell-wind interactions.

Keywords: remote sensing, typhoon intensity, cyclone global navigation satellite system, advanced microwave scanning radiometer 2, asymmetry of typhoon winds

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Oceanic environmental change due to Typhoon Faxai(T1915) and Hagibis(T1919)

*Koki Iida[1,2], Fudeyasu Hironori[1], Yuusuke Tanaka[2], Satoshi Iizuka[3], Yoshiaki Miyamoto[4]

1. Yokohama National University, 2. Japan Agency for Marine-Earth Science and Technology, 3. National Research Institute for Earth Science and Disaster Resilience, 4. Keio University

Typhoons are strongly affected by the ocean through heat and momentum fluxes at the ocean surface, while they in turn affect the ocean by the strong cyclonic winds. Typhoon Faxai (2019) and Hagibis (2019) have different features, in terms of their intensity, size and moving speed, whereas they moved over the almost same path and caused enormous damage to Kanto district in Japan. This study investigates the changes in the ocean caused by the two typhoons, Faxai and Hagibis, using a high resolution ocean model (1.85 km) based on the Meteorological Research Institute Community Ocean Model (MRI.COM). The mixing of sea water caused by typhoons leads to decreases in sea surface temperature (SST) during and after the passage of typhoons. Faxai has a relatively small radius of maximum winds and caused the deceases of SST locally by about 0.8℃ at the right side of typhoon track after its passage. On the other hand, Hagibis has a relatively large radius of maximum winds and decreased SST widely and remarkably by about 2℃. According to the vertical diffusivity and the tendency of changes in sea water temperature for the model results, the impact of Faxai reached a depth of 35 m in the ocean while Hagibis a depth of about 75 m. The differences of their impacts are resulted from typhoon features, namely Hagibis has higher intensity and larger size with slower moving speed. In addition, the different features in SST are related to the tracks. Faxai passed over the Kuroshio Current with warm water extendint to a depth of about 45 m. On the other hand, Hagibis passed over the cold water area associated with large meander of the Kuroshio where there was cold water beneath the surface mixed layer. Furthermore, in the vicinity of the Kuroshio, SST drastically increased about 2℃ at two days after the passage of typhoons.

Keywords: typhoon, ocean, SST, mixing effect, ocean model, Kuroshio

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[E] Oral | A (Atmospheric and Hydrospheric Sciences) | A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Sachie Kanada(Nagoya University)

Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.07 (Zoom Room 07)

In 2019, Typhoon Faxai (T1915) hit the Kanto District and caused a long-term shut-down by high winds. In October, Typhoon Hagibis (T1919) provided a huge amount of water vapor and contributed to the record breaking heavy rainfalls over the Japanese Islands. In 2020, Typhoon Haishen (2020) approached Japan; the typhoon exhibited unique concentric eyewall structures and underwent eyewall replacement cycle over the sea south of the Japanese Islands. Tropical cyclones (TCs) often cause tremendous disasters in the coastal regions by torrential rainfall, gale, storm surge, and high surf. A number of future projection studies have implied that higher-latitude occurrences of intense TCs will increase, because the projected future increase in sea surface temperature is larger at higher latitudes. Understanding such phenomena associated with translation, intensity change, and precipitation of TCs and their accurate forecasts are still challenging issues to be solved in the earth and planetary science. Advances in innovative observations including meteorological aircrafts and next generation satellites, and supercomputers have led to novel development of numerical weather forecasting and understanding of the phenomena in both the forecast and long-term projection. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide new direction for future TC research activity.

10:20 AM - 10:30 AM

[AAS03-06]Discussion

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.07 Zoom Room 07

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University)

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Advances in innovative observations including meteorological aircrafts and next generation satellites, and supercomputers have led to novel development of numerical weather forecasting and understanding of the phenomena in both the forecast and long-term projection. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide new direction for future TC research activity.

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

[AAS03-07] Three-Dimensional Aspects of the Fujiwara Effect

Jae-Deok Lee[1], *Kosuke Ito[2], Johnny C. L. Chan[3] (1.Kyungpook National University, 2.University of the Ryukyus, 3.City University of Hong Kong)

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

[AAS03-08] Precipitation Enhancement by Northward Ageostrophic Winds Associated with a Tropical Cyclone. - -Cloud Resolving Simulation- -

*Kazuo Saito[1,2,3], Takumi Matsunobu[4], Tsutao Oizumi[2,3] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Japan Meteorological Business Support Center, 3.Meteorological Research Institute , 4.Meteorologisches Institut, Ludwig-Maximilians-Universität)

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

[AAS03-09] Climatology of Tropical Cyclone Seeds and Survival Rates to Tropical Storms

*Kohsuke Ikehata[1], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AAS03-10] Change of Tropial Cyclone Characteristics under the Changing Climate

*Fumiya Matsushima[1], Kazuhisa Tsuboki[1], Sachie Kanada[1] (1. Institute for Space-Earth Environmental Research, Nagoya University)

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

[AAS03-11] Future Changes of a Slow-moving Intense Typhoon with Global Warming: A Case Study using a regional 1-km-mesh atmosphere–ocean coupled model

*Sachie Kanada[1], Hidenori AIKI[1], Kazuhisa Tsuboki[1], Izuru Takayabu[2] (1.Nagoya University, 2.MRI/JMA)

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

[AAS03-12] Discussion

Three-Dimensional Aspects of the Fujiwara Effect

Jae-Deok Lee[1], *Kosuke Ito[2], Johnny C. L. Chan[3]

1. Kyungpook National University, 2. University of the Ryukyus, 3. City University of Hong Kong

A set of *f*-plane idealized numerical simulations at 15° N was conducted to understand the fundamental three-dimensional characteristics of the binary interaction of tropical cyclones (TCs). When the vortices are zonally separated by more than or equal to (less than) 10° of longitude, they tend to repel (rotate or merge). Binary interacting TCs have two maximum diabatic heating regions: one in the boundary layer and the other in the mid-troposphere. The maximum diabatic heating in the boundary layer is related to the supergradient wind with large radial inflows. As the vortex intensifies, the upper-anticyclonic circulation is also strengthened. These two upper-anticyclonic circulations form an extensive single anticyclonic circulation. In the absence of a background flow, this single anticyclonic circulation results in a vertical wind shear that contributes to a substantial asymmetry in diabatic heating, subsequently modifying TC motion. This shear-induced diabatic heating results in repelling storm trajectories. In contrast, experiments without microphysical heating show distinctly approaching trajectories. These two different experiments demonstrate the importance of diabatic heating in storm movement. The time series of the potential vorticity (PV) budget shows a well-balanced feature between the local change term and the sum of other PV diagnostic terms. Above the boundary layer, the PV budget is balanced between the diabatic and advective terms. The local change in PV shows that the subsequent TC motion coincides with the positive PV area. In addition, the positive PV explained by the PV advection term accounts for the same scenario. Meanwhile, When two vortices interact in closer proximity, vortex Rossby waves form inward of the vortex. Since the horizontal shear could generate these vortex Rossby waves, this result may account for an increase in the horizontal shear as a result of the direct binary interaction of TCs.

Keywords: tropical cyclone, Fujiwhara effect

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Precipitation Enhancement by Northward Ageostrophic Winds Associated with a Tropical Cyclone. --Cloud Resolving Simulation--

*Kazuo Saito[1,2,3], Takumi Matsunobu[4], Tsutao Oizumi[2,3]

1. Atmosphere and Ocean Research Institute, the University of Tokyo, 2. Japan Meteorological Business Support Center, 3. Meteorological Research Institute , 4. Meteorologisches Institut, Ludwig-Maximilians-Universität

In Japan, heavy rainfalls often occur when a typhoon exists off the south coast of Japan. These pre-typhoon rainfalls are also known in other countries and called as ‘PRE’. Saito (2019) examined the origin of observed northward winds for the case of T0918 (Melor) and showed that the ageostrophic winds are dynamically induced by the acceleration vectors of horizontal winds. Saito and Matsunobu (2020) conducted a numerical experiment with a horizontal resolution of 10 km and analyzed the northward moisture fluxes by the ageostrophic winds. They showed that PRE rainfalls over western Japan decreased substantially when the contributions in moisture fluxes by ageostrophic winds were removed. In this study, we perform simulations by a cloud resolving model with a horizontal resolution of 2 km to see the cloud microphysical aspects of precipitation enhancement by the upper-level moistening. Effect of the large-scale updraft induced by a secondary circulation of the ageostrophic winds on PRE is also investigated.

References:

Saito, K., 2019: On the northward ageostrophic winds associated with a tropical cyclone. SOLA, 15, 222-227.
Saito, K. and T. Matsunobu, 2020: Northward ageostrophic winds associated with a tropical cyclone. Part 2: Moisture transport and its impact on PRE. SOLA, 16, 198-205.

Keywords: tropical cyclone, ageostrophic wind, pre-typhoon rainfall (PRE), cloud resolving model

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Climatology of Tropical Cyclone Seeds and Survival Rates to Tropical Storms

*Kohsuke Ikehata[1], Masaki Satoh[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

A mechanism behind the variation of tropical cyclone (TC) genesis frequency can be understood more deeply by focusing on tropical cyclone seeds (TC seeds). Previous studies indicate that the change in the number of TCs due to global warming is primarily explained by that of TC seeds. However, the validity of such a relationship is not clarified on monthly or yearly variations in the present climate. In this study, we examine the relationship between TC seeds and TC genesis, and underlying factors for survival rates to TC. Tracks of weak lower tropospheric vortices are extracted as TC seeds from the reanalysis ERA5 during the period of boreal summer from 2000 to 2018. Survival rates, the ratios of developing TC seeds to the sum of developing and non-developing ones, are then calculated by comparing with TC observations. Horizontal distributions and subseasonal to annual variations of TC seeds genesis frequency and survival rates show that the main factor influencing TC genesis frequency is survival rate, with the number of TC seeds also having secondary effects. Local variations of TC seeds genesis frequency positively correlate with mean values of low-level relative vorticity related to large-scale wind fields. On the other hand, survival rates change with surrounding atmospheric conditions at an early stage after TC seed genesis. These results suggest that survival rates affected by environmental fields largely control subseasonal to annual variations of TC genesis frequency, while the integrated number of TC seeds changes relatively smaller in the present climate.

Keywords: tropical cyclone, tropical cyclone seed, survival rate

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Change of Tropial Cyclone Characteristics under the Changing Climate

*Fumiya Matsushima[1], Kazuhisa Tsuboki[1], Sachie Kanada[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

Since typhoons cause great damage to Southeast Asia and north western Pacific regions, it is an important problem how the typhoons change with global warming. Previous studies have shown that the number and ratio of strong typhoons are increasing. However, there are no simulations that have been performed for many typhoons with high resolution, and the future changes in typhoon intensity have not been thoroughly examined. Therefore, the purpose of this study is to clarify the changes in typhoon intensity and internal structure of typhoons with global warming by examining about 60 typhoons in each climate experiment of "current climate, near-future climate, and future climate" with about 2 km horizontal resolution. Latitudes of typhoons lifetime maximum intensity are 20.38 ˚, 21.61 ˚and 21.95 ˚N for the present climate , the near future climate and the future climate, respectively. In the future climate, the maximum intensity latitude was about 1.5 ˚north of the present climate. In order to show how strong typhoons change between climate experiments, we investigated the warm core structure and wind field for the strongest 30% typhoons in each climate. From composite analyses at the maximum intensity normalized by the radius of maximum wind speed at an altitude of 2 km, the maximum potential temperature anomaly was larger in the future climate than in the present climate, and the warm core was stronger. In addition, we found that the upward vertical velocity is stronger in the future climate than the present climate. This means that secondary circulation of typhoon is stronger in the future climate. A new finding in this study is the future change of typhoon intensity shown by detailed physics-based simulations. The average minimum central pressure showed no trend with global warming. This is attributed to increases in both strong and weak typhoons in the future climate. On the other hand, focusing on typhoons with the 30% of the highest maximum intensity as strong typhoons, the average minimum central pressure in the future climate was significantly smaller than that of the present climate.

Keywords: typhoons, global warming

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Future Changes of a Slow-moving Intense Typhoon with Global Warming: A Case Study using a regional 1-km-mesh atmosphere–ocean coupled model

*Sachie Kanada[1], Hidenori AIKI[1], Kazuhisa Tsuboki[1], Izuru Takayabu[2]

1. Nagoya University, 2. MRI/JMA

Numerical experiments on Typhoon Trami (2018) using a regional 1-km-mesh three-dimensional atmosphere–ocean coupled model in current and pseudo-global warming (PGW) climates were conducted to investigate future changes of a slow-moving intense typhoon under the warming climate. Over the warmer sea in the PGW climate, the maximum near-surface wind speed rapidly increased around the large eye of the simulated Trami. The stronger winds in the PGW simulation versus the current simulation caused a 1.5-fold larger decrease of sea surface temperature (SST) in the storm core-region. In the PGW climate, near-surface air temperature increased by 3.1˚C. A large SST decrease due to ocean upwelling caused downward heat fluxes from the atmosphere to the ocean. The magnitude of the SST decrease depended strongly on initial ocean conditions. Consideration of the SST decrease induced by an intense typhoon, and a slow-moving storm in particular, indicated that such a typhoon would not always become more intense under the warmer climate conditions. An atmosphere–ocean coupled model should facilitate making more reliable projections of typhoon intensities in a warming climate.

Keywords: ocean impact, Numerical simulation

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[E] Oral | A (Atmospheric and Hydrospheric Sciences) | A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus), Chairperson:Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University)
Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.07 (Zoom Room 07)
In 2019, Typhoon Faxai (T1915) hit the Kanto District and caused a long-term shut-down by high winds. In October, Typhoon Hagibis (T1919) provided a huge amount of water vapor and contributed to the record breaking heavy rainfalls over the Japanese Islands. In 2020, Typhoon Haishen (2020) approached Japan; the typhoon exhibited unique concentric eyewall structures and underwent eyewall replacement cycle over the sea south of the Japanese Islands. Tropical cyclones (TCs) often cause tremendous disasters in the coastal regions by torrential rainfall, gale, storm surge, and high surf. A number of future projection studies have implied that higher-latitude occurrences of intense TCs will increase, because the projected future increase in sea surface temperature is larger at higher latitudes. Understanding such phenomena associated with translation, intensity change, and precipitation of TCs and their accurate forecasts are still challenging issues to be solved in the earth and planetary science. Advances in innovative observations including meteorological aircrafts and next generation satellites, and supercomputers have led to novel development of numerical weather forecasting and understanding of the phenomena in both the forecast and long-term projection. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide new direction for future TC research activity.

12:00 PM - 12:15 PM

[AAS03-12]Discussion

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.02_1

[A-AS03] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Kosuke Ito(University of the Ryukyus)

In 2019, Typhoon Faxai (T1915) hit the Kanto District and caused a long-term shut-down by high winds. In October, Typhoon Hagibis (T1919) provided a huge amount of water vapor and contributed to the record breaking heavy rainfalls over the Japanese Islands. In 2020, Typhoon Haishen (2020) approached Japan; the typhoon exhibited unique concentric eyewall structures and underwent eyewall replacement cycle over the sea south of the Japanese Islands. Tropical cyclones (TCs) often cause tremendous disasters in the coastal regions by torrential rainfall, gale, storm surge, and high surf. A number of future projection studies have implied that higher-latitude occurrences of intense TCs will increase, because the projected future increase in sea surface temperature is larger at higher latitudes. Understanding such phenomena associated with translation, intensity change, and precipitation of TCs and their accurate forecasts are still challenging issues to be solved in the earth and planetary science.
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[AAS03-P01] Meso–scale structure in the eye of Typhoon Trami(2018)

*Lana Yamashiro[1], Kazuhisa Tsuboki[1], Hiroyuki Yamada[2] (1.Nagoya University Institute for Space - Earth Environmental Research , 2.University of the Ryukyus)

[AAS03-P02] Simulation of sea salt transport and deposition assuming salt damage by typhoon using NHM-Chem

*Mirai Abe[1], Yoshiaki Miyamoto[1], Mizuo Kajino[2] (1.Keio University, 2.Meteorological Research Institute, Japan Meteorological Agency)

[AAS03-P03] Accelerated increase in tropical cyclone heat potential within typhoon rapidly intensifying region during 1955-2019

*Haruka Sasaki[1], Tatsuo Motoi[1] (1.Meteorological College)

[AAS03-P04] Analysis of Precipitation Distribution Associated with the Tropical Cyclones in the Northwest Pacific

Ayano Shirakawa[1], *Akiyo Yatagai[2], Ryuji Yoshida[3,4], Yuno Sakashita[1] (1.Faculty of Science and Technology, Hirosaki University, 2.Graduate School of Science and Technology, Hirosaki University, 3.CIRES University of Colorado Boulder, 4.NOAA Earth System Research Laboratories, CSL)

[AAS03-P05] The mechanism by which updraft and the downdraft of a cumulonimbus cloud in subtropical waters turn in the opposite direction.

*Shinji Karasawa[1] (1.Miyagi National College of Technology Professor emeritus)

[AAS03-P06] Correlation Analysis of Microphysical Parameters in Typhoon Deep Convective Cloud Based on CloudSat

*Shuang Luo[1] (1.Shanghai Ecological Forecasting and Remote Sensing Center)

[AAS03-P07] An Advancement of the Korean Typhoon Pre-disaster Prevention Model for Improving the Prediction Accuracy of 3-second Gust and the Damage Cost During the Typhoon

Period

*Woo-Sik JUNG[1] (1.Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.)

[AAS03-P08] Evaluation of the Sensitivity of Typhoon Pre-disaster Prevention Model According to the Application of the Type of Soil Data During Typhoon Season

*Woo-Sik JUNG[1], HANA NA[1] (1.Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.)

[AAS03-P09] Maximum Wind Speed Radius Formula That Can Be Used for Typhoons Affecting the Korean Peninsula – Evaluation of the Pilot Study-

*Woo-Sik JUNG[1] (1.Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.)

Meso-scale structure in the eye of Typhoon Trami(2018)

*Lana Yamashiro[1], Kazuhisa Tsuboki[1], Hiroyuki Yamada[2]

1. Nagoya University Institute for Space - Earth Environmental Research , 2. University of the Ryukyus

Typhoons are a disturbance with an overall scale of 1000 km while meso-scale systems that form within them are a phenomenon with a scale of only a few 10 km. Meso-scale structures within typhoons are accompanied by strong winds and heavy rains, and are considered to be the most important part for disaster prevention. When Typhoon Trami (2018) passed between Okinawa main Island and Kume Island on September 29-30, weather radars on Okinawa Island observed the inner core region of the typhoon. The purpose of this study is to reveal characteristics and structure of the meso-scale systems that occurred in the eye of Typhoon Trami. In this study, we used Meteorological Satellite Himawari-8, JMA RSMC Best Track data, surface observation, NICT Okinawa Bistatic Polarimetric RAdar (COBRA), and Phased Array Weather Radar (PAWR).

The time-series of surface wind at four observation sites in Kume Island, Naha, Onna, and Nago showed the common characteristics of a passing typhoon: weaker winds in the eye and stronger winds within the eyewall cloud. On the other hand, a strong wind was observed with sharp drop of the equivalent potential temperature during the passage of the eye and the inner edge of the eyewall. The decrease of equivalent potential temperature lasted for about 40 minutes and was accompanied by an increase of wind speed. The mixing ratio also decreased during the period. This indicates that a dry air passed over the observation sites and that it was accompanied by the strong wind.

The radar observation of COBRA and PAWR showed that the size of Trami eye was larger than 100 km in radius, which was a very large and polygonal eye. The CAPPI display of COBRA radar reflectivity at an altitude of 1.0 km showed a meso-vortex in the typhoon eye. The equivalent potential temperature had started to decrease after the meso-vortex passed over the Onna observation site. However, there was no close relationship between the meso-vortex and strong wind because the meso-vortex was located more than 50 km away at the time the strong wind was observed at Onna.

To investigate the vertical motion in the inner core region, we developed a CVAD method and used it to analyze the wind field. The CVAD method calculates the vertical distribution of horizontal velocity above the radar from Doppler velocity data obtained by PAWR. This analysis shows that the downdraft was pronounced during the period when the equivalent potential temperature was decreasing. The results for a radius of 20 km showed strong horizontal wind and updraft. This suggests that Onna was located near the updraft of the secondary circulation, and that there were strong tangential winds of the primary circulation with a strong wind field within the eyewall near Onna. This indicates that the strong downward motion transported the upper-level dry air to the surface. This also suggests that the strong winds were caused by momentum transport of low equivalent temperature air from the upper-level of the inversion layer to the surface around the polygonal eyewall of the typhoon.

In this study, we identified the meso-scale structure causing strong winds that occur at the surface in the eye of Typhoon Trami. This strong wind was observed when the inner edge of the polygonal eyewall approached. We infer that the strong wind was caused by the compensating downdraft of the strong updraft of the typhoon secondary circulation. The low equivalent potential temperature air was transported by the downdraft from the above of the inversion layer to the surface.

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Simulation of sea salt transport and deposition assuming salt damage by typhoon using NHM-Chem

*Mirai Abe[1], Yoshiaki Miyamoto[1], Mizuo Kajino[2]

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Typhoons occur and develop over the southern seas of Japan, approach and make landfall in Japan in summer and autumn, and cause severe disasters by strong winds and heavy rains. Due to the strong winds associated with typhoons, a large number of sea salt particles is generated from the sea surface, transported by the wind, and deposited on the ground. The deposition of sea salt particles on crops and buildings can cause salt damage. There are three deposition processes: wet deposition, dry deposition, and fog deposition. Despite of the severeness of salt damage, there remains many unknown processes on the transport of sea-salt aerosols by typhoons.

This study investigates the emission, transportation, and deposition processes of sea salt in Typhoon No. 9 in August 2016 based on the results of the numerical simulation using the regional-scale nonhydrostatic meteorology-chemistry model (NHM-Chem) (Kajino et al., 2019).

The result of simulation indicated that the spatial distributions of wet deposition, dry deposition, and fog deposition are remarkably different from each other. The percentages of deposition by the dry, wet, and fog depositions were about 35%, 65%, and less than 1%, respectively. Dry deposition was concentrated in the coastal areas, but wet deposition was also observed inland. Surprisingly, fog deposition was observed associated with the simulated typhoon in the eastern part of Hokkaido. There are few previous studies on the salt damage caused by fog and the relationship between fog and typhoons. The results of our analyses suggest that approaching typhoon can produce fog, and that the deposition of sea salt by the fog can cause salt damage.

Reference:
Kajino, M., et al. 2019: NHM-Chem, the Japan Meteorological Agency's Regional Meteorology –Chemistry Model: Model Evaluations toward the Consistent Predictions of the Chemical, Physical, and Optical Properties of Aerosols, *J. Meteor. Soc. Japan*, 97(2), 337-374.

Keywords: Thphoon, Chemical transport model, fog, sea salt, salt damage

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Accelerated increase in tropical cyclone heat potential within typhoon rapidly intensifying region during 1955-2019

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The changes in the tropical cyclone heat potential (TCHP) within the rapidly intensifying region (RIR) of typhoon over the past six decades, from 1955 to 2019, are investigated by using the objectively analyzed (1˚ grid) annual and 3-month climatological data of temperature [Locarnini et al., 2010] and salinity [Antonov et al., 2010] from the World Ocean Atlas 2009[1] , and the annual and 3-month anomaly data of temperature from 1955 to 2019 and salinity from 2005 to 2019 [Levitus et al., 2012][2]. 3-month periods from January to March, from April to June, from July to September, and from October to December are referred as winter, spring, summer, and fall, respectively, for season. The RIR is defined as 6-24˚N and 124-170˚E, based on the locations of onset of rapidly intensifying tropical cyclone (RITC). The RITC is defined as a wind speed increase of 30 kt or more in a 24-h period and is detected by using the best track data from the Regional Specialized Meteorological Center of Tokyo–Typhoon Center of the Japan Meteorological Agency[3]. Figures 1 (a) and (c) show time series of annual TCHP anomalies (TCHPA) averaged in global and RIR and their 31-y linear trends, respectively. Figures 1 (b) and (d) are the same as (a) and (c) but for seasonal and only within RIR. The trends which are not statistically significant at the 95% confidence level are indicated by broken lines in Figs 1 (c) and (d). There is a clear shift toward positive TCHPA within RIR during the 1990s (Figs. 1(a) and (b)). The annual TCHPA trends exhibit increasing trends in both global and RIR (Fig. 1(c)), but those in RIR are not significant from 1970 to 1983. It is identified that the insignificant increasing trends are accelerated and turn to be significant increasing trend in all seasons (Fig. 1(d)). These results indicate that the past six decades is possible to be separated into the two periods of three decades of the early half (33-y period 1955-1987) with smaller trends and latter half (32-y period 1988-2019) with larger trends. The centroids of the early and latter sub-periods are around 1971 and 2003, respectively. Geographical distributions of the difference of mean TCHPA [10^8 J/m^2] are shown in Fig. 2. Only the values those are statistically significant at the 95% confidence level are colored. It is revealed that the increase of mean TCHPA from the early half period to the latter half period is statistically significant in almost all locations in RIR for all seasons.

[1] Available from https://www.ncei.noaa.gov/products/world-ocean-atlas.
[2] Available from https://www.ncei.noaa.gov/access/global-ocean-heat-content.
[3] Available from http://www.jma.go. jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/besttrack.html.

Keywords: tropical cyclone heat potential, typhoon rapidly intensifying region

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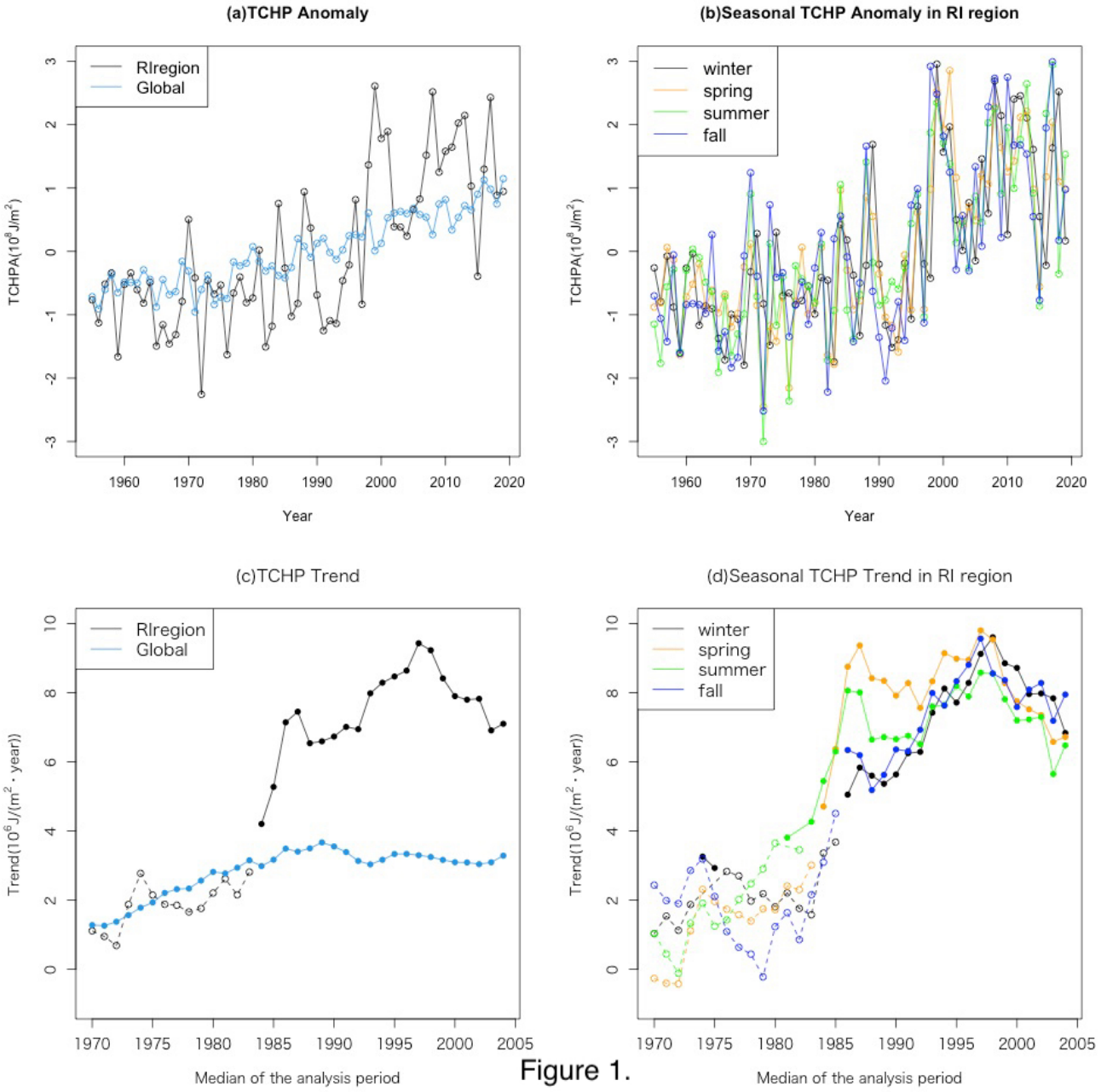
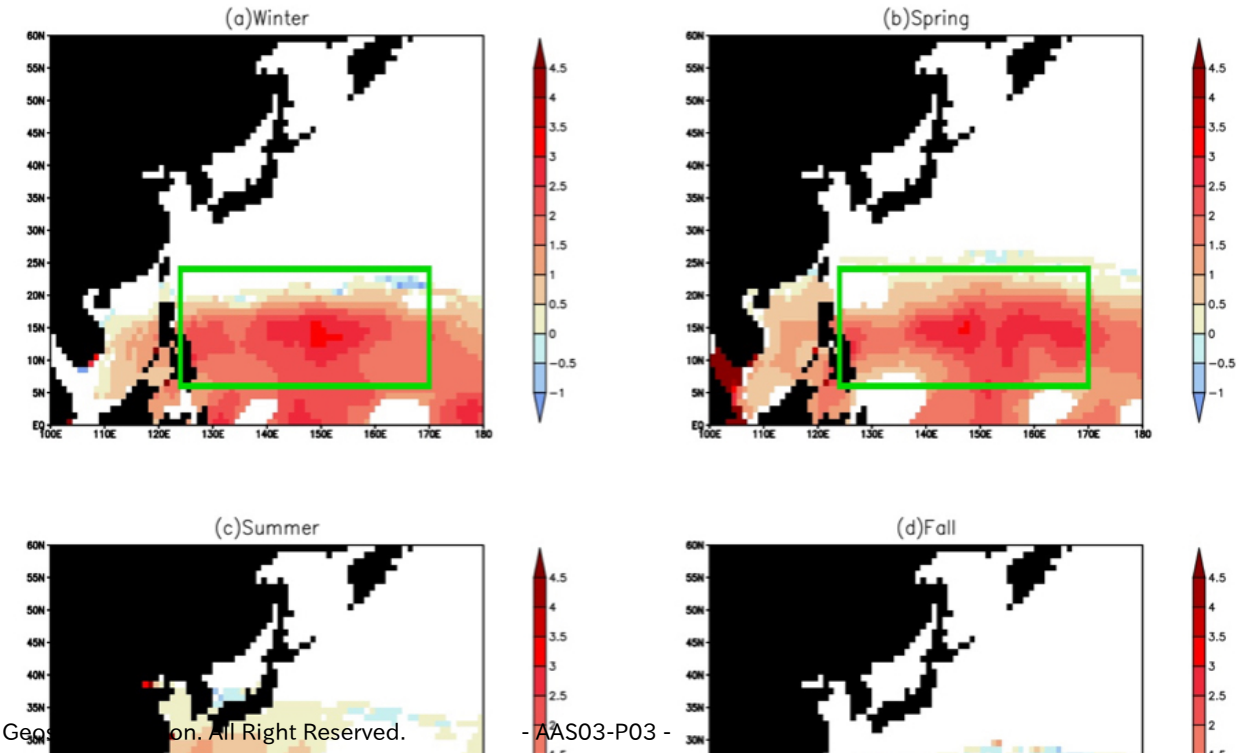


Figure 1.



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Analysis of Precipitation Distribution Associated with the Tropical Cyclones in the Northwest Pacific

Ayano Shirakawa[1], *Akiyo Yatagai[2], Ryuji Yoshida[3,4], Yuno Sakashita[1]

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Recent satellite precipitation products allow analysis of tropical cyclones (TCs) with high spatial and temporal resolutions. Fudeyasu and Yoshida (2018) pointed out that subsequent development and tracks differ depending on the environmental factors of TC occurrence. In this study, we clarify the diurnal cycle of TC precipitation according to TC intensity and precipitation distributions according to the environmental factors of TC generation by using 1-hour precipitation data.

Precipitation data used in this study were combined Radar AMeDAS for the Japanese land area and GPM IMERG Final Precipitation for the other land and sea areas to produce 1-hour precipitation with 0.1 degree grid. TC precipitation is defined as precipitation within 1,000 km of the TC center location from RSMC Best Track Data. Precipitation distribution is analyzed for TCs occurring in the northwest Pacific Ocean from July to October in 2015 to 2019. TCs were classified into five intensity classes: tropical depressions (TDs), typhoons (defined as Tropical Storm (TS), Severe Tropical Storm (STS), and Typhoon (TY) in terms of maximum wind speed), and extratropical cyclones (ECs). In addition, the environmental factors of TC occurrence were also synthesized. In addition, TC-generating environmental factors are classified into five categories: monsoon shear line (SL), monsoon confluence region (CR), monsoon gyre (GY), easterly wave (EW), and preexisting TC (PTC).

Diurnal changes of typhoon (TS, STS, TY) precipitation by TC class are shown in Fig. 1. In TD, the maximum precipitation area is located near the center, while in TS, the strong precipitation area shifts from the center to the south. At STS, the precipitation areas were concentrated in a north-south direction. As the intensity of the typhoon increased, the shape of precipitation distribution became concentric circles at TY, and the eye of the typhoon became clearer. In addition, we compared the differences between each time period and the morning, as well as the north-south and east-west cross sections across to the center of the TCs. The STS, which showed the largest diurnal changes among the typhoons, showed heavy precipitation at the north of the center in the afternoon and evening, and heavy precipitation appeared at south of the center in the morning. Two precipitation peaks were found in the center-north and the center-south directions for the evening.

Next, analysis by environmental factors of TC occurrence shows different composite precipitation distribution each other (Fig.2). These characteristics imply that the middle and lower troposphere is relatively moist in SL and CR due to high mean precipitation, while EW is dry. In addition, GY has a wide range of precipitation at the time of TS formation, and PTC tends to be strong during the maturation period and does not remain weak, which is consistent with the previous studies.

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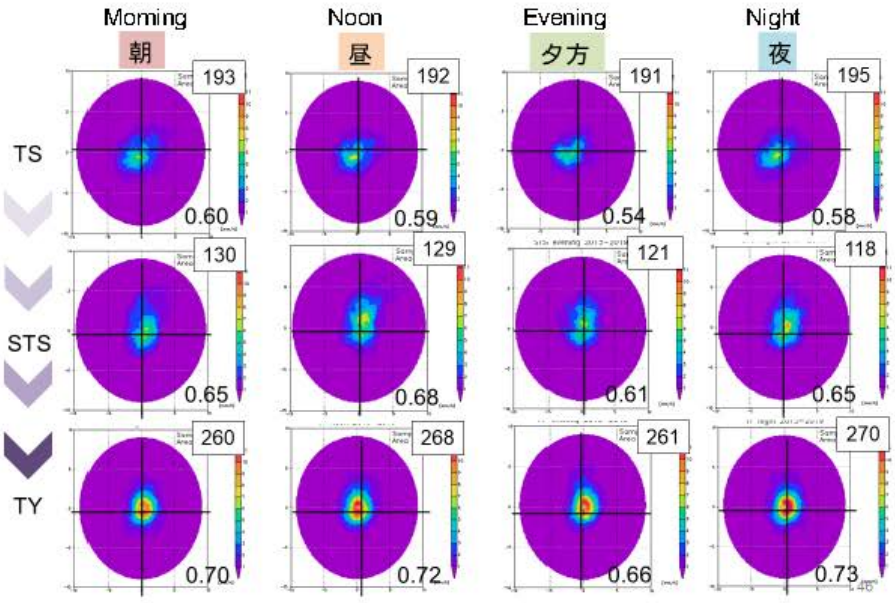


Fig.1 Composite maps of hourly precipitation according to the typhoon intensity (TS, STS, TY) and to the time-zone (morning, noon, evening, night). Number at upper-right corner of each panel shows sample number, and that of lower-right shows averaged precipitation (unit: mm/h) over the area.

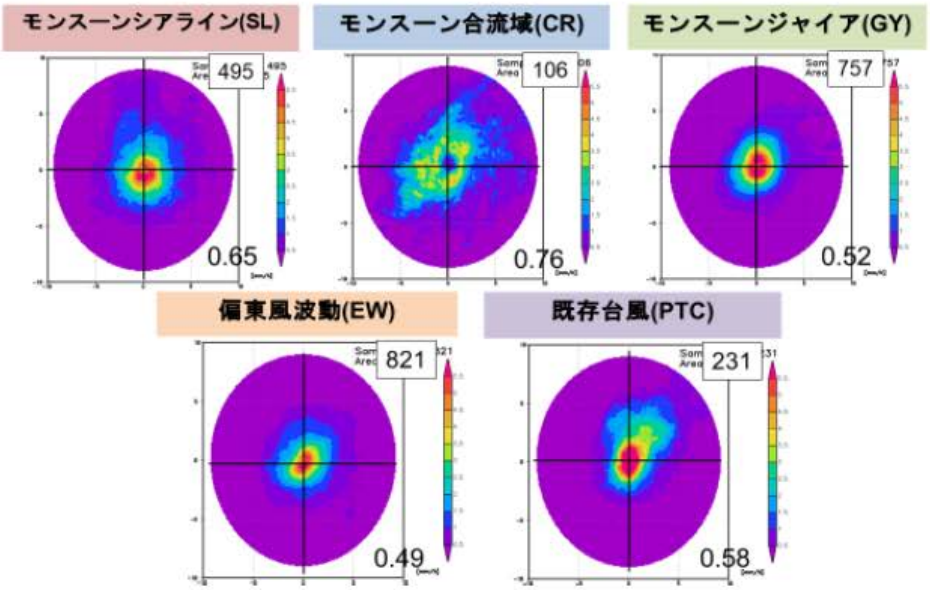


Fig.2 Composite maps of hourly precipitation according to the type of TC generation. Details are the same with Fig.1.

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The mechanism by which updraft and the downdraft of a cumulonimbus cloud in subtropical waters turn in the opposite direction.

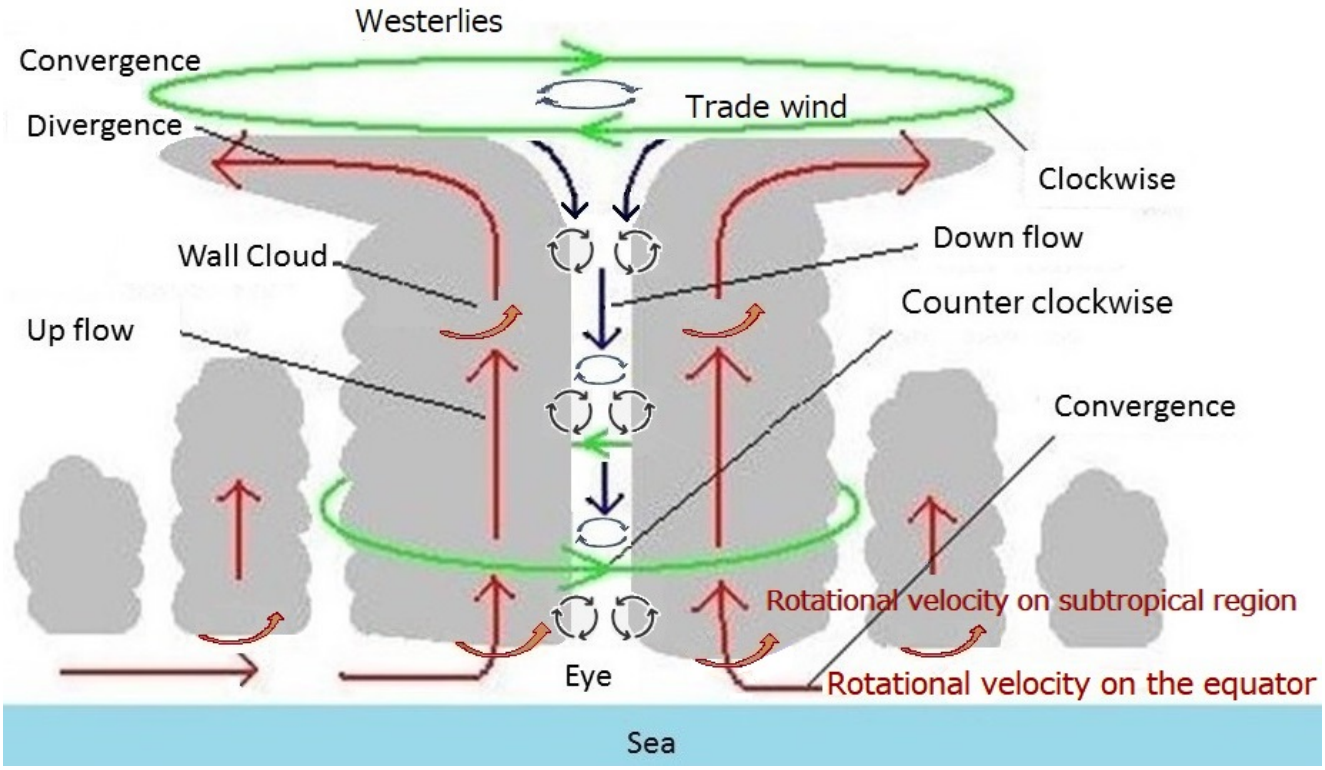
*Shinji Karasawa[1]

1. Miyagi National College of Technology Professor emeritus

Changes in high and low pressures rotates around the Earth in 4-5 days. It is proposed in this report that the solar wind is driving the flow of the atmosphere which orbited faster than the Earth's rotation in this east-west direction. The solar wind is emitted from the Sun at a speed exceeding the escape speed of 617.5 km/sec, and it has a rotating motion of 1.89 km/sec in the counterclockwise direction, according to the rotation of the Sun.
The main component of the solar wind is protons, and their hydrogen ions collide repeatedly with Earth's atmospheric molecules, so they do not reach the Earth's earth. Earth's gravity can't hold hydrogen. However, there are hydrogen atoms in the atmosphere upper sky. The peak of hydrogen density exists altitude 80 km. The solar wind collides with the Earth's atmosphere.
In the daytime hemisphere near the Earth's equator, the solar wind hits the atmosphere directly, and the momentum of the rotation in the clock rotation direction of the solar wind moves the atmosphere in the sky in the clock rotation direction by the method of the gear. The atmosphere of upper sky near the equator of the Earth is rotated in the clock rotation direction by the solar wind. That is the trade wind. The atmosphere of the Earth moves by the Earth’ s rotation in the direction of counterclockwise. The solar wind that winds through the east side of the Earth collides with the atmosphere moving in the same direction, accelerating the flow of the rotating atmosphere, even though west side collides with the atmosphere moving in the opposite direction. It is the westerly wind. In the sky over the subtropical region, the influence of the westerly wind is strong, and the trade wind weakens, and the air flow is turned in the clockwise direction.
In Madden Julian Oscillation (MJO), it is known that the winds from east-to-west in the east of a cumulonimbus clouds are weak, but the wind from west-to-east is strong. This is the effect of the Earth's rotation moving from west to east with an anti-clock rotation of 463m/sec near the equator. The distance to orbit the Earth is shorter in areas with higher latitudes than near the equator, and slower rotational speed in high latitudes where the distance to go around is shorter. Therefore, the equatorial counter current moving from west to east near the equator is fast. So, the equatorial current moving from east to west both sides in the opposite direction will flow.
The rising air at the bottom of the cumulonimbus cloud in the subtropical waters of the northern hemisphere moves counterclockwise direction owing to the current of sea water. Then, when a cumulonimbus cloud occurs, water vapor condenses in the sky, and a descending air flow of clock rotation is generated. In this way, a typhoon is born, because the ups and downs flow of the cumulonimbus cloud generated in the subtropical sea area turns in the opposite direction [1].
[1] S. Karasawa, “Mechanism of typhoon”, 2021, 27/Jan, https://youtu.be/HCY9m0npYyw

Keywords: Typhoon, Madden Julian Oscillation, Cumulonimbus cloud , Trade wind, Westerlies, Solar wind

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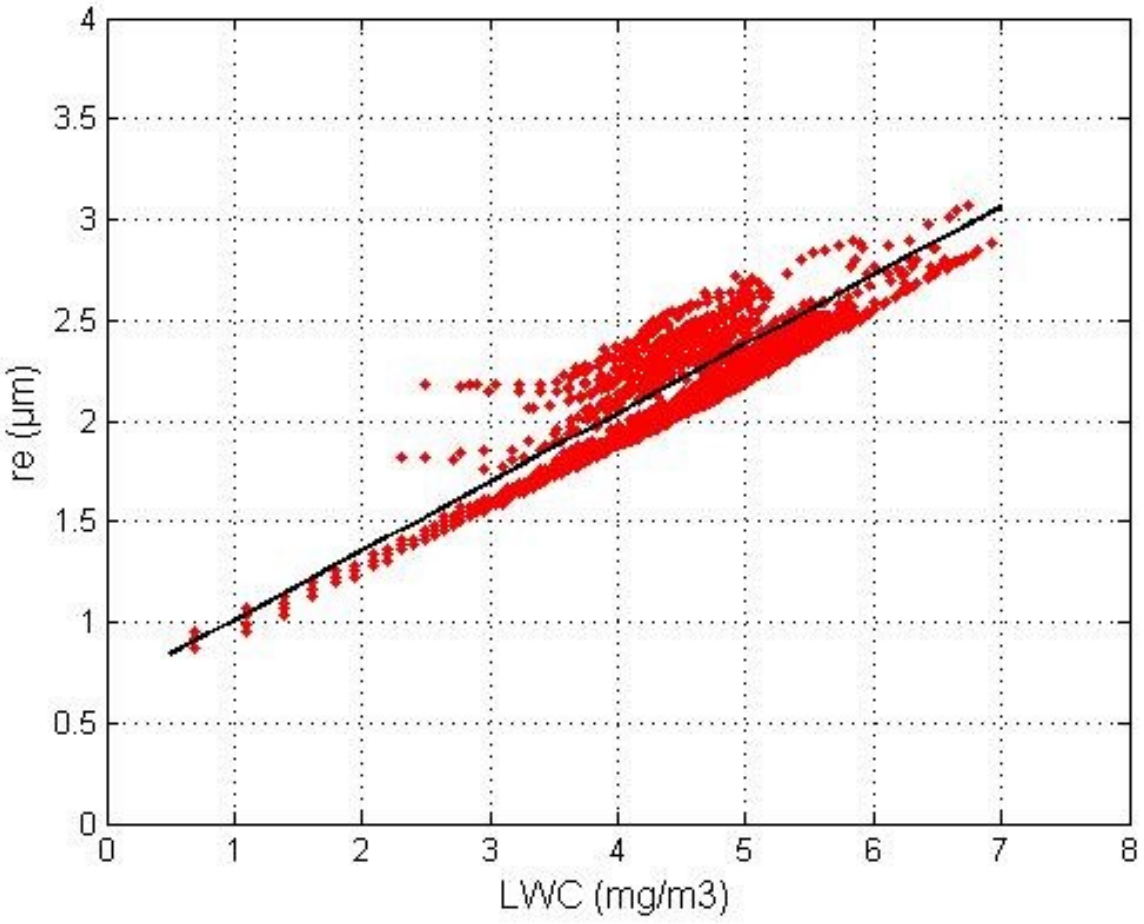
Correlation Analysis of Microphysical Parameters in Typhoon Deep Convective Cloud Based on CloudSat

*Shuang Luo[1]

1. Shanghai Ecological Forecasting and Remote Sensing Center

Microphysical properties of water cloud and ice cloud in deep convective cloud of typhoon ‘Choi-wan’ which is the 14th in 2009, are analyzed by using cloud products from CloudSat. The correlation between the effective particle radius and cloud water content are also discussed. Account for the universality, we checked multiple typhoon in different development periods. Results reveal that, no matter water cloud or ice cloud, the lower boundary exists in the effective radius and cloud water content scatter diagram in typhoon deep convective cloud, taking the cloud water content as x-axis, and the effective particle radius as y-axis. Besides, the boundary value increases with cloud microphysical parameters. The effective particle radius and liquid water content have a positive correlation under the zero layer, which can be unified by a logarithm linear fitting. Meanwhile, the relationship is also applicable to typhoons at other stages of development.

Keywords: CloudSat, Typhoon, Cloud microphysical parameters



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An Advancement of the Korean Typhoon Pre-disaster Prevention Model for Improving the Prediction Accuracy of 3-second Gust and the Damage Cost During the Typhoon Period

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1. Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.

Recently, the frequency and intensity of typhoons affecting the Korean Peninsula has increased, causing enormous damage. Typhoon pre-disaster prevention model is that calculates the maximum instantaneous wind speed of 3-second GUST and the amount of damage that can occur when a typhoon is attacked, and it is the most important to improve the accuracy of 3-second GUST and damage. Therefore, in this work, we conduct a study on improving the prediction accuracy of typhoon pre-disaster prevention model through application of high-resolution data in time and space and analyzing Weather Research and Forecasting (WRF) sensitivity. By replacing inputs from Regional Data Assimilation Prediction System (RDAPS) to WRF and producing high-resolution data onto both time and space, and by analyzing the sensitivity of WRF's high-resolution sea surface temperature data, data assimilation, weather input data, and soil data. In addition, the grid system, which calculated the amount of damage to the existing RDAPS (30 km/12 km), was classified into the WRF (3 km) grid system and improving and supplementing the model to calculate more specific and accurate damage. Through this study, it is believed that the accuracy of typhoon pre-disaster prevention model will be evaluated, and the damage caused by typhoons will be reduced efficiently in the future.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2020R1F1A1068738)

Keywords: Typhoon, 3-second GUST, Damage cost

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Evaluation of the Sensitivity of Typhoon Pre-disaster Prevention Model According to the Application of the Type of Soil Data During Typhoon Season

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1. Department of Atmospheric Environment Information Engineering, INJE University, Republic of Korea.

Recently, as global warming has become more serious, SST in the northwest Pacific Ocean has risen, and the frequency and intensity of typhoons affecting the Korean Peninsula have been increasing. Therefore, we are conducting research by developing a Korean typhoon pre-disaster prevention model optimized for the Korean Peninsula based on the Florida Public Hurricane Loss Model (FPHLM) model of the U.S. FDFS. This typhoon pre-disaster prevention model can predict and diagnose the maximum instantaneous wind speed (3-second GUST) and maximum damage that can occur due to strong winds accompanying the typhoon. Since natural disasters have the risk of destroying almost everything at the moment they exceed the intensity of the threshold, it is very important to accurately predict the 3-second GUST and provide reliable information on possible future damage from the perspective of prevention of strong winds accompanying typhoons. To improve the prediction accuracy of the Korean typhoon pre-disaster prevention model, it is very important to improve the reliability of the Weather Research and Forecasting (WRF) numerical model that produces the initial wind information input into the model. Therefore, to improve the accuracy of the WRF model, we perform a sensitivity analysis of the WRF model according to the type of soil data. As a result of comparative analysis of each modeling result by applying the Unified Model (UM) based Global Data Assimilation Prediction System (GDAPS) soil data and Global Forecasting System (GFS) soil data to each WRF model, the accuracy of the WRF modeling results using UM-based GDAPS soil data is better. In addition, the results of the 3-second GUST of the Korean typhoon pre-disaster prevention model, which used WRF modeling results using GDAPS soil data as input, were also found to be more accurate than those of GFS soil data. In terms of preventing damage caused by strong winds accompanied by typhoons in advance, it is thought that the use of a Korean typhoon pre-disaster prevention model with improved accuracy will play an effective role in minimizing damage from typhoons.

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2020R1F1A1068738)

Keywords: Typhoon Pre-Disaster Prevention Model, Soil Data, WRF

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Maximum Wind Speed Radius Formula That Can Be Used for Typhoons Affecting the Korean Peninsula –Evaluation of the Pilot Study-

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Radius of Maximum Wind speed (RMW) of a typhoon refers to an area where stronger wind speeds occur and is very important and useful information in terms of disaster prevention. Therefore, it is very important to forecast a reasonable and accurate RMW. Regional Specialized Meteorological Center (RSMC) provides long and short radius for 15 m/s and 25 m/s, while the Joint Typhoon Warning Center (JTWC) provides wind radius for 35, 50, 60, and 100 kts. Korea Meteorological Administration (KMA) provides a strong wind radius of more than 15 m/s and a storm radius of more than 25 m/s as information for typhoons since May 15, 2020. This study analyzed the strong wind radius provided by KMA, JTWC, and RSMC, and then applied the empirical formulas to calculate the maximum 3-second GUST around the Korean Peninsula during the typhoon period. As a result of the analysis, the maximum wind speed radius empirical formula suitable for the Korean Peninsula was adopted among the several formulas. If disaster prevention activities are carried out based on this, it is believed that damage from typhoons will be reduced more efficiently.

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2020R1F1A1068738)

Keywords: Typhoon, RMW, 3-second GUST, KMA, RSMC, JTWC

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.06 Zoom Room 06

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology)



The dynamical, radiative, and chemical processes involved in the interactions between the stratosphere and troposphere are essential for understanding the present and future climate. Both observed data and high-resolution models have now clearly demonstrated that stratospheric processes can affect various tropospheric phenomena. On the other hand, it has been confirmed that the stratospheric processes are changing significantly with climate change. For example, the polar vortex was exceptionally strong, cold, and persistent in the Northern Hemisphere winter stratosphere in 2019-2020, resulting in record ozone depletion and contributing to unusually warm temperatures in mid-latitudes.
In this session, we will focus on stratospheric phenomena and invite presentations on the latest findings (case studies, long-term variations, predictability, etc.). We welcome studies on the effects of these phenomena on the troposphere and mesosphere. Inheriting the significance of the Stratosphere-troposphere Processes And their Role in Climate (SPARC) sessions held at JpGU, this division aims to enhance the development of this field in close cooperation with the atmospheric chemistry sessions.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[AAS06-01] Updated atmospheric composition chemica reanalysis and emission estimates

★Invited Papers

*Kazuyuki Miyazaki[1] (1.NASA Jet Propulsion Laboratory)

9:20 AM - 9:40 AM JST | 12:20 AM - 12:40 AM UTC

[AAS06-02] Ozone variability associated with the dynamical fields during YMC-Sumatra2017 field campaign

★Invited Papers

*Junko Suzuki[1], Shin-Ya Ogino[1], Takenari Kinoshita[1], Ryuichi Shirooka[1], Suginori Iwasaki[2], Kunio Yoneyama[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Defense Academy of Japan)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[AAS06-03] Tropical coastal bidirectional gravity waves robustizing QBO

*Manabu D. Yamanaka[1,2], Shin-Ya Ogino[2] (1.Research Institute for Humanity and Nature / Professor Emeritus of Kobe University, 2.Japan Agency for Marine-Earth Science and Technology)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[AAS06-04] Study for influence of temperature at TTL on evolution of deep convection and tropical cyclones

Kenta Kobayashi[1], *Nawo Eguchi[1], Tomoe Nasuno[2], Yohei Yamada[2], Kunihiko Kodera[3] (1.Kyushu University, 2.JAMSTEC, 3.Meteorological Research Institute)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[AAS06-05] Stratospheric Influence on the Troposphere During the Remarkably Strong Arctic Circumpolar Vortex Condition in 2019-2020 Winter

*Shunsuke Noguchi[1,2], Kunihiko Kodera[2], Ryo Mizuta[2], Seiji Yukimoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

[AAS06-06] Discussion

Updated atmospheric composition chemica reanalysis and emission estimates

*Kazuyuki Miyazaki[1]

1. NASA Jet Propulsion Laboratory

This study presents the results from the Tropospheric Chemistry Reanalysis version 2 (TCR-2) for the period 2005–2018 at 1.1 horizontal resolution obtained from the assimilation of multiple updated satellite measurements of ozone, CO, NO_2, HNO_3, and SO_2 from the OMI, SCIAMACHY, GOME-2, TES, MLS, and MOPITT satellite instruments. The reanalysis calculation was conducted using a global chemical transport model MIROC-CHASER and an ensemble Kalman filter technique that optimizes both chemical concentrations of various species and emissions of several precursors, which was efficient for the correction of the entire tropospheric profile of various species and its year-to-year variations. Comparisons against independent aircraft, satellite, and ozonesonde observations demonstrate the quality of the reanalysis fields for numerous key species on regional and global scales, as well as for seasonal, yearly, and decadal scales, from the surface to the lower stratosphere. The multi-constituent data assimilation brought the model vertical profiles and interhemispheric gradient of OH closer to observational estimates, which was important in improving the description of the oxidation capacity of the atmosphere and thus vertical profiles of various species. The evaluation results demonstrate the capability of the chemical reanalysis to improve understanding of the processes controlling variations in atmospheric composition, including long-term changes in near-surface air quality and emissions. The estimated emissions can be employed for the elucidation of detailed distributions of the anthropogenic and biomass burning emissions of co-emitted species (NO_x, CO, SO_2) in all major regions, as well as their seasonal and decadal variabilities.

Keywords: Atmospheric composition, Satellite observation, Data assimilation

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Ozone variability associated with the dynamical fields during YMC-Sumatra2017 field campaign

*Junko Suzuki[1], Shin-Ya Ogino[1], Takenari Kinoshita[1], Ryuichi Shirooka[1], Suginori Iwasaki[2], Kunio Yoneyama[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Defense Academy of Japan

The field observation focused on the atmospheric science in the troposphere and stratosphere was conducted in Bengkulu, Indonesia in December 2017 as part of the observation of the Years of the Maritime Continent (YMC). We deployed land-based the ozone sonde-observation to understand the ozone diurnal cycle.

Keywords: Ozone, Gravity wave, Diurnal cycle

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Tropical coastal bidirectional gravity waves robustizing QBO

*Manabu D. Yamanaka[1,2], Shin-Ya Ogino[2]

1. Research Institute for Humanity and Nature / Professor Emeritus of Kobe University, 2. Japan Agency for Marine-Earth Science and Technology

The equatorial lower-stratospheric quasi-biennial oscillation (QBO) is explained basically by the wave-mean flow interaction theory, but equi-amplitude east-/west-ward waves suggested from the robust periodicity and meridional-vertical extension have not been clarified. Recent observations have revealed that the coastal diurnal cycle (CDC) is the most dominant mode of cloud-rainfall generation in the equatorial troposphere, in particular along the world's longest coastlines surrounding major islands of the Indonesian maritime continent (IMC) [1]. The CDC (sea-land breeze) circulation is a sum of internal gravity waves forced by the sea-land temperature contrast dependent on sea-surface temperature variations and land-surface modifications. Therefore, the CDC gravity waves may be a key candidate to explain the robustness of QBO and its interactions with El Niño, global warming etc.

The CDC cloud (updraft) area migrations observed in the IMC [1] start from mountains in the evening with destination to seas in the morning, or from seas before sunrise to the mountainous destination in the evening. The horizontal phase velocity is 10^2 km/half a day ≒ 10 km/h ≒ 3 m/s on land, and faster off the coast. Individual cloud movements and cloud-bottom convergent winds reach about 20 m/s. Under the linear theory for |latitude| < 30° (|Coriolis factor| < 2π/1 day) the CDC circulation is given by a superposition of internal inertio-gravity waves of which the dispersion relation is a cubic equation for vertical wavenumber squared m^2. At the surface both the up-/down-ward components exist to satisfy zero vertical velocity condition, and large eddy viscosity/diffusivity (m^6 term) balancing the buoyancy (m^0 term) makes the velocity field almost similar to a steady horizontal-convection cell, of which the intensity and horizontal scale (inverse horizontal wavenumber $k^{-1} \approx 10^2$ km) are governed by the land-sea temperature contrast $k\Delta T$. Above this cell, the acceleration (m^2 term) balances the buoyancy, and the radiation condition selects upward propagating waves. $k\Delta T$ is reversed between day/night (with frequency $\omega = 2\pi$ /1 day), and the horizontal phase velocity $c = \omega/k \simeq 10^0$ m/s directs land-/sea-ward, respectively.

The CDC bidirectional (east-/west-ward) gravity-wave generation resembles the bottom condition in the Plumb's QBO analog [3] (Fig. 1). In this case the meridional range of QBO is narrower than the internal region of inertio-gravity waves, and is given by the region (|latitude| < about 10°) where the solar diurnal cycle is stronger than annual, which is close to the meridional range of the IMC. The zonal-wind amplitude of QBO is dependent on migration velocities of individual clouds, somewhat faster than c for CDC. The period of QBO decreases with an increase of the CDC amplitude, i.e., $k\Delta T$, and becomes biperiodic for too strong CDC. The QBO-period becomes longer for a weaker CDC, and decayed if too weak.

The CDCs in the low-latitudes, as well as mountain waves in the mid-latitudes [4], are mechanisms of the rotating earth controlling the atmosphere. Longitudinal locations of Africa (−90°) and South America (+180°) and rapid rotation of the earth homogenize the local solar heating zonally (Fig. 2). If the sea surface around the IMC becomes cooler by El Niño and/or Indian-Ocean dipole mode, CDCs become weaker and the QBO period becomes longer. The CDCs do not generate a "moving frame" mechanism [5] considered for global diurnal cycles (tides) in the Venusian atmosphere. The CDCs appear only on an sea-land coexistent planet such as the earth. The CDCs interact with meridional circulations, water cycles (cold trap), vegetation and human activity (heat island), and hence the QBO also may be affected by them.

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References: [1] Yamanaka et al., 2018: *Prog. Earth Planet. Sci.*, **5**, 21. [2] Rotunno, 1983: *J. Atmos. Sci.*, **40**, 1999. [3] Plumb, 1977: *J. Atmos. Sci.*, **34**, 1847. [4] Tanaka & Yamanaka, 1985: *J. Meteor. Soc. Japan*, **63**, 1047. [5] Schubert & Whitehead, 1969: *Science*, **163**(3862), 71.

Keywords: diurnal-cycle sea-land breeze circulations, internal gravity waves, wave-mean flow interaction, quasi-biennial oscillation

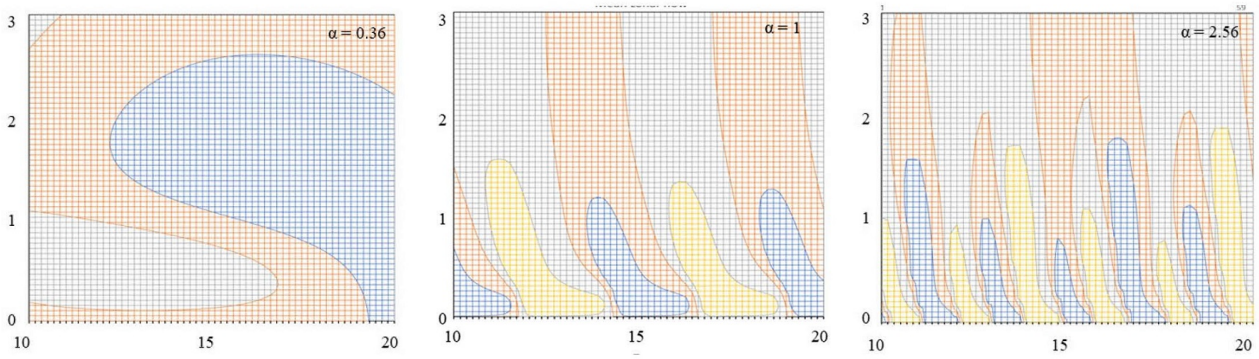


図1 Plumb モデル[3]（横軸・縦軸は適当に無次元化した時間・高度）において CDC 双方向重力波が QBO を生成する場合（中）に対し，CDC の地表温度差振幅が 40%減（運動量束 0.36 倍）の場合（左），および 60%増（2.56 倍）の場合（右）を示す．（図中 α は運動量束の比率で，Plumb 原論文の Newton 冷却率とは異なることに注意）

Fig.1 QBOs generated by the CDC gravity waves in the Plumb's model [3], plotted in the altitude (vertical) - time (horizontal) plane (units are non-dimensionalized). The "control" run (middle), and 40% weaker (left) and 60% larger (right) sea-land temperature gradients (corresponding to 0.36 and 2.56 times of the momentum fluxes for the control run) are shown. (Note that alpha is a momentum flux ratio, different from the Newtonian cooling rate in Plumb's original paper.)

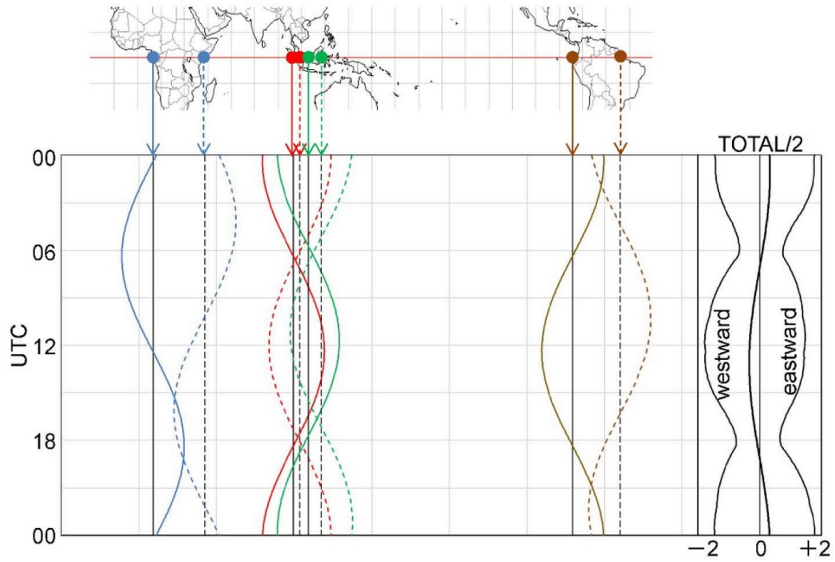


図 2 地球赤道域の海岸線が生成する CDC 重力波の東向き・西向き運動量束の時間（世界時）による変動.

Fig. 2 Variations of east-/westward momentum fluxes of the CDC gravity waves generated near the equatorial coastlines, as functions of time (UTC).

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Study for influence of temperature at TTL on evolution of deep convection and tropical cyclones

Kenta Kobayashi[1], *Nawo Eguchi[1], Tomoe Nasuno[2], Yohei Yamada[2], Kunihiko Kodera[3]

1. Kyushu University, 2. JAMSTEC, 3. Meteorological Research Institute

Previous studies based on satellite observation and general circulation model found the increase of tropical cyclone number/magnitude during a Stratospheric Sudden Warming (SSW) event [e.g., Kodera et al., ACP, 2015; Noguchi et al., GRL, 2020]. One of key factors for enhancement of deep convection and tropical cyclone is the temperature decrease at tropical tropopause layer (TTL). We evaluated the influence of stratospheric dynamical change through temperature change at TTL on the genesis/evolution of deep convection and tropical cyclones by the ensemble simulation from a global nonhydrostatic model, NICAM (Nonhydrostatic ICosahedral Atmospheric Model) [Satoh, et al., 2014] which explicitly calculates moist physics at a cloud-system-resolving resolution. We used the high-top NICAM version, approximately 50km altitude, the vertical layer is 78 number and the vertical resolution around TTL is about 380 m. The analysis period is August - September, 2019 when the tropical cyclone occurred frequently from late August to beginning September and the SSW occurred in Southern Hemisphere.

The ensemble simulation was taken each calculation with 12-hourly shifted from 00UTC 23 to 12UTC 26 August, 2019. The temperature at the tropical lower stratosphere decrease small before 24 August simulation and large after 25 August simulation [Yamada et al., personal communication], the difference is about 1 degree C on tropical average at 100 hPa. We usage the difference of temperature at TTL to analyze the change of deep convection and tropical cyclone. We mainly analyze the simulation between 00UTC 23 and 00UTC 25 Aug. From the analysis of dynamical field (geopotential height), the simulation of 25 Aug could find the amplification of planetary wave at the stratosphere, but not find that in the simulation of 23 Aug. The dynamical activation in the stratosphere enhanced the Brewer-Dobson circulation and the heat flux in 25 Aug simulation was larger than in 23 Aug simulation, in addition the temperature at TTL decrease visibly in the 25 Aug simulation. The convective activity was enhanced around 10N after the onset of SSW and six tropical cyclones occurred in the 25 Aug simulation, but two cyclones occurred in the 23 Aug simulation.

Keywords: Stratosphere-Troposphere Interaction, Tropical cyclone

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Stratospheric Influence on the Troposphere During the Remarkably Strong Arctic Circumpolar Vortex Condition in 2019-2020 Winter

*Shunsuke Noguchi[1,2], Kunihiko Kodera[2], Ryo Mizuta[2], Seiji Yukimoto[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Meteorological Research Institute

Tropospheric responses to the remarkably strong stratospheric polar vortex condition in 2019-2020 Arctic winter and spring have been investigated by conducting a series of ensemble forecast experiments. In particular, by conducting ensemble "nudged" integrations, whose stratospheric circulation is relaxed toward a reanalysis, and comparing them with reference ensemble integrations, we deduce a significant effect of the stratosphere on the culmination of the anomalous circulation pattern characterized by a positive phase of the Arctic Oscillation. Various factors that led to the formation of anomalies in the stratosphere and troposphere during this extreme season will also be discussed through comparisons between the experiments and additional experiments.

Keywords: Stratosphere-Troposphere Coupling, Arctic Ozone Depletion, Arctic Oscillation/Northern Annular Mode

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology)
Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.06 (Zoom Room 06)

The dynamical, radiative, and chemical processes involved in the interactions between the stratosphere and troposphere are essential for understanding the present and future climate. Both observed data and high-resolution models have now clearly demonstrated that stratospheric processes can affect various tropospheric phenomena. On the other hand, it has been confirmed that the stratospheric processes are changing significantly with climate change. For example, the polar vortex was exceptionally strong, cold, and persistent in the Northern Hemisphere winter stratosphere in 2019-2020, resulting in record ozone depletion and contributing to unusually warm temperatures in mid-latitudes.

In this session, we will focus on stratospheric phenomena and invite presentations on the latest findings (case studies, long-term variations, predictability, etc.). We welcome studies on the effects of these phenomena on the troposphere and mesosphere. Inheriting the significance of the Stratosphere-troposphere Processes And their Role in Climate (SPARC) sessions held at JpGU, this division aims to enhance the development of this field in close cooperation with the atmospheric chemistry sessions.

10:25 AM - 10:30 AM

[AAS06-06]Discussion

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.06 Zoom Room 06

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Takatoshi Sakazaki(Graduate School of Science, Kyoto University)



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

[AAS06-07] Do sudden stratospheric warmings boost convective activity in the tropics?

★Invited Papers

*Kohei Yoshida[1], Ryo Mizuta[1] (1.Meteorological Research Institute)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AAS06-08] Dynamical Features of Antarctic Sudden Stratospheric Warming in 2019

*Guangyu Liu[1], Toshihiko Hirooka[2], Nawo Eguchi[3], Kirstin Krüger[4] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Research Institute for Applied Mechanics, Kyushu University, 4.Department of Geosciences, University of Oslo)

11:20 AM - 11:40 AM JST | 2:20 AM - 2:40 AM UTC

[AAS06-09] Seasonal predictability of the persisted negative Antarctic oscillations after sudden stratospheric warming in the Southern Hemisphere in 2019

★Invited Papers

*Chiaki Kobayashi[1], Shuhei Maeda[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[AAS06-10] **The stratospheric QBO affects Antarctic sea ice through the tropical convection in early austral winter**

*Koji Yamazaki[1], Tetsu Nakamura[1] (1.Hokkaido University)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[AAS06-11] A study of Kelvin-Helmholtz billow in the Antarctic troposphere and lower stratosphere based on the PANSY radar observation using a frequency domain interferometry technique

*Yuichi Minamihara[1], Kaoru Sato[1], Masaki Tsutsumi[2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.National Institute of Polar Research)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[AAS06-12] Discussion

Do sudden stratospheric warmings boost convective activity in the tropics?

*Kohei Yoshida[1], Ryo Mizuta[1]

1. Meteorological Research Institute

Influence of stratospheric meridional circulation changes related to sudden stratospheric warmings (SSW) on the tropical troposphere have been examined in many previous studies. However, due to small sample size of SSWs and large internal variability in the tropical troposphere, influence of the SSW on the tropical troposphere is still uncertain. We examine impact of the stratospheric circulation changes related to SSW on the tropical troposphere using 5,000-year scale ensemble simulations with a 60 km horizontal resolution global atmospheric model MRI-AGCM3.2. More than 1,000 of SSW-like circulation change events are extracted thanks to the large ensemble simulations. A composite analysis of the SSW-like events shows significant stratospheric upwelling and cooling in the tropics. Synchronized with the upwelling, statistically robust tropospheric signals such as enhanced convective activity including tropical cyclone are found. Although the mean tropospheric signals tend to be small, relative probability of their extreme events significantly increases. Influence of tropospheric waves to tropical troposphere is also discussed.

Keywords: Sudden stratospheric warming, Stratosphere-Troposphere coupling in the tropics, High-resolution large-ensemble simulations

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Dynamical Features of Antarctic Sudden Stratospheric Warming in 2019

*Guangyu Liu[1], Toshihiko Hirooka[2], Nawo Eguchi[3], Kirstin Krüger[4]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3. Research Institute for Applied Mechanics, Kyushu University, 4. Department of Geosciences, University of Oslo

The sudden stratospheric warming (SSW) is a spectacular event first discovered by Scherhag (1952). During the SSW event, a rapid deceleration or reversed westerly polar vortex along with abrupt increasing temperatures by tens of Kelvins occurs in a few days. The theoretical studies of mechanism of the SSW has been noted that enhanced quasi-stationary planetary waves propagate from the troposphere bring about the SSW (Matsuno 1971; Andrew et al., 1987). The SSW events are commonly observed in Northern Hemisphere (NH) but rarely occur in the Southern Hemisphere (SH) due to its geographical condition, topography and land-sea temperature contrast.

The present study analyzed the unusual SSW event in September 2019 (hereafter SSW2019) in the SH with comparing to the only major SSW occurred in 2002 (hereafter SSW2002) by using the Japanese 55-year Reanalysis (JRA-55) data. The reversal temperature gradient between the south pole and 60S, decelerated westerly winds in 60S and 10 hPa were observed. It is found that the quasi-stationary wave driving with zonal wavenumber 1 play an important role in the occurrence of SSW2019, which brought a large disturbance on the polar vortex and decelerate the polar nigh jet. However, because the reversal of westerly winds to easterly winds have not been observed at 60S, 10 hPa, the SSW2019 was classified as a minor warming event.

Keywords: sudden stratospheric warming

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Seasonal predictability of the persisted negative Antarctic oscillations after sudden stratospheric warming in the Southern Hemisphere in 2019

*Chiaki Kobayashi[1], Shuhei Maeda[2]

1. Meteorological Research Institute, 2. Japan Meteorological Agency

In the early September 2019, a sudden stratospheric warming (SSW) occurred in the southern hemisphere for the first time in 17 years. The impact extended downward to the Earth’ s surface, and the negative-phase of the Antarctic Oscillation (AAO) in the troposphere persisted from mid-October to the end of December. In this study, we investigate the relationship between the persistence of the negative AAO and SSW, and show that wave activity anomalies was formed in which the negative AAO is easily maintained. We also examine the seasonal predictability of the negative AAO using a seasonal prediction system of the Japan Meteorological Agency. It is shown that the persistence of the negative AAO is predictable, but that SST anomalies in the tropical Indian Ocean have little effect on this predictability.

The data used for the analysis of the circulation field is the JMA long-term reanalysis data JRA-55 (Kobayashi et al., 2015). The forecast data are the results of an ensemble 6-month forecast experiment with initial values of September 13 and 28, 2019, by an in-service seasonal forecast model (the coupled global atmosphere-ocean model CPS2, Takaya et al., 2018). The mass-weighted average method (MIM, Iwasaki 1989, 1992) on the isothermal surface is applied to these data to analyze the wave activity anomalies.

The evolution of the strength of the polar vortex from the stratosphere to the troposphere associated with SSW in the SH shows that the weakness of the polar vortex persisted in the upper stratosphere after the SSW, and the center of the anomaly descended to the lower stratosphere to the troposphere after mid-October. This was well predicted by the seasonal prediction experiment.

The zonal mean field during the period of persisted negative AAO is confirmed in terms of wave-mean flow interaction. The stratospheric polar night jet seen in the climatology is absent in the 3-month averaged zonal mean zonal winds from October to December 2019.

Corresponding to the zonal mean zonal winds, there is no waveguide along the climatological polar night jet, making it more difficult for planetary waves from the troposphere to propagate vertically than normal. In terms of wave activity, there was a strong convergence of E-P flux from 50S to 70 S in the middle and upper troposphere. As diagnosed by the spatial structure of the convergence-divergence anomalies of E-P fluxes, the direct meridional circulation in the extratropics in the troposphere showed enhanced anomalies, which suggest intensification anomalies of the cold air outflow to the mid-latitudes in the lower troposphere. This meridional circulation anomaly was also predicted in the seasonal prediction experiment.

From October to December 2019, SST anomalies in the tropical Indian Ocean were distributed high in the west and low in the east, and high temperature anomalies were also observed across the tropical Indian Ocean. In order to confirm the effect of the tropical SST on the negative phase of AAO, a sensitivity experiment was conducted by nudging the Indian Ocean tropical SST to the climatological SST.

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Similar to the seasonal prediction experiment in the previous section, the results of this sensitivity experiment predicted downward propagation of the weakness of the polar vortex and the persistence of the negative phase AAO in the troposphere after mid-October. The anomalies in the zonal-mean wave activity, EP flux, also show similar characteristics to those of the seasonal prediction experiment. This indicates that the persistent negative AAO can be predict even without the Indian Ocean tropical SST anomalies.

The results of the experiment suggest that SST anomalies in the tropical Indian Ocean has little effect on the persistence of the negative phase of the AAO. As future work, we would like to analyze what contributed to the persistence of the negative phase of the AAO and what was the source of the seasonal predictability. It is also interesting to note that the seasonal prediction experiment was able to predict the timing of the onset of negative AAO. Investigating the reasons for the predictions and improving our understanding of stratosphere-troposphere coupling are future tasks.

Keywords: sudden stratospheric warming, Antarctic Oscillation, Seasonal predictability

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The stratospheric QBO affects Antarctic sea ice through the tropical convection in early austral winter

*Koji Yamazaki[1], Tetsu Nakamura[1]

1. Hokkaido University

We found a statistically significant relationship between the stratospheric quasi-biennial oscillation (QBO) and Antarctic sea ice concentration (SIC) in austral winter. SIC differences between the easterly phase of the QBO (EQBO) and westerly phase of the QBO (WQBO) show positive anomalies of SIC in the following regions: over the Ross Sea, Weddell Sea, and around 90˚E. This wave-3 pattern is clearly seen in June and July, and decays in August. The increased SIC regions correspond to anomalous offshore wind regions, and the reduced SIC regions correspond to onshore wind regions, indicating the atmospheric circulation anomaly produced the SIC anomaly. The atmospheric circulation anomaly is barotropic and closely related with the upper atmospheric flow. The upper circulation anomaly shows a stationary Rossby wave train propagating from Indian Ocean. We show the enhanced convection in the tropical Indian Ocean in EQBO can excite the Rossby wave train. In summary, the stratospheric QBO affects the tropical convection, then generating the Rossby wave train which propagates into southern high latitude, and finally affecting Antarctic sea ice. There exists a possibility to predict winter sea ice in one-year advance, because the QBO is a quasi-regular oscillation.

Keywords: Antarctic sea ice, stratospheric quasi-biennial oscillation, Rossby wave propagation, tropical convection, Indian Ocean

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A study of Kelvin-Helmholtz billow in the Antarctic troposphere and lower stratosphere based on the PANSY radar observation using a frequency domain interferometry technique

*Yuichi Minamihara[1], Kaoru Sato[1], Masaki Tsutsumi[2]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. National Institute of Polar Research

Atmospheric turbulence plays a potentially important role in the mixing and irreversible transport of heat, momentum, and minor constituents. Due to its small spatial and temporal scales, it is difficult to observe its structure directly and the entire time evolution from the onset to the disappearance. Thus, the role of turbulence is not well understood qualitatively. Kelvin-Helmholtz instabilities (KHIs) resulting from enhanced vertical shear in the atmosphere are among the significant sources of atmospheric turbulence; when KHI occurs, it generates Kelvin-Helmholtz waves (KH waves), which mix heat and materials up and down. Fukao et al. (2011) reported that small-scale phenomena with a duration as long as 30 minutes and depth smaller than 2.5 km like KH waves are often observed based on the MU radar observation (34.8°N, 136.1°E). The purpose of this study is to elucidate the dynamical structure and formation mechanism of KH waves in the Antarctic troposphere and lower stratosphere using the PANSY radar at Syowa Station (69.0°S, 39.6°E). We used the frequency-domain interferometry (FDI) technique with the high-resolution in both time and space.

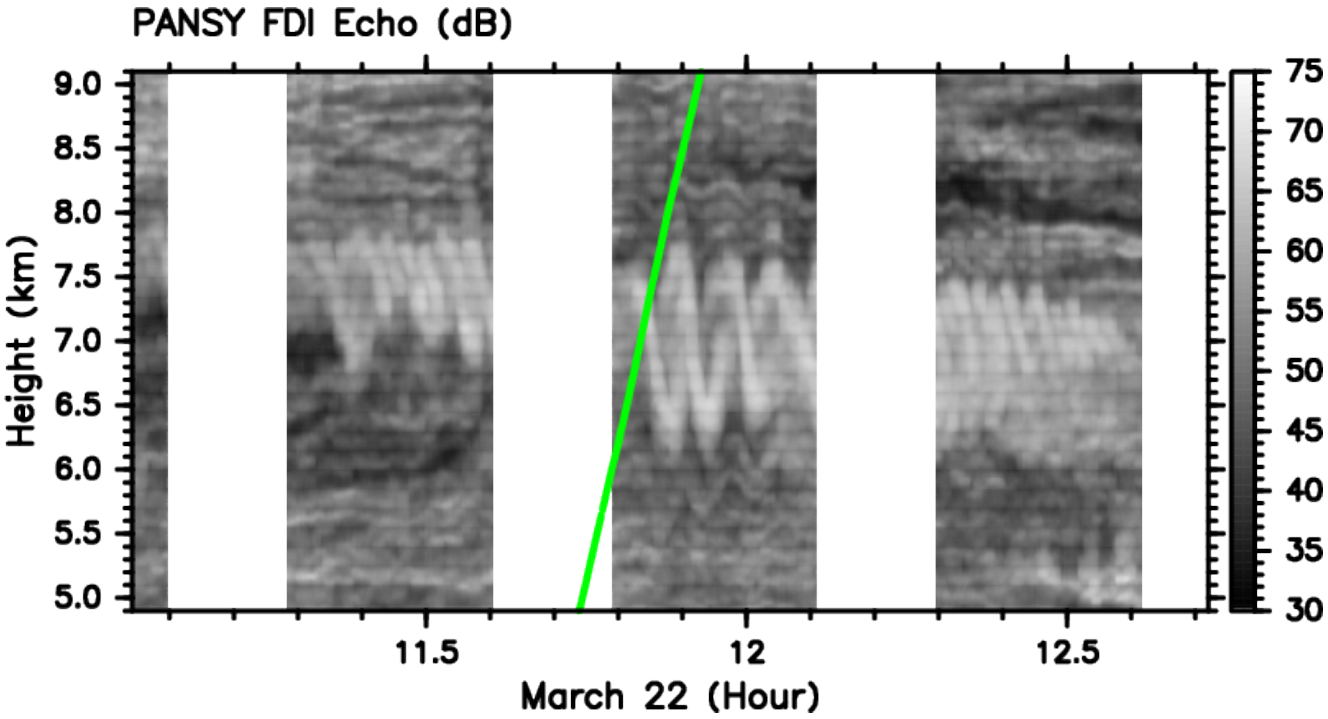
The PANSY radar observation is usually performed with standard observation mode at a fixed central frequency providing line-of-sight wind velocities for five directions at temporal and vertical resolutions of 200 seconds and 150 m, respectively. On the other hand, the FDI observation mode uses five different frequencies of transmitted waves and provides echo power with a resolution higher than the transmitted pulse width. Note that for MST radar such as the MU radar and the PANSY radar, it is considered that the echo mainly comes from Bragg scattering by isotropic atmospheric turbulence. The FDI observation campaign by the PANSY radar performed from March 14-24 and August 2-12, 2019 (20 days in total) for the troposphere and lower stratosphere. The FDI mode observations (~22 min) and the standard mode observations (~ 7 min) were repeated. Radiosonde observations were also made every 4 hours. The FDI mode observations provide fine vertical profiles of vertical winds in addition to the echo power, while the standard observation mode provides vertical profiles of the three-dimensional winds, including vertical wind. Vertical profiles of horizontal winds, temperature, and humidity were also obtained from the radiosonde observations.

During the campaign, 73 structures that appear to be KH waves were captured. In this presentation, we focus on the KH waves detected at 1100UT-1730UT on 21 March around the height of 9.0 km (A) and 1100UT-1300UT on 22 March around the height of 7.0 km (B). In case (A), a wave-like structure dominant in the horizontal winds having a wave-period shorter than one day was observed in association with the KH waves. A hodograph analysis was conducted and found that this wave-like structure is likely due to an inertia-gravity wave (GW) having a northeast- or southwestward wave vector and upward group velocity. The slow ground-based phase velocity of about 2.3 m s-1 suggests that this inertia-gravity wave is an orographic one. These dynamical properties are consistent with the generation in the northeasterly wind of about 20 m s-1 near the surface during this period. In case (B), a strong vertical shear of meridional winds localized around the height of 7.0 km was observed. This structure corresponds to the strong wind

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region in the upper troposphere associated with a developed low-pressure system approaching Syowa Station. We will also discuss how this low-pressure system was developed and accompanied such a strong wind region in the upper troposphere, based on the numerical simulations using the Nonhydrostatic ICosahedral Atmospheric Model (NICAM).

Keywords: Kelvin-Helmholtz billows, polar meteorology, middle atmosphere



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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Takatoshi Sakazaki(Graduate School of Science, Kyoto University)
Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.06 (Zoom Room 06)
The dynamical, radiative, and chemical processes involved in the interactions between the stratosphere and troposphere are essential for understanding the present and future climate. Both observed data and high-resolution models have now clearly demonstrated that stratospheric processes can affect various tropospheric phenomena. On the other hand, it has been confirmed that the stratospheric processes are changing significantly with climate change. For example, the polar vortex was exceptionally strong, cold, and persistent in the Northern Hemisphere winter stratosphere in 2019-2020, resulting in record ozone depletion and contributing to unusually warm temperatures in mid-latitudes.
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12:10 PM - 12:15 PM

[AAS06-12]Discussion

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.06 Zoom Room 06

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo)



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

[AAS06-13] LODEWAVE (LOng-Duration balloon Experiment of gravity WAVE over Antarctica)

*Yoshihiro Tomikawa[1,2], Kaoru Sato[3], Yoshitaka Saito[4], Isao Murata[5], Naohiko Hirasawa[1,2], Masashi Kohma[3], Kyoichi Nakashino[6], Daisuke Akita[7], Takuma Matsuo[8], Masatomo Fujiwara[9], Lihito Yoshida[2] (1.National Institute of Polar Research, 2.School of Multidisciplinary Sciences, The Graduate University for Advanced Studies, SOKENDAI, 3.Graduate School of Science, The University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 5.Graduate school of Environmental Studies, Tohoku University, 6.School of Engineering, Tokai University, 7.School of Environment and Society, Tokyo Institute of Technology, 8.School of Science and Technology, Meiji University, 9.Faculty of Environmental Earth Science, Hokkaido University)

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

[AAS06-14] Sporadic, large gravity wave events over Syowa Station in summer -Comparison between the PANSY radar and the ERA5 reanalysis-

*Lihito Yoshida[1], Yoshihiro Tomikawa[2,1], Mitsumu K. Ejiri[2,1], Masashi Kohma[3], Kaoru Sato[3] (1.Department of Polar Science, School of Multidisciplinary Sciences, The Graduate University for Advanced Studies, 2.National Institute of Polar Research, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:15 PM - 2:35 PM JST | 5:15 AM - 5:35 AM UTC

[AAS06-15] Detection of a climatological short break in the polar night jet in early winter and its relation to cooling over Siberia

★Invited Papers

*Yuta Ando[1,2], Koji Yamazaki[3], Yoshihiro Tachibana[2], Masayo Ogi[3], Jinro Ukita[1] (1.Faculty of Science, Niigata University, 2.Weather and Climate Dynamics Division, Mie Univesity, 3.Hokkaido University)

2:35 PM - 2:55 PM JST | 5:35 AM - 5:55 AM UTC

[AAS06-16] Characteristics of planetary-wave packet propagation during a major sudden stratospheric warming event in January 2021

★Invited Papers

*Yayoi Harada[1], Takenari Kinoshita[2], Kaoru Sato[3], Toshihiko Hirooka[4] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) , 3.Department of Earth and Planetary Sciences, University of Tokyo, 4.Department of Earth and Planetary Sciences, Kyushu University)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[AAS06-17] A Statistical Analysis of Downward Propagation of Planetary Wave Packets in the Stratosphere Using Large Ensemble Data

*Matsuyama Yuya[1], Toshihiko Hirooka[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)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

[AAS06-18] Discussion

LODEWAVE (LOng-Duration balloon Experiment of gravity WAVE over Antarctica)

*Yoshihiro Tomikawa[1,2], Kaoru Sato[3], Yoshitaka Saito[4], Isao Murata[5], Naohiko Hirasawa[1,2], Masashi Kohma[3], Kyoichi Nakashino[6], Daisuke Akita[7], Takuma Matsuo[8], Masatomo Fujiwara[9], Lihito Yoshida[2]

1. National Institute of Polar Research, 2. School of Multidisciplinary Sciences, The Graduate University for Advanced Studies, SOKENDAI, 3. Graduate School of Science, The University of Tokyo, 4. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 5. Graduate school of Environmental Studies, Tohoku University, 6. School of Engineering, Tokai University, 7. School of Environment and Society, Tokyo Institute of Technology, 8. School of Science and Technology, Meiji University, 9. Faculty of Environmental Earth Science, Hokkaido University

Atmospheric gravity waves transport momentum in the atmosphere and play an important role in determining temperature and material distribution through driving the meridional circulation in the middle atmosphere. However, they have wide spatial and temporal scales, which make it difficult to capture the whole feature of gravity waves with any of the latest observations and models. The first Mesosphere-Stratosphere-Troposphere (MST)/ Incoherent Scatter (IS) radar in the Antarctic, PANSY, which was installed at Syowa Station in 2011, can directly estimate the momentum flux of gravity waves in all frequency bands by observing 3-dimensional winds with high precision and high resolution. On the other hand, the super pressure (SP) balloon observation can also estimate momentum transport due to gravity waves in all frequency bands, and its horizontal distribution is also clarified. In order to carry out this SP balloon observation in the Antarctic where the observational constraint on the momentum transport due to gravity waves is especially insufficient, we proposed the LOng-Duration balloon Experiment of gravity WAVE over Antarctica (LODEWAVE). By combining it with the PANSY observation and the state-of-the-art meteorological reanalysis data, the 3-dimensional picture of momentum transport due to gravity waves is acquired, which contributes to the improvement of the future prediction by the climate model.

We have performed a test production of SP balloon and onboard instruments during FY 2019. The further development and test of the SP balloon and onboard instruments was carried out in FY 2020. In the latter half of FY 2021, a maximum of 3 SP balloon observations will be carried out at Syowa Station in the Antarctic. By developing the SP balloon and onboard instruments which are light and small enough to ease the restrictions of the Civil Aeronautics Act, we aim to establish a regular observation system in the Antarctic.

Keywords: Gravity wave, Super pressure balloon, Antarctic, PANSY radar

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Sporadic, large gravity wave events over Syowa Station in summer -Comparison between the PANSY radar and the ERA5 reanalysis-

*Lihito Yoshida[1], Yoshihiro Tomikawa[2,1], Mitsumu K. Ejiri[2,1], Masashi Kohma[3], Kaoru Sato[3]

1. Department of Polar Science, School of Multidisciplinary Sciences, The Graduate University for Advanced Studies, 2. National Institute of Polar Research, 3. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Gravity waves (GWs) are atmospheric waves whose restoring force is buoyancy. They are generated by mountains, jet streams, etc, and can change a global wind distribution through momentum transport and deposit. They do not only decelerate the mesospheric jet stream, but also affect the horizontal wind in the lower stratosphere, and the global meridional circulation. However, GW observations are not enough to verify their behaviour in the Antarctic, due to the harsh environment. In addition, GWs have a wide range of horizontal wavelength (i.e., from several km to several thousand km) and period (i.e., from Brunt-Väisälä period (approximately 5 minutes) to inertial period (over 12 hours)), which makes it difficult to reproduce GWs in the entire frequency range even in the state-of-the-art atmospheric models in spite of the recent increase of their resolution. In order to implement the effect of subgrid-scale phenomena into the models, which are not explicitly represented, a GW parameterization is introduced. In general, nonorographic GW parameterization assumes nearly constant wave sources and instantaneous upward propagation, but in reality the wave sources are not constant and GWs propagate horizontally as well (Plougonven et al., 2020). Thus it is required to constrain the GW effect in the models based on observations which cover the whole frequency range of GWs and estimate the GW momentum transport in the Antarctic.

Intermittency, a measure of how transient or intermittent a GW event is, has recently received much attention. Even if the total amount of momentum flux is the same, continuous, small amplitude events deposit momentum to higher altitudes, while sporadic, large amplitude events deposit momentum to lower altitudes. As a result, the structure and strength of the driven meridional circulation depend on the GW intermittency (Hertzog et al., 2008). In Antarctica, intermitency has been studied using super pressure balloons (Hertzog et al., 2012) and the Program of the Antarctic Syowa MST/IS radar (PANSY radar) at Syowa Station (Minamihara et al., 2020), suggesting differences in the characteristics of intermittency due to different wave generation mechanisms.

Our purpose of this study is to investigate the characteristics of GWs for sporadic, large amplitude events that have a large impact on the overall momentum transport, and also to investigate how well the reanalysis data reproduces the GWs events in the Antarctic. We used the PANSY radar, for the observation data and the ERA5 reanalysis for the reanalysis data. The PANSY radar, which was installed at Syowa Station (69˚S,40˚E) in 2011, can observe three dimensional winds in the troposphere and lower stratosphere with high accuracy and high temporal and vertical resolution. It is the only instrument in the Antarctic that enables us to capture GWs in the almost entire frequency range (Sato et. al., 2014). The ERA5 reanalysis is the latest meteorological reanalysis dataset provided by the European Centre for Medium-Range Weather Forecasts. The ERA5 data is distributed at 137 vertical levels from the surface to 0.01 hPa with a horizontal spacing of 0.25 degree every 1 hour.

We use three dimensional winds of the PANSY radar and the ERA5 reanalysis during the time period of January to March 2016. We focus on inertia GWs in austral summer period because they can be extracted from both the PANSY and ERA5 data (i.e., even one hour resolution of ERA5) and their attribution to wave

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sources are more straightforward (i.e., there are few downward group velocity waves in summer according to the past studies using the PANSY radar (Minamihara et. al., 2018)). The inertia GWs are extracted by applying a bandpass filter with a cutoff period of 4-24 h and a cutoff vertical wavelength of 1.5-8 km. As a result, we found similar wave-like structure in the PANSY radar and the ERA5 analysis.

In order to examine the propagation characteristics of inertia GWs, we use a hodograph analysis. It utilizes the feature that the hodograph (i.e., the altitude change of the horizontal wind vector drawn in the zonal and meridional wind space) becomes an ellipse, in which the amplitude, intrinsic period, vertical wavelength, phase velocity, and group velocity of GWs can be estimated. Although the hodograph analysis generally has an ambiguity of propagation direction by 180˚, we exclude it by estimating the ground-based period directly using the data both in time and altitude.

The estimated momentum flux of each GW event is larger than the most-frequently observed GWs by the PANSY radar (Minamihara et al., 2020). We will discuss the wave sources through the ray tracing analysis of the observed GWs.

Keywords: gravity wave, reanalysis, Antarctic

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Detection of a climatological short break in the polar night jet in early winter and its relation to cooling over Siberia

*Yuta Ando[1,2], Koji Yamazaki[3], Yoshihiro Tachibana[2], Masayo Ogi[3], Jinro Ukita[1]

1. Faculty of Science, Niigata University, 2. Weather and Climate Dynamics Division, Mie Univesity, 3. Hokkaido University

The polar night jet (PNJ) is a strong stratospheric westerly circumpolar wind at around 65N in winter, and the strength of the climatological PNJ is widely recognized to increase from October through late December. Remarkably, the climatological PNJ temporarily stops increasing during late November. We examined this “short break” in terms of the atmospheric dynamical balance and the climatological seasonal march. We found that it results from an increase in the upward propagation of climatological planetary waves from the troposphere to the stratosphere in late November, which coincides with a maximum of the climatological Eliassen–Palm (EP) flux convergence in the lower stratosphere. The upward propagation of planetary waves at 100 hPa, which is strongest over Siberia, is related to the climatological strengthening of the tropospheric trough over Siberia. We suggest that longitudinally asymmetric forcing by land–sea heating contrasts caused by their different heat capacities can account for the strengthening of the trough.

The part of this presentation was published as the article, Ando et al. (2018).

Ando, Y., K. Yamazaki, Y. Tachibana, M. Ogi, and J. Ukita, 2018: Detection of a climatological short break in the polar night jet in early winter and its relation to cooling over Siberia. Atmospheric Chemistry and Physics, 18, 12639-12661, doi:10.5194/acp-18-12639-2018.

Keywords: Stratosphere, Rossby wave, Land-sea thermal contrast

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Characteristics of planetary-wave packet propagation during a major sudden stratospheric warming event in January 2021

*Yayoi Harada[1], Takenari Kinoshita[2], Kaoru Sato[3], Toshihiko Hirooka[4]

1. Meteorological Research Institute, Japan Meteorological Agency, 2. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) , 3. Department of Earth and Planetary Sciences, University of Tokyo, 4. Department of Earth and Planetary Sciences, Kyushu University

Observational features of atmospheric fields during a major sudden stratospheric warming (MSSW) event that occurred in January 2021 (MSSW21) are analyzed using the Japanese 55-year Reanalysis, and a three-dimensional wave activity flux (3D-flux-W, Kinoshita and Sato 2013; Sato et al. 2013; Harada et al. 2019). MSSW21 is characterized by strong easterlies over 70 m s^{-1} around the stratopause observed in early January 2021 and a mixed signature of wavenumber 1 (WN1), WN2 and WN3 planetary waves, although WN1 has been predominant during MSSW21 except its early stage (from late December 2020 to early January 2021). In the early stage, the polar vortex was displaced from the North Pole and simultaneously broken up into two centers. After a couple of days, they were merged into one but again broken around mid-January. After that the two centers were again merged and the polar vortex begun to travel eastward around the North Pole. Thus, the synoptic feature of the polar vortex was very variable. Resultantly, MSSW21 lasted until mid-February and several warming peaks were observed during the course of its time evolution.

Further analyses revealed that wave packets repeatedly propagated upward in the Eastern Hemisphere during MSSW21. During the early stage, localized wave packets propagated upward into the upper stratosphere over western Siberia. During the mature stage (mid-January 2021), upward wave-packet propagation was observed over eastern Siberia and even in the easterly region of the upper stratosphere.

Keywords: Sudden stratospheric warming, Planetary-wave packet propagation, Three-dimensional wave activity flux

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A Statistical Analysis of Downward Propagation of Planetary Wave Packets in the Stratosphere Using Large Ensemble Data

*Matsuyama Yuya[1], Toshihiko Hirooka[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

Our former analyses (Matsuyama and Hirooka, JpGU Meeting 2019) investigated downward propagation of planetary wave packets from the stratosphere to the troposphere during winter in the Northern Hemisphere and its influence on the tropospheric circulation by the use of JRA-55 reanalysis data over the past 60 years. In the study, we partitioned the longitudinal circle into eight sectors of 45 degrees longitude and set a criterion value for each sector to the vertical component of Plumb’ s (1985) wave activity flux (WAFz) at 30 hPa, to show the geographical frequency distribution of the extracted downward propagation events and features of the composited geopotential height distribution during the event occurrence. However, the numbers of the events were not enough for statistical analysis in some longitudinal sectors, for example, in the Western Hemisphere. Hence, we make a statistical analysis of the downward propagation using the large ensemble data, d4PDF (Mizuta et al., 2017). We introduce following two methods to extract strong downward propagation events. The first method is the same as in our former analysis. In this case, similar results are obtained to those based on JRA-55. Moreover, enough numbers of the events are extracted for statistical discussions, because of the large member number in d4PDF, i.e., 100 members. In the second method, a criterion is set for each grid point (2.5˚×2.5˚); resultantly, more detailed geographical frequency distribution of the events is successfully obtained. Although the overall feature of the geographical distributions of the events obtained by the two methods is similar each other, significant differences are found in the composited geopotential distribution during the event occurrence.

Keywords: planetary wave packet, downward propagation, wave activity flux

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University), Chairperson:Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.06 (Zoom Room 06)

The dynamical, radiative, and chemical processes involved in the interactions between the stratosphere and troposphere are essential for understanding the present and future climate. Both observed data and high-resolution models have now clearly demonstrated that stratospheric processes can affect various tropospheric phenomena. On the other hand, it has been confirmed that the stratospheric processes are changing significantly with climate change. For example, the polar vortex was exceptionally strong, cold, and persistent in the Northern Hemisphere winter stratosphere in 2019-2020, resulting in record ozone depletion and contributing to unusually warm temperatures in mid-latitudes.

In this session, we will focus on stratospheric phenomena and invite presentations on the latest findings (case studies, long-term variations, predictability, etc.). We welcome studies on the effects of these phenomena on the troposphere and mesosphere. Inheriting the significance of the Stratosphere-troposphere Processes And their Role in Climate (SPARC) sessions held at JpGU, this division aims to enhance the development of this field in close cooperation with the atmospheric chemistry sessions.

3:10 PM - 3:15 PM

[AAS06-18]Discussion

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.02_2

[A-AS06] Stratosphere-troposphere Processes And their Role in Climate

convener:Takenari Kinoshita(Japan Agency for Marine-Earth Science and Technology), Takatoshi Sakazaki(Graduate School of Science, Kyoto University), Masashi Kohma(Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo), Nawo Eguchi(Kyushu University)



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[AAS06-P01] Radiosonde Observations in the 30-40 km Altitude Range Using 3000 g Balloons

*Takenari Kinoshita[1], Shin-Ya Ogino[1], Junko Suzuki[1], Ryuichi Shirooka[1], Takuji Sugidachi[2], Kensaku Shimizu[2], Matthew H Hitchman[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meisei Electric Co. Ltd., 3.University of Wisconsin-Madison)

[AAS06-P02] Influence of a SH SSW in September 2019 on tropical tropospheric circulation and deep convective activity

*Kunihiko Kodera[1], Shunnsuke Noguchi[2], Nawo Eguchi[3], Tomoe Nasuno[2] (1.Meteorological Research Institute, 2.JAMSTEC, 3.Kyushu University)

[AAS06-P03] Dynamical analysis of extreme tropopause folding events in the coastal region of Antarctica

Masatoshi Mizukoshi[1], *Masashi Kohma[1], Kaoru Sato[1] (1.Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo)

[AAS06-P04] Response of the Brewer-Dobson circulation to the major volcanic eruptions in reanalysis datasets

*Masatomo Fujiwara[1], Marta Abalos[2], Patrick Martineau[3], Jonathon Wright[4] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Universidad Complutense de Madrid, 3.JAMSTEC, 4.Tsinghua University)

[AAS06-P05] Impact of the upper troposphere and stratosphere on the climate change around Japan

*Yoshio Kawatani[1], Takeshi Horinouchi[2], Naoki Sato[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Faculty of Environmental Earth Science, Hokkaido University, 3.Tokyo Gakugei University)

[AAS06-P06] Analysis of Arctic spring ozone anomaly in the phases of QBO and 11-year solar cycle for 1979–2011

Yousuke Yamashita[1,2], *Hideharu Akiyoshi[1], Masaaki Takahashi[1,3] (1.National Institute for Environmental Studies, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AAS06-P07] Morphology of zonal asymmetry of QBO zonal wind

*Takatoshi Sakazaki[1], Kevin Hamilton[2], Yoshio Kawatani[3] (1.Graduate School of Science, Kyoto University, 2.International Pacific Research Center, University of Hawai'i, 3.Japan Agency for Marine-Earth Science and Technology)

[AAS06-P08] Relationships between Unusual Antarctic Ozone Hole in 2019 and Dynamical Fields

*Guangyu Liu[1], Toshihiko Hirooka[2], Nawo Eguchi[3] (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, 3.Research Institute for Applied Mechanics, Kyushu University)

Radiosonde Observations in the 30-40 km Altitude Range Using 3000 g Balloons

*Takenari Kinoshita[1], Shin-Ya Ogino[1], Junko Suzuki[1], Ryuichi Shirooka[1], Takuji Sugidachi[2], Kensaku Shimizu[2], Matthew H Hitchman[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Meisei Electric Co. Ltd., 3. University of Wisconsin-Madison

Observation of temperature and wind velocity in the 30–40 km altitude layer have been sparse since the elimination of the standard rocketsonde sounding network in 1990s. In an effort to the vertical range of radiosonde observations into the upper stratosphere, experiments were conducted with a 3000 g balloon at Tsukuba, Japan on November 5, 2019. Four radiosondes were launched, with two reaching above 40 km altitude. To confirm the accuracy of the obtained data, especially the temperature data, these profiles were compared with satellite and reanalysis data in the 30–40 km layer. The ability to quantify gravity wave parameters from the obtained data is described, with application to wave events detected near 38–40 km. This system extends the ability to provide information regarding gravity wave and planetary wave activity upward to ~40 km. Finally, we will introduce an enhanced observation campaign using this system.

Keywords: radiosonde, atmospheric waves

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Influence of a SH SSW in September 2019 on tropical tropospheric circulation and deep convective activity

*Kunihiko Kodera[1], Shunnsuke Noguchi[2], Nawo Eguchi[3], Tomoe Nasuno[2]

1. Meteorological Research Institute, 2. JAMSTEC, 3. Kyushu University

A large stratospheric sudden warming (SSW) occurred in early September 2019 in the southern hemisphere (SH). Although stratospheric polar vortex was not broken up as the SSW in September 2002, changes associated with the Brewer-Dobson circulation were large and the tropical lower stratospheric temperature was largely decreased. A possible impact of the 2019 SH SSW on development of the tropical convection along the ascending branch of the Hadley circulation was demonstrated by Noguchi et al. (2020) by means of ensemble mean forecast experiment.

In the present study, we show that enhanced tropical convective activity induced by the SSW lead global development of tropical storms and cyclones in the Eastern and Western Pacific as well as the Atlantic sectors. Changes in the tropical convection also modified a distribution of subtropical high and subtropical jet. Accordingly, trajectory of the cyclone was influenced through change in environmental wind field. For instance, tropical cyclone Lingling, formed on 31 August over Philippine Sea, which has been forecasted to hit southwest of the Korean peninsula around 7 September, finally went slightly westward and landed on North Korea due to development of Bonin subtropical high. This development of Bonin high also produced a very high temperature over Japan in early September 2019, could also be related to an effect of this SH SSW on tropical convection.

Keywords: SSW, Tropical circulation, Convection

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Dynamical analysis of extreme tropopause folding events in the coastal region of Antarctica

Masatoshi Mizukoshi[1], *Masashi Kohma[1], Kaoru Sato[1]

1. Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo

Rapid and deep descent in the tropopause (the so-called tropopause folding; TF) is often observed in the extratropics. Previous studies examined the global distribution of frequency of TF events using reanalysis data [e.g., Škerlak et al., 2015]. They showed that the frequency of deep TF is maximized along the coast of Antarctica. However, the dynamics of TF in the Antarctic region have not yet been studied adequately. In the present study, the extreme TF in the Antarctic are examined using state-of-art reanalysis data to clarify the uniqueness of TF in the Antarctic.

Extreme TF events were defined as time periods during which the deviation of the dynamical tropopause height from 30 days running mean is negatively large. Fluctuations associated with the synoptic-scale eddies are extracted with a high-pass filter with a cut-off period of 10 days. Composite analyses of the extreme TF events at Syowa Station are performed.

When the negative anomaly of tropopause height is maximized, the significant downwelling is observed at the location of the extreme TF. From the analyses using Q-vector in the quasi-geostrophic equation, it is found that the divergence of the Q-vector is observed to the north of Syowa Station. The distribution of Q-vector is explained by the local westerly jet and strengthening of the frontal structure associated with a synoptic low-pressure system extending west-east centered at 70˚S over Antarctica and a high-pressure system.

The synoptic low-pressure system extending east-west centered at 70˚S over Antarctica is discussed based on ray tracing theory under the WKB approximation. The low-pressure system extends northeast-southwest from 24 hours before the lowest tropopause is observed, which means that this system has a southward group velocity. From the ray tracing theory, the meridional wavenumber increases with southward propagation of the wave packet since a strong meridional PV gradient associated with radiative cooling along the coast of Antarctica. Then, the meridional scale of the system becomes small. As a result, the westerly jet and frontal structure are enhanced along the coast of Antarctica. Then, the strong downward flow is located to the south of the entrance of the westerly jet. And thus, it is considered that the frequent occurrence of extreme TF along the coast of Antarctica is mainly due to the enhanced downwelling associated with shrinkage of the synoptic low-pressure system in the meridional direction.

Keywords: Tropopause folding, Antarctic

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Response of the Brewer-Dobson circulation to the major volcanic eruptions in reanalysis datasets

*Masatomo Fujiwara[1], Marta Abalos[2], Patrick Martineau[3], Jonathon Wright[4]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Universidad Complutense de Madrid, 3. JAMSTEC, 4. Tsinghua University

The responses of the Brewer-Dobson circulation (BDC, i.e., the residual mean circulation) to the eruptions of Mt. Agung in March 1963, El Chichón in April 1982, and Mt. Pinatubo in June 1991 are investigated using global atmospheric reanalysis datasets, JRA-55, MERRA-2, and ERA-Interim. Multiple linear regression is applied to the zonal and monthly mean time series of temperature, zonal wind, BDC stream function, Eiassen-Palm flux divergence, and other variables/terms for two periods, 1980–2010 (for the three datasets) and 1958–2001 (for JRA-55 only), by considering explanatory factors of seasonal harmonics, linear trends, Quasi-Biennial Oscillation, solar cycle, and El Niño Southern Oscillation. The residuals are used to define the volcanic signals for the three eruptions separately.

Analysis using JRA-55 data showed the following: (1) in the first DJF season after each eruption, the Northern-Hemisphere BDC cell was weakened after Mt. Pinatubo and Mt. Agung eruptions, but was strengthened after El Chichón eruption; (2) in the second-year JJA, the Southern-Hemisphere BDC cell was weakened after El Chichón and Mt. Agung eruptions, but was strengthened after Mt. Pinatubo eruption. MERRA-2 and ERA-Interim showed qualitatively the same results for Mt. Pinatubo and El Chichó n eruptions as JRA-55. Thus, the BDC response was different for different eruptions and for different seasons. The EPFD response (anomaly) was found to correspond to the BDC (v_bar_star) response (anomaly) for all the cases. Interpretation of these results will be discussed at the meeting.

Keywords: Brewer-Dobson circulation, volcanic eruption

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Impact of the upper troposphere and stratosphere on the climate change around Japan

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1. Japan Agency for Marine-Earth Science and Technology, 2. Faculty of Environmental Earth Science, Hokkaido University, 3. Tokyo Gakugei University

Impact of the upper troposphere and stratosphere on the climate change around Japan was investigated by analyzing CMIP5 model datasets for historical and rcp8.5 scenarios. Based on previous studies (Zappa and Shepherd 2017, Manzini et al. 2014), two remote drivers of climate were selected; tropical warming defined as temperature changes at 250 hPa in 30˚S-30˚N and stratospheric vortex strength defined as zonal mean zonal wind changes at 20 hPa in 70˚-80˚N. These indices were scaled by annual mean 2-m temperature changes associated with global warming. Here, climate response in cold season (November to April) was investigated by subtracting 1959-1990 from 2068-2099 mean data. Models with low tropical amplification and weak polar vortex projected southward shift of the subtropical jet over the east Asia. Higher SLP anomalies elongated from southeast Asia toward Japan, and negative precipitation anomalies extended from southwest to northeast. On the other hand, models with high tropical amplification and strong polar vortex projected northward shift of the subtropical jet. Higher SLP anomalies with an extreme value over the central Pacific were formed and their western parts covered most of Japan regions. Negative precipitation anomalies were seen in the southern part of Japan while positive anomalies were found in the northern part. These results demonstrate that different responses of global warming in the upper troposphere and lower stratosphere could affect climate changes around Japan.

Acknowledgement
This research was performed by the Environment Research and Technology Development Fund (JPMEERF20192004) of the Environmental Restoration and Conservation Agency of Japan.

Keywords: Troposphere-Stratosphere coupling

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Analysis of Arctic spring ozone anomaly in the phases of QBO and 11-year solar cycle for 1979–2011

Yousuke Yamashita[1,2], *Hideharu Akiyoshi[1], Masaaki Takahashi[1,3]

1. National Institute for Environmental Studies, 2. Japan Agency for Marine-Earth Science and Technology, 3. Atmosphere and Ocean Research Institute, The University of Tokyo

This study investigates Arctic spring ozone in relation to the phase of quasi-biennial oscillation (QBO)/the 11-year solar cycle, using satellite observations, reanalysis data, and outputs of a chemistry climate model (CCM) during the period of 1979–2011. For this duration, we found that the composite mean of the Northern Hemisphere high-latitude total ozone in the QBO-westerly (QBO-W)/solar minimum (S_{min}) phase is slightly smaller than those averaged for the QBO-W/S_{max} and QBO-E/S_{max} years in March. An analysis of the passive ozone tracer defined at the pressure levels between 220 hPa and 12 hPa in the CCM simulation indicates that this negative anomaly is primarily caused by transport. The negative anomaly is consistent with a weakening of the residual mean downward motion in the polar lower stratosphere. The contribution of chemical processes estimated using the column amount difference between ozone and the passive ozone tracer is less than 6% of the total anomaly in February and between 10–20% in March. The lower ozone levels in the Arctic spring during the QBO-W/S_{min} years are associated with a stronger Arctic polar vortex from late winter to early spring, which is linked to the reduced occurrence of sudden stratospheric warming in the winter during the QBO-W/S_{min} years.

Keywords: Arctic, ozone, QBO, 11-year solar cycle, CCM, sudden stratospheric warming

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Morphology of zonal asymmetry of QBO zonal wind

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1. Graduate School of Science, Kyoto University, 2. International Pacific Research Center, University of Hawai'i, 3. Japan Agency for Marine-Earth Science and Technology

Although the QBO primarily shows a zonally symmetric nature, a smaller but significant eddy component is sometimes observed. This study demonstrates the basic morphology of zonal asymmetry in QBO zonal wind in the middle stratosphere based on the statistical analysis of the ERA5 dataset from 1958 to 2019. As pointed out by previous studies, the zonal eddy component is found to be statistically large in the westerly phase of QBO during boreal/austral winter seasons, since the tropical westerly allows a lateral, equatorward propagation of stationary planetary waves from the winter Hemisphere. Moreover, it is found that the QBO eddy component shows a strong inter-annual to decadal variability; the underlying processes (and possibly the uncertainty in QBO wind in reanalyses) will be discussed in the poster.

Keywords: Stratosphere, Quasi-biennial oscillation, Zonal asymmetry

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Relationships between Unusual Antarctic Ozone Hole in 2019 and Dynamical Fields

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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, 3. Research Institute for Applied Mechanics, Kyushu University

Extreme ozone depletion occurs during early austral spring in the lower strarosphere over Antarctica, i.e., the Antarctic ozone hole, showing large interannual changes in its area as well as its ozone depletion amount. In 2019 a minor Antarctic sudden stratospheric warming (SSW) was observed in September and a smaller ozone hole was developed over Antarctica. Before this year, a small Antarctic ozone hole was also formed in 2017, even though there occurred no pronounced sudden stratospheric warmings. Hence, in this study, we use the Aura Microwave Limb Sounder (MLS) observations and the Japanese 55-year Reanalysis (JRA-55) data to try to find plausible mechanisms to bring about such small ozone holes in the two years. Resultantly, our ozone volume mixing ratio analyses show that positive volume mixing ratio anomalies from the climatological seasonal march appeared in the polar lower and middle stratosphere throughout the spring in both two years, which corresponds to the insufficient ozone hole development. We examined dynamical analyses based on Eliassen-Palm (E-P) flux and the residual mean meridional circulation and found that the wave activity of zonal wavenumber 1 was extremely strong in 2019 to cause the minor SSW while that of zonal wavenumbers 1 and 2 became strong intermittently in 2017; thus, the enhanced wave activity induced downward advection of ozone-rich air to bring about the small ozone holes.

Keywords: Antarctic Ozone Hole

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.09 Zoom Room 09

[A-OS09] Climate variability and predictability on subseasonal to multidecadal timescales

convener:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Chairperson:Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology)

Climate variability on subseasonal-multidecadal timescales (e.g. Madden-Julian Oscillation, ENSO, Indian Ocean Dipole, Pacific Decadal Variability, Atlantic Multidecadal Variability) has serious impacts on global and regional socioeconomic activities through changes in intensity and frequency of extreme weather events (e.g. cold/heat waves, tropical storms, and floods/droughts). Efforts have been made to understand and predict subseasonal-multidecadal climate variability, but climate simulations and predictions using state-of-the-art coupled general circulation models have biases that represent large uncertainties in amplitude and spatial patterns of the climate variability. The model uncertainties arise from multiple factors such as inadequate understanding of weather and climate interactions across different spatiotemporal scales (e.g. tropical cyclones-ENSO) and insufficient representation of the complex and non-linear climate system (e.g. troposphere-stratosphere coupling, atmosphere-ocean-sea ice-land interactions). Recently, Coupled Model Intercomparison Project Phase 6 (CMIP6) has opened up new model simulation datasets to the public, which can be expected to further advance our understanding and prediction of subseasonal-multidecadal climate variability under the changing climate. This session invites all research related to the subseasonal-multidecadal climate variability using observational, theoretical, modelling and AI/ML frameworks and especially novel approaches.

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

[AOS09-01] Beyond day 2: Variable-resolution convective-scale prediction on medium-range, subseasonal, and longer timescales.

★Invited Papers

*Lucas Harris[1] (1.NOAA/Geophysical Fluid Dynamics Laboratory)

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

[AOS09-02] Background Factors for the Interannual Variations of the Realization of the Madden–Julian Oscillation

*Daisuke Takasuka[1], Tsubasa Kohyama[1], Tamaki Suematsu[2], Hiroaki Miura[3] (1.Department of Information Sciences, Ochanomizu University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Department of Earth and Planetary Science, The University of Tokyo)

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

[AOS09-03] Warming of the Indian Ocean weakens the Atlantic Niño - El Niño Southern Oscillation connection

*Shreya Dhame[1], Andrea Taschetto[1], Agus Santoso[1,2], Giovanni Liguori[3], Katrin Meissner[1] (1.ARC Centre of Excellence for Climate Extremes, Climate Change Research Centre, University of New South Wales, Sydney, Australia, 2.Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Australia, 3.ARC Centre of Excellence for Climate Extremes, School of Earth, Atmosphere and Environment, Monash University, Melbourne, Australia)

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

[AOS09-04] Decadal Variability of the Pacific Meridional Modes without Equatorial Pacific Influence

*Yu Zhang[1,2], Shiyun Yu[1,2], Dillon J. Amaya[3], Yu Kosaka[4], Sarah M. Larson[5], Xudong Wang[6], Jun-Chao Yang[1,2], Malte F. Stuecker[7], Shang-Ping Xie[8], Arthur J. Miller[8], Xiaopei Lin[1,2] (1.Ocean University of China,

2.Qingdao National Laboratory for Marine Science and Technology, 3.University of Colorado Boulder, 4.The University of Tokyo, 5.North Carolina State University, 6.Nanjing University of Information Science and Technology, 7.University of Hawai'i at Mānoa, 8.University of California San Diego)

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

[AOS09-05] Synchronized Tropical Pacific Decadal Variability and Cold Ocean-Warm Land Pattern Modulate Global Warming Rate

*Jun-Chao Yang[1,2], Xiaopei Lin[1,2], Shang-Ping Xie[3], Yu Zhang[1,2], Yu Kosaka[4], Ziguang Li[1,2] (1.Frontiers Science Center for Deep Ocean Multispheres and Earth System and Physical Oceanography Laboratory, Ocean University of China, 2.Qingdao National Laboratory for Marine Science and Technology, 3.Scripps Institution of Oceanography, University of California, 4.Research Center for Advanced Science and Technology, University of Tokyo)

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

[AOS09-06] A consecutive development of MJO events reproduced by three-month SST-forced experiments with NICAM

★Invited Papers

*Tamaki Suematsu[1], Tomoro Yanase[4,2], Hiroaki Miura[3], Chihiro Kodama[5], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.RIKEN Center for Computational Science, 3.Graduate School of Science, The University of Tokyo , 4.Graduate School of Science, Kyoto University , 5.Japan Agency for Marine-Earth Science and Technology)

Beyond day 2: Variable-resolution convective-scale prediction on medium-range, subseasonal, and longer timescales.

*Lucas Harris[1]

1. NOAA/Geophysical Fluid Dynamics Laboratory

Current medium-range and longer (beyond 48–60 hour) prediction is limited to global models with resolutions too coarse to explicitly represent deep convection, and are limited by the quality of existing deep convective and gravity-wave drag parameterizations. Regional convective-scale models are often found to be inadequate for prediction on these timescales. In this talk I will discuss the prospects for using variable-resolution global-to-regional models for extending convective-scale prediction into these extended lead times. Results from the GFDL SHiELD model, which heavily relies upon the variable-resolution capabilities in the FV3 dynamical core, demonstrates medium-range predictability of severe thunderstorm outbreaks and significantly enhanced predictability of the Madden-Julian Oscillation. I also discuss the role of explicit deep convection in these predictions and challenges that arise in the absence of a deep convective parameterization. I also discuss how these models fit into a seamless modeling suite with traditional-resolution weather and climate models, and how variable-resolution models can be a “stepping stone” to global cloud-resolving models.

Keywords: Subseasonal-to-seasonal, Variable-resolution Modeling, Cloud-resolving model, Severe Weather, Madden-Julian Oscillation

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Background Factors for the Interannual Variations of the Realization of the Madden–Julian Oscillation

*Daisuke Takasuka[1], Tsubasa Kohyama[1], Tamaki Suematsu[2], Hiroaki Miura[3]

1. Department of Information Sciences, Ochanomizu University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Department of Earth and Planetary Science, The University of Tokyo

The Madden–Julian oscillation (MJO) is an eastward-propagating large-scale convective system coupled with zonal overturning circulations on the planetary scale in the tropics. In canonical views, MJO convection is realized over the Indo-Pacific warm pool quasi-periodically on the intraseasonal time scale (20–100-day period), which is the most prominent in boreal winters. Meanwhile, it is also known that the year-to-year variability of the longevity of boreal-winter MJOs is clearly noticeable; MJO realization is active in some years and inactive in other years. Since whether the MJO is vigorously realized or not is one of important aspects affecting the activities of other weather and climate phenomena, it is worthwhile to reveal what can determine active and inactive years of MJO realization and utilize the revealed mechanisms for the sub-seasonal prediction.

This study is aimed at understanding the background conditions and mechanisms that control the interannual variations of the activity of MJO realization in boreal winters, using the observation-based data in 1979–2018. The activity of MJO realization in each boreal winter (November to March) from 1980/81 to 2017/18 is measured by days on which MJO events detected by the tracking of the Wheeler-Hendon index are active. Results suggest that, in active years of MJO realization, boreal-winter mean convection tends to be enhanced over the western Pacific (WP) and suppressed over the Maritime Continent, and vice versa in inactive years. This contrast can result from collective (i.e., not separable) effects of the El Niño–Southern Oscillation (ENSO) and quasi-biennial oscillation (QBO); MJO realization is prompted under the moderate El Niño conditions irrespective of QBO phases, and in other ENSO phases, the more enhanced easterly phases of the QBO favor MJO realization. For the latter, which is almost unrelated to the ENSO amplitudes, the zonally inhomogeneous QBO response that the static stability near the tropopause associated with QBO easterlies is more decreased in the WP may support enhanced background convection there.

In comparison of individual MJOs in the MJO active and inactive years, the number of MJOs initiated in the Indian Ocean is indeed much smaller in inactive years, whereas MJO amplitudes are not so different from each other. In addition, MJOs in inactive years tend to fail to propagate into the WP because of the disruption of vertical advective moistening, which is affected by the background suppressed convection in the WP. To sum up, the cooperation of the ENSO and QBO changes background convection and circulations over the warm pool, which in turn largely modulates the frequency of MJO initiation and the duration of MJOs.

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Warming of the Indian Ocean weakens the Atlantic Niño - El Niño Southern Oscillation connection

*Shreya Dhame[1], Andrea Taschetto[1], Agus Santoso[1,2], Giovanni Liguori[3], Katrin Meissner[1]

1. ARC Centre of Excellence for Climate Extremes, Climate Change Research Centre, University of New South Wales, Sydney, Australia, 2. Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Australia, 3. ARC Centre of Excellence for Climate Extremes, School of Earth, Atmosphere and Environment, Monash University, Melbourne, Australia

The tropical Indian Ocean has warmed by 1 degree Celsius since the mid-twentieth century. This warming is likely to continue as the atmospheric carbon dioxide levels keep rising. Here, we discuss how the warming trend could influence the El Niño Southern Oscillation (ENSO) via interaction with the Pacific and the Atlantic Ocean mean state and variability. The warming trend leads to the strengthening of easterlies in the western equatorial Pacific, subsequent downwelling and increase of the mixed later depth in the west, and an increase in the subsurface temperature gradient across the equatorial Pacific. In the eastern equatorial Pacific, the response of upwelling ocean currents to surface wind stress decreases, resulting in a weakening of ENSO amplitude. The Indian Ocean warming influences ENSO via the Atlantic Ocean as well. There, it is associated with the strengthening of equatorial easterly winds, and anomalous warming in the west and upwelling induced cooling in the east, especially in austral winter, during the peak of the Atlantic Niño. Consequently, this results in a decrease of the amplitude of Atlantic Niño events and weakening of the Atlantic Niño-ENSO teleconnection, thereby hindering the transition of El Niño events to La Niña events. Thus, the Indian Ocean warming trend is found to modulate tropical Pacific and Atlantic mean state and variability, with implications for ENSO predictability under a warming climate.

Keywords: Indian Ocean, ENSO , Atlantic Niño, Climate change, Atmosphere-Ocean interactions

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Decadal Variability of the Pacific Meridional Modes without Equatorial Pacific Influence

*Yu Zhang[1,2], Shiyun Yu[1,2], Dillon J. Amaya[3], Yu Kosaka[4], Sarah M. Larson[5], Xudong Wang[6], Jun-Chao Yang[1,2], Malte F. Stuecker[7], Shang-Ping Xie[8], Arthur J. Miller[8], Xiaopei Lin[1,2]

1. Ocean University of China, 2. Qingdao National Laboratory for Marine Science and Technology, 3. University of Colorado Boulder, 4. The University of Tokyo, 5. North Carolina State University, 6. Nanjing University of Information Science and Technology, 7. University of Hawai'i at Mānoa, 8. University of California San Diego

The Pacific meridional mode (PMM) is the ocean-atmosphere coupled variability in the subtropical eastern Pacific. The one in the subtropical northeastern Pacific is referred to as the north PMM (NPMM), and its counterpart in the subtropical southeastern Pacific is called the south PMM (SPMM). Both the NPMM and SPMM strongly interact with the equatorial Pacific variability, thus impacting the predictability of equatorial Pacific climate. The two PMMs vary on a range of timescales, including interannual and decadal timescales, while the latter of which paid little attention in the literature. Here we investigate the decadal variability of the NPMM and SPMM based on a mechanically decoupled experiment. In this experiment, air-sea mechanical coupling is disengaged only in the tropical Pacific by prescribing the climatological wind stress. Without the interactive ocean dynamics, the equatorial Pacific variability is substantially reduced. This experiment thus can be used to study the decadal NPMM and SPMM variability without the equatorial Pacific influence. Our result shows that their variabilities exist in the experiment, suggesting their possible origin from the extratropics. Further investigation on their formation mechanism indicates that the decadal NPMM is not driven by the North Pacific Oscillation, a well-known mechanism for the NPMM formation, but is forced stochastically by a northwest-southeast oriented tripole pattern of sea level pressure variability. We refer to it as the North Pacific tripole (NPT) mode. The decadal SPMM is suggested to be stochastically forced by the South Pacific Oscillation. After the decadal NPMM and SPMM formation, they can also feed back to the atmosphere. These feedback processes are not only confined locally over the subtropical Pacific, but also manifest as atmospheric teleconnections emanating poleward to the Northern and Southern Hemisphere extratropics, respectively. These teleconnections are excited through influencing the Intertropical Convergence Zone and South Pacific Convergence Zone, respectively. Consequently, both decadal NPMM and SPMM have the potential to impact the extratropical climate. Given the model bias such as in simulating their spatial patterns, further study on the atmospheric forcing and response processes associated with the decadal PMM variability is needed based on observations and targeted model experiments.

Keywords: Pacific meridional mode, extratropical origin, atmospheric process

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Synchronized Tropical Pacific Decadal Variability and Cold Ocean-Warm Land Pattern Modulate Global Warming Rate

*Jun-Chao Yang[1,2], Xiaopei Lin[1,2], Shang-Ping Xie[3], Yu Zhang[1,2], Yu Kosaka[4], Ziguang Li[1,2]

1. Frontiers Science Center for Deep Ocean Multispheres and Earth System and Physical Oceanography Laboratory, Ocean University of China, 2. Qingdao National Laboratory for Marine Science and Technology, 3. Scripps Institution of Oceanography, University of California, 4. Research Center for Advanced Science and Technology, University of Tokyo

Internally generated decadal variability modulates global warming rate under anthropogenic radiative forcing. Although the tropical Pacific decadal variability (TPDV) dominates internally generated decadal variability, substantial internal temperature variations in the Northern Hemispheric extratropics are independent of the TPDV, particularly in boreal cold season. These extratropical variations are well tracked by the cold ocean-warm land (COWL) pattern. By analyzing observations and model results, we find that the TPDV and COWL variability vary in phase by chance during the recent three decades as their decadal trends show extremely high correlations. Their synchronized variability strengthens internal modulations on global mean surface temperature, contributing to the early 2000s global warming slowdown and early 2010s acceleration. Because both the TPDV and COWL are strongest in boreal cold season, their synchronized variability also determines the striking seasonality of the recent slowdown and acceleration. Further analyses based on climate model simulations suggest that in a warming future, the co-variability of TPDV and COWL is still important for modulating global warming rate while their respective spatial pattern may change. Although TPDV shows some predictabilities, we highlight that COWL is largely induced by atmospheric internal variability, which limits the predictability of global warming slowdown and acceleration.

Keywords: global mean surface temperature, tropical Pacific decadal variability, cold ocean-warm land pattern, global warming slowdown, global warming acceleration

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A consecutive development of MJO events reproduced by three-month SST-forced experiments with NICAM

*Tamaki Suematsu[1], Tomoro Yanase[4,2], Hiroaki Miura[3], Chihiro Kodama[5], Masaki Satoh[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. RIKEN Center for Computational Science, 3. Graduate School of Science, The University of Tokyo , 4. Graduate School of Science, Kyoto University , 5. Japan Agency for Marine-Earth Science and Technology

Simulation of the Madden-Julian Oscillation (MJO) has been notoriously difficult in atmospheric models. This is partly due to the fact that the reproducibility of the MJO is highly sensitive to parameters that are difficult to fix from observation or theory, and require empirical tuning based on model behaviors. Moreover, model settings fine-tuned for MJO simulations are not necessarily compatible with longer simulations due to biases in the long-term mean.

To address this problem, we first conducted 46-days parameter sweep experiments on a convection-permitting model, NICAM (Nonhydrostatic ICosahedral Atmospheric Model) at 14 km horizontal resolution. Combinations of different microphysics and surface flux parameters were tested with the target of improving the reproducibility of an MJO event in December 2018. We then selected a model setting that best reproduced the MJO (MJO-tuned setting) to conduct longer integrations to test whether MJO can be reproduced by NICAM not only as a solution to an initial value problem but also as one of the modes of internal variability of the atmosphere reproduced by the model.

For this, we employed the MJO-tuned setting and conducted an ensemble of eight 90-day simulations initiated at 6-hour intervals from UTC-00h 1 October 2018. The sea surface temperatures were given from the observations and the simulations do not include air-sea interactions. Analyses of the ensemble indicated that of the three MJO events (MJO1 –3), which were included in the integration period, the first event in November 2018 (MJO1) was well represented in most of the ensemble simulations. Moreover, as an ensemble mean, another MJO event was consecutively reproduced after the MJO1 at a timing close to the MJO2 in observation. The results of the experiments imply that NICAM has the potential to reproduce the MJO as a mode of internal variability of the model reproduced atmosphere when realistic bottom boundary conditions are given.

Keywords: Madden-Julian Oscillation, NICAM , convective-permitting model

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.09 Zoom Room 09

[A-OS09] Climate variability and predictability on subseasonal to multidecadal timescales

convener:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Chairperson:V Ramaswamy(NOAA GFDL), Yushi Morioka(Japan Agency for Marine-Earth Science and Technology)

Climate variability on subseasonal-multidecadal timescales (e.g. Madden-Julian Oscillation, ENSO, Indian Ocean Dipole, Pacific Decadal Variability, Atlantic Multidecadal Variability) has serious impacts on global and regional socioeconomic activities through changes in intensity and frequency of extreme weather events (e.g. cold/heat waves, tropical storms, and floods/droughts). Efforts have been made to understand and predict subseasonal-multidecadal climate variability, but climate simulations and predictions using state-of-the-art coupled general circulation models have biases that represent large uncertainties in amplitude and spatial patterns of the climate variability. The model uncertainties arise from multiple factors such as inadequate understanding of weather and climate interactions across different spatiotemporal scales (e.g. tropical cyclones-ENSO) and insufficient representation of the complex and non-linear climate system (e.g. troposphere-stratosphere coupling, atmosphere-ocean-sea ice-land interactions). Recently, Coupled Model Intercomparison Project Phase 6 (CMIP6) has opened up new model simulation datasets to the public, which can be expected to further advance our understanding and prediction of subseasonal-multidecadal climate variability under the changing climate. This session invites all research related to the subseasonal-multidecadal climate variability using observational, theoretical, modelling and AI/ML frameworks and especially novel approaches.

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

[AOS09-07] GFDL's SPEAR Seasonal Prediction

★Invited Papers

*Feiyu Lu[1,2], Matt Harrison[2], Anthony Rosati[2,3], Tom Delworth[2], Xiaosong Yang[2], William Cooke[2,3], Liwei Jia[3,2], Colleen McHugh[2,4], Nathaniel Johnson[2], Mitchell Bushuk[2,3], Yongfei Zhang[1,2], Alistair Adcroft[1,2] (1.Princeton University, 2.NOAA/GFDL, 3.UCAR, 4.SAIC)

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

[AOS09-08] Summertime sea-ice prediction in the Weddell Sea improved by sea-ice thickness initialization

*Yushi Morioka[1], Doroteaciro Iovino[2], Andrea Cipollone[2], Simona Masina[2], Swadhin Behera[1] (1.JAMSTEC/VAiG/APL, 2.CMCC/ODA)

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

[AOS09-09] Changes and future predictions of Oyashio Intermediate Water: Weakened overturning vs. enhanced tidal mixing

*Vigan Mensah[1], Kay I. Ohshima[1] (1.Institute of Low Temperature Science)

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

[AOS09-10] Interdecadal Variation of Perturbational Feedback Parameter in MIROC6 piControl Simulation

*Kou Tsuchida[1], Takashi Mochizuki[1], Ryuichi Kawamura[1], Tetsuya Kawano[1] (1.Kyushu Univ.)

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

[AOS09-11] A paleoclimatological approach to the multidecadal climate variability

*Takeshi Nakatsuka[1], Tsukasa Mizutani[2] (1.Graduate School of Environmental Studies, Nagoya University, 2.Institute of Industrial Science, The University of Tokyo)

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

[AOS09-12] Towards understanding climate extremes, variability and predictability under changing climate over East Asia

★Invited Papers

*Takashi Mochizuki[1,2], Yu Kosaka[3], Masato Mori[4], Yukiko Imada[5], Tomoki Miyakawa[6] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Research Center for Advanced Science and Technology, The University of Tokyo, 4.Research Institute for Applied Mechanics, Kyushu University, 5.Meteorological Research Institute, 6.Atmosphere and Ocean Research Institute, The University of Tokyo)

GFDL's SPEAR Seasonal Prediction

*Feiyu Lu[1,2], Matt Harrison[2], Anthony Rosati[2,3], Tom Delworth[2], Xiaosong Yang[2], William Cooke[2,3], Liwei Jia[3,2], Colleen McHugh[2,4], Nathaniel Johnson[2], Mitchell Bushuk[2,3], Yongfei Zhang[1,2], Alistair Adcroft[1,2]

1. Princeton University, 2. NOAA/GFDL, 3. UCAR, 4. SAIC

The next-generation seasonal prediction system is built as part of the Seamless System for Prediction and EArth System Research (SPEAR) at the Geophysical Fluid Dynamics Laboratory (GFDL) of NOAA. SPEAR is an effort to develop a seamless system for prediction and research across timescales. The ensemble-based ocean data assimilation (ODA) system is updated for Modular Ocean Model version 6 (MOM6), the ocean component of SPEAR. In this talk, we will describe the updated ODA system and discuss our choice of the coupled model initialization scheme for seasonal predictions. A bias-reduction scheme called Ocean Tendency Adjustment (OTA) is applied to coupled model seasonal predictions to reduce model drift. OTA applies the climatological temperature and salinity increments obtained from ocean data assimilation as 3-dimensional tendency terms to the MOM6 ocean component of the coupled SPEAR models. Based on retrospective seasonal forecasts, we demonstrate that OTA reduces model drift—especially SST forecast drift—in coupled model predictions and improves seasonal prediction skill for applications such as El Niño-Southern Oscillation (ENSO).

Keywords: seasonal prediction, bias correction, SPEAR, data assimilation

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Summertime sea-ice prediction in the Weddell Sea improved by sea-ice thickness initialization

*Yushi Morioka[1], Doroteaciro Iovino[2], Andrea Cipollone[2], Simona Masina[2], Swadhin Behera[1]

1. JAMSTEC/VAiG/APL, 2. CMCC/ODA

Skillful sea-ice prediction in the Antarctic Ocean remains a big challenge due to paucity of sea-ice observations and insufficient representation of sea-ice processes in climate models. Using a coupled general circulation model, this study demonstrates skillful prediction of the summertime sea-ice concentration (SIC) in the Weddell Sea with wintertime SIC and sea-ice thickness (SIT) initializations. During low sea-ice years of the Weddell Sea, negative SIT anomalies initialized in June retain the memory throughout austral winter owing to horizontal advection of the SIT anomalies. The SIT anomalies continue to develop in austral spring owing to more incoming solar radiation and the associated warming of mixed layer, contributing to further sea-ice decrease during late austral summer-early autumn. Concomitantly, the model reasonably reproduces atmospheric circulation anomalies during austral spring in the Amundsen-Bellingshausen Seas besides the Weddell Sea. These results provide evidence that the wintertime SIT initialization benefits skillful summertime sea-ice prediction in the Antarctic Seas.

Keywords: Weddell Sea, Sea Ice, Predictability, Coupled General Circulation Model

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Changes and future predictions of Oyashio Intermediate Water: Weakened overturning vs. enhanced tidal mixing

*Vigan Mensah[1], Kay I. Ohshima[1]

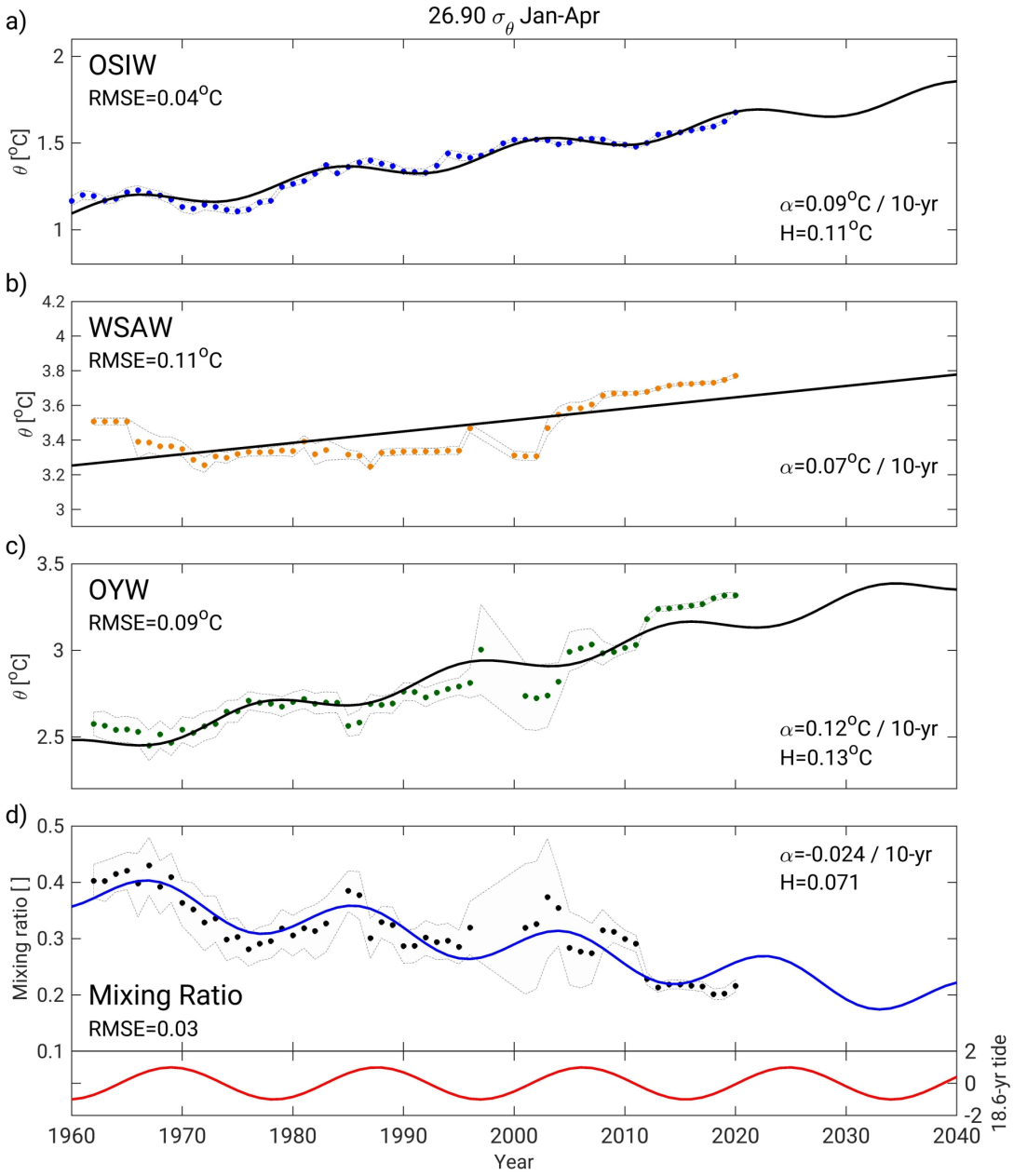
1. Institute of Low Temperature Science

The western subarctic Pacific exhibits major biological productivity and possesses one of the largest biological CO2 drawdown in the world. This biological productivity is fed by the Oyashio Current and its two source waters: Western Subarctic Water, which supplies nutrients from the subarctic Pacific, and cold Okhotsk Sea Intermediate Water (OSIW), which supplies iron from the Sea of Okhotsk. As iron content is a limiting factor for biological productivity, it is essential to understand and predict the variability in OYW properties in a changing climate, and specifically the content of OSIW in OYW (mixing ratio).

Here, we created seasonal climatologies of water properties to understand how the long-term trend (~50 years) and 18.6-year tidal cycle affect the Oyashio Intermediate Water (OYW). We found that the “recipe” of OYW is modified mainly in winter via decreased OSIW outflow over the trend and increased (decreased) outflow in high-tide (low-tide) years. Based on this, we provide a 20-year prediction of OYW temperature and mixing ratio. We predict that the opposite effects of the trend and high tide in the 2020s will lead to stagnation of the OYW properties, followed by accelerated warming in the 2030s (low-tide years). Besides, we found that OYW temperature will increase by 1 ˚C, and the mixing ratio of OSIW in OYW will decrease by 50% between 1960 and 2040, which might greatly impact biological productivity and carbon drawdown in the North Pacific.

Keywords: Oyashio, Climate change, Sea of Okhotsk, Western subarctic Pacific, 18.6 year tidal cycle, Pacific overturning

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Interdecadal Variation of Perturbational Feedback Parameter in MIROC6 piControl Simulation

*Kou Tsuchida[1], Takashi Mochizuki[1], Ryuichi Kawamura[1], Tetsuya Kawano[1]

1. Kyushu Univ.

How much the temperature will rise in the future by global warming is a quite fundamental question. The uncertainty of prediction in temperature rise in the future is, however, still large, and the difficulty in estimating climate sensitivity (climate system response towards external forcing, such as greenhouse gas increase) from the past to the future is the main cause of the uncertainty. Climate sensitivity is usually defined by global temperature rise responded to the doubling of CO_2 when the earth system has reached the equilibrium state, which is called equilibrium climate sensitivity (ECS: Yoshimori et al., 2012). It is suggested, however, that climate sensitivity before equilibrium state is not constant, but varies on interdecadal time scales. such as, feedback parameter variation in the historical experiment (e.g. Gregory and Andrews, 2016) and global warming hiatus in the beginning of 21st century (e.g. Easterling and Wehner, 2009). It has been shown that the atmospheric circulation and cloud property changes according to spatiotemporal pattern of sea surface temperature (SST) rise are the causes of feedback parameter variation (Mauritsen, 2016, Zhou et al., 2014). Spatiotemporal pattern variation of SST involves factors not only external forcing change that is directly related to global warming, such as greenhouse gas increase, but also internal variability in annual to interdecadal timescales. These factors are both taken into account in the preceding studies, and it is not easy to sort them separately.

Therefore, a new feedback parameter (Perturbational Feedback Parameter, hereafter, PFP) was defined and medium to long term variation was identified in order to investigate the impact of internal variation on climate sensitivity variation. Values of PFP varied on interdecadal time scales and the equatorial SST had positive anomaly in the eastern Pacific and negative anomaly in the western Pacific when PFP was large. On the background field, ENSO amplitude, relative to the global mean surface temperature change by 1K, became large. Consequently, the equatorial high SST more effectively contributes to convective clouds shift towards the equator caused by ITCZ shift and to lower cloud increase in the subtropics caused by strengthening of descending flow and static stability. These cloud responses brought about the net downward radiative flux change through reflection increase and thus enhanced PFP.

Further analysis, to make sure the robustness of ENSO amplitude and property change impact, suggested that Hadley circulation and its following cloud changes are, however, not fully explained by ENSO change. Another longer variation, which dominates over the extratropical North Pacific, also play an important role in controlling low-level cloud cover and thus PFP variation.

Keywords: Climate sensitivity, Internal variation, ENSO, Decadal variation, Background field

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A paleoclimatological approach to the multidecadal climate variability

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[Introduction]
In general observational studies, high-frequency climate variability like subseasonal variations is investigated using short-term high-resolution meteorological records, while low-frequency climate variability like glacial-interglacial cycle is studied based on long-term low-resolution geological records. In multidecadal variability (MDV), however, the instrumental observed data are too short to collect many examples, so that it is difficult to compare various MDV cases for elucidating its underlying mechanism. Recently, a novel method in isotope dendrochronology has been developed to reconstruct summer monsoon in East Asia seamlessly from annual to millennial time scales (1). Here, we show the annually resolved 2600-year time series including MDV and investigate its temporal variability using a wavelet method to provide a new observational resource for research in the multidecadal climate variability and predictability.

[Data and Method]
In order to obtain long-term annually resolved summer monsoon records, 67 wood samples with hundreds of year rings, including living trees, architectural woods, archaeological woods, and buried logs covering last 2600 years, have been collected in central Japan and analyzed for their tree-ring cellulose oxygen and hydrogen isotope ratios. After fixing the date of all rings in all woods by a cross-dating method using the oxygen isotope ratio, hydrogen isotope ratios were integrated to remove long-term biological trends and extract climatological components purely from the time-series of oxygen isotope ratios (Fig.1A; 1). By comparison with meteorological observed data (Fig.1B-D; 2), numerous historical documents on past weather, and long-term low-frequency paleoclimate records, the time-series in Fig.1A has been demonstrated to reflect precisely the variation in summer monsoon activity seamlessly from annual to millennial time scales. In order to investigate temporal changes in MDV during last 2600 years, we applied a wavelet method for the time series (3-5).

[Result and Discussion]
By transforming Fig.1A into periodic domains (Fig. 2A-C), we find that MDV is enhanced at about every 400 years since 2600 years ago. The enhancements of MDV correspond to those of the Pacific Decadal Oscillation (PDO) (6) (Fig. 2B-C), reflecting the close relationship between the East Asian summer monsoon and the PDO (7). Interestingly, episodes of enhanced MDV were followed by political regime shifts in China and Japan in almost all cases (Fig. 2D-E). The synchronous MDV is found in Taiwan, too (Fig. 2B-C) (8), indicating that the periodic enhancements of MDV were universal through East Asia, reflecting the East Asian summer monsoon activity. The tight correlation between the MDV modulations and East Asian history during last 2600 years suggests that the enhancement of MDV underlies the periodic and simultaneous political regime shifts throughout East Asia. While the relationship between MDV of summer monsoon activity and East Asian human history are now being studied in historical and archaeological contexts (9), mechanisms of the periodical MDV enhancement at about every 400 years are still unclear and worth studying not only for understanding MDV itself but also for elucidating human history.

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Keywords: multidecadal climate variability, paleoclimate record, East Asian summer monsoon, isotopic dendrochronology

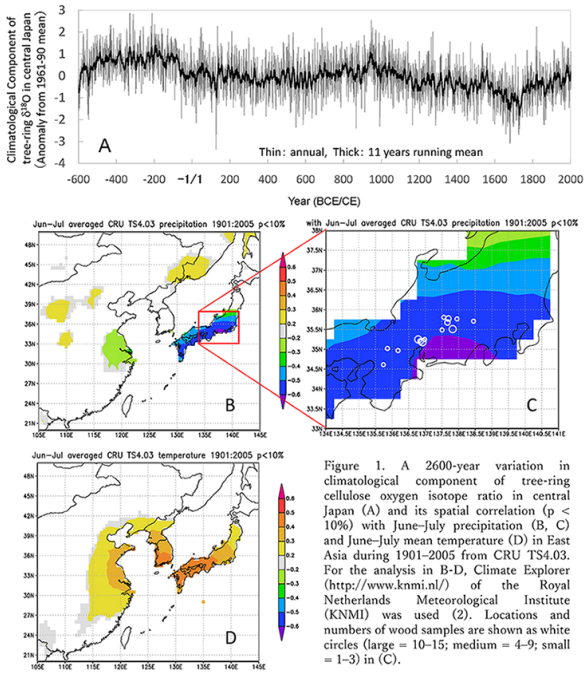


Figure 1. A 2600-year variation in climatological component of tree-ring cellulose oxygen isotope ratio in central Japan (A) and its spatial correlation ($p < 10\%$) with June–July precipitation (B, C) and June–July mean temperature (D) in East Asia during 1901–2005 from CRU TS4.03. For the analysis in B-D, Climate Explorer (http://www.knmi.nl/) of the Royal Netherlands Meteorological Institute (KNMI) was used (2). Locations and numbers of wood samples are shown as white circles (large = 10–15; medium = 4–9; small = 1–3) in (C).

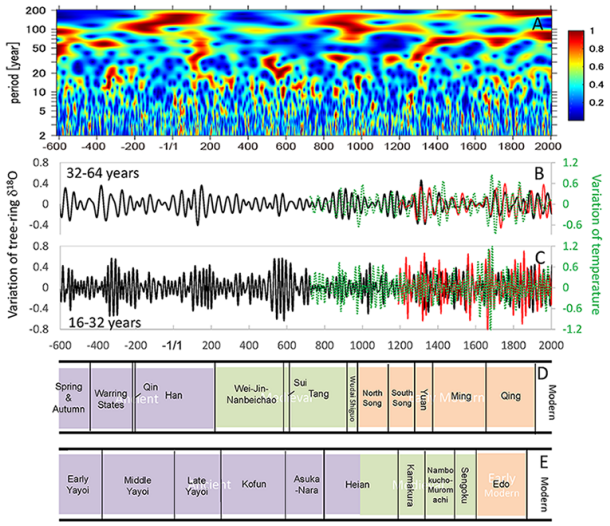


Figure 2. A wavelet diagram and different period-band components of paleoclimate proxies in comparison with Chinese and Japanese history. (A) Continuous wavelet transforms (3) of Fig. 1A by Morlet wavelet (4). (B-C) Different period-band components in the climatological components of tree-ring cellulose oxygen isotope ratio in central Japan (Fig. 1A) (black) and Taiwan (Fig. 2A) (red) (8) together with the tree-ring width based reconstruction of Jan-Sep air temperature in coastal Gulf of Alaska, well-representing PDO (green) (6), extracted by 5-level multi-resolution analysis (5) (32-64 year-period (B), and 16-32 year-period (C), reconstructed from level 5 detail coefficients, and level 4 detail coefficients, respectively). (D-E) Chronological tables of Chinese (D) and Japanese (E) history since 2600 years ago. While Chinese history can be described mainly in terms of country-wide dynastic change, Japanese history consists of successive periods as follows; Yayoi: coexistence of small polities, Kofun: united chiefdoms, Asuka & Nara: centralized state, Heian: aristocratic government, Kamakura-Sengoku: unstable government by warriors, Edo: stable warrior government.

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Towards understanding climate extremes, variability and predictability under changing climate over East Asia

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1. Department of Earth and Planetary Sciences, Kyushu University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Research Center for Advanced Science and Technology, The University of Tokyo, 4. Research Institute for Applied Mechanics, Kyushu University, 5. Meteorological Research Institute, 6. Atmosphere and Ocean Research Institute, The University of Tokyo

We aim at enhancing our understanding of climate extremes, variability and predictability under changing climate. In particular, we focus on decadal modulation of climate extremes over East Asia, mainly by preforming and analyzing comprehensive sets of climate simulations. Preliminary results underline that remote effects from the other oceans over the world will play important roles in modulating climate extremes such as heavy rainfall.
The Database for Policy Decision making for Future climate change (d4PDF) is composed of large ensembles of highly-resolved simulations using the atmospheric model and prescribed sea surface temperature (SST). We find that the interannual fluctuation of the chance of the heavy rainfall around the western Japan (over Kyushu island) is closely related to the tropical Pacific SST during 1981-2010. In addition, a close examination indicates decadal modulation in the relationship. The interannual fluctuations of the summertime heavy rainfall before 2000 and after 2000 are highly correlated with the Nino3 SST and the Nino West SST, respectively. The decadal modulation can be related to changes of the spatial patterns of the decadal SST anomalies predominantly observed in the tropical Pacific, on which our sensitivity experiments demonstrate the potential impacts of the Atlantic decadal variability. On the other hand, our analyses also indicate that the global warming worked to enhance the chance of the heavy rainfall particularly that is not accompanied by the tropical cyclone.
Other numerical studies suggest that other areas can also contribute to modulating the climate extremes in the East Asia. The so-called Silk Road Pattern which controls the remote influences from the extratropical Atlantic will be weakened with global warming. The recent sea ice loss over the Arctic area will work to enhance the chance of cold winter in the East Asia.

Keywords: Climate extreme, Decadal variability, Global warming

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.03_1

[A-OS09] Climate variability and predictability on subseasonal to multidecadal timescales

convener:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Hiroyuki Murakami(Geophysical Fluid Dynamics Laboratory/University Corporation for Atmospheric Research), Masuo Nakano(JAMSTEC Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL)

Climate variability on subseasonal-multidecadal timescales (e.g. Madden-Julian Oscillation, ENSO, Indian Ocean Dipole, Pacific Decadal Variability, Atlantic Multidecadal Variability) has serious impacts on global and regional socioeconomic activities through changes in intensity and frequency of extreme weather events (e.g. cold/heat waves, tropical storms, and floods/droughts). Efforts have been made to understand and predict subseasonal-multidecadal climate variability, but climate simulations and predictions using state-of-the-art coupled general circulation models have biases that represent large uncertainties in amplitude and spatial patterns of the climate variability. The model uncertainties arise from multiple factors such as inadequate understanding of weather and climate interactions across different spatiotemporal scales (e.g. tropical cyclones-ENSO) and insufficient representation of the complex and non-linear climate system (e.g. troposphere-stratosphere coupling, atmosphere-ocean-sea ice-land interactions). Recently, Coupled Model Intercomparison Project Phase 6 (CMIP6) has opened up new model simulation datasets to the public, which can be expected to further advance our understanding and prediction of subseasonal-multidecadal climate variability under the changing climate. This session invites all research related to the subseasonal-multidecadal climate variability using observational, theoretical, modelling and AI/ML frameworks and especially novel approaches.

[AOS09-P01] **Trigger of multi-year La Niña and its physical link with preceding extreme El Niño**

*Tomoki Iwakiri[1], Masahiro Watanabe[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

Trigger of multi-year La Niña and its physical link with preceding extreme El Niño

*Tomoki Iwakiri[1], Masahiro Watanabe[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

El Niño/La Niña, characterized by anomalous sea surface temperature warming/cooling in the central-eastern equatorial Pacific, is a dominant interannual variability with irregularity, impacting worldwide weather and socioeconomics. The observed records show that La Niña often persists for more than two years, called “multi-year La Niña” which tends to accompany extreme El Niño in the preceding year; however, the physical linkage between them remains unclear. Here we show using reanalysis data that an extreme El Niño excites atmospheric conditions that favor the generation of the multi-year La Niña in subsequent years. Easterly wind anomalies along the northern off-equator in the Pacific during the decay phase of an extreme El Niño are crucial. They act to discharge ocean heat content (OHC) via an anomalous northward Ekman transport; the negative OHC anomaly is large enough to be restored by a single La Niña and, therefore, causes another La Niña to occur in the second year. Furthermore, analyses of the Coupled Model Intercomparison Project Phase 6 (CMIP6) models show that the occurrence frequencies of multi-year La Niña and extreme El Niño are highly correlated, supporting the abovementioned mechanism. Our results provide physical evidence that the increasing frequency of multi-year La Niña is explained by the increasing El Niño amplitude since the late 20th century.

Keywords: ENSO, Multi-year La Niña

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.11 Zoom Room 11

[A-OS10] Continental Oceanic Mutual Interaction - Planetary Scale Material Circulationn

convener:Alexandre Yosuke Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Takanori Sasaki(Department of Astronomy, Kyoto University), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001), Chairperson:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001)

The main purpose of this session is to promote discussion on mutual interaction between Continental zone and Oceanic zone. The global-scale material circulation induced by River runoff through oceanic general circulation as major topic on Continental-Oceanic Interaction, where the ENSO/IOD influence into continental climate as major topics on Oceanic-Continental Interaction. Numerical simulation and field observation of radionuclide transport from continental zone into ocean and its potential impact is also important topics of this session. Monitoring featuring satellite remote sensing and Image Recognition featuring AI. The session also extend discussion on planetary hydrology and oceanography focusing on subsurface ocean in Jovian moon and Ancient Martian Hydrology.

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

[AOS10-01] Wintertime impacts of the 2019 Super Indian Ocean Dipole on East Asia

★Invited Papers

*Takeshi Doi[1], Swadhin Behera[1], Toshio Yamagata[1,2] (1.JAMSTEC/VAiG/APL, 2.NUITS/ICAR)

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

[AOS10-02] River-ocean interaction across a mega-delta

*Shinichiro Kida[1], Dai Yamazaki[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Institute of Industrial Sciences, The University of Tokyo)

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

[AOS10-03] Vegetation indices using unmanned aerial vehicle to monitor plant-level tomato plant height under till and no-till farming conditions

*Kenichi TATSUMI[1], Noa Igarashi[1], Mengxue Xiao[1] (1.Tokyo University of Agriculture and Technology)

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

[AOS10-04] **An ocean-atmosphere wave number-4 pattern in the southern subtropics**

*Swadhin Behera[1], Balaji Senapati[2], Mihir Dash[2] (1.Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001, 2.Centre for Oceans, Rivers, Atmosphere and Land Sciences, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, India)

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

[AOS10-05] **Hydrological Hindcasts and Parameterizations for Flash Floods Real-Time Forecasting of Typhoon Hagibis 2019 in Japan**

*Josko Troselj[1], Han Soo Lee[1] (1.Graduate School of Advanced Science and Engineering, Hiroshima University)

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

[AOS10-06] Long-Term Stay Facility for Living with the Sea on the Mars

★Invited Papers

*takuya ONO[1] (1.Kajima corporation)

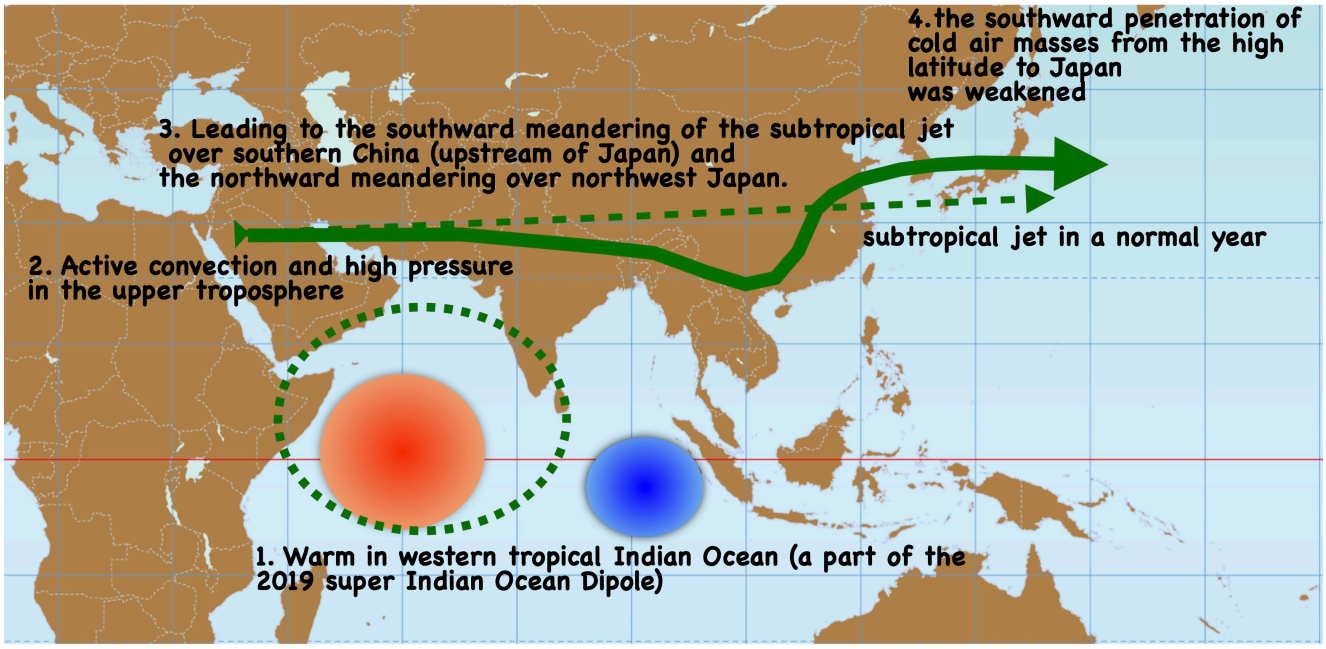
Wintertime impacts of the 2019 Super Indian Ocean Dipole on East Asia

*Takeshi Doi[1], Swadhin Behera[1], Toshio Yamagata[1,2]

1. JAMSTEC/VAiG/APL, 2. NUITS/ICAR

The Indian Ocean Dipole (IOD) is an intrinsic ocean-atmosphere coupled climate phenomenon in the tropical Indian Ocean with warm (cold) sea surface temperature anomalies with enhanced (reduced) rainfall in the western (eastern) tropical Indian Ocean during a positive phase. A strong and long-lasting positive IOD event occurred in 2019, which caused climate-related disasters in countries not only around the Indian Ocean but also East Asia, including Japan. For example, many parts of Australia were seriously affected by a series of massive bushfires owing to the drier than normal conditions, while crop yield in East Africa was threatened by a plague of locusts owing to the wetter condition there. Japan experienced extremely warm conditions during the 2019-2020 winter. In this study, the wintertime impacts on East Asia is the focus. These were successfully predicted in October of 2019 by the 108-member ensemble numerical seasonal prediction system based on a dynamical climate model "SINTEX-F". Successful prediction of the teleconnection of such a super event may contribute to reducing the risks of socioeconomic losses under suitable measures for adaptation and mitigation.

Keywords: Seasaonal prediction, Indian Ocean Dipole Mode, Large ensemble numarical prediction



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River-ocean interaction across a mega-delta

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The Ganges-Brahmaputra river is a major source of freshwater for the Bay of Bengal. River discharge occurs through the Ganges-Brahmaputra Delta, which consists of multiple river mouths. The seasonal cycle of this river discharge is observed with a minimum from late winter to early spring and a maximum from late summer to early fall. We investigated how the dynamics of this river discharge occurs near the river mouth based on a high-resolution numerical model that resolves the various channels of the Ganges-Brahmaputra Delta. The model simulates the basic seasonal cycle of the river discharge that is comparable to observations, with a river plume forming from the major river mouth and along the coast. We find that the river outflow through the main channel influences the surrounding narrow channels through the formation of this river plume by raising the sea level at the river mouth and reversing the direction of the flow. While the widths of these narrow rivers are narrow and less than the deformation radius, our model results suggest active river-ocean interaction occurring across the delta.

Keywords: River-ocean interaction, Delta

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Vegetation indices using unmanned aerial vehicle to monitor plant-level tomato plant height under till and no-till farming conditions

*Kenichi TATSUMI[1], Noa Igarashi[1], Mengxue Xiao[1]

1. Tokyo University of Agriculture and Technology

Precise plant height (PH) estimation is consequential for precision farming. Most vegetation indices derived from remote sensing measurements are used for monitoring and predicting PH. However, few studies have estimated tomato (Solanum lycopersicum L.) PH at the plant level using multi-spectral reflectance data obtained from unmanned aerial vehicle (UAV). In this study, 14 vegetation indices were compared for estimating tomato PH at the plant level under till (with mulching) and no-till (without weed clipping treatments) conditions. The experiment was carried out at the Field Museum Fuchu, Tokyo University of Agriculture and Technology during the growing season from 13 May to 30 July 2020. Results showed good logistic growth relationships obtained between measured tomato PH and some vegetation indices. In particular, good performance for predicting PH was observed for: Infrared Percentage Vegetation Index and Transformed Vegetation Index under till treatment (R2 of 0.688 and 0.717 and RMSE of 0.139 and 0.136 m, respectively); and Green Normalized Difference Vegetation Index (GNDVI) and Weighted Difference Vegetation Index (WDVI) under no-till treatment (R2 of 0.571 and 0.561 and RMSE of 0.166 and 0.147 m, respectively). However, the variability of each vegetation index increased with increasing PH, and the prediction accuracy under fully expanded leaf cover conditions was lower than that under the early growth stage. In addition, all vegetation indices except for the Enhanced Vegetation Index, GNDVI, and WDVI under no-till treatment had lower performance for estimating PH as compared with those under till treatment due to soil background effects and presence of weeds. Overall, results indicate that certain vegetation indices provided an effective method to a certain degree for monitoring tomato PH at plant scale.

Keywords: Multispectral reflectance, Plant scale, Precision farming

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An ocean-atmosphere wave number-4 pattern in the southern subtropics

*Swadhin Behera[1], Balaji Senapati[2], Mihir Dash[2]

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A stationary zonal wavenumber-4 (W4) pattern is revealed in Southern subtropics from an empirical orthogonal function analysis in the sea surface temperature (SST) anomalies. A thermodynamic coupling of atmosphere and the upper ocean helps in generating the W4 pattern, which later terminates due to the breaking of the ocean-atmosphere positive feedback. This W4 pattern is found to be seasonally phase-locked to the austral summer (persists up to mid-autumn) and independent of other known tropical and extra-tropical climate phenomena. During the positive phase of the W4 event, the cold SST anomaly develops over the south- eastern and -western side (SE-NW) of Australia creating an anomalous divergence circulation. It favours the moisture transport towards the southeastern region of the continent. Consequently, the specific humidity increases and causes an above-normal rainfall in a SE-NW axis over Australia. An opposite process is seen in case of a negative W4 event.

Keywords: wave number 4 , coupled, ocean and atmosphere

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Hydrological Hindcasts and Parameterizations for Flash Floods Real-Time Forecasting of Typhoon Hagibis 2019 in Japan

*Josko Troselj[1], Han Soo Lee[1]

1. Graduate School of Advanced Science and Engineering, Hiroshima University

As a result of climate change, unprecedented heavy rainfall disasters are increasingly occurring worldwide. It is therefore important to develop Early Warning Systems for real-time forecasting of extreme river water levels and discharges. This study applies the Cell Distributed Runoff Model version 3.1.1 (CDRM) hydrological model with five river basin parameters calibrated by the Shuffled Complex Evolution optimization method developed at the University of Arizona (SCE-UA) for nine first-class river basins in north-eastern Japan, to obtain hydrological parameterizations and hindcasts of river mouth discharge hydrographs during the Typhoon Hagibis 2019. The CDRM accurately projected river mouth discharges from three Japanese typhoons (Hagibis-2019, Roke-2011 and Chataan-2002) using calibrated parameter sets from each typhoon. Using this approach, this study produced cross-validation results with very high reproducibility metrics. Therefore, this study' s results show that the methodology and model used in the study has the capability of simulating extreme discharge events by calibrations using previous extreme typhoon case events with similar trajectories. Then, the calibrated parameter sets from the three typhoons were applied with forecasted rainfall data from Typhoon Hagibis for all nine rivers to project and validate possibilities and accuracy of real-time forecasting of river mouth hydrographs. These findings contribute to developing the real-time forecasting tools for extreme river discharges during unprecedented heavy rainfall-induced flash floods.

Keywords: extreme river discharge, Typhoon Hagibis in Japan, CDRM hydrological model, SCE-UA optimization method, real-time flood forecasting

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Long-Term Stay Facility for Living with the Sea on the Mars

*takuya ONO[1]

1. Kajima corporation

Human race requires several essential conditions, a gravity environment, substances, and shielding for long-term stay on the Mars. Water and air are indispensable substances for human life support. Shielding is necessary for cosmic rays and meteorites. Moreover, if human race visualizes the artificial sea, which brings mental stability and gives space for safety lives to them. Under low gravity condition, human race has difficulty of health growth and physical retention. It may cause of human race has a body which cannot stand on its own feet. This may promote division of human race and furthermore it may cause of conflict is concerned. As a solution for this task, suggests that to use artificial gravity by centrifugal force due to rotation. To add it to Martian gravity is defined to create a similar gravitational environment of the Earth. For the material task, there are large amount of water and carbon dioxide and trace amount of nitrogen on the Mars is conceivable. Therefore, human race needs to create a section for living area on the Mars.

To suggest the Mars glass city is constructed by two-hundred-meter height rotating facility, is including its upper canopy part, a flared-skirt-shape bottom part, and an underground part. The residential area is separated by a part which is built on the Mars ground surface directly, a rotating artificial gravity area, and a skyscraper which also served as canopy steady braces. A rotating to generate gravity part is located only its bottom side. A heliport, a hub, for a sky transportation system between other facilities is placed on the top of the facility. The artificial gravity facility is holding water, this condition occurs its surface rises along the side wall. Inside of this facility can see rich water from everywhere by this phenomenon. Human race’ s secure feeling is included by the Mars glass city has enough water and visually see it.

The internal pressure of artificial gravity facility is one atm on the Mars. The Mars atmospheric pressure is dilute, about 1/100 of the Earth, therefore its internal and external pressure difference is nearly one atm. This becomes 10t / m^2 artificial gravity facility is required strong tension for suppressing all itself. The ground and horizontal direction are done with a tension ring. Expanding wires to the ground is come from the underground, which is deeply dived into it. The wires are connected at underground of the artificial gravity facility and they apply reaction force to the ground.

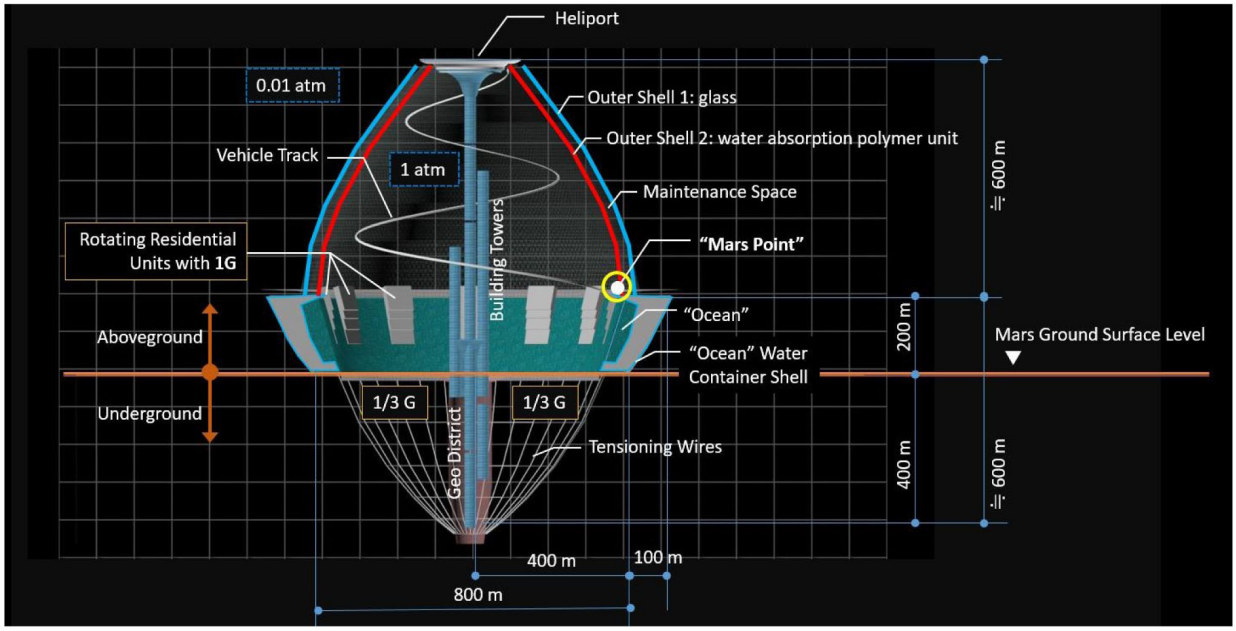
The facility is designed a double dome structure. Its exterior is mainly constructed as capable of withstand flying objects from space. A moistened super absorbent polymer is located inside of the artificial gravity facility for cosmic ray shielding. Considering by constructing the artificial gravity facility on the Moon, the Mars, and asteroids, insures for human race space development warranties to support comfortable long-term stay in space.

Keywords: sea, space architecture, artificial gravity by revolving

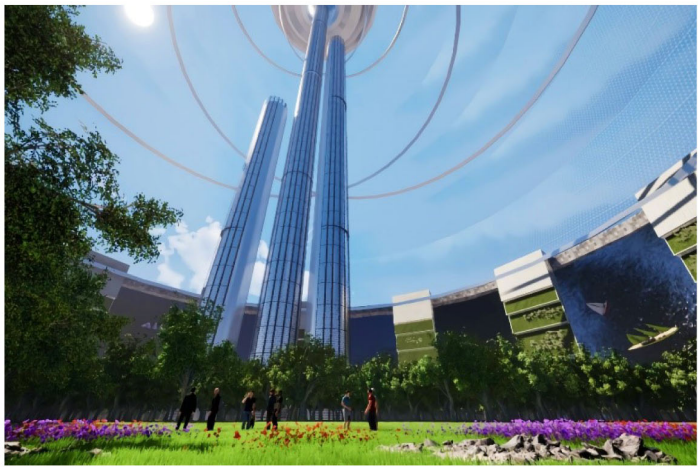
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Long-Term Stay Facility for Living with the Sea on the Mars

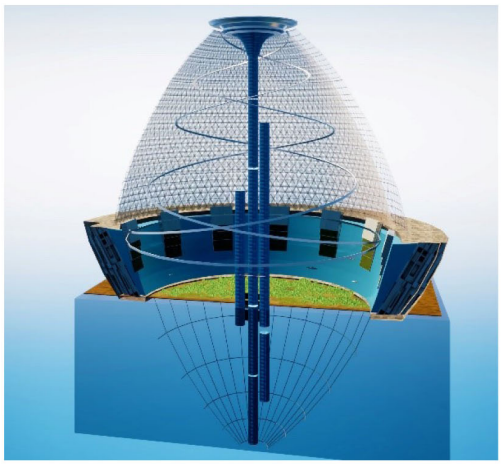
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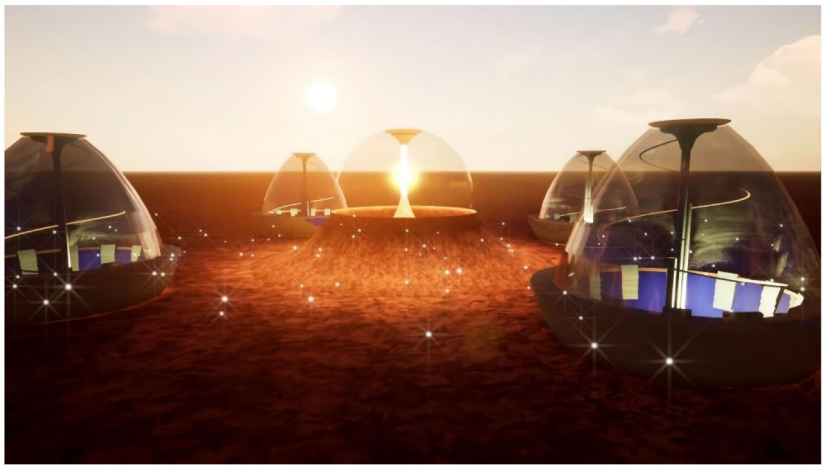
Cross section of Mars Glass City (artificial gravity facility on Mars)



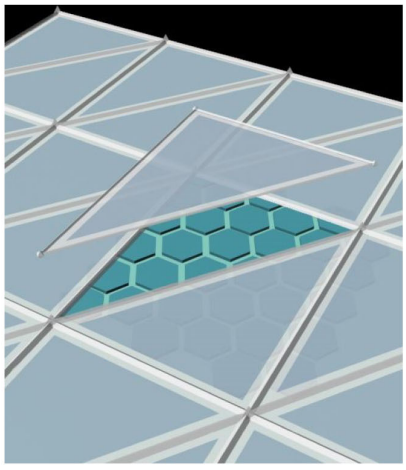
internal view



Cross-sectional view



Glass group around the solar furnace



Superabsorbent polymer unit

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.11 Zoom Room 11

[A-OS10] Continental Oceanic Mutual Interaction - Planetary Scale Material Circulationn

convener:Alexandre Yosuke Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Takanori Sasaki(Department of Astronomy, Kyoto University), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001), Chairperson:Yosuke Alexandre Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Takanori Sasaki(Department of Astronomy, Kyoto University)

The main purpose of this session is to promote discussion on mutual interaction between Continental zone and Oceanic zone. The global-scale material circulation induced by River runoff through oceanic general circulation as major topic on Continental-Oceanic Interaction, where the ENSO/IOD influence into continental climate as major topics on Oceanic-Continental Interaction. Numerical simulation and field observation of radionuclide transport from continental zone into ocean and its potential impact is also important topics of this session. Monitoring featuring satellite remote sensing and Image Recognition featuring AI. The session also extend discussion on planetary hydrology and oceanography focusing on subsurface ocean in Jovian moon and Ancient Martian Hydrology.

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

[AOS10-07] The Atmospheric Response of Earth-like Exoplanets to X-ray and Extreme UV emission from G-M planet hosts: Case of TOI-700b

★Invited Papers

*Vladimir Airapetian[1], Jared M. Bell[1], Alex Glocer[1] (1.NASA Goddard Space Flight Center, USA)

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

[AOS10-08] How do we understand habitable climets on exoplanets?

★Invited Papers

*Takanori Kodama[1] (1.Kodama Institute for Science, The University of Tokyo)

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

[AOS10-09] Building Sustainable Human Society on the Moon

★Invited Papers

*Yoshiufumi Inatani[1] (1.Japan Aerospace Exploration Agency)

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

[AOS10-10] Space camp at Bioshere2: Field educational activity for future space mission, environmental research and international coordination

*Tomoyuki Tajima[1], Masahiro Terada[1], Satoko Tsujihiro[1], Takao Doi[2], Yosuke Alexandre Yamashiki[2,1] (1.Unit of Synergetic Studies for Space, Kyoto University, 2.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

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

[AOS10-11] Relationship between three-dimensional velocity of filament eruptions and CME association

*Daikichi SEKI[1,3], Kenichi Otsuji[2], Takako T. Ishii[3], Ayumi Asai[3], Kiyoshi Ichimoto[3] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2.National Institute of Information and Communications Technology, 3.Astronomical Observatory, Kyoto University)

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

[AOS10-12] Development of virus container for exposure to stratospheric environment

*Kenji Miki[1,2], Osamu Sahara[3], Takanori Endo[4] (1.Tokyo Institute of Technology Earth-Life Science Institute, 2.Keio University Faculty of Science and Technology, 3.Tokushima University, 4.GOCCO Co., Ltd.)

The Atmospheric Response of Earth-like Exoplanets to X-ray and Extreme UV emission from G-M planet hosts: Case of TOI-700b

*Vladimir Airapetian[1], Jared M. Bell[1], Alex Glocer[1]

1. NASA Goddard Space Flight Center, USA

Recent Kepler, TESS, HST and ground-based observations of G-M planet hosts suggest that exoplanets around them should be exposed to high level of ionizing radiation in the form of stellar coronal and flare driven X-ray and Extreme UV (XUV) and wind fluxes. What is the impact of this high-energy radiation on atmospheres of rocky exoplanets? The answer to this question is one of the central issues to exoplanetary habitability, because the presence of a thick high molecular weight atmosphere over sufficiently long timescales is crucial factor associated with planetary surface pressure and its exposure to stellar UV and particle irradiation. Here we present the modeling results of thermodynamics and atmospheric dynamics of an Earth-like exoplanet controlled by quiescent coronal XUV emission from K and M dwarfs. We show that ionospheric escape is the dominant process in atmospheric escape at the XUV flux ~ 1- 10 times of the solar flux with the escape rate of nitrogen ions approaching the rate of oxygen ion escape. Our models suggest that the transition from ion escape to hydrodynamic escape occurs at ~ 60 times of the XUV solar flux. We discuss the implications of the atmospheric escape due to XUV driven photoionization driven heating and Joule heating rate for a magnetized planet and habitability conditions for a recently discovered Earth-like exoplanet, TOI-700d, around a quiet M2 dwarf star.

Keywords: Earth, exoplanets, atmospheric dynamics, atmospheric escape

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How do we understand habitable climets on exoplanets?

*Takanori Kodama[1]

1. Kodama Institute for Science, The University of Tokyo

A large number of exoplanets have been detected since 1995. Some of these are expected to be rocky planets with Earth-like bulk composition and would have habitable climate. Habitable exoplanets seem to be significant targets for observation of exo-terrestrial planet and exo-life. Most of studies for habitable planets assumed planets with a large amount of water on their surface and estimated the atmospheric structure using the one-dimensional radiative-convective equilibrium model. They introduce the habitable zone, in which planets can maintain liquid water on their surface for a long term. Recently, estimation of the habitable zone with a three-dimensional climate model has begun. They focus on the spatially non-uniform distribution of water vapor in its atmosphere and can discuss climate for terrestrial exoplanets. However, exoplanets should have a wide range of planetary parameter, which includes the amount of water, radius and mass of a planet, atmospheric pressure, orbital parameters, and so on.

We investigate the climate for a planet with a small amount of water on its surface, a land planet. Land planets have less water amount in their atmosphere and can radiate stronger planetary radiation than for aqua planets, which have a large amount of water on their surface. Thus, a planet with a small amount of water on its surface has a wider habitable zone than that for a planet with a large amount of water on its surface has a wider habitable zone than that for a planet with a large amount of water on its surface [Abe et al., 2011; Kodama et al., 2018; 2019]. Here, we investigate the relationship between the width of the habitable zone and the surface water distribution using 3D GCM(General Circulation Model). We confirm that the habitable zone strongly depends on the surface environment. In this presentation, we summarize the climates and habitability for exo-land planets.

Additionally, in this presentation, I summarize the dependence of planetary parameters for terrestrial exoplanets on their climate.

Keywords: Exoplanets, Habitable Planets, Climates

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Building Sustainable Human Society on the Moon

*Yoshiufumi Inatani[1]

1. Japan Aerospace Exploration Agency

Starting with building a society on the Moon, many considerations for the sustainable human presence have been conducted. Assuming the number of a thousand of residence on the Moon, not only technical considerations such as keeping human life in space, so called ISRU (resource & energy), supply chain management & transportation, and so on, but also societal / economical considerations and humanity issues such as bearing children, birth & death..., would be good examples for enhancing-our-imagination-type of consideration. Our Moon Village workshop has been held since 2019, and discussions and lectures from various field have been continuously made. To figure out a reference model of the society to be built is also one of the goals of our workshop. This talk will focus on these topics.

Keywords: the Moon, human presence in space, society in space

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Space camp at Bioshere2: Field educational activity for future space mission, environmental research and international coordination

*Tomoyuki Tajima[1], Masahiro Terada[1], Satoko Tsujihiro[1], Takao Doi[2], Yosuke Alexandre Yamashiki[2,1]

1. Unit of Synergetic Studies for Space, Kyoto University, 2. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University

Unit of Synergetic Studies for Space (USSS) of Kyoto University has held the intensive educational program, Space Camp at Biosphere 2 (SCB2), since 2019, collaborating with University of Arizona and NASA. In this camp, 5 students are respectively selected from Kyoto University and University of Arizona. Biosphere 2 (B2) is primarily constructed to examine whether human can survive enclosed environments where we must endure and thrive after colonization of Mars. For the experiment and research, B2 contains several artificial biomes inside the huge building (rainforest, ocean, savannah, and fog desert). SCB2 aims to train 10 selected students to become prospective candidates who will contribute to future human space mission. The concept of SCB2 was built as a simulated short space mission on Mars. The curriculums are divided into three components: (1) How to monitor environmental parameters, (2) How to evaluate the level of radiation induced by Galactic Cosmic Rays (GCRs) and Solar Energetic Particles (SEP) induced by thinner atmospheric depth, (3) How to monitor own health condition during the camp in order to deal with the stressful situation, (4) How to make satellite communication in space. Through those curriculums of the camp, students will acquire the essential knowledge for future human space mission. They also can get the ideas how to create the structure of Biosphere 3 on the Mars as one of the consequences of discussion among participants. SCB2 may provide a new form of learning opportunity for considering the realistic way of migration into the different planets. SCB2 requires the students from Japan and USA to conduct collaborative works and it may contribute to foster the skills for international coordination that is be indispensable to the promotion of human space activity in future. Since 2020, we have been facing global pandemic of COVID-19 and international trips are restricted. We therefore switched from the in-person practice at Bioshere2 to domestic fieldwork practice in Japan. We picked up 3 different places to represent forest, marine and sand dune. Here we will report on what we learned about “Biosphere1” as a basis of the construction for Biosphere2 and 3, with our filed practice in Asiu forest, Tanabe bay and Tottori sand dune. And, we also introduce about the practices on space radio communication and radiation.

Keywords: Space Camp, Biosphere2, Filed eduaction

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Relationship between three-dimensional velocity of filament eruptions and CME association

*Daikichi SEKI[1,3], Kenichi Otsuji[2], Takako T. Ishii[3], Ayumi Asai[3], Kiyoshi Ichimoto[3]

1. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2. National Institute of Information and Communications Technology, 3. Astronomical Observatory, Kyoto University

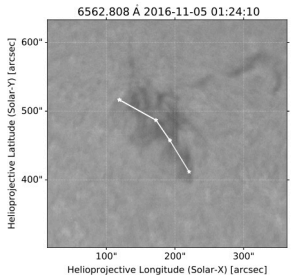
It is widely recognised that filament disappearances or eruptions are frequently associated with Coronal Mass Ejections (CMEs). Since CMEs are a major source of disturbances of the space environment surrounding the Earth, it is important to investigate these associations in detail for the better prediction of CME occurrence. However, the proportion of filament disappearances associated with CMEs is under debate. The estimates range from ~10% to ~90% and could be affected by the manners to select the events.

In this study, we aim to reveal what parameters control the association between filament eruptions and CMEs. We analysed the relationships between CME associations and the physical parameters of filaments including their length, maximum ascending velocity, and direction of eruptions using 28 events of filament eruptions observed in Hα. We found that the product of the maximum radial velocity and the filament length is well correlated with the CME occurrence. If the product is larger than 8.0×106 km2 s−1, the filament will become a CME with a probability of 93%, and if the product is smaller than this value, it will not become a CME with a probability of 100%. We suggest a kinetic-energy threshold above which filament eruptions are associated with CMEs. Our findings also suggest the importance of measuring the velocity vector of filament eruption in three-dimensional space for the better prediction of CME occurrence.

Keywords: Coronal Mass Ejection, Solar filaments, Space weather prediction, Filament eruption, Halpha observation

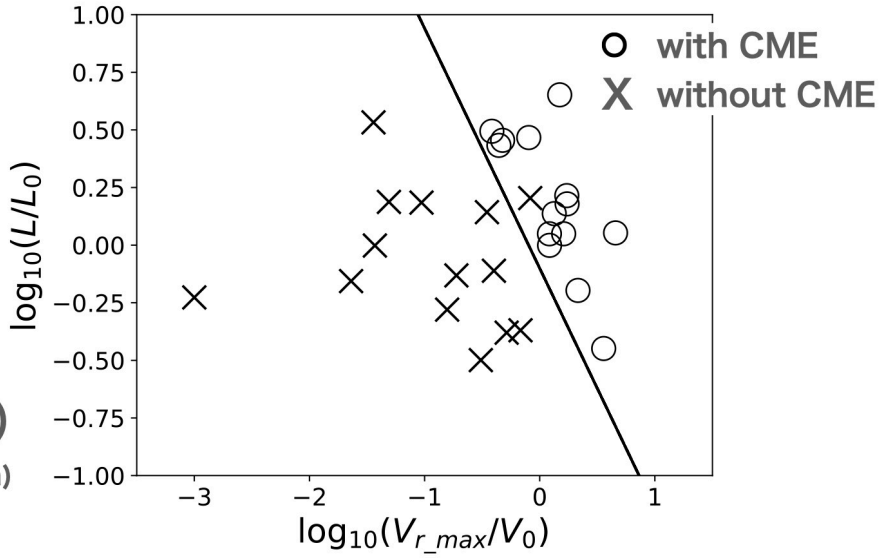
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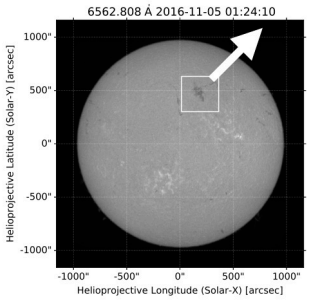
Longer & Faster filaments => More associated with CMEs



filament length (L)

L_0 : typical length (=100 Mm)





radial maximum velocity (Vr_max)

V_0 : typical velocity (=100 km/s)

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Development of virus container for exposure to stratospheric environment

*Kenji Miki[1,2], Osamu Sahara[3], Takanori Endo[4]

1. Tokyo Institute of Technology Earth-Life Science Institute, 2. Keio University Faculty of Science and Technology, 3. Tokushima University, 4. GOCCO Co., Ltd.

Our team is working on analysing the survivability of DNA in the stratospheric environment. In order to achieve this DNA survivability analysis, we are trying to launch virus to the stratosphere as the DNA carrier. We are developing a light sampler which opens and closes during the flight time. By using this device, we will be able to perform the complete exposure of virus to the stratospheric environment taking all the stratospheric environmental factors such as low temperature, low pressure, high UV level, and cosmic rays.

Keywords: stratosphere, virus

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.03_2

[A-OS10] Continental Oceanic Mutual Interaction - Planetary Scale Material Circulationn

convener:Alexandre Yosuke Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Takanori Sasaki(Department of Astronomy, Kyoto University), Swadhin Behera(Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001)

The main purpose of this session is to promote discussion on mutual interaction between Continental zone and Oceanic zone. The global-scale material circulation induced by River runoff through oceanic general circulation as major topic on Continental-Oceanic Interaction, where the ENSO/IOD influence into continental climate as major topics on Oceanic-Continental Interaction. Numerical simulation and field observation of radionuclide transport from continental zone into ocean and its potential impact is also important topics of this session. Monitoring featuring satellite remote sensing and Image Recognition featuring AI. The session also extend discussion on planetary hydrology and oceanography focusing on subsurface ocean in Jovian moon and Ancient Martian Hydrology.

[AOS10-P01] How the delay time the rainfall flow into the lake?

*Maho Iwaki[1], Yosuke Alexandre Yamashiki[2], Takashi Toda[1], Chunmeng Jiao[3], Michio Kumagai[4] (1.Lake Biwa Museum, 2.Kyoto University, 3.Lake Biwa Environmental Research Institute, 4.Ritsumeikan University)

[AOS10-P02] A Proposal of a Preprocessing Using Deep Reinforcement Learning for Improving the Accuracy of Marine Animal Identification

*Okamura Shin[1], Yosuke Yamashiki[1] (1.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University)

[AOS10-P03] Quantification of Submerged Aquatic Vegetation in Lake Biwa using GCOM-C

*Hiroaki Sato[1], Yosuke Alexandre Yamashiki[2], Junichi Susaki[1], Kanako Ishikawa[3] (1.Kyoto University, 2.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 3.Lake Biwa Environmental Research Institute)

[AOS10-P04] Mangrove as the third way to obtain salt in space colonization

*Kaho Jasmine Takahata[1], Kazusa Fukuhara[1], Keiko Kurooka[1], Erina Kawashima[1], Kiyotaka Okada[2], Yosuke Alexandre Yamashiki[3] (1.Kindai University, Faculty of Medicine, 2.Department of Arts and Science, Kindai University Faculty of Medicine, 3.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University)

[AOS10-P05] Characteristics of the filament eruption event on August 9, 2016 with CME using Hα Doppler velocity field analysis.

*Nami Kimura[1], Ayumi Asai[2], Kenichi Otsuji[3], Yosuke Alexandre Yamashiki[4] (1.Kyoto University, 2.Astronomical Observatory, Kyoto University, 3.National Institute of Information and Communications Technology, 4.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Japan)

[AOS10-P06] Characterization of long-term groundwater level changes associated with the 2016 Kumamoto Earthquake

*Shun Yamamoto[1], Katsuaki Koike[2], Yosuke Alexandre Yamashiki[1] (1.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2. Environmental Geosphere Engineering Laboratory, Department of Urban Management, Graduate School of Engineering, Kyoto University)

How the delay time the rainfall flow into the lake?

*Maho Iwaki[1], Yosuke Alexandre Yamashiki[2], Takashi Toda[1], Chunmeng Jiao[3], Michio Kumagai[4]

1. Lake Biwa Museum, 2. Kyoto University, 3. Lake Biwa Environmental Research Institute, 4. Ritsumeikan University

Our study indicated that an impulse response function can determine the precipitation retention time at the surface of a catchment area and estimate the time required for the precipitation to reach a lake. We calculated the response function of rainfall to water levels in Lake Biwa during summer and winter. The calculated delay time increased with increasing river length and river catchment area. Based on the time scales, we divided the delay time after rainfall into two groups: those occurring due to direct rainfall in the lake and seiches, and river inflow (surface and return flows). We concluded that the rapid (direct rainfall into the lake, surface and quick return flows) and short-term response [surface flow, quick return flow, and slow return flow (or subsurface flow)] runoff patterns could be distinguished by considering the time scale of the delay time determined from the response function.
The shape of the response function reflects the lake system itself, enabling a better understanding of lake systems and dominant processes, even in arid areas. Delay time acquired from the response function may be useful for estimating the contribution of rainfall (evaporation) to the increase (decrease) in lake water levels, and other factors. Our method assists the analysis of lake systems by defining both input and output flows. For example, for endorheic lakes, rainfall is the input and evaporation is the output; for exorheic lakes, rainfall is the input and discharge is the output; and for lakes in arid regions, discharge volume (or rainfall) is the input and lake surface area (or evaporation volume) is the output. Therefore, the proposed method could be applied to different types of lake systems, where the response function could assist in developing watershed management strategies in response to climate change.

Keywords: Frequency response function, Lake water levels, Lake Biwa

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A Proposal of a Preprocessing Using Deep Reinforcement Learning for Improving the Accuracy of Marine Animal Identification

*Okamura Shin[1], Yosuke Yamashiki[1]

1. Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University

Since Krizhevsky et al. proposed a convolutional neural network method as a highly accurate model for image recognition in 2012, the field of computer vision has achieved rapid development. As a result, the algorithms are being used in every research field. In the field of marine ecosystems, techniques such as deep learning are beginning to be used for species identification. However, unlike ordinary images, the accuracy of image identification of species living in water tends to be relatively low. Images were taken underwater often have a blue-black filtered look due to the effect of light attenuation, which makes it impossible to extract enough features from the image, resulting in a phenomenon that makes it difficult to increase accuracy. In order to prevent this phenomenon, it is common practice to pre-process the images when performing identification using underwater images. Preprocessing of underwater images has been widely studied, and several methods have been proposed, such as those that take into account environmental factors at the time the image was acquired and those that use deep learning. In this study, we propose a preprocessing method for underwater images using deep reinforcement learning based on the above background. This method is implemented using Deep Q-Network Learning, a deep reinforcement learning algorithm commonly used in reinforcement learning, and a trained discriminative model, which is a preprocessing model specialized for improving the accuracy of image identification of specific species. Unlike many previous studies on preprocessing of underwater images, this preprocessing model does not need to take into account environmental factors such as the lighting conditions at the time the image was acquired, suspended particles in the water, or the presence of artificial light sources, The system spontaneously searches for an appropriate combination of pre-processing and learns the filter to increase the accuracy of the species discriminator. Therefore, it is expected to reduce all the costs related to the preprocessing of underwater images and to increase the accuracy of species identification. In this study, the automatic preprocessing model described above was used to verify the identification accuracy of Dendronephthya gigantea, a species of coral reef. a species of soft coral reef. As a result, the generated preprocessed identification model improved the prediction accuracy by 11% compared to the original model. In addition, by combining the generated preprocessed classifier model with the original model, we confirmed a significant improvement in the prediction error, from 2.05 of the original model to 1.27. This result confirms that the proposed preprocessing model for the classifier for underwater images can contribute to the improvement of the accuracy and robustness of the classifier. In future research, we plan to use the automatic preprocessing method developed in this study for the efficient evaluation of the ecosystem from underwater images.

Keywords: Ocean biology

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Quantification of Submerged Aquatic Vegetation in Lake Biwa using GCOM-C

*Hiroaki Sato[1], Yosuke Alexandre Yamashiki[2], Junichi Susaki[1], Kanako Ishikawa[3]

1. Kyoto University, 2. Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 3. Lake Biwa Environmental Research Institute

We performed the application of satellite remote sensing data to quantify submerged aquatic vegetation in Lake Biwa. The previous study (Shweta et al. 2017) focuses primarily on the South Basin featuring the satellite data obtained by Landsat 7. Our current survey conducted the estimation of submerged height of species using GCOM-C data and calibration data from Lake Biwa. GCOM-C SGLI-VNR sensor provides products with different wavelengths of Visual Ray and NIR with nine different wavelengths. In this study, we only use used sensors VN03, VN04, VN06, and VN07. There are overlapping wavelengths between the estimation of Chlorophyll-a concentration in the water column and the estimation of SAV height. We have to consider the difference between the North and South basin of Lake Biwa, the former with deep and mesotrophic basin and the latter with shallow and eutrophic basin. In this study, the classification of two basins was accomplished using VN07. We will make further applications in order to improve the results and apply to the different basin.

Keywords: remort sensing, submerged aquatic vegetation

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Mangrove as the third way to obtain salt in space colonization

*Kaho Jasmine Takahata[1], Kazusa Fukuhara[1], Keiko Kurooka[1], Erina Kawashima[1], Kiyotaka Okada[2], Yosuke Alexandre Yamashiki[3]

1. Kindai University, Faculty of Medicine, 2. Department of Arts and Science, Kindai University Faculty of Medicine, 3. Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University

In this survey, we introduce effective means for extracting salt in the partially terraformed future environment. The “salt” is an essential item in order to secure health condition for human, accordingly, it is an urgent issue how we can obtain salt if we live on a planet or in an aircraft in space. When living on the earth, it is basically possible to obtain salt by heating or drying seawater. Heating in closed space means not only that we have to consume oxygen and fuels but also we may have the risk of fire in closure environment. However, the non-artificial way of drying seawater requires large space and has the risk of turbidity of regolith. Additionally, in the first place, it is harder under microgravity because water forms a sphere. Here we would like to propose that we utilize mangrove as the third way to obtain salt. It's the way to grind their leaves because they store higher concentrations of salt from seawater.

Keywords: salt, space colonization, Mangrove, health condition, microgravity, biology

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Characteristics of the filament eruption event on August 9, 2016 with CME using Hα Doppler velocity field analysis.

*Nami Kimura[1], Ayumi Asai[2], Kenichi Otsuji[3], Yosuke Alexandre Yamashiki[4]

1. Kyoto University, 2. Astronomical Observatory, Kyoto University, 3. National Institute of Information and Communications Technology, 4. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Japan

Space weather refers to environmental changes in the space around the Earth caused by solar activity and other factors. Space weather forecasting is important because solar surface explosions (flares) and eruptions can cause magnetic storms and increased radiation in the Earth's environment, which can have a serious impact on human social activities. In particular, eruptions of cold plasma (filament/prominences) floating by magnetic force in the solar corona are often accompanied by coronal mass ejections (CMEs), in which a large amount of solar plasma is ejected into interplanetary space, and are said to be one of the causes of magnetic storms. In many cases, CMEs are observed after filamentary eruptions, and statistical analysis has shown that there is a high correlation between the two phenomena. However, the process of the transition from filament eruptions to CME cannot be directly observed due to gaps in the field of view, and has not yet been clarified. In this study, we used the Solar Dynamics Doppler Imager (SDDI) onboard the Solar Magnetic Activity Research Telescope (SMART) at Kyoto University's Hida Observatory to investigate the relationship between these phenomena. We studied in detail the filamentary eruption and associated CME that occurred near the northeastern limb of the Sun from 23:30 on August 9, 2016 to 3:30 on August 10, 2016. The filament is known to have generated a large CME (370 km/s) at 4:00 UTC on August 10, 2016 after the eruption. In particular, from SMART/SDDI observations at 73 wavelengths in the ±9° A range centered on the Hα line, we derived the line-of-sight velocity of the filament by adapting the "cloud model" of Beckers [Beckers 1964, 1979], and the 3-dimensional velocity field of the filament was derived by combining its line-of-sight velocity and the apparent motion. The vertical motion of the filament was investigated by creating a time slice image along a slit placed vertically near the center of its arch-like structure. This revealed a rotational motion inside the filament, and this rotational motion was spatially and temporally related to the later CME. We also focused on each plasma blobs inside the filament and followed the time variation of the velocity in the direction of the line of sight and the direction perpendicular to the line of sight to investigate the change in the structure of the filament before and after the eruption in detail.

Keywords: Sun, filaments, prominences, flares, coronal mass ejections(CMEs)

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Characterization of long-term groundwater level changes associated with the 2016 Kumamoto Earthquake

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The recharge sources of groundwater are mainly rainfall and river water, and it is known that the groundwater level is affected by changes in the recharge rate from these sources, by atmospheric pressure and tides from the structure of observation wells, and by earthquakes and changes preceding earthquakes. A multivariate linear regression model that does not include the groundwater level itself as an explanatory variable is appropriate for detecting groundwater level changes due to earthquakes or changes preceding earthquakes (Matsumoto et al., 1989). In this study, we aim to extract the characteristics of long-term groundwater level fluctuations in the Kumamoto Plain using a multivariate linear regression model in order to clarify the relationship between long-term groundwater level fluctuations and seismic activity.
In Kumamoto City, groundwater levels are constantly observed at 33 groundwater level observation wells in 20 locations, and this information is available on the website. In this study, we obtained the data directly from the Water Conservation Division, Environment Promotion Department, Environment Bureau, and collected and compiled the data on the website. The daily total of precipitation and daily mean local pressure were obtained from the observation data measured and published by the Japan Meteorological Agency, and the global tide values were calculated using GOTIC2, which is available on the website of the Mizusawa Observatory of the National Astronomical Observatory of Japan. Using a multivariate linear regression model with groundwater level fluctuation as the objective variable and precipitation, atmospheric pressure, and earth tide as explanatory variables, we extracted the characteristics of long-term groundwater level fluctuation up to the Kumamoto earthquake by removing the effects of precipitation, atmospheric pressure, and earth tide.
In contrast to the results of the model calculations based on the 2007-2009 period, the measured values at Suizenji showed a decrease toward 2014 and an increase toward 2016. The strainer of the observation well at Suizenji is a porous Togawa lava formation, and groundwater fluctuations at this location may be influenced by subsurface pressure changes due to crustal movement.

Keywords: time series analysis

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.07 Zoom Room 07

[A-OS18] Kuroshio Large Meander

convener:Toru Miyama(Japan Agency for Marine-Earth Science and Technology, Application Laboratory), Norihisa Usui(Meteorological Research Institute), Hidetaka Hirata(Rissho University), Takashi SETOU(Japan Fisheries Research and Education Agency), Chairperson:Hidetaka Hirata(Rissho University), Takashi Setou(Japan Fisheries Research and Education Agency)

The Kuroshio Large Meander that started in August 2017 is the second longest historic event in the observed record, next to the event in 1975-1980 (4 years and 8 months). In October 2020, a massive eddy separation occurred, and the Kuroshio path is beginning to take shape in a way that has not been seen before. There are strong public interests on the possible impacts of the Kuroshio Large Meander on fisheries and other phenomena along the coast. However, the actual impacts have not been well investigated. In addition, new findings such as the impacts of the Kuroshio Large Meander on weather are emerging. This session aims to shed light on this intriguing phenomenon by discussing its trends, dynamics, impacts, and comparison with past examples. Presentations from a variety of perspectives in the fields of ocean physics, biology, chemistry, and atmospheric effects will be welcomed.

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

[AOS18-01] Impact of the 2017 Kuroshio Large Meander on the Decadal Kuroshio Extension Variability

★Invited Papers

*Bo Qiu[1], Shuiming Chen[1], Niklas Schneider[1], Eitarou Oka[2], Shusaku Sugimoto[3] (1.University of Hawaii at Manoa, 2.University of Tokyo , 3.Tohoku University)

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

[AOS18-02] Subtropical Mode Water in a recent persisting Kuroshio large meander period. Part I: Formation and advection over the entire distribution region

*Eitarou Oka[1], Hatsumi Nishikawa[1], Shusaku Sugimoto[2], Bo Qiu[3], Niklas Schneider[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.Department of Oceanography, University of Hawaii at Manoa)

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

[AOS18-03] Subtropical Mode Water in a recent persisting Kuroshio large meander period. Part II: Formation and temporal evolution in the recirculation gyre off Shikoku.

*Hatsumi Nishikawa[1], Shusaku Sugimoto[2], Eitarou Oka[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Graduate School of Science, Tohoku University)

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

[AOS18-04] Increase in summer surface air temperature at the Kanto district attributable to Kuroshio large meander

*Shusaku Sugimoto[1], Bo Qiu[2], Niklas Schneider[2] (1.Graduate School of Science, Tohoku University, 2.The University of Hawaii)

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

[AOS18-05] Comparison of the processes of their response to the Kuroshio Large Meander between explosive cyclones that differ in the development type

*Hidetaka Hirata[1], Ryuichi Kawamura[2], Masami Nonaka[3] (1.Rissho University, 2.Kyushu University, 3.Japan Agency for Marine-Earth Science and Technology)

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

[AOS18-06] Why has the 2017 Kuroshio large meander lasted so long?

*Norihisa Usui[1], Nariaki Hirose[1], Yosuke Fujii[1], Nadao Kohno[1] (1.Meteorological Research Institute)

Impact of the 2017 Kuroshio Large Meander on the Decadal Kuroshio Extension Variability

*Bo Qiu[1], Shuiming Chen[1], Niklas Schneider[1], Eitarou Oka[2], Shusaku Sugimoto[3]

1. University of Hawaii at Manoa, 2. University of Tokyo , 3. Tohoku University

Decadal modulations of the Kuroshio Extension (KE) system between a stable and an unstable dynamic state in the western North Pacific have prevailed in the past three decades. This dominance of decadal variations is controlled by the negative feedback loop involving the wind-forced KE variability and its feedback onto the overlying extratropical stormtracks and the basin-scale surface wind field. The wind-forced decadal KE modulations were disrupted in August 2017 due to the development of the Kuroshio large meander south of Japan. By forcing the inflow KE paths northward and by avoiding override the shallow Izu Ridge, the Kuroshio large meander was able to compel rapidly the KE from the wind-forced, pre-existing, unstable state to a stable state. Following the large meander occurrence in late 2017, the stabilized KE change is found to affect the overlying stormtracks and the basin-scale wind field the same way as those generated by the wind-forced KE change prior to 2017. Given the consistent atmospheric response to both the large-meander-induced and wind-forced KE variability, we expect that the KE dynamic state will resume its decadal modulation after the phase reset relating to the 2017 large meander event.

Keywords: Kuroshio large meander, Kuroshio Extension, decadal variability

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Subtropical Mode Water in a recent persisting Kuroshio large meander period. Part I: Formation and advection over the entire distribution region

*Eitarou Oka[1], Hatsumi Nishikawa[1], Shusaku Sugimoto[2], Bo Qiu[3], Niklas Schneider[3]

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The current Kuroshio large-meander (LM) period, which started in August 2017, has exceeded three years, being second longest only to the 1975-80 occurrence. This study aims to examine how the current persisting LM has impacted the formation and advection of Subtropical Mode Water (STMW), based on observation data.

In the 137E section maintained by the Japan Meteorological Agency since 1967, the cross-sectional area of STMW had fluctuated decadally from mid-1970s to 2016 with an increase (decrease) during the stable (unstable) period of the Kuroshio Extension (KE; Oka et al., 2019). The KE transitioned from the stable state to the unstable state in mid-2016, following the start of a warm PDO phase in 2014, but unexpectedly switched back to the stable state in mid-2017 due to the LM occurrence (Qiu et al., 2020). Nevertheless, the cross-sectional area of STMW has continuously decreased since 2016, exhibiting a tendency different from the previous stable-KE periods. This might be due to the decrease of westward STMW advection from the region south of the KE to the region south of Japan in association with the LM (Suga and Hanawa, 1995), the decrease of STMW formation south of the KE, or both.

We next analyzed Argo float data during 2005-20. Out of STMW defined as low-potential vorticity water of 16-19.5C, a relatively cold variety of 16-18C, which is formed south of the KE, occupied more than 80% of the total volume. The formation volume of the 16-18C STMW was small during 2006-09 in the unstable KE period and large during 2010-15 in the stable KE period, leading to a decrease (increase) of its volume in the former (latter) period. In 2016, anomalously shallow and warm winter mixed layers were formed south of the KE, drastically decreasing the STMW formation volume. In 2018-20 after the current LM began, the formation volume of the 16-18C STMW has not restored to large amount despite the stable KE, being intermediate between the 2006-09 small and 2010-15 large values. In addition, since the current LM began, the 16-18C STMW has had to make a southern detour as indicated by previous studies, which led to the significant decrease of its westward advection from the formation region south of the KE to the region south of Japan. Due to such decline in the formation and advection, the total volume of STMW has gradually decreased since 2016.

Keywords: Subtropical Mode Water, Kuroshio large meander, Kuroshio Extension

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Subtropical Mode Water in a recent persisting Kuroshio large meander period. Part II: Formation and temporal evolution in the recirculation gyre off Shikoku.

*Hatsumi Nishikawa[1], Shusaku Sugimoto[2], Eitarou Oka[1]

1. Atmosphere and Ocean Research Institute, University of Tokyo, 2. Graduate School of Science, Tohoku University

The Kuroshio large meander (LM) since in August 2017 has continued for more the 3 years for the first time in 40 years. When the Kuroshio took a meandering path (i.e., a typical large meander path and an offshore non-large-meander path), an anomalously warm Subtropical Mode Water (STMW) exceeding 19℃ was formed in the recirculation gyre off Shikoku, forming a two-layer structure with a colder STMW formed in the previous years (Sugimoto and Hanawa, 2014), although each meandering period examined in the preceding study spanned only one year. This study aims to examine how an LM event longer than 2 years influences the formation and temporal evolution of STMW in the recirculation gyre off Shikoku, based on the data from Argo floats, satellite altimeter, and shipboard observation.

In spring 2017 before the Kuroshio large meander began, a single STMW layer with thickness of 400m and temperature of 18℃, which was thought to be formed in the late winter 2017, existed at depths of 100-500 m in the recirculation gyre off Shikoku. In the late winter 2018 after the current LM began, warm STMW with temperature exceeding 19℃ was formed to 300m depth, while the STMW layer formed in the previous year shifted downward to the depths of 350-650m, forming a two-layer structure. The shallower warmer STMW layer was not renewed in the late winter of 2019 due to insufficient mixed layer development, persisting for nearly 2 years, and then renewed in the late winter of 2020. The deeper STMW layer formed in the late winter of 2017 survived until 2020 while its thickness gradually decreased to 200 m. The two-layer structure of STMW was thus maintained.

A shipboard CTDO_2 profile obtained by the Japan Meteorological Agency near the center of the recirculation gyre in June 2018 clearly captured the two-layer structure. Apparent oxygen utilization at the potential vorticity minima in the shallower and deeper STMW layers was 0.2560 ml/l (236 m) and 0.4229 ml/l (545 m), respectively. The oxygen utilization rate estimated from their difference was 0.1669 ml/l/yr, which was much smaller than values presented by previous studies. This is presumably because the STMW layer formed in 2017 shifted to the greater depths where oxygen consumption was slow, and because the dissipation of the STMW trapped and isolated in the recirculation gyre was slow.

Keywords: Subtropical Mode Water, Kuroshio large meander, recirculation gyre off Shikoku

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Increase in summer surface air temperature at the Kanto district attributable to Kuroshio large meander

*Shusaku Sugimoto[1], Bo Qiu[2], Niklas Schneider[2]

1. Graduate School of Science, Tohoku University, 2. The University of Hawaii

The summer climate in the Kanto district, Japan, including Tokyo, where has 40 million inhabitants, is characterized by high temperature and humidity. The Kuroshio that flows off the southern coast of Kanto district has taken a large meander (LM) path since the summer of 2017, which is still continuing after three and a half years. It has been recognized that the cool water pool is broadly distributed in the onshore region between the Kuroshio and the southern coast of Kanto-Tokai district during the LM path period. Recently-developed satellite observations detected marked coastal warming off the Kanto-Tokai district during the LM path period. In this study, we conducted regional atmospheric model experiments to quantitatively assess the influence of LM-induced coastal warming on the summer climate of Japan via atmospheric responses. Results indicated that summertime coastal warming increases water vapor in the low-level atmosphere through enhanced evaporation from the ocean and influences near-surface winds via the vertical mixing effect over the warming area. These two changes induce an increase in water vapor in Kanto district, leading to an increase in downward longwave radiation at the surface and then surface warming through a local greenhouse effect. Resultantly the summer in Kanto district becomes increasingly hot and humid in LM years, with double the number of discomfort days compared with non-LM years. Our simulations and supplementary observational studies reveal the significant impacts of the LM-induced coastal warming on the summertime climate in Japan, which can exceed previously identified atmospheric teleconnections and climate patterns. Our results could improve weather and seasonal climate forecasts in this region.

Keywords: Kuroshio large meander, Hot summer, Kanto district, Greenhouse effect, Discomfort index

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Comparison of the processes of their response to the Kuroshio Large Meander between explosive cyclones that differ in the development type

*Hidetaka Hirata[1], Ryuichi Kawamura[2], Masami Nonaka[3]

1. Rissho University, 2. Kyushu University, 3. Japan Agency for Marine-Earth Science and Technology

Recent studies pointed out that the Kuroshio Large Meander affects the development of extratropical cyclones. However, the processes related to the cyclones' response to the Kuroshio Large Meander are still under debate. This study conducted multiple numerical sensitivity experiments with respect to sea surface temperature (SST) and examined the processes of their response to the Kuroshio Large Meander between extratropical cyclones that differ in the type of the intensification. We focused on two explosively developing extratropical cyclones: One is a cyclone that developed mainly due to the diabatic process (case 1), and the other is a cyclone that intensified primarily due to the baroclinic process (case 2). In both cases, the decreases in the central pressure of cyclones were suppressed in experiments with cold SST anomalies associated with the Kuroshio Large Meander path, compared with experiments with warm SST anomalies associated with the Kuroshio Straight path. Thus, the response of the cyclone central pressure to the SST anomalies of cases 1 and 2 were similar. However, primary causes leading to the cyclones' response differed between the two cases. In case 1, the SST anomalies derived from the variation of the Kuroshio path influenced the time evolution of the cyclone central pressure through the diabatic process. On the other hand, in case 2, the SST anomalies affected the central pressure via the baroclinic process. These results suggest that the main process causing the cyclones' response to the Kuroshio Large Meander varies owing to the development types.

Keywords: Explosive cyclone, Kuroshio Large Meander, Cloud Resolving Model

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Why has the 2017 Kuroshio large meander lasted so long?

*Norihisa Usui[1], Nariaki Hirose[1], Yosuke Fujii[1], Nadao Kohno[1]

1. Meteorological Research Institute

The Kuroshio large meander (KLM) occurred in the end of August 2017 for the first time in 12 years. It is still maintained in February 2021, although it became unstable and a cyclonic eddy was detached in the late 2020. The duration of the 2017 KLM exceeds three years, which is the second longest after the KLM in 1975-1980. Former studies have suggested that duration of the KLM is correlated with the Kuroshio transport and a lower transport leads to a longer duration of the KLM. In fact, the observed Kuroshio transport south of Japan has been relatively low since 2017, when the current KLM was formed. The Kuroshio transport diagnosed by a 1.5-layer reduced gravity model driven by the wind stress field of the atmospheric reanalysis also shows a low transport state, suggesting that the low Kuroshio transport caused by the wind stress field in the North Pacific is a possible cause for the long duration of the 2017 KLM. Former studies have also pointed out that the Kuroshio transport increased when past large meanders such as KLMs in 1975-1980 and 2004-2005 decayed. There is currently no signal in the wind stress field to significantly increase the Kuroshio transport. In the presentation, we would like to discuss the characteristics of the wind stress fields in the North Pacific leading to the low Kuroshio transport and their relation to climate indices.

Keywords: Kuroshio large meander, Kuroshio transport, Wind stress

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.03_3

[A-OS18] Kuroshio Large Meander

convener:Toru Miyama(Japan Agency for Marine-Earth Science and Technology, Application Laboratory), Norihisa Usui(Meteorological Research Institute), Hidetaka Hirata(Rissho University), Takashi SETOU(Japan Fisheries Research and Education Agency)

The Kuroshio Large Meander that started in August 2017 is the second longest historic event in the observed record, next to the event in 1975-1980 (4 years and 8 months). In October 2020, a massive eddy separation occurred, and the Kuroshio path is beginning to take shape in a way that has not been seen before. There are strong public interests on the possible impacts of the Kuroshio Large Meander on fisheries and other phenomena along the coast. However, the actual impacts have not been well investigated. In addition, new findings such as the impacts of the Kuroshio Large Meander on weather are emerging. This session aims to shed light on this intriguing phenomenon by discussing its trends, dynamics, impacts, and comparison with past examples. Presentations from a variety of perspectives in the fields of ocean physics, biology, chemistry, and atmospheric effects will be welcomed.

[AOS18-P01] Characteristics and evolution of the cyclonic eddy in the Kuroshio coastal area in association with the Kuroshio large meander

★Invited Papers

*Daiki Ito[1], Takashi Setou[1], Daisuke Ambe[1], Yugo Shimizu[1,2] (1.Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 2.(Present affiliation) Fisheries Agency)

[AOS18-P02] The relationship between Kuroshio meander and observed tidal-regime shift along southern coast of Japan

*Takumi Kamura[1], Hiromi Matsuura[1], Katsuto Uehara[2] (1.Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Research Institute for Applied Mechanics, Kyushu University)

[AOS18-P03] Eddy separation from the Kuroshio Large Meander in 2020

*Toru Miyama[1], Yasumasa Miyazawa[1], Sergey M Varlamov[1], Zhang Ruochao[1] (1.Japan Agency for Marine-Earth Science and Technology, Application Laboratory)

[AOS18-P04] Study on the temporal and spatial variation of the Kuroshio Current path

*Yuya Hirano[1], Kazuyuki Uehara[1] (1.Graduate School of Earth Environmental Science, Tokai University)

[AOS18-P05] Impact of a Marine Heatwave Attributable to a Kuroshio Large Meander on Extreme Heavy Rainfall Caused by an Extratropical Cyclone

*Eigo Tochimoto[1], Satoshi Iizuka[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[AOS18-P06] The Kuroshio volume transport in near future estimated by Reduced Gravity model

*Takashi SETOU[1], Akira KUSAKA, Daisuke Ambe, Daiki Ito[1], Takashiko Kameda (1.Japan Fisheries Research and Education Agency)

Characteristics and evolution of the cyclonic eddy in the Kuroshio coastal area in association with the Kuroshio large meander

*Daiki Ito[1], Takashi Setou[1], Daisuke Ambe[1], Yugo Shimizu[1,2]

1. Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 2. (Present affiliation) Fisheries Agency

The Kuroshio coastal area, which is located between the south coast of Japanese islands and the Kuroshio, is nutrient-rich and becomes a major spawning grounds of various fishes. This area is occupied by the cyclonic eddy in association with the Kuroshio large meander. Therefore, during the Kuroshio large meander period, dynamical structures and evolutions of the cyclonic eddy greatly influence the marine resources and fisheries through the variation of the marine environment such as temperature, salinity (*S*) and dissolved materials. In addition, previous studies have demonstrated that the dynamical evolution of the cyclonic eddy is a key factor to predict the generation and decay of the Kuroshio large meander. While the monitoring and analysis of the cyclonic eddy are necessary in understanding of the dynamical processes and the variability of the marine resources, studies based on the observation are limited. To examine the characteristics and evolution of the cyclonic eddy in the Kuroshio coastal area in association with the Kuroshio large meander, we conducted hydrographic surveys in and around the cyclonic eddy and its upstream region in September 2020, along with analyzing fixed line observation data along 138˚E during the Kuroshio large meander period. The low-*S*and high-potential vorticity (*Q*) water in the surface layer was found in the Kuroshio coastal area from the small meander southeast of Kyushu to the cyclonic eddy. The high-*Q* water was in the similar density range, suggesting the supply of high-*Q* water into the cyclonic eddy from the upstream region. On the other hand, a cold eddy pinched off from the cyclonic eddy had a core of high-*Q* in the different density range from the cyclonic eddy. Eddy-eddy interaction associated with the Kuroshio large meander was discussed using the observation data, with particular attention to the magnitude of *Q*, the depth of cores, and the size of eddies. Moreover, the analysis of the fixed line observation data along 138˚E showed the temporal variation of *Q* in the cyclonic eddy from 2017 to 2021.

Keywords: Potential vorticity, Small meander, Eddy-eddy interaction

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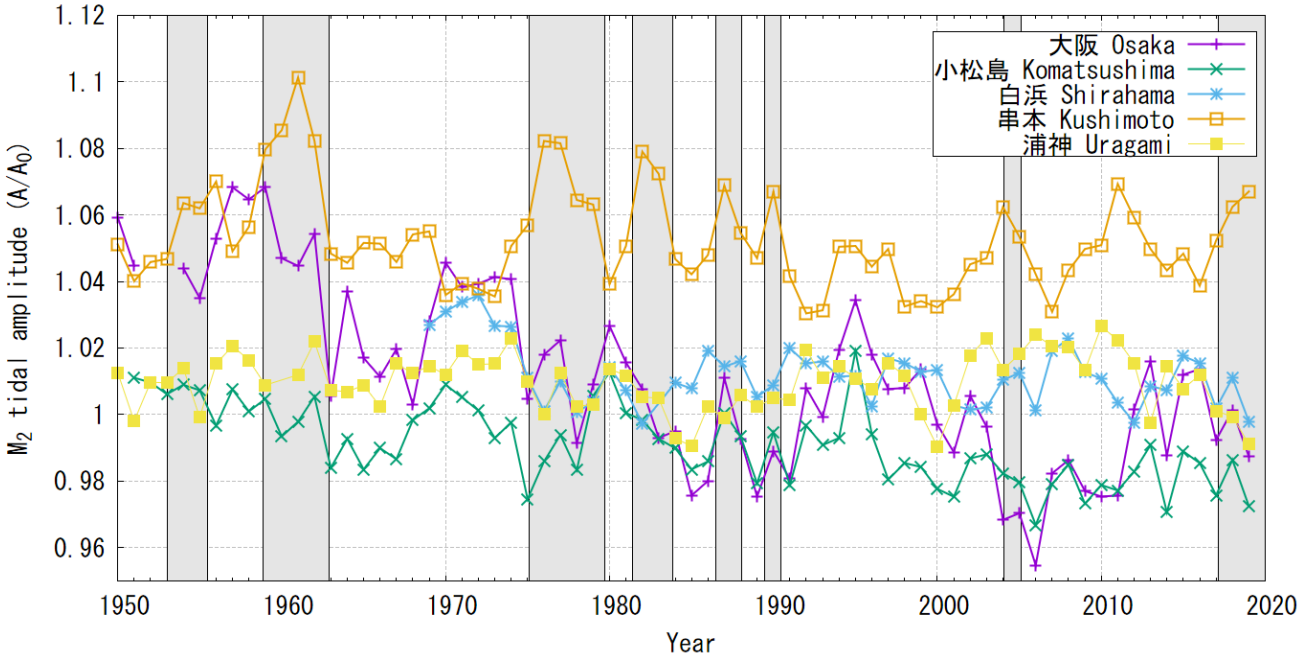
The relationship between Kuroshio meander and observed tidal-regime shift along southern coast of Japan

*Takumi Kamura[1], Hiromi Matsuura[1], Katsuto Uehara[2]

1. Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2. Research Institute for Applied Mechanics, Kyushu University

Relationships between the Kuroshio meander and tidal changes over decadal time scales along Japanese coasts, which has not been well verified compared to the relationship between the meandering phase and the sea-level difference, were studied by conducting harmonic analyses of sea levels at five tide-gauge stations north of the major Kuroshio meandering region, Osaka, Komatsushima, Shirahama, Kushimoto, and Uragami, for duration from 1950 to 2019. It was found that at Kushimoto located on the western side of the southern end of the Kii Peninsula, M2 tidal amplitudes increased intermittently by about 4%, which have taken place at irregular intervals ranging from years to decades, and that the timing of such events coincided with the occurrence of the Kuroshio meander. This result indicates a relation between changes in coastal tides and the Kuroshio path.

Keywords: Kuroshio meandering, tides, sea level



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Eddy separation from the Kuroshio Large Meander in 2020

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The Kuroshio Large Meander has been continuing since 2017. The large eddy was detached from the Meander in October 2020. The Large Meander temporarily ended. Correspondingly, Kushimoto-Urakami sea level difference, whose smallness is an indicator of the Large Meander, increased. Subsequently, the small meanders that existed east of Kyushu developed into the Large Meander by moving eastward and replacing the previous eddy, resulting in the continuation of the Large Meander. The Kushimoto-Urakami sea level difference decreased again. Alternatively, the eddy detached moved westward and formed a small meander by joining the Kuroshio southeast of Kyushu from the end of January to the beginning of February 2021. This behavior is different from the eddy HARUKAZE after the Harukaze Maru of the Kobe Marine Observatory, which was observed it in 1978 during the great Kuroshio Large Meander period of 1975–1980. In 2020, the Kuroshio Large Meandering Current was in a state of instability. Therefore, several small eddies shredded before the large eddy detachment described above. The instability was due to the small meander east of Kyushu and high sea level anomaly extended from the Kuroshio Extension. In this presentation, I will discuss the dynamics and predictability of the unstable Kuroshio Large Meander.

Keywords: kuroshio Large Meander, Eddy, ocean reanalysis, predictability

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Study on the temporal and spatial variation of the Kuroshio Current path

*Yuya Hirano[1], Kazuyuki Uehara[1]

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Kawabe (1995) classified the Kuroshio flowing along the southern coast of Honshu into three flow patterns: non-Large-Meander path (nearshore and offshore) and Large-Meander path. After this study, studies has been reported to show pattern of the Kuroshio Current paths, but the time-varying characteristics of the flow pattern have not been discussed. In this study, we therefore extracted the flow paths from the sea surface dynamic height data, then conducted time-frequency analysis for the Kuroshio detachment distance from the coast. In the result, we found the clear difference in periodicity from east to west, with the Kii Peninsula offshore as a border. West of the Kii Peninsula, the dominant peaks seen off southeast Kyushu at 30 days or less, 90-180 days, and 360 days gradually weakened while moved toward the Kii Peninsula. On the other hand, east of the Kii Peninsula, the stronger peaks with various periods were observed get closer to the Izu-Ogasawara Ridge.

Keywords: Kuroshio detachment distance, Wavelet analysis

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Impact of a Marine Heatwave Attributable to a Kuroshio Large Meander on Extreme Heavy Rainfall Caused by an Extratropical Cyclone

*Eigo Tochimoto[1], Satoshi Iizuka[1]

1. National Research Institute for Earth Science and Disaster Resilience

Extratropical / Tropical cyclones often cause extreme rainfall events over eastern coastal region characterized by a western boundary current and an extended coastal mountain range. On 12–13 April, 2020, extreme heavy rainfall event was occurred over the east of the Kii Peninsula, Japan. Concurrently, the Kuroshio large-meander started from 2017 caused the notable positive sea surface temperature (SST) anomalies along the coast south of Japan. The present study examines the impact of the positive SST anomaly on the heavy rainfall event associated with an extratropical cyclone using numerical experiments. The control simulation (CNTL) showed that strong low-level easterly winds associated with a cold conveyor belt in the northeast of the cyclone brought humid airmass toward east of the Kii Peninsula, resulting in strong updraft and local intense precipitation. A sensitivity experiment in which the SST anomalies attributable to the LM was removed showed at least 25 % reduction of the maximum precipitation for 3 hours because of the smaller latent and sensible heat fluxes from the sea surface compared to those in CNTL. Thus, the SST anomalies attributable to the LM contributed to the heavy rainfall. Furthermore, additional numerical experiment without the evaporation of rainwater and ice pieces indicated that cold air temperature from the near surface to middle troposphere over land were maintained by the evaporation and contributed to the persistent of horizontal temperature gradient along the coastal region. Our results suggest that air-sea interaction on synoptic- and meso-scale can drive extreme precipitation. We have confirmed that there was another heavy rainfall event affected by warm SST anomalies attributable to the meander of the Kuroshio south of Japan on 2 May 2012. A sensitivity experiment in which SST values are replaced by those for climate values showed the reduction of total precipitation for CLM from CNTL.

Keywords: Kuroshio Large Meander, Extratropical Cyclone, Extreme rainfall

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The Kuroshio volume transport in near future estimated by Reduced Gravity model

*Takashi SETOU[1], Akira KUSAKA, Daisuke Ambe, Daiki Ito[1], Takashiko Kameda

1. Japan Fisheries Research and Education Agency

In August 2017, for the first time in 12 years, the Kuroshio large meander event has occurred and is still continuing after three years and five months, making it the second-longest-lasting meander event in history among those that have occurred since 1970. Once the Kuroshio Meanders occur, the fishing environment in the surrounding seas will change and the fishing industry will be greatly affected. It is known that the duration of the Kuroshio large meander has an inverse linear relationship with the Kuroshio volumeflow transport, i.e., the lower the transport, the longer the duration (Usui et al. 2013). We has calculated the 137E eastward Kuroshio flow using a 1.5-layer Reduced Gravity model driven by wind stress, and then created a regression model to fit the 2017 Kuroshio Large Meander to the transport until 2020. As a result, it is estimated to continue for about 48 months, that is, until July 2021 (±7 months). However, as the transport will continue to be low in the future, there is a possibility that the large meander will become more prolonged.

Keywords: the Kuroshio large meander

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.13 Zoom Room 13

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Hiroto Nagai(Waseda Univ., School of Education)

Glaciology conducts academic research on snow and ice using a wide variety of methods such as observation, sampling, laboratory experiments, and numerical calculations. Since 2020 Coronavirus disease (COVID-19) pandemic has had a critical impact on the global society, whereas it may derive "new-normal" regimes. Glaciological studies have also had some impacts, such as the cancellation of scheduled overseas surveys and user number restriction in laboratories, but their severity depends on their study methods.
How long period of data lacking is allowed on long-term continuous observations? Is there another alternative approach? Will information and communication technologies that are rapidly becoming widespread for web meeting and/or remote work contribute for glaciological studies?
In this session, regular reports of research results are welcomed. In addition, in this year, we will share various issues caused by the pandemic and their solutions. Discussing the new normal of the glaciology, furthermore, we aim to contribute for developing a more resilient and sustainable academic community of glaciology than before.

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

[ACC25-01] Fieldwork under the COVID19 circumstances –Examples from Alaska and Siberia–

★Invited Papers

*Go Iwahana[1] (1.International Arctic Research Center, University of Alaska Fairbanks)

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

[ACC25-02] Mapping of permafrost distribution in mid-Amur basin by satellite data analysis and local vegetation research

*Yuto Tashiro[1], Muneoki Yoh[2], Takayuki Shiraiwa[3], Takeo Onishi[4] (1.Institute for Space Earth Environmental Research, Nagoya University, 2.Tokyo University of Agriculture and Technology, 3.Institute of Low Temperature Science, Hokkaido University, 4.Gifu University)

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

[ACC25-03] Observation at Ny-Alesund, Svalbard under the COVID-19 situation

★Invited Papers

*Junji Matsushita[1], Hiroshi Miyaoka[1] (1.National Institute of Polar Research)

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

[ACC25-04] Study of the formation of stratified firn on the snow surface near Dome Fuji, Antarctica, by multiple physicochemical analyses

*Ryo Inoue[1], Shuji Fujita[2,1], Kenji Kawamura[2,1,3], Jun Ogata[2], Motohiro Hirabayashi[2], Kaori Fukuda[2], Kyotaro Kitamura[2], Ayaka Yonekura[1], Kumiko Goto-Azuma[2,1], Fumio Nakazawa[2,1], Ikumi Oyabu[2], Hideaki Motoyama[2,1] (1.The Graduate University for Advanced Studies, 2.National Institute of Polar Research, 3.Japan Agency for Marine-Earth Science and Technology)

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

[ACC25-05] Evolution of supraglacial ponds at the southern Inylchek Glacier, Kyrgyz Republic

*Natsumi Homma[1], Chiyuki Narama[1], Naoki Sakurai[2] (1.Niigata Univ., 2.Aero Asahi Co.)

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

[ACC25-06] **The area fluctuations of short-lived glacial lake in the Teskey Range, Central Asia**

*Naho Yamada[1], Chiyuki Narama[1], Mirlan Daiyrov[2] (1.niigata university, 2.CAIAG)

Fieldwork under the COVID19 circumstances –Examples from Alaska and Siberia–

*Go Iwahana[1]

1. International Arctic Research Center, University of Alaska Fairbanks

This presentation introduces the impact of the COVID 19 pandemic on field research in Alaska and Siberia and the research communities' responses. Fairbanks, Alaska, where the presenter lives, is a base for fieldwork in terrestrial Alaska. Researchers across the United States and worldwide have used research infrastructure such as the University of Alaska. Since March 2020, out-of-state travelers have been required to quarantine themselves for two weeks. University of Alaska constituents have been working from home except for persons with special permits. In Alaska, fieldwork season usually starts before or after the snowmelt, and most field activities are carried out in the snow-free summer. However, COVID19 influenced all the fieldwork activities in the 2020 season. Alaska's local community, which is only accessible by plane, is particularly vulnerable to pandemics due to the limited healthcare resources. They placed substantial restrictions on external human traffic, and the research community could not conduct a field survey for the 2020 season. Besides, major scientific research foundations in the United States (NSF, DOE, etc.) restricted fieldwork also at research sites accessible by road from Fairbanks and Anchorage, which have international airports. Even if permitted, two weeks or more self-quarantine period hindered most out-of-state (including international) researchers to plan the fieldwork in Alaska. Under these circumstances, the presenter was allowed to conduct fieldwork in Fairbanks' vicinity and supported some field research activities for Japanese researchers who could not visit Alaska by themselves. On the other hand, the presenter could not conduct field surveys scheduled in Siberia and relied on collaborators' help to minimize the impact of COVID 19 on research plans. Having these experiences and comparing responses by various communities against the COVID 19 pandemic, the transition to "New Normal" in cryosphere studies, which often depends on field surveys, will be discussed.

Keywords: COVID19, Fieldwork, Alaska, Siberia

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Mapping of permafrost distribution in mid-Amur basin by satellite data analysis and local vegetation research

*Yuto Tashiro[1], Muneoki Yoh[2], Takayuki Shiraiwa[3], Takeo Onishi[4]

1. Institute for Space Earth Environmental Research, Nagoya University, 2. Tokyo University of Agriculture and Technology, 3. Institute of Low Temperature Science, Hokkaido University, 4. Gifu University

The Sea of Okhotsk is known as one of the world's richest marine ecosystems. This is because large amount of iron, an essential nutrient for the growth of phytoplankton, flows out of wetlands in the Amur River basin and supports to high primary productivity. In late 1990s, dissolved iron (dFe) concentration in the Amur river and its main tributaries increased dramatically. The reason for this is still unclear, but one possible reason may be permafrost degradation due to unusual high air temperatures in the late 1990s in Russian Far East. To consider this possibility, it is needed to understand iron dynamics in permafrost areas and reveal the permafrost distribution in Russian Far East.

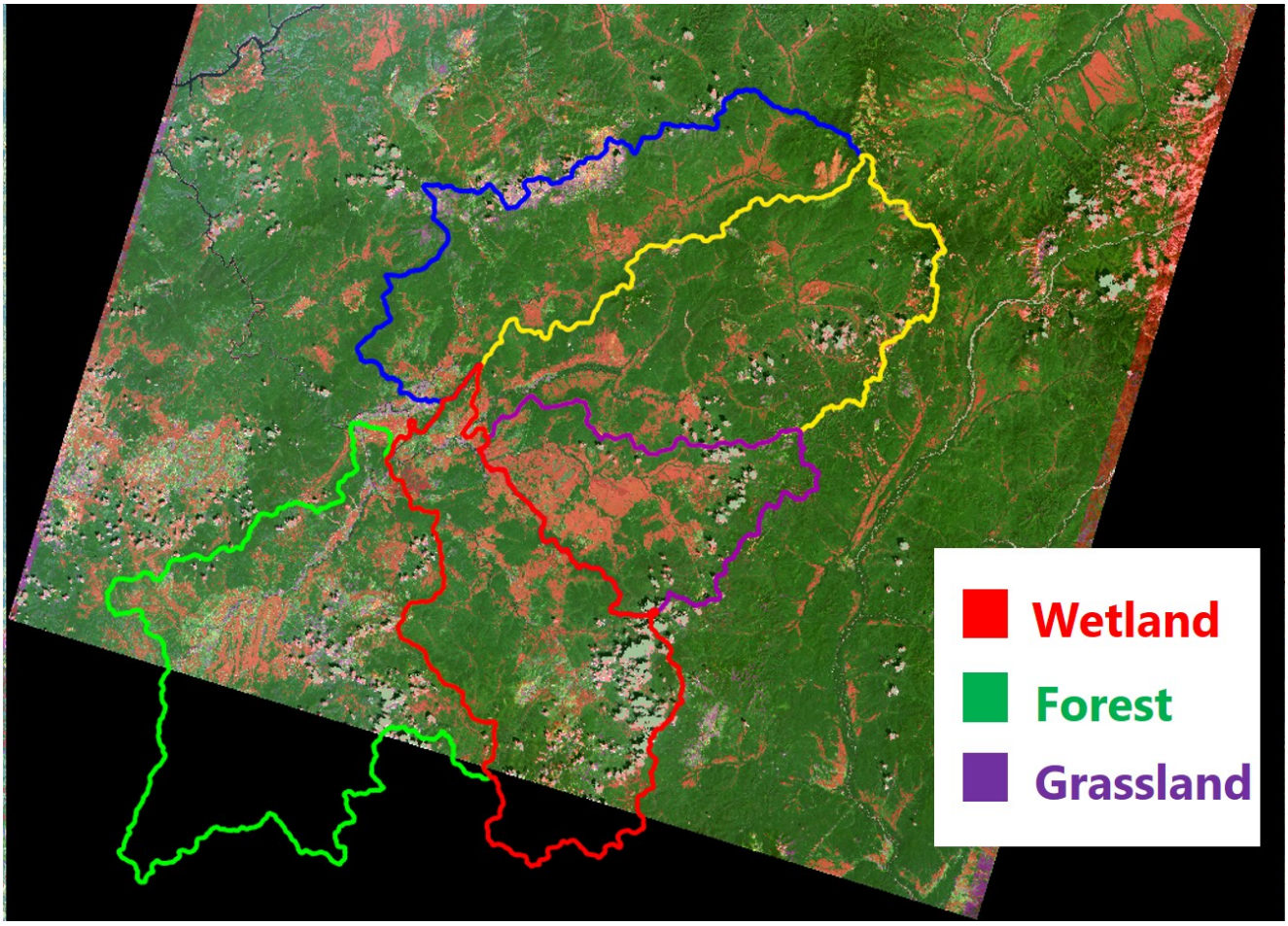
In the present study, we attempted to clarify the permafrost distribution in the Tyrma region of mid-Amur basin by using satellite data (Landsat-8) and conducting local field research. Tyrma is located in approximately 270 km northwest of Khabarovsk in the Russian Far East. Mean annual air temperature is −1.96 ℃ and annual precipitation is 654.6 mm.

Using the Landsat-8 satellite data, we calculated a normalized difference vegetation index (NDVI) and a normalized difference soil index (NDSI). Both values were summarized for typical vegetation types of wetlands, forests, and grasslands based on the local ground truth in the Tyrma region. In addition, we conducted cross-sectional field research in wetlands to confirm that permafrost continuously exists under wetlands. Landform, vegetation, soil condition, groundwater level, and permafrost existence were investigated by crossing wetland in valley area from near river to hillslope.

The range of NDVI and NDSI summarized for wetlands, forests, and grasslands were clearly different. Based on NDVI and NDSI, landcover distribution of wetlands, forests, and grasslands were extracted in the whole Tyrma region (Figure). Local field research revealed that permafrost continuously exists under wetlands, and the top layer of permafrost was confirmed at 60~80 cm depth. Therefore, permafrost will exist with high probability under the extracted wetlands in Fig.1 (Red area). Furthermore, we found that the greater the permafrost distribution area in catchment area, the higher dFe concentration in rivers, suggesting that permafrost existence strongly affects dFe discharge from land to river.

Keywords: Permafrost, Remote sensing, Wetland

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Observation at Ny-Alesund, Svalbard under the COVID-19 situation

*Junji Matsushita[1], Hiroshi Miyaoka[1]

1. National Institute of Polar Research

Located in Ny-Alesund, Svalbard, Norway (79N,12E), the Ny-Alesund NIPR Observatory was established after concluding an agreement for cooperation with the Norwegian Polar Institute (NPI) in 1991 as the Japan’s first high Arctic research station, so it marks the 30th anniversary this year. Under the international collaborative research framework in Ny-Alesund, the NIPR Obseravatory has been supporting a variety of studies such as clouds, aerosols, radiation, greenhouse gases, vegetation and ecologies in the high Arctic. In April 2019, the Observatory relocated to the brand new observation building ‘Kingsbay Veksthus’ which was constructed at the central area in Ny-Alesund. After the relocation, NIPR started to send a technical staff who stays at the Observatory to maintain facilities and supports for researchers.
Since March 2020, NPI and Kingsbay AS, in charge of management of the whole infrastructure in Ny-Alesund, started to apply the strict safety regulation to block the COVID-19 infections from the mainland and abroad. Due to this restriction, researchers and technicians have met a difficult situation, but we succeeded to send two researchers from NIPR to Ny-Alesund to maintain monitoring instruments, amid the pandemic outbreak in October by closely collaborating with NPI and the Norwegian Embassy in Tokyo.
The Arctic Environment Research Center (AERC), NIPR has been regularly updating these restrictions on immigration in Arctic countries. https://www.nipr.ac.jp/aerc/topics20200525.html
In this presentation, we will share our experience to maintain Ny-Alesund NIPR Observatory in the COVID-19 situation and some ideas for the coming operation in 2021.

Keywords: COVID-19, Ny-Alesund, Arctic

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Study of the formation of stratified firn on the snow surface near Dome Fuji, Antarctica, by multiple physicochemical analyses

*Ryo Inoue[1], Shuji Fujita[2,1], Kenji Kawamura[2,1,3], Jun Ogata[2], Motohiro Hirabayashi[2], Kaori Fukuda[2], Kyotaro Kitamura[2], Ayaka Yonekura[1], Kumiko Goto-Azuma[2,1], Fumio Nakazawa[2,1], Ikumi Oyabu[2], Hideaki Motoyama[2,1]

1. The Graduate University for Advanced Studies, 2. National Institute of Polar Research, 3. Japan Agency for Marine-Earth Science and Technology

The physicochemical properties of ice cores characterized on the surface of the ice sheet not only record past climate signals but also affect the densification and bubble formation processes of firn. For example, the impurity concentrations and microstructure such as developed vertical bonds of snow grains change the densification rate for each layer, controlling the degree of density variability. The density variability in deep firn changes the range of the bubble close-off zone, which would, in turn, affects the chronology and the degree of fractionation of gas components; e.g., when the bubble close-off zone is narrow, the age distribution at a depth is also narrowed and the amount of gas fractionation is reduced. Therefore, to better interpret paleoclimatic signals in ice cores, it is important to understand the physicochemical properties and their layering formation on the ice sheet surface.

To investigate and select a site for the third Dome Fuji deep core drilling, one of the base camp was placed at about 54 km south of the Dome Fuji station (tentatively named as NDF , 77°47’ 18S, 39° 3’ 15E, 3763 m a.s.l.), where a 152-m firn core was collected in December 2017. In this area, the accumulation rate is extremely low, and the surface snow is affected by sublimation and condensation for a long period. We performed multiple high-resolution (2.5-20 mm depth increment) continuous measurements of physical and chemical properties on this core. The properties include (1) density measured by a gamma-ray absorption method, (2) microwave permittivity ε as a proxy for density, (3) dielectric anisotropy $\Delta\varepsilon$ as a proxy for vertical elongation of ice and pore spaces, (4) reflectance R for near-infrared light as a proxy for specific surface area, and (5) water stable isotope ratios $\delta^{18}O$, δD, (6) concentration of major elements (Na, Mg, Al, S, K, Ca, Fe) measured by a continuous flow analysis system. Here, we mainly focus on the surface roughly down to a depth of 10 m.

We found significant positive correlations between ρ, ε, $\Delta\varepsilon$, R, $\delta^{18}O$, and δD, calculated within 1-m segments, near the surface. We also found significant negative correlations between these properties and the concentration of all the major elements, although impurities in the precipitation must show different seasonal fluctuations. Hoshina et al. (2016) suggested that the negative correlations between impurity concentrations and $\delta^{18}O$ at low-accumulation site can be formed by long-term sublimation and condensation within snow and between snow and atmosphere, which alter the original signal. However, the detailed process has not been clarified. In the JpGU presentation, we will discuss the snow deposition and sublimation-condensation process that alter the impurity concentrations and water stable isotope ratios, considering the development of density and microstructure of firn.

Keywords: Firn, Densification, Surface snow, Dome Fuji

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Evolution of supraglacial ponds at the southern Inylchek Glacier, Kyrgyz Republic

*Natsumi Homma[1], Chiyuki Narama[1], Naoki Sakurai[2]

1. Niigata Univ., 2. Aero Asahi Co.

A debris-covered glacier has ablation zone covered by debris produced from the rock walls around the glacier. Supraglacial lake develops on the debris glacier. Some supraglacial lakes are connected by englacial conduits. They appear and expand when the canals are closed, and a large drainage occurs from connected glacial lakes simultaneously when the canals are opened. (Sakurai et al., 2020).
Recently, outburst floods from several supraglacial lakes have caused disasters in the Asian mountains, and damages in the downstream villages. An increase in supraglacial lake which assumed to be in response to a warmer climate and glacier surface lowering, has been observed in recent decades in the Tien Shan and eastern Himalaya (Wang et al., 2013). The disasters associated with outburst floods from supraglacial lakes will be increasing in these areas.
It is important to assess the likelihood and magnitude of such events for flood risk management. In most cases, this requires an understanding of the drainage scale impounded in the lake, the structural of network and development process of the basin (Cook and Quincey, 2015).
Therefore, in this study, we investigated the topographical characteristics of the lake basin and its topographical changes using satellite images and UAV aerial images.

Keywords: debris-covered, supraglacial ponds, englacial conduit

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The area fluctuations of short-lived glacial lake in the Teskey Range, Central Asia

*Naho Yamada[1], Chiyuki Narama[1], Mirlan Daiyrov[2]

1. niigata university, 2. CAIAG

In the northern part of the Tien Shan Mountains (Kyrgyz Republic), many short-lived glacial lakes that appear and disappear within a few months are confirmed. Large-scale floods from short-lived glacial lakes have caused serious damages to the surrounding area. In the Tong district of the Teskey Range of this study area, five large-scale debris flows related to short-lived lakes have been reported since 2006 (Narama et. al., 2018; Daiyrov et al., 2020). Short-lived glacial lakes are formed by the closure of ice tunnels inside of moraine-complex, due to the freezing of stored water or deposition of ice-debris. In addition, short-lived glacial lakes appeared due to the influx of glacial meltwater (Daiyrov et al., 2020). However, there are no research reports that area changes of short-lived glacial lakes are related to the balance between inflows and outflows. In this study, we investigated the area changes of short-lived glacial lakes in the Tong district using satellite images (PlanetScope) in June-September 2017-2020.

Keywords: Glacial lake, Glacial lake outburst flood, Satellite images, Short-lived glacial lake, Tien Shan

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.13 Zoom Room 13

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

Glaciology conducts academic research on snow and ice using a wide variety of methods such as observation, sampling, laboratory experiments, and numerical calculations. Since 2020 Coronavirus disease (COVID-19) pandemic has had a critical impact on the global society, whereas it may derive "new-normal" regimes. Glaciological studies have also had some impacts, such as the cancellation of scheduled overseas surveys and user number restriction in laboratories, but their severity depends on their study methods.
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10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACC25-07] The formation environment of glacier-derived rock glacier in the Tien Shan, Central Asia

*Shun Okuyama[1], Chiyuki Narama[2], Akiko Yamamura[3], Hideyuki Takadama[4], yamanokuti Tsutomu[5] (1.Graduate Student,Niigata Univ., 2.Niigata Univ., 3.Aero Asahi Co., 4.PASCO Co., 5.Remote Sensing Technology Center of Japan)

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

[ACC25-08] Collapse of snow patch in the Hakuba-Daisekkei, northern Japanese Alps

*Ryoji Yoshimura[1], Chiyuki Narama[1] (1.Niigata Univ.)

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

[ACC25-09] Characteristics of topography where glaciers can exist in the northern Japanese Alps

*Kenshiro Arie[1], Chiyuki Narama[1], Kotaro FUKUI[2], Hajime IIDA[2], Ryohei Yamamoto[3] (1.Niigata University, 2.Tateyama Caldera Sabo Museum, 3.Aero Asahi corporation)

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

[ACC25-10] Seasonal and altitudinal variations in snow algal bloomings in Mt. Gassan in Yamagata prefecture, Japan

*Takumi Suzuki[1], Nozomu Takeuchi[1] (1.Chiba University)

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

[ACC25-11] Research life under COVID19 in Colorado, USA

★Invited Papers

*Uetake Jun[1] (1.Field Science Center for Northern Biosphere, Hokkaido University)

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

[ACC25-12] Discussion

The formation environment of glacier-derived rock glacier in the Tien Shan, Central Asia

*Shun Okuyama[1], Chiyuki Narama[2], Akiko Yamamura[3], Hideyuki Takadama[4], yamanokuti Tsutomu[5]

1. Graduate Student,Niigata Univ., 2. Niigata Univ., 3. Aero Asahi Co., 4. PASCO Co., 5. Remote Sensing Technology Center of Japan

Rock glacier is composed of permafrost mixed with ice and debris, and flows by deformation of internal ice as well as glacier. The formation of rock glacier requires climatic constraints such as temperature and precipitation, mechanical constraints such as the supply of debris from the rock wall behind the glacier, and the existence of a debris deposit site at the base of the rock wall (Barsch, 1992; Ikeda and Yoshikawa, 2008). Rock glaciers are classified into "talus-derived type" and "glacier-derived type" based on the difference in the source of debris and internal ice (Matsuoka, 1998). The "talus-derived type" is a type in which residual snow or underground water becomes a source of permafrost, and develops on the cliff formed by gravel supplied from the bedrock behind it. The "glacier-derived type" is a type in which a glacier exists superior of a rock glacier, and develops from glacier ice and meltwater from the glacier. The distribution of "glacier-derived type" rock glaciers is limited, and its development process is not clear. Study area is unique in that "glacier-derived type" rock glacier account for about 60% of all rock glacier. In this study, we attempted to clarify the spatial distribution and formation conditions of "glacier-derived type" rock glacier in the Kyrgyz Range in the northern Tien Shan Mountains using satellite image analysis.

Keywords: rock glacier, mountain permafrost, glacier, DInSAR, Tien Shan

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Collapse of snow patch in the Hakuba-Daisekkei, northern Japanese Alps

*Ryoji Yoshimura[1], Chiyuki Narama[1]

1. Niigata Univ.

In the Chubu Mountains, the winter season from autumn 2015 to spring 2016 and the spring from autumn 2019 to spring 2020 have been the years with little snowfall even in the past few decades. As a result, in Hakuba-Daisekkei, which is located in Hakuba-mura, Kitaazumi-gun, Nagano Prefecture, the snow patch rapidly became unstable and collapsed.The trail was closed despite the climbing season due to the increased risk of the snow patch collapse.
Snow patch collapse is a phenomenon in which a cavity such as an ice tunnel is formed at the snow bottom and the upper part collapses. Climbers should avoid unstable areas to prevent accidents due to the collapse of snow patches. However, the underground topography of the bottom of the snow patch has not been elucidated, and the location of the ice tunnel that causes the snow patch to collapse and the unstable location where the snow patch is likely to collapse are unknown.
Therefore, in this study, we carried out ground penetrating radar exploration in Hakuba-Daisekkei and estimated the location of the ice tunnel formed in the main stream by restoring the underground of the snow patch. In addition, by creating ortho-images and DSM from aerial images taken multiple times using SfM-MVS technology, we considered the topographical features of the points where ice tunnels are formed.

Keywords: Hakuba-Daisekkei, collapse of snow patch, GPR, UAV, stress analysis

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Characteristics of topography where glaciers can exist in the northern Japanese Alps

*Kenshiro Arie[1], Chiyuki Narama[1], Kotaro FUKUI[2], Hajime IIDA[2], Ryohei Yamamoto[3]

1. Niigata University, 2. Tateyama Caldera Sabo Museum, 3. Aero Asahi corporation

Many perennial snow patches are distributed in the northern Japanese Alps due to the coastal area of the Sea of Japan experiences the heaviest snowfall worldwide (Asahi, 2013). In recent years, seven glaciers were confirmed in the northern Japanese Alps (e.g., Arie et al., 2019). The formation of glaciers and perennial snow patches needs particular environments that acquire the large amounts of snow accumulation in the northern Japanese Alps' current climatic environment. The distributions of glaciers and perennial snow patches in the northern Japanese Alps are limited to places where has special conditions such as snow supply due to avalanche (Higuchi, 1968). Hughes (2008) proposed that a high value of the ratio (avalanche-ratio) of the total avalanche-release area (> 30-degree slope gradient area in the glacier catchment) to the total glacier area indicates a strong avalanche contribution to glacier accumulation. This study compared the catchment area and avalanche ratio of glaciers and perennial snow patches with an area of >10000 m2 in the northern part of the northern Japanese Alps.

Keywords: Glacier, Avalanche, SfM, Mass barance

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Seasonal and altitudinal variations in snow algal bloomings in Mt. Gassan in Yamagata prefecture, Japan

*Takumi Suzuki[1], Nozomu Takeuchi[1]

1. Chiba University

Snow algae are photosynthetic microbes growing on melting snow surface. Bloomings of snow algae can be commonly observed on alpine snow in Japan during melting season and vary in color such as red, green and yellow. Previous studies showed that red snow appears under oligotrophic conditions with strong sunlight, and green snow appears under eutrophic conditions with weak sunlight (Thomas and Duval, 1995). In Mount Gassan in Yamagata Prefecture, Japan, green and yellow snow appears every year on the snow surface of the floor of broad-leaved forests. However, it is not known how the algal bloomings are distributed in alpine snow and changes with seasons. It is necessary to understand their distribution and seasonal changes in order to understand the conditions of snow algal blooming. Therefore, we aim to describe the seasonal and altitudinal variations of this bloomings and to determine the factors to induce them.

In this study, we collected colored snow from the lower deciduous forest to the upper alpine area above tree line in the period from May to July of 2019 at Mt. Gassan in Yamagata prefecture, Japan. From the collected snow, we measured the chlorophyll *a* concentration, the cell volume biomass (biovolume) of snow algae, and the absorption spectra of the algal pigment extracted from the samples. In addition, in order to determine the cause of the algal blooming, we analyzed the nutrient concentration and calculated the coverage of the forest using aerial images of satellite and drones.

Chlorophyll *a* concentration in the colored snow continuously increased at all of the sites from May to July, especially significant increase occurred at the lower area in the forest. Chlorophyll *a* in the alpine area increased in July, but it was significantly lower than the forest site. Multiple snow algal cells with different morphologies were observed by microscopic analyses. The composition of morphological types of snow algae differs between the alpine area and the forest area. In addition, as the season progressed, the dominant algal types changed at the all of sites. The absorption spectra of algal pigments extracted from the samples can be mainly divided into three types (red, green, and orange types) according to their spectral curve. These types are likely to be due to different pigment composition contained in algal cells. The snow type changed with altitude, red type appeared only in the alpine area, and the green type predominated in the forest area. As the season progressed, red type increased in the alpine area, and green type increased in the forest area. The orange type appeared only at low altitudes in the forest area in the early melting season.

We compared the altitudinal distribution of chlorophyll *a* concentration, cell type composition, nutrient concentration and the coverage of the forest leave above the snowy floor. Results showed that the nutrients are likely to be sufficiently supplied to the snow surface at all of the sites, but the vegetation changed with the altitude. The light conditions appear to differ significantly between above and below the tree line in the study area. Solar radiation was more intense on the snow surface in the alpine area than in the forest. The difference of dominant type of snow algae between alpine and forest areas is probably due to such light condition. In the alpine area, the production of red pigments was promoted against the intense radiation. On the contrary, in the forest area, the light conditions may be suitable for algal growth and thus the red pigment may not have been produced. Furthermore, the increase of chlorophyll *a*

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concentration in the forest area may be due to coming into leaf of trees, which shade and reduce the solar radiation on the snow surface at the forest floor. These results suggest that the presence of trees and their timing of coming into leaf are largely control the appearance of colored snow in this area.

Keywords: Snow algae, Bloomings of snow algae

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Research life under COVID19 in Colorado, USA

*Uetake Jun[1]

1. Field Science Center for Northern Biosphere, Hokkaido University

Coronavirus disease 2019 (COVID-19), started from Wuhan, China in December 2019, was spread all over the world very rapidly. Even after more than one year from the first report (written on 3 February 2021), pandemics have never been unrestrained.
In this presentation, I will report the research situation and activities under COVID-19 at Colorado State University (CSU), where I had worked as a Research Scientist by the end of 2020. After the pandemic surged, even all staff worked remotely at their homes, online workshops about COVID-19 was organized every week by faculty staff in the CSU. That impressed me (as a typical Japanese scientist) how quickly scientists organized the community and developed new sciences. In November 2020, CSU started operating the system to detect SARS-CoV-2 from sewage in campus facilities and saliva from staff, then from December, all staff working on the campus were screed every week by PCR test. The minimum human resources very well organized the testing. Otherwise, Japanese quarantine in the Narita Airport was unorganized because there was too much staff, and they were using the paper form in this digital era. That reminded me the social structural difference between the two countries.
Additionally, I will introduce our study, which was released during COVID-19 and Black Lives Matter activities. Probably due to under those negative atmosphere, that was unexpectedly spread over the multimedia worldwide as "Scientists say they have found the cleanest air on Earth"

Keywords: SARS-CoV-2, COVID-19, Research in the USA

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-CC Cryospheric Sciences & Cold District Environment

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.13 (Zoom Room 13)

Glaciology conducts academic research on snow and ice using a wide variety of methods such as observation, sampling, laboratory experiments, and numerical calculations. Since 2020 Coronavirus disease (COVID-19) pandemic has had a critical impact on the global society, whereas it may derive "new-normal" regimes. Glaciological studies have also had some impacts, such as the cancellation of scheduled overseas surveys and user number restriction in laboratories, but their severity depends on their study methods.

How long period of data lacking is allowed on long-term continuous observations? Is there another alternative approach? Will information and communication technologies that are rapidly becoming widespread for web meeting and/or remote work contribute for glaciological studies?

In this session, regular reports of research results are welcomed. In addition, in this year, we will share various issues caused by the pandemic and their solutions. Discussing the new normal of the glaciology, furthermore, we aim to contribute for developing a more resilient and sustainable academic community of glaciology than before.

12:00 PM - 12:15 PM

[ACC25-12]Discussion

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.04_1

[A-CC25] Glaciology in the new normal

convener:Hiroto Nagai(Waseda Univ., School of Education), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Ishikawa Mamoru(Hokkaido University), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

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[ACC25-P01] Evidence for long-range transport of atmospheric microplastic

*Osamu Nagafuchi[1], Koyomi Nakazawa[1] (1.Fukuoka Institute of Techology)

[ACC25-P02] **A discussion of the circumstances and causes of the massive avalanche that occurred at Mt. Kiso Ontake on May 21st 2019**

*Hideo Suzuki[1], Takeshi Saito[2], Kuniaki Makino[2] (1.Institute of Science, Academic Assembly School of Science and Technology, Shinshu University, 2.Department of Geology, Faculty of Science, Shinshu University)

[ACC25-P03] Preliminary observation report of snow-buried corner reflectors for SAR-based snow-depth monitoring in Nagaoka, Niigata (2020/2021)

*Hiroto Nagai[1,2], Sojiro Sunako[2], Katsuya Yamashita[2], Satoru Yamaguchi[2] (1.Waseda Univ., School of Education, 2.National Research Institute for Earth Science and Disaster Resilience)

[ACC25-P04] Radiation characteristics of thin sea ice in the ice tank experiment using multifrequency passive microwave radiometers

*Kzutaka Tateyama[1], Hiroyuki Enomoto[2], Masashige Nakayama[3], Naoto Shoji[1], Yurika Watanabe[1], Sae Ohira[1], Kohei Sato[1] (1.National University Corporation Kitami Institute of Technology, 2.Arctic Environment Research Center, National Institute of Polar Research, 3.National University Corporation Hokkaido University of Education, Kushiro campus)

[ACC25-P05] Polar snow monitoring by satellite microwave radiometer

*Nuerasimuguli Alimasi[1], Hiroyuki Enomoto[1] (1.National Institute of Polar Research)

[ACC25-P06] The observation plan of glacier research and its modification due to covid-19

*Keiko Konya[1] (1.Japan Agency for Marine-Earth Science and Technology)

[ACC25-P07] **Relationship between Haliaeetus pelagicus flights route over the Russian Far East and surface atmospheric conditions**

*Kazutoshi Sato[1], Kzutaka Tateyama[1], Saiko Shiraki[2], Yusuke Murata[1] (1.Kitami Institute of Technology, 2.Tokyo University of Agriculture)

Evidence for long-range transport of atmospheric microplastic

*Osamu Nagafuchi[1], Koyomi Nakazawa[1]

1. Fukuoka Institute of Techology

In these days, marine, freshwater and terrestrial pollution with microplastics (MPs) has been discussed extensively, whereas there are few reports on long-range transport of atmospheric MPs. Here, we attempted to detect atmospheric MPs by focusing on rime-ice on mountain site located in the free troposphere. MPs were identified by Fourier transform infrared imaging in all samples. The MPs concentrations of rime-ice was significantly higher ($10^{\sim}20 \times 10^{-3}$ N liter^{-1}) than snow on same mountain (1×10^{-3} N liter^{-1}). The major polymer which detected was polyethylene. Most of particles were in the smaller size below 50mm. Furthermore, from the results of the back trajectory analysis, our data emphasize that atmospheric transport and deposition can be notable pathways for MPs.

Keywords: rime-ice, microplastic, long-range transport

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A discussion of the circumstances and causes of the massive avalanche that occurred at Mt. Kiso Ontake on May 21st 2019

*Hideo Suzuki[1], Takeshi Saito[2], Kuniaki Makino[2]

1. Institute of Science, Academic Assembly School of Science and Technology, Shinshu University, 2. Department of Geology, Faculty of Science, Shinshu University

A large-scale snow avalanche that occurred on 21st May 2019 on the slope between Ichinoike and Ninoike craters at Mt. Kiso Ontake was unprecedented in terms of location and scale. This avalanche caused damage to the trail and Ninoike mountain lodge. On the same day, a collapse of the snow layer and mudflow occurred in the upper Yukawa River downstream from Ninoke crater. Similar collapse and mud flow were observed at Yukawa River in May 2011, suggesting that small collapse of snow layer and mud flow generation are common at Yukawa in snowmelt season. Ontake was erupted in September 2014, resulted in cohesive muddy volcanic ash deposits around the summit area. Not only appropriate weather and snow conditions but the presence of volcanic ash very likely promote sliding of the snow layer. In order to clarify the generation process of this avalanche, we carried out field observation. The sediments transported by the avalanches and water samples were analyzed. In addition, simple snow block sliding experiments were conducted in order to investigate snow conditions and the effect of volcanic ash.

As a result, several sharp-edged crown fractures were observed at the slope between Ichinoike and Ninoike craters. Snow slabs deposited at Ninoike maintains sedimentary structures formed before the avalanche generation, indicating the slabs simply slid the slope. Although Kunitomo et al. (2019) reported this avalanche was occurred as a slush avalanche, our results indicate the avalanche was generated as a surface-onset full-layer avalanche. At Yukawa River, the gully cracks were formed and slush was deposited on the levees, suggesting the avalanche was transformed to slush flows after entering Yukawa River.

Muddy volcanic ash derived from the 2014 eruption was deposited on the bed surface. The ash contains gypsum and the water sampled at Ichinoike and Ninoike craters showed high concentration of Ca and SO_4. These muddy gypsum bearing ash possibly promoted the avalanche generation. Simple snow block sliding experiments indicated that not only appropriate weather and snow conditions but the presence of volcanic ash promote sliding.
We concluded that the avalanche was possibly promoted by muddy water with volcanic ash in addition to appropriate weather and snow conditions (heavy rains and rapid temperature increasing around 0 degrees C).

Keywords: Avalanche, Slush, Clay volcanic ash, Mt. Kiso Ontake, Mudflow, Phreatic eruption

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Preliminary observation report of snow-buried corner reflectors for SAR-based snow-depth monitoring in Nagaoka, Niigata (2020/2021)

*Hiroto Nagai[1,2], Sojiro Sunako[2], Katsuya Yamashita[2], Satoru Yamaguchi[2]

1. Waseda Univ., School of Education, 2. National Research Institute for Earth Science and Disaster Resilience

Understanding the distribution of snow depth over a wide area is basic information for disaster prevention. The number of ground-based observation points is limited especially in mountainous areas with heavy snowfall, therefore further development of observation systems is expected. Satellite-based synthetic aperture radars (SARs) are expected to observe a wide area and generate detailed information of snow depth distribution in such an area. SAR backscatter amplitude is decreased by snowpack, because reflection and scattering occur on the surface and inside of the snow cover. The backscatter amplitude is considered to depend on the depth and physical properties (water content) of the snow layer.
In this study, metal-made Corner Reflectors (CRs) for SAR are built and buried in actual snowpack. The signal on the CRs is significantly stronger than the surroundings. Using these, we aim to understand the microwave-propagation process in more detail and with lower noise than before.
The CRs are built with three 1-m squared panels. Steel-made CRs are made for extremely heavy snowpack (>3 m) in addition to stainless-made one. Totally four CRs are set in experimental fields operated by the National Research Institute for Earth Science and Disaster Resilience (NIED) in Nagaoka, Niigata Prefecture. CR installation was completed in November 2019. In addition, real-time camera monitoring system were installed and started on December 2020, which enables image transmission of snow-burring CRs in every 30-min. or 1-hours.
Significant heavy snowfall in a short time occurred on around December 14, 2021 around Niigata, Japan. This event caused social affects, for example, hundreds of cars getting stuck on the highway for a long time. The CR cameras captured the sudden increase of snow depth. Snow depth has not been lower than 50 cm in Nagaoka and not been lower than 1 m in Tochio-tashiro since this time. Regular automatic snow-depth measurement is operated at both points, but the snow depth is not completely uniform around the area. There is a slight spatial-heterogeneity caused by the shade, ground features, and wind direction. Especially in Nagaoka, the snow depth increases and decreases around 1 m, the CR’ s height. Because whether the CR is completely buried or partially exposed is important information in later analysis, the image from the camera shows the situation most reliably.
While recording the snow condition of CR, the Sentinel-1a/b satellites of the European Space Agency are conducting observations in multiple satellites/orbits, deriving three times observation opportunity in 12days for our study sites. In addition, Japanese SAR satellite "DAICHI-2" is scheduled to carry out observations twice in February in the high-resolution mode. In this presentation, we will analyze these satellite observation data and CR snow cover conditions, and give a preliminary report of the obtained results.

Keywords: SAR, Snow depth, Extreme weather, PALSAR-2

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Radiation characteristics of thin sea ice in the ice tank experiment using multifrequency passive microwave radiometers

*Kzutaka Tateyama[1], Hiroyuki Enomoto[2], Masashige Nakayama[3], Naoto Shoji[1], Yurika Watanabe[1], Sae Ohira[1], Kohei Sato[1]

1. National University Corporation Kitami Institute of Technology, 2. Arctic Environment Research Center, National Institute of Polar Research, 3. National University Corporation Hokkaido University of Education, Kushiro campus

Microwave radiation characteristics of sea ice with a thickness ranged from 0 cm to around 30 cm was measured using the passive microwave radiometers having the observation frequencies of 6, 18, 36 GHz. Sea ice was grown in the ice tank which has a diameter of 2.6m and a depth of 0.9m and filled by 5 tons of saline water (32psu) transported from the Saroma-ko lagoon. The ice tank was set up outdoors next to the baseball ground in the campus of Kitami Institute of technology. In order to avoid the effects of melting by sunlight and disturbance by snow, a movable roof was installed and a refrigerator was installed inside the roof. Portable microwave radiometers MMRS2 were used and installed at same incident angle (55 degree) to GCOM-W/AMSR2.

The brightness temperature showed a rapid increasing from open water to newly formed sea ice. After maximum value appeared at a few centimeters thin ice, the brightness temperatures showed the tendency to decrease gradually with sea ice thickens.

Keywords: Sea ice, Remote sensing, Passive microwave radiometrer

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Polar snow monitoring by satellite microwave radiometer

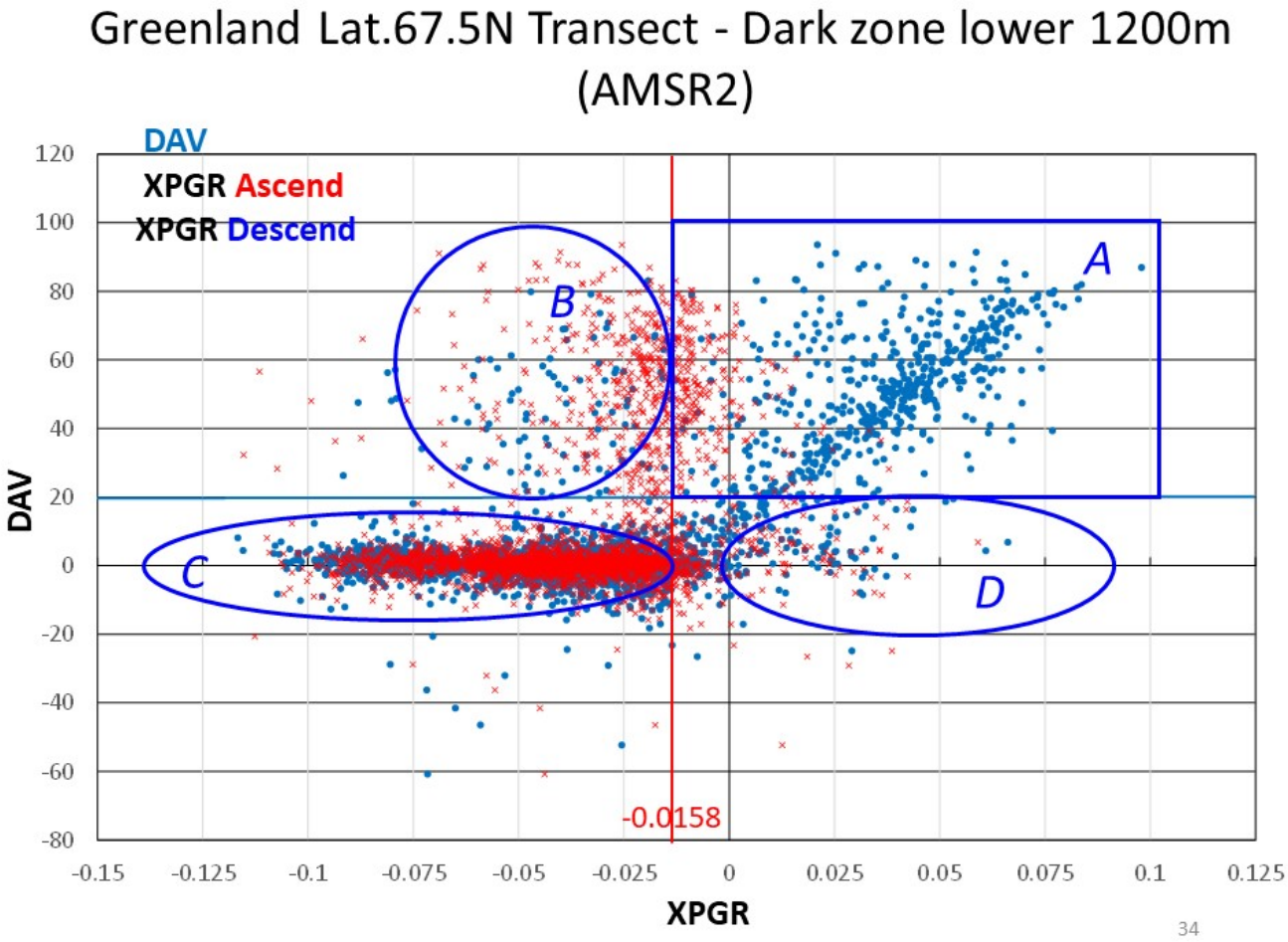
*Nuerasimuguli Alimasi[1], Hiroyuki Enomoto[1]

1. National Institute of Polar Research

The melting of snow covered areas, glacier and ice sheets is important information for the effects of climate change, the water cycle, and disaster prevention. Satellite observations are used to observe melting. There are methods such as investigating changes in the reflection characteristics of snow and ice with visible and near infrared observation, investigating that the temperature of snow and ice reaches the melting point by infrared observation, and detecting water contains by microwave radiation. Microwave observations, which allow observation of melting in all weather and at night, have been used since satellite microwave observations became possible in the 1980s. A method called XPGR (Cross-Polarization Gradient Ratio) has been used as the main observation algorithm since the latter half of the 1990s, and has been used for climate change research as an index of ice sheet melting. In addition, a method called the Diurnal Amplitude observation Variation (DAV) has been used to observe melting in snowy areas on land by observing daytime melting and nighttime freezing. The current study investigated the characteristics and precautions for use of XPGR and DAV.
In this study, we compared XPGR and DAV using ASMR_E and AMSR2 data. Although it is effective for DAV that the observation times are 13:30 (Ascending) and 01:30 (Descending). It turns out that XPGR should be careful when using Ascending data. XPGR was expected to overlook melting when it melted and the surface moisture increased.

Keywords: melt, DAV, glacier and ice sheets

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The observation plan of glacier research and its modification due to covid-19

*Keiko Konya[1]

1. Japan Agency for Marine-Earth Science and Technology

As part of ArCSII project, observations of methane emitted from the Gulkana Glacier area in Alaska were planned for the summer of 2020. Methane is a greenhouse gas that has a large impact even in small amounts. In recent years, methane has been found to be emitted from the glacier area at the margin of the Greenland ice sheet and the Icelandic glacier area. While glacier areas are accounted for as new sources of methane, observation data are limited, and the mechanism of methane emission is unknown. Therefore, the authors have planned to conduct field measurements at the mountain glaciers area.
However, we found it impossible to carry out field observations due to covid-19. Since covid-19 was a global phenomenon, unlike SARS and MERS in the past, it was difficult to travel to countries where the number of infected people was higher than in Japan, or to areas where ethnic minorities lived in the Arctic region. In order to compensate for the missing data in 2020, we decided to construct a new method that is expected to get various data. As for 2021, the plan was divided into cases where observations could be conducted and cases where observations could not be conducted, and further changes were considered for the cases where observations could not be conducted.

Keywords: Glacier research, covid-19, the Arctic

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Relationship between Haliaeetus pelagicus flights route over the Russian Far East and surface atmospheric conditions

*Kazutoshi Sato[1], Kzutaka Tateyama[1], Saiko Shiraki[2], Yusuke Murata[1]

1. Kitami Institute of Technology, 2. Tokyo University of Agriculture

The Haliaeetus pelagicus, which stays over the coastal region of Okhotsk sea of East Hokkaido during winter, is migratory bird. After breeding season over the coastal region of Okhotsk Sea in Russia during summer, they migrate southward in autumn and reach East Asia in early winter. However, no previous study has reported the influence of atmospheric conditions on migration route and timing of Haliaeetus pelagicus. Using reanalysis data and geolocation loggers data, we investigate the relationship between change in surface conditions (e.g. snow cover, sea ice cover, surface temperature) and migration factors (e.g. timing and route) of Haliaeetus pelagicus.
In autumn 2018, two birds stay over Khabarovsk area in Russia. Although departure and arrival areas of two birds are almost same, there are differences in departure date and route of migration of two birds. One bird starts migration toward south in middle of October 2018. After leaving Khabarovsk area, snow accumulation is seen over Khabarovsk area, meaning that this bird avoids snow. In contrast, another one stays over Khabarovsk area even high snow cover. However, this bird starts to migrate when temperature drops below -20 oC. In addition, Haliaeetus pelagicus selects high sea ice cover areas when they migrate northward after winter season. From these results, surface conditions would be an indicator of timing and route of Haliaeetus pelagicus.

Keywords: Haliaeetus pelagicus, Migratory bird, Sea of Okhotsk

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.13 Zoom Room 13

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Nozomu Takeuchi(Chiba University), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(Nagoya University), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Chairperson:Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems)

Analyses of ice cores from polar and mountain regions have contributed to the reconstruction and understanding of the past environmental changes on timescales from years to several hundred thousand years. In this session, we welcome paleoenvironmental studies using ice cores and paleoclimatic modeling. Studies on reconstruction methods, recording processes and new paleoenvironmental proxies, technical aspects of paleo-modeling are also welcomed. Studies with marine sediment cores, terrestrial sediment cores and tree-rings on similar timescales are also important and welcomed, in order to discuss past environmental changes from multidisciplinary viewpoints.

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

[ACC26-01] Fractionation of O_2/N_2 and Ar/N_2 in polar ice cores during bubble formation, bubble-clathrate hydrate transition, and gas loss during storage from precise gas measurements of the Dome Fuji ice core, Antarctica

★Invited Papers

*Ikumi Oyabu[1], Kenji Kawamura[1,2,3], Tsutomu Uchida[4], Shuji Fujita[1,2], Kyotaro Kitamura[1], Motohiro Hirabayashi[1], Jeffrey Severinghaus[5], Morgan Jacob[5] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.The Graduate University of Advanced Studies (SOKENDAI), 3.Japan Agency for Marine Science and Technology (JAMSTEC), 4.Hokkaido University, 5.Scripps Institution of Oceanography)

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

[ACC26-02] Analysis of Dome Fuji ice core fabric by dielectric tensor measurement

★Invited Papers

*Tomotaka Saruya[1], Shuji Fujita[1,2] (1.National Institute of Polar Research, 2.SOKENDAI (The Graduate University for Advanced Studies))

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

[ACC26-03] Methane concentration in Dome Fuji ice core measured with a continuous flow analysis system

*Ayaka Yonekura[1], Kenji Kawamura[1,2,3], Ikumi Oyabu[2], Kyotaro Kitamura[2], Jun Ogata[2], Motohiro Hirabayashi[2], Kaori Fukuda[2], Yoshimi Tsukagawa[2], Tomotaka Saruya[2], Fumio Nakazawa[1,2], Shuji Fujita[1,2], Kumiko Goto-Azuma[1,2], Hideaki Motoyama[1,2] (1.The Graduate University for Advanced Studies, SOKENDAI, 2.National Insutitute of Polar Research, 3.JAMSTEC)

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

[ACC26-04] The role of Southern warming on global ocean states and abrupt warming events during the last deglaciation

★Invited Papers

*Takashi Obase[1], Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1], Tristan Vadsaria[1], Christo Buizert[2] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Oregon State University)

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

[ACC26-05] Climate model study on the driving mechanisms for abrupt climate changes during glacial periods and the effects of climatic precessions on the stability of the AMOC

*Yuta Kuniyoshi[1], Ayako Abe-Ouchi[1], Sam Sherriff-Tadano[2], Wing-Le Chan[1], Fuyuki SAITO[3] (1.The University of Tokyo, 2.University of Leeds, 3.JAMSTEC)

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

[ACC26-06] Comparative analysis of interglacial (MIS1, 5e, 11) climate responses to orbital elements and internal feedbacks

*Lynn Hirose[1], Ayako Abe-Ouchi[1], Wing-Le Chan[1] (1.the University of Tokyo)

Fractionation of O_2/N_2 and Ar/N_2 in polar ice cores during bubble formation, bubble-clathrate hydrate transition, and gas loss during storage from precise gas measurements of the Dome Fuji ice core, Antarctica

*Ikumi Oyabu[1], Kenji Kawamura[1,2,3], Tsutomu Uchida[4], Shuji Fujita[1,2], Kyotaro Kitamura[1], Motohiro Hirabayashi[1], Jeffrey Severinghaus[5], Morgan Jacob[5]

1. National Institute of Polar Research, Research Organization of Information and Systems, 2. The Graduate University of Advanced Studies (SOKENDAI), 3. Japan Agency for Marine Science and Technology (JAMSTEC), 4. Hokkaido University, 5. Scripps Institution of Oceanography

The variations of $\delta O_2/N_2$ and $\delta Ar/N_2$ in the Dome Fuji ice core were measured from 112 m (bubbly ice) to 2000 m (clathrate hydrate ice) at high precision. Our method combined with low storage temperature (-50 ˚C) successfully remove post-coring gas-loss fractionation signals from our data. From bubbly ice to the middle of bubble-clathrate transition zone (BCTZ) (112 –800 m) and below the BCTZ (>1200 m), the $\delta O_2/N_2$ and $\delta Ar/N_2$ data exhibit orbital-scale variations similar to local summer insolation. The data in the lower BCTZ (800 –1200 m) have large scatters, which may be caused by mm-scale inhomogeneity of air composition combined with finite sample lengths. In the clathrate hydrate zone, the scatters around the orbital-scale variability decrease with depth, indicating diffusive smoothing of $\delta O_2/N_2$ and $\delta Ar/N_2$. A simple gas diffusion model was used to reproduce the smoothing and thus constrain permeation coefficients of the gases. Relationship between $\delta Ar/N_2$ and $\delta O_2/N_2$ is markedly different for the datasets representing bubble close-off (slope ~0.5), diffusion within the ice sheet (~1), and post-coring gas-loss (~0.2), suggesting that the dominant fractionation processes are different for those cases. The method and data presented here may be useful for improving the orbital dating of deep ice cores over the multiple glacial cycles, and for further studying non-insolation-driven signals (e.g., atmospheric composition) of these gases.

Keywords: ice core, ice sheet, Dome Fuji, fractionation, O2/N2, Ar/N2

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Analysis of Dome Fuji ice core fabric by dielectric tensor measurement

*Tomotaka Saruya[1], Shuji Fujita[1,2]

1. National Institute of Polar Research, 2. SOKENDAI (The Graduate University for Advanced Studies)

Crystal orientation fabric (COF) is one of the most important factors determining the physical properties of polar ice sheets. The orientation of the c-axis is commonly determined from thin ice sections using automatic crystal fabric analyzers based on optical techniques. Recent advance of the automated fabric analyzers improved the quality of measurements dramatically; however, there are still limitations. Obtaining a continuous COF profile along a lengthy ice core section requires the labor-intensive preparation of many thin sections. Accordingly, the sampling frequency along an ice core is often limited, with typical sampling intervals of at least 5 or 10 m.

To conduct the bulk-ice-core based fabric measurements, we developed a new system by measuring tensorial components of the dielectric permittivity using an open resonator. Polycrystalline ice is known to exhibit macroscopic anisotropy in dielectric permittivity depending on the formation of a crystal orientation fabric. By measuring the macroscopic dielectric property of ice core, we can estimate the degree of c-axis clustering. This technique permits the continuous nondestructive assessment of the COF in thick ice sections.

Using a new system, we investigated the dielectric anisotropy as indicator of COF in Dome Fuji ice core. From measurements with vertical slab sections, we found the increase of dielectric anisotropy around the core axis with increasing depth, supporting previous findings that c-axes cluster around the vertical direction. Analyses of horizontal disk sections showed that the magnitude of dielectric anisotropy in the horizontal plane was 10–15% of that in the vertical plane. We confirmed that the dielectric anisotropy adequately represents preferred orientation of the c-axes, and that the anisotropy can be used as substitute of the normalized eigenvalue of COF. In this presentation, we discuss the depth variation of dielectric anisotropy and correlations with other physical and chemical properties.

Keywords: ice-sheet core, crystal orientation fabric, dielectric tensor

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Methane concentration in Dome Fuji ice core measured with a continuous flow analysis system

*Ayaka Yonekura[1], Kenji Kawamura[1,2,3], Ikumi Oyabu[2], Kyotaro Kitamura[2], Jun Ogata[2], Motohiro Hirabayashi[2], Kaori Fukuda[2], Yoshimi Tsukagawa[2], Tomotaka Saruya[2], Fumio Nakazawa[1,2], Shuji Fujita[1,2], Kumiko Goto-Azuma[1,2], Hideaki Motoyama[1,2]

1. The Graduate University for Advanced Studies, SOKENDAI, 2. National Insutitute of Polar Research, 3. JAMSTEC

We have been measuring CH_4 concentration in the Dome Fuji ice core by using a Continuous Flow Analyses (CFA) system. The CFA system can continuously measure multiple components contained in ice cores. It provides high-resolution data more efficiently than traditional discrete measurements, and thus has become a common way to obtain detailed paleoclimatic data from deep ice cores.

Millennial-scale variations of CH_4 in the last glacial period have been extensively studied by analyzing ice cores from high-accumulation sites (e.g., Rhodes et al., 2017). To reconstruct the CH_4 variabilities in older periods beyond the last glacial period, the high-resolution analysis of low-accumulation ice cores such as Dome Fuji ice core is essential. However, the currently available resolutions of the CH_4 data from the low-accumulation ice cores are insufficient for the millennial-scale reconstructions in the older glacial periods, and CH_4 data using CFA is still absent.

Here, we present the Dome Fuji CH_4 record in selected periods from the last glacial to Holocene using the CFA system. We discuss age distribution and associated smoothing of atmospheric signals for the low-accumulation core, as well as the reconstructed millennial- and centennial-scale CH_4 variabilities by comparing our results with the high-accumulation WAIS-Divide ice core data (Rhodes et al., 2017) and low-accumulation (EDC and Vostok) ice-core CFA data (Fourteau et al.,2017; 2020).

Our data includes abrupt changes such as the transitions during the last deglaciation, and the 8.2ka event in the Holocene. We find strong smoothing effect of atmospheric signals due to the broad age distribution of the Dome Fuji ice core. Moreover, we observe fine-scale age reversals along depth probably due to the so-called layered trapping (i.e., firn layers with air bubbles formed at the depths significantly different from the average close-off depth), which have originally been reported from the Vostok ice core (Fourteau et al., 2017; 2020). We will also present the CH_4 record around Dansgaard-Oeschger event 17 (about 60 kyr before present).

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Fourteau et al., 2017: Analytical constraints on layered gas trapping and smoothing of atmospheric variability in ice under low-accumulation conditions. *Clim. Past*, 13, 1815–1830.
Fourteau et al., 2020: Estimation of gas record alteration in very low-accumulation ice cores. *Clim. Past*, 16, 503–522.

Keywords: Dome Fuji ice core, Methane, CFA

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The role of Southern warming on global ocean states and abrupt warming events during the last deglaciation

*Takashi Obase[1], Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1], Tristan Vadsaria[1], Christo Buizert[2]

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There were a number of abrupt climate changes associated with changes in Atlantic Meridional Overturning Circulation (AMOC) during the last glacial period (120 to 20 ka before present) and the last deglaciation (20 to 11 ka before present). Previous studies have elucidated that the AMOC has several distinct modes associated with sea ice extent and deep water formation in the North Atlantic, but the cause of triggering these AMOC mode shifts is still unclear. Recent climate modeling studies suggested the thermal condition in the Southern Ocean is important for the AMOC through the process of Antarctic bottom water formation and meridional density gradient in the North Atlantic.

In this study, we conduct sensitivity experiments of the last deglaciation to understand the role of the Southern thermal forcing. In the control experiment, the model was forced by changing orbital parameters and rising atmospheric CO_2 based on ice core reconstructions (same as Obase and Abe-Ouchi 2019). The control experiment exhibits abrupt AMOC recovery around 14.7 ka BP, in good agreement with observations.

Next, we conducted sensitivity experiments in which the deglacial rise in CO_2 radiative forcing was applied to a limited latitudinal band, with radiative forcing elsewhere held fixed at 18 ka levels. We find that only the experiments with rising radiative forcing in the southern high latitudes exhibit abrupt AMOC recovery. The results show that the rise in the Southern CO2, not the Northern CO2 is necessary for an abrupt AMOC increase, despite smaller SST increase in the North Atlantic. The analysis suggests that the abrupt changes in the AMOC is preconditioned with gradual density difference between the North Atlantic and the Southern Ocean, therefore Southern warming is more important than the Northern warming in the last deglaciation. We conclude that Southern hemisphere high-latitude warming is both a sufficient and a necessary condition for AMOC recovery at the Bølling onset at 14.7 ka before present.

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Climate model study on the driving mechanisms for abrupt climate changes during glacial periods and the effects of climatic precessions on the stability of the AMOC

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It is well known that abrupt climate changes with global-scale impacts, which are called Dansgaard–Oeschger (DO) events, occurred repeatedly during the glacial periods. These abrupt climate changes have been shown to be closely related to the changes in the strength of the Atlantic meridional overturning circulation (AMOC). In recent years, a few coupled atmosphere-ocean models have successfully reproduced the self-induced oscillation of the AMOC with periods shorter than 1000 years, and several mechanisms of the DO events have been proposed, mainly due to internal factors of the atmosphere-ocean system around the North Atlantic. Our recent experiments by using the coupled atmosphere-ocean model MIROC4m reproduce not only those short-period oscillations of the AMOC but also oscillations with a period of several thousand years. Furthermore, experiments using maxima and minima as boundary conditions for the climatic precession that produces seasonal changes in the high latitudes of both the northern and southern hemispheres show that oscillations with relatively short periods occur frequently when the precession is at its maximum. In this study, from the analysis of the precession experiments and additional sensitivity experiments in which the value of precession is divided by the northern and southern hemispheres, we investigated the effect of precession on the stability of AMOC and how the seasonality of the northern and southern hemispheres is involved in each of the several mechanisms of the AMOC oscillation.

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Comparative analysis of interglacial (MIS1, 5e, 11) climate responses to orbital elements and internal feedbacks

*Lynn Hirose[1], Ayako Abe-Ouchi[1], Wing-Le Chan[1]

1. the University of Tokyo

It is generally believed that the glacial ice volume variations that define the glacial-interglacial cycle are driven by changes in summer insolation at Northern hemisphere high latitudes due to periodic changes in the Earth's orbital elements. However, MIS11, which is known to be one of the warmest interglacials with the highest sea levels, cannot be easily explained by orbital elements and greenhouse gases (GHGs) alone, pointing to the need to consider amplifying feedbacks and broader-scale effects. In this study, we compare the climate simulations of MIS11 with that of MIS1 and MIS5e using a coupled atmosphere-ocean vegetation model (MIROC 4m AOVGCM), focusing on the presence or absence of ice sheets in order to examine the effects of different internal feedbacks on temperature in the Northern Hemisphere high latitudes. The orbital elements, land cover, including ice sheet distribution, and GHGs were fixed every 5000 years as boundary conditions and the experiments were run for more than 3000 years each with appropriate initial conditions. The preliminary results of surface air temperature, sea ice distribution, and albedo at Northern Hemisphere high latitudes and the role of the North American Ice Sheet as well as vegetation change will be discussed.

Keywords: interglacial, internal feedback, North American Ice Sheet

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.13 Zoom Room 13

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Nozomu Takeuchi(Chiba University), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(Nagoya University), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Chairperson:Nozomu Takeuchi(Chiba University), Ryu Uemura(Nagoya University)

Analyses of ice cores from polar and mountain regions have contributed to the reconstruction and understanding of the past environmental changes on timescales from years to several hundred thousand years. In this session, we welcome paleoenvironmental studies using ice cores and paleoclimatic modeling. Studies on reconstruction methods, recording processes and new paleoenvironmental proxies, technical aspects of paleo-modeling are also welcomed. Studies with marine sediment cores, terrestrial sediment cores and tree-rings on similar timescales are also important and welcomed, in order to discuss past environmental changes from multidisciplinary viewpoints.

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

[ACC26-07] Impacts of large scale atmospheric circulation on water isotopes of daily precipitation at Dome Fuji Station: A study with an isotope-enabled AGCM MIROC5-iso

*Kanon Kino[1,2], Okazaki Atsushi[3], Alexandre Cauquoin[2], Kei Yoshimura[2] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Institute of Industrial Science, the University of Tokyo, 3.The Pennsylvania State University)

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

[ACC26-08] The correlations between cloud amount over Northern mid-high latitudes and aerosol proxies preserved in the SE-Dome ice core, Greenland

* AKIHISA WATARI[1], Iizuka Yoshinori[1], Koji Fujita[2], Hirohiko Masunaga[2], Kazuaki Kawamoto[3] (1.Hokkaido university, 2.Nagoya university, 3.Nagasaki university)

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

[ACC26-09] Possible albedo reduction of snow surface due to black carbon over the past 350 years on the Greenland Ice Sheet estimated from the SIGMA-D ice core

*Teruo Aoki[1,2], Kumiko Goto-Azuma[1,2], Sumito Matoba[3], Rigen Shimada[4], Yutaka Kondo[1], Nobuhiro Moteki[5], Makoto Koike[5], Koji Fujita[6], Hideaki Motoyama[1,2], Masahiro Hori[7] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Institute of Low Temperature Science, Hokkaido University, 4.Earth Observation Research Center, Japan Aerospace Exploration Agency, 5.School of Science, University of Tokyo, 6.Graduate School of Environmental Studies, Nagoya University, 7.School of Sustainable Design, University of Toyama)

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

[ACC26-10] Intra-ice and intra-sediment cryopeg brine occurrence in permafrost near Utqiagvik (Barrow)

*Go Iwahana[1], Zachary S. Cooper[2], Shelly D. Carpenter[2], Jody W. Deming[2], Hajo Eicken[1] (1.International Arctic Research Center, University of Alaska Fairbanks, 2.School of Oceanography, University of Washington)

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

[ACC26-11] Ice core drilling on a high-elevation accumulation zone of Trambau Glacier in the Nepal Himalaya

*Nao Esashi[1], Akane Tsushima[2], Ryu Uemura[1], Yoshinori Iizuka[3], Sumito Matoba[3], Koji Fujita[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Graduate School of Science, Chiba University,

3.Institute of Low Temperature Science, Hokkaido University)

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

[ACC26-12] An attempt to reconstruct air temperature in the past using DNA information in ice core samples on Gregoriev Glacier, Kyrgyz Tienshan

★Invited Papers

*Segawa Takahiro[1], Koji Fujita[2], Ayumi Akiyoshi[3], Nozomu Takeuchi[4] (1.University of Yamanashi, 2.Nagoya University, 3.National Institute of Polar Research, 4.Chiba University)

Impacts of large scale atmospheric circulation on water isotopes of daily precipitation at Dome Fuji Station: A study with an isotope-enabled AGCM MIROC5-iso

*Kanon Kino[1,2], Okazaki Atsushi[3], Alexandre Cauquoin[2], Kei Yoshimura[2]

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Thanks to water isotope records in polar ice cores, it has been possible to study past Earth’ s climate variations at different time scales. However, the different contributions at regional and global scales determining the isotopic signal in these ice cores are still unclear. The observations at Dome Fuji Station, inland East Antarctica, and further analyses of weather situations have investigated the relationship between $\delta^{18}O$ of daily precipitation ($\delta^{18}O_p$) and the synoptic precipitation events, which are mostly accompanied by increased temperature [1,2], whereas the climatic understanding is not established.

One way to progress our understanding of the question is to make direct comparisons of isotopic data with simulation results from isotope-enabled General Circulation Models (GCMs). We here used such a model, the Japanese atmospheric GCM MIROC5-iso [3], and conducted a simulation with the horizontal winds nudged to the JRA-25 reanalysis [4] for 1981-2010. The simulation nicely reproduces the observed $\delta^{18}O_p$ at Dome Fuji, as well as the synoptic precipitation events.

We reveal that the large-scale atmospheric circulation variations, specifically related to the Southern Annular Mode, significantly affect the $\delta^{18}O_p$ at Dome Fuji during cold seasons (austral autumn, winter, and spring). This is because the advection of the warm air largely changes the local temperature and $\delta^{18}O_p$, supporting previous studies [1]. However, in the austral summer, the contribution of the precipitation amounts relatively large for the variability of $\delta^{18}O_p$, while temperature rise affects only a little the $\delta^{18}O_p$ signal.

Our result suggests the water isotopes in the ice cores do not capture the whole variations of local temperature, and precipitation events contribute to a warm bias in the cold seasons. Interpretation for past climate situations (e.g. Last Glacial Maximum) will be further investigated.

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[2] Dittman et al., Atmos. Chem. Phys., 16, 6883-6900, 2016.
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Keywords: climate model, water isotopes, ice cores, paleo proxies, Antarctica

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The correlations between cloud amount over Northern mid-high latitudes and aerosol proxies preserved in the SE-Dome ice core, Greenland

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1. Hokkaido university, 2. Nagoya university, 3. Nagasaki university

The SE-Dome Ice Core(SE-Core), drilled out from a high elevation and accumulation area, preserves paleoenvironmental proxies such as aerosols of the last 60 years with a high time resolution(±2month) [1)]. Past aerosols in the SE-Core mainly came from North Atlantic Ocean and North America[1)]. Although many papers suggested that aerosols act as cloud condensation nuclei (CNN)[2)3)], the relationships between past cloud amount and aerosols in ice cores are not well understood yet. If past aerosols preserved in ice cores can be a proxy of past cloud amount, that would help better understand the fluctuation mechanism of aerosol-cloud interactions than ever before.

To examine the relationships between cloud amount over Northern mid-high latitudes and the aerosol proxies preserved in the SE-Core, we used the cloud amount data sets from satellite and reanalysis of Ⅰ) Advanced Very High Resolution Radiometer(AVHRR), Ⅱ) International satellite cloud climatology project(ISCCP), and Ⅲ) ERA5 products provided by European Centre for medium-range weather forecasts(ECMWF) from 1979 to 2014.We calculated cloud-aerosol correlation coefficients at a resolution of 2.5˚latitude by 2.5˚longitude over Northern mid-high latitudes.We use 15 aerosol proxies from the SE-Core(calcium ion, sulfate ion, and so on)[4)] and cloud amount divided into 4 types (low, middle, high, and total levels) of the 3 data sets for 6 types of season or annual{Winter(DJF), Spring(MAM), Summer(JJA), Autumn(SON), Spring-Summer(AMJJAS), and Autumn-Winter(ONDJFM)}. Thus, the combination amounts to 1,260 cases (15×4×3×7) for the correlation coefficient.

Among the 1,260 cases, the correlation coefficients between total and low-levels cloud amount, and sulfate ion flux in North America(75˚W - 100˚W,45˚N - 70˚N) and North Atlantic Ocean (20˚W - 50˚W,45˚N - 60˚N) are significantly high ($R > 0.329$) in all the 3 data sets. The sulfate ion in the SE-Core mainly originates from anthropogenic SO_2 in North America and biologic SO_2 in the North Atlantic[5)]. The significant correlations suggest that sulfate aerosols may contribute to increasing cloud amount in the emission area. We also examined the correlation coefficients between sulfate ion flux and cloud amount under fixed conditions on relative humidity, temperature and surface pressure, which are considered as main factors of clouds formation. For example, we analyzed the correlation coefficients between sulfate ion flux and total cloud amount in AMJJAS when the relative humidity variability in North Atlantic Ocean was within 1 standard deviation from 1979 to 2014. The correlation coefficients were significantly high ($R > 0.496$) in North Atlantic Ocean. Thus, the correlation coefficients between cloud amount and sulfate ion flux preserved in the SE-Core are significant even under the same condition of the main factors of clouds formation.

It is suggested that sulfate aerosols contribute to an increase of cloud amount in the process of acting as a CCN.

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Keywords: SE-Dome ice core, sulfate ion flux, cloud amount, correlation coefficient, North Atlantic Ocean

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Possible albedo reduction of snow surface due to black carbon over the past 350 years on the Greenland Ice Sheet estimated from the SIGMA-D ice core

*Teruo Aoki[1,2], Kumiko Goto-Azuma[1,2], Sumito Matoba[3], Rigen Shimada[4], Yutaka Kondo[1], Nobuhiro Moteki[5], Makoto Koike[5], Koji Fujita[6], Hideaki Motoyama[1,2], Masahiro Hori[7]

1. National Institute of Polar Research, 2. SOKENDAI, 3. Institute of Low Temperature Science, Hokkaido University, 4. Earth Observation Research Center, Japan Aerospace Exploration Agency, 5. School of Science, University of Tokyo, 6. Graduate School of Environmental Studies, Nagoya University, 7. School of Sustainable Design, University of Toyama

Snow surface albedo strongly depends on snow grain size and impurity concentration (Wiscombe and Warren, 1980; Warren and Wiscombe, 1980). If these snow parameters are known, the albedo can be calculated with a radiative transfer model. This study presents the possible albedo reduction due to black carbon (BC) in snow over the past 350 years on the Greenland Ice Sheet (GrIS) based on BC concentration from an ice core and satellite-derived snow grain size. The albedo is calculated with a physically based snow albedo model (PBSAM, Aoki et al., 2011) for two temporal variations of higher and lower cases of BC concentrations obtained from the SIGMA-D ice core (Matoba et al., 2015, Goto-Azuma et al., 2019) and snow grain radius R_{s1} derived from Moderate Resolution Imaging Spectroradiometer (MODIS) data from 2000 to 2019 over the GrIS (Aoki et al., 2020). We employed three R_{s1} averaged over accumulation areas in the GrIS at an elevation $h < 1$ km ($R_{s1} = 478$ μm), all range of h ($R_{s1} = 185$ μm), and $h > 3$ km ($R_{s1} = 94$ μm) based on the monthly median of R_{s1} in June when the maximum insolation is expected. The higher and lower BC concentrations are the annual maximum of monthly mean values and annual mean value, respectively. From those two BC concentrations and BC free case, and three values of R_{s1}, a total of 9 kinds of temporal albedo variations are calculated for solar zenith angle at local solar noon on June 21. The albedo reductions are calculated by the albedo difference between the BC-contained case and the BC free case. Assuming the BC concentration from SIGMA-D to be the same all over the GrIS, possible albedo reduction due to BC for lower, overall, higher elevation areas of GrIS can be estimated. The maximum albedo reduction is estimated to be 0.025 in 1925 for higher BC and the largest $R_{s1} = 478$ μm ($h < 1$ km), and the second largest reduction is 0.019 in 1710, and the average albedo reduction over the 350 years is 0.0054. In the lower BC case, the albedo reductions all over the period are almost less than 0.01 for any case of R_{s1}. For the area at $h > 3$ km ($R_{s1} = 94$ μm), the maximum albedo reductions are estimated to be 0.011 and 0.0045 in 1925 for the higher and lower BC cases, respectively. These results indicate that BC on GrIS usually has not a large effect on albedo reduction but sometimes cannot be ignored (albedo reduction > 0.01) under the high concentration events.

Keywords: albedo, ice core, Greenland Ice Sheet, black carbon, snow grain size, SIGMA-D

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Intra-ice and intra-sediment cryopeg brine occurrence in permafrost near Utqiagvik (Barrow)

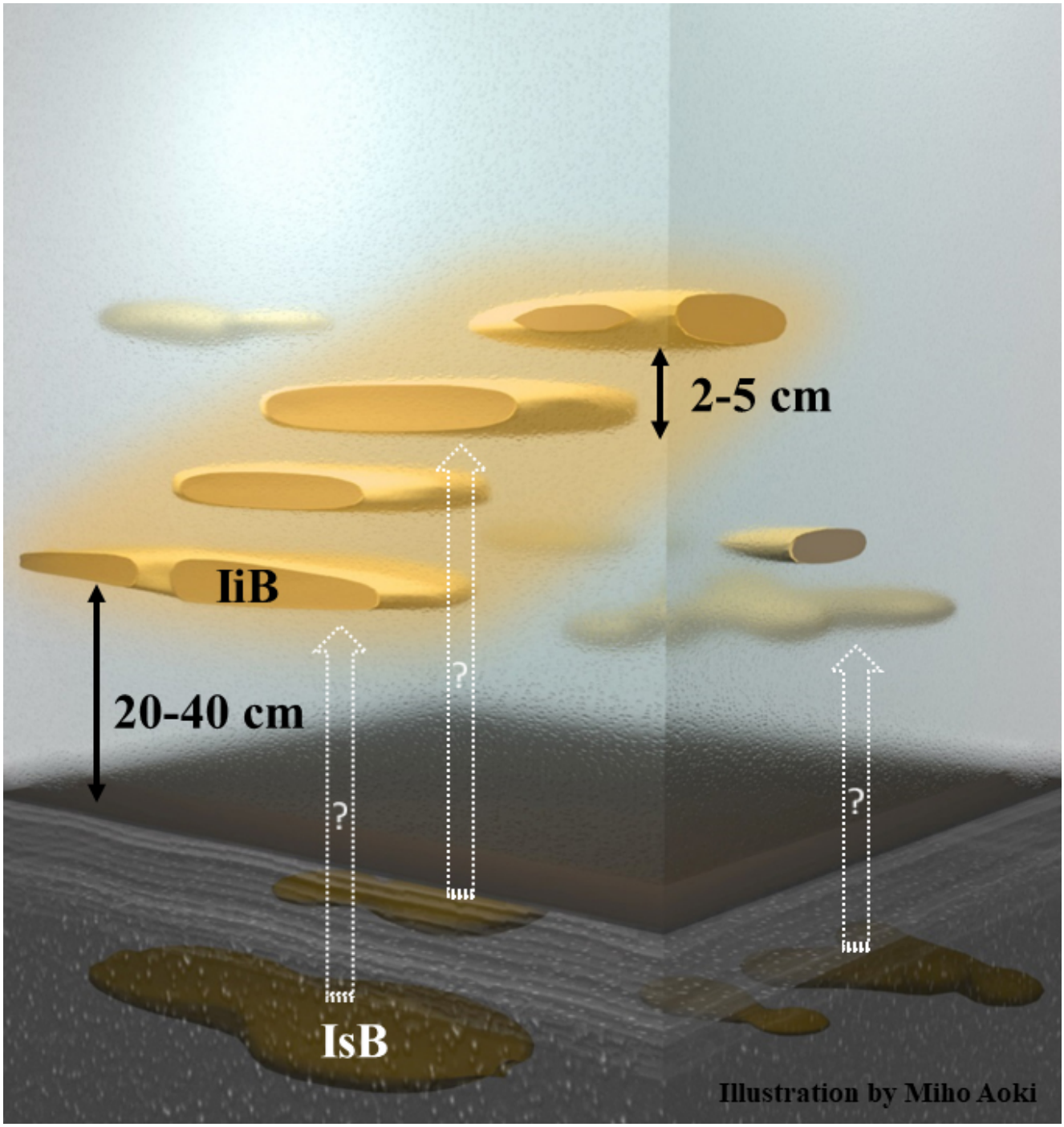
*Go Iwahana[1], Zachary S. Cooper[2], Shelly D. Carpenter[2], Jody W. Deming[2], Hajo Eicken[1]

1. International Arctic Research Center, University of Alaska Fairbanks, 2. School of Oceanography, University of Washington

Cryopeg is a volume of permafrost with a significant amount of cryotic unfrozen water as a result of freezing-point depression by dissolved salt content. Cryopeg and saline permafrost have been reported for coastal areas of the Arctic seas, and their current distribution and future changes are a great concern for the warming Arctic, as the state of permafrost controls ground stability and the functioning of ice cellars in Arctic villages. To describe the distribution and segregation of cryopeg lenses, and to explore the origin and development of the cryopeg and associated brines found near Utqiagvik, we conducted extensive sampling campaigns in the Barrow Permafrost Tunnel during May of 2017 and 2018.
We found two types of cryopeg brines based on their distinctive spatial occurrences: (1) intra-ice brine (IiB), entirely bounded by massive ice; and (2) intra-sediment brine (IsB), found in unfrozen sediment lenses within permafrost. While two examples of IiB have been reported previously, they were each found within ice layers below ice-sealed lakes in the McMurdo Dry Valleys of Antarctica, geological settings very different from ours. In our study, the IiBs were at roughly atmospheric pressure and situated in small pockets of ellipsoidal or more complex shape (dimensions of up to about 30 cm wide and 3 cm height) within 17–41 cm above the underlying sediment layer (Figure). Several individual IiB pockets may have been connected by porous ice of low permeability. Radiocarbon dating suggests that, at the earliest, the IiB was segregated about 11 ka BP from IsB-bearing cryopeg underneath. IsB lenses were interpreted as having developed through repeated evaporation and cryoconcentration of seawater in a lagoonal environment, then isolated at the latest when the surrounding sediment froze up and became covered by an upper sediment unit around 40 ka BP or earlier.
Considering the common characteristics among the cryopeg brines accessed from the tunnel and those found in brine-bearing marine sediment around Utqiagvik, all occurrences of cryopeg brine in the region may have experienced analogous development despite potentially contrasting salinities and estimated ages. An increase in permafrost temperature invariably will result in expansion of cryopeg lenses and may change movement of liquids within the permafrost, which potentially become threats to Arctic coasts, infrastructure, and food security.

Keywords: cryopeg, brine, ground ice, geochemistry, isotope, Barrow

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Ice core drilling on a high-elevation accumulation zone of Trambau Glacier in the Nepal Himalaya

*Nao Esashi[1], Akane Tsushima[2], Ryu Uemura[1], Yoshinori Iizuka[3], Sumito Matoba[3], Koji Fujita[1]

1. Graduate School of Environmental Studies, Nagoya University, 2. Graduate School of Science, Chiba University, 3. Institute of Low Temperature Science, Hokkaido University

We drilled an 81.2-m-long ice core in the accumulation area (5,860 m above sea level) of the Trambau Glacier, Rolwaling region, Nepal Himalaya, during October–November 2019. The drilling operation was conducted with a lightweight electro-mechanical drill system after two reconnaissance field expeditions in the post-monsoon seasons of 2017 and 2018, during which two shallow firn cores were drilled with a hand auger. The drill system and ice core samples were transported by helicopter at a high elevation of 6,000 m above sea level. A further challenging issue was the ice core transportation between Nepal and Japan, as no regular commercial flight was available for the frozen samples. The addition of dry ice imported from India immediately prior to leaving Nepal allowed the ice core samples to be successfully transported to a cold room in Japan, and remain in a frozen state. Stratigraphic observations during the drilling operation suggest the drill site has been affected by melting and refreezing. However, preliminary water stable isotope data in the shallow firn core indicate that the ice core preserves climatic signals during the past 150 yr.

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An attempt to reconstruct air temperature in the past using DNA information in ice core samples on Gregoriev Glacier, Kyrgyz Tienshan

*Segawa Takahiro[1], Koji Fujita[2], Ayumi Akiyoshi[3], Nozomu Takeuchi[4]

1. University of Yamanashi, 2. Nagoya University, 3. National Institute of Polar Research, 4. Chiba University

Ice cores drilled from glaciers can provide a means of direct analysis of microbes in the past. The species composition of microorganisms in the ice core could reflect the environmental condition at that time. Ancient DNA analyses help clarify the phylogenetic relationships among organisms with branching dates. However, the DNA in these samples is often highly degraded and fragmented. Therefore, to analyze the small amount of DNA preserved in these samples, an effective technique to extract total DNA, shotgun sequencing, and molecular evolution analysis is required. Several recent studies have focused on glacier microorganisms such as snow algae and bacteria on glacial ice melting. Snow microorganisms are currently attracting a great deal of attention as they accelerate glacier melting. Despite the ecological importance in glacial environments, little is known about what kind of snow microorganisms lived in the past and their evolutionary dynamics because of the lack of knowledge regarding past microbial information.
We report the cyanobacterial community structure results and their evolution by molecular DNA analysis collected from the ice core samples collected on Gregoriev Glacier, Kyrgyz Tienshan. We successfully reconstruct the cyanobacterial community living on the modern glacier surface in the ice core samples. We also present detailed pictures of global distribution patterns of glacier cyanobacteria over the Arctic, Antarctic, and Asian high mountains, using the sequences of the nuclear rDNA internal transcribed spacer 2 (ITS2) region. Furthermore, we attempted to reconstruct air temperature in the past based on cyanobacteria's genetic information detected in ice cores and glacier surfaces' temperature conditions in various regions where the cyanobacteria live. Our results enhance understanding of the enigmatic time scale of cyanobacterial microevolution, which has the potential to elucidate environmental responses of them to the drastic climatic change events of the Quaternary.

Keywords: ice core, microorganism, DNA

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.04_2

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Nozomu Takeuchi(Chiba University), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(Nagoya University), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems)

Analyses of ice cores from polar and mountain regions have contributed to the reconstruction and understanding of the past environmental changes on timescales from years to several hundred thousand years. In this session, we welcome paleoenvironmental studies using ice cores and paleoclimatic modeling. Studies on reconstruction methods, recording processes and new paleoenvironmental proxies, technical aspects of paleo-modeling are also welcomed. Studies with marine sediment cores, terrestrial sediment cores and tree-rings on similar timescales are also important and welcomed, in order to discuss past environmental changes from multidisciplinary viewpoints.

[ACC26-P01] A biomass burning record over the past 350 years in an ice core from Northwest Greenland

*Kumiko Goto-Azuma[1,2], Yoshimi Ogawa-Tsukagawa[1], Yutaka Kondo[1], Remi Dallmayr[9], Jun ogata[1], Nobuhiro Moteki[3], Sho Ohata[4], Tatsuhiro Mori[5], Makoto Koike[3], Kaori Fukuda[1], Motohiro Hirabayashi[1], Sumito Matoba[6], Yuki Komuro[1], Akane Tsushima[7], Naoko Nagatsuka[1], Koji Fujita[4], Naga Oshima[8], Kyotaro Kitamura[1], Kenji Kawamura[1,2], Wataru Shigeyama[1,2], Hideaki Motoyama[1,2], Teruo Aoki[1,2] (1.National Institute of Polar Research, 2.SOKENDAI, 3.University of Tokyo, 4.Nagoya Univeristy, 5.Tokyo University of Science, 6.Hokkaido University, 7.Chiba University, 8.Meteorological Research Institute, 9.Alfred Wegner Institute for Polar and Marine Research)

[ACC26-P02] Seasonal changes in concentration, metal composition and size distribution of mineral particles in recent snow at EGRIP, Greenland

*Yuki Komuro[1], Fumio Nakazawa[1,2], Kumiko Goto-Azuma[1,2], Motohiro Hirabayashi[1], Wataru Shigeyama[1,2], Naoko Nagatsuka[1] (1.National Institute of Polar Research, 2.The Graduate University for Advanced Studies, SOKENDAI)

[ACC26-P03] Implementation of higher-order advection schemes in a numerical ice-sheet model for ice-core studies

*Fuyuki SAITO[1], Takashi Obase[2], Ayako Abe-Ouchi[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

[ACC26-P04] An ice-flow modeling study for evaluation of sites for an oldest ice core around Dome Fuji, Antarctica

*Takashi Obase[1], Ayako Abe-Ouchi[1,2], Fuyuki SAITO[3], Shun Tsutaki[2], Shuji Fujita[2,4], Kenji Kawamura[2,4] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.National Institute of Polar Research, Japan, 3.Japan Agency for Marine-Earth Science and Technology, 4.SOKENDAI, the Graduate University for Advanced Studies)

[ACC26-P05] The effect of ocean circulation on glacial-interglacial cycles

*Ryotaro Todoroki[1], Ayako Abe-Ouchi[1], Fuyuki SAITO[2], Takashi Obase[1], Wing-Le Chan[1], Sam Sherriff-Tadano[3], Yasuto Watanabe[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 3.The University of Leeds, 4.The University of Tokyo)

[ACC26-P06] Transient simulations of the last deglaciation using MIROC AOGCM and time evolving ice-topography

*Tristan Vadsaria[1], Takashi Obase[1], Ayako Abe-Ouchi[1], Sam Sherriff-Tadano [2,1], Wing-Le Chan[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, Japan, 2.School of Earth and Environment, The University of Leeds, Leeds, UK)

[ACC26-P07] **Inactivating microorganisms in melted snow and ice samples using ultraviolet germicidal radiation**

*Fumio Nakazawa[1,2], Kumiko Goto-Azuma[1,2] (1.National Institute of Polar Research, 2.The Graduate University for Advanced Studies, SOKENDAI)

[ACC26-P08] The origin of moisture inferred from water stable-isotopes of an ice-core drilled in the Pamir-Alay Mountains in Central Asia

*Daiki Seto[1], Nozomu Takeuchi[1], Aizen Vladimir[2], Akane Tsushima[3], Kenji Kawamura[4], Koji Fujita[5] (1.CHIBA university, 2.University of Idaho, 3.Graduate School of science, Chiba university, 4.Graduate School of Environmental Studies, Nagoya University, 5.National Institute of Polar Research, Research Organization of Information and Systems)

[ACC26-P09] Analyses of pollen grains and insoluble particles in an ice core drilled in the Pamir-Arai Mountains in central Asia

*Nozomu Takeuchi[1], Haruka Ogaya[1], Koji Fujita[2], Kenji Kawamura[3], Akane Tsushima[1], Vladimir Aizen[4] (1.Chiba University, 2.Nagoya University, 3.National Institute of Polar Research, 4.University of Idaho)

A biomass burning record over the past 350 years in an ice core from Northwest Greenland

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Black carbon (BC) is one of the major light-absorbing aerosols, which can affect Earth’ s radiation budget. BC in the atmosphere absorbs sunlight and heats the atmosphere, whereas BC deposited on snow and/or ice reduces the surface albedo and enhances snowmelt. BC can also act as cloud condensation nuclei and ice nucleating particles, which play important roles in climate change. To understand the role of BC in climate change, we need to know concentrations, size distributions, and spatial and temporal variability in them. However, observations of BC in the atmosphere and snow have been started only recently. There have been no direct observations of BC in the preindustrial time, which was unaffected by anthropogenic input. Ice cores can provide proxy records of the past BC concentration and size distribution in the preindustrial period as well as the industrial period. The records from the preindustrial period are of special importance in understanding the role of BC in the pristine environment.

We analyzed an ice core drilled at SIGMA-D site, Northwest Greenland (Matoba et al., 2015), down to the depth of 113 m using a Continuous Flow Analysis (CFA) system developed at the National Institute of Polar Research. The CFA system enabled us to obtain high-resolution data of BC, stable isotopes of water, microparticles and six elements (Na, K, Mg, Ca, Fe, and Al). For BC analysis, we used a recently developed Wide-range (WR) SP2 (Single Particle Soot Photometer), which can detect BC particles in size range between 70 and 4000 nm (Mori et al., 2016). A combination of WR-SP2 and a high-efficiency nebulizer allowed us accurate measurements of BC concentrations and size distributions. We dated the core by annual layer counting using mainly Na and water stable isotopes. Our ice-core record covers the past 350 years. We divided each year into 12 months and calculated monthly averaged BC concentrations and size distributions.

Concentrations of BC started to increase in the 1870s, reached its maximum in the 1920s - 1930s, and decreased again since then. The increases are likely due to anthropogenic BC, which we as found to deposit mainly in fall and winter months. Before the increases started, the major source of BC was biomass burning, which showed summer peaks in BC concentrations. Based on the different seasonality of anthropogenic and biomass burning BC, we reconstructed temporal variability in biomass burning BC. Except for occasional large biomass burning events, we found relatively stable biomass burning BC concentrations over the past 350 years. We did not find particularly high summer BC concentrations in warm periods.

Keywords: Greenland, Black carbon, Biomass burning, Ice core

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Seasonal changes in concentration, metal composition and size distribution of mineral particles in recent snow at EGRIP, Greenland

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Changes in meteorological and ground surface conditions can cause changes in mineral particle supply to the Greenland ice sheet and thus influence the particle concentration in snow. To reveal the factor causing the changes of the particle supply and concentration, an understanding of their source areas is required. Metal composition and size distribution of the particles should be able to estimate source areas of the particles. To clarify recent seasonal changes in the concentration of mineral particles in snow and their source area, we analyzed the total concentration of metals and particle distribution in snow pit samples obtained from EGRIP (East Greenland Ice Core Project).

In summer 2017, we dug a 2.01 m snow pit at EGRIP camp. Snow samples were collected at 0.03 m intervals. The snow samples were melted, then fractions of them were analyzed for the particle size distribution (0.52-12 μm) with a Coulter counter (Beckman Coulter: Multisizer 4). Other fractions of the samples were treated with a microwave acid digestion method to decompose particulates. Total concentrations of Al, Ca and Na in samples were measured by inductively coupled plasma mass spectrometry.

Concentrations of total Al (t-Al) and non-sea-salt Ca (nssCa) increased in winter to spring layers. This indicates that mineral particle concentration in the snow at EGRIP increased in the periods. In addition, volume fractions of fine particles (<4 μm) tended to be relatively high in the layers. This suggests that fine mineral particles from remote source areas were predominantly deposited on the snow at that time. Additionally, nssCa/t-Al ratios tended to be relatively high in those layers, having 2-3 times higher than the crustal average of Ca/Al ratio in some of the layers. Thus, it is suggested that mineral particles originated from remote desert areas were supplied to EGRIP in the periods. In contrast, in summer to autumn layers, the nssCa/t-Al ratios and volume fractions tended to be relatively low. This suggests the supplies from soil areas having Ca-poor compositions near Greenland in the periods.

Keywords: Greenland, snow, mineral dust

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Implementation of higher-order advection schemes in a numerical ice-sheet model for ice-core studies

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Computation of temperature and age fields by numerical ice-sheet models is an important issue for ice-core related studies. Generally the evolution of temperature and/or age in an ice-sheet model is formulated using an advection equation. There are many variation of the formulation, which differ in numerical aspects such as stability, accuracy, numerical diffusivity, conservation and/or computational costs. Saito et al (2020, GMD) implement Rational Constrained Interpolation Profile (RCIP) scheme on vertical 1-d age computation of ice sheet, and demonstrate its efficiency, in particular, to preserve surface mass balance properties recorded at the deposit in terms of annual layer thickness. Successively, we have been extending the development using RCIP or similar higher-order advection schemes on 3-d age or temperature computation. In this study, we demonstrate 1-d temperature computation by various numerical schemes including classical upwind schemes and compare the accuracy of those schemes.

Keywords: ice-sheet model

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An ice-flow modeling study for evaluation of sites for an oldest ice core around Dome Fuji, Antarctica

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(notes: authors and texts will be edited by 2/18.)
The recovery of a new Antarctic ice core to cover one-million years before present will advance our understandings of the Quaternary climate. Previous ice flow modeling studies indicates that such old ice may exist in inland areas of the Antarctic continent, where the ice is thick enough, accumulation rate is low, basal temperature is well below the pressure melting point, and horizontal ice flow is slow. The 59th Japanese Antarctic Research Expedition (JARE59, 2017-2018 Antarctic summer) conducted glaciological field surveys for the selection of next deep drilling around Dome Fuji. In particular, a set of ground radar surveys were conducted around Dome Fuji for improved mapping of the bedrock topography as well as internal layers of the ice sheet.

In the present study, we use an one-dimensional ice flow model to investigate the influence of uncertain parameters, such as ice thickness, accumulation rate, geothermal heat flux, and thinning rate on the age estimation of ice especially in the lowest few hundred meters. The calculated age and temperature profiles are compared with previous depth-age models and borehole temperature at Dome Fuji for assessing the model performance for our purposes. The one-dimensional model is then applied to the vicinity of Dome Fuji along the transect of JARE 59 surveys, and simulated age profiles are compared with dated internal layers from the observation. We discuss the evaluation of potential site and the influences of uncertain parameters on the age of the deep ice core.

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The effect of ocean circulation on glacial-interglacial cycles

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The climate of the Pleistocene is characterized by glacial cycles which are said to be driven by orbital forcing. On the other hand, the state of the ocean like the AMOC strength also has an important role in the earth system. For example, the AMOC is closely related to a bi-polar seesaw mechanism, not only during deglaciation, but it may also affect ice sheet extent throughout entire glacial cycle. Indeed, some recent studies showed the effect of millennial scale oscillations, namely Dansgaard-Oeschger events (DOE), on ice sheets using ice-sheet models. In this study, we use an ice-sheet model (IcIES; Abe-Ouchi et al., 2013) and introduce the effects of DOE by applying temperature anomalies from hosing experiments in GCM and NGRIP ice core $\delta^{18}O$ data, which can be seen as an indicator of the AMOC strength. Including the effects of a DOE-like ocean circulation in the ice-sheet model, the North American ice sheet retreats to the southern margins of the Hudson Bay and the total ice volume of the North American and Eurasian ice sheets decreases to 50m (SLE) in MIS3. As for the last deglaciation, during the Bølling-Allerød (B-A) interstadial, the Northern American and Eurasian ice sheets melt rapidly in accordance with AMOC recovery and both discharge meltwater. When applying the DOE effect, meltwater from the Eurasian ice sheet increases dramatically and the amount surpasses that from the North American ice sheet during peak melting, leading to a near-complete deglaciation of the Eurasian ice sheet during the B-A warming period.

Keywords: Glacial-Interglacial Cycles, Dansgaard-Oeschger Event

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Transient simulations of the last deglaciation using MIROC AOGCM and time evolving ice-topography

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The last deglaciation (from 21 to 9 ka BP, also called T1) is the transition from the last glacial maximum (LGM) to the present interglacial. From the LGM, the increase in global temperature rise was about +4˚C to +6˚C and the Atlantic Meridional Overturning Circulation was largely affected. Previous transient simulations were performed at the University of Tokyo, using transient greenhouse gases (GHC) and orbital parameters with LGM ice sheet topography and bathymetry throughout the simulation (Obase & Abe-Ouchi., 2019). The previous study shows that abrupt AMOC increase, associated with the Bolling-Allerod (BA, about 14.7 to 14.2 ka BP) event, can be caused by gradual warming induced by orbital and greenhouse gases forcing without meltwater addition, and, that different hosing transient experiments using meltwater reconstruction affect the BA event timing.

The aim of the current study is to realize similar transient experiment using time-evolving ice-sheet according to recent reconstruction (ICE-5G, Peltier et al., 2015). To date, several simulations using this protocol and the same model as Obase & Abe-Ouchi. (2019), have been performed with sensitivity to freshwater discharge after 16 ka BP (when northern ice-sheet retreat is accelerated) and ocean bathymetry.

To equivalent freshwater forcing –i.e., 0.04 Sv applied uniformly between 50 and 70˚N after 16 ka (“control” run in Obase & Abe-Ouchi., 2019) –the retreat of the northern ice sheet induces warming in the ice sheet margins especially over northern America Abrupt warming occurred simultaneously (about 15.5 ka) in hosing experiments (time-evolving ice-sheet vs fixed ice-sheet). This timing is delayed when greater meltwater is applied (0.05Sv) inducing a Greenland warming in good agreement with temperature proxies, in term of timing (14.5 ka) and amplitude (about +10˚C within 500 years).

Keywords: Last deglaciation, Transient experiments, Hosing experiments, PMIP protocol

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Inactivating microorganisms in melted snow and ice samples using ultraviolet germicidal radiation

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The storage of melted snow and/or ice samples from snow pits and ice cores in a refrigerator for long durations may be limited by an increase in particle concentration caused by microbial growth after approximately 1–2 weeks. In this study, we examined an ultraviolet (UV) disinfection method for the storage of melted snow and/or ice samples. Surface snow obtained from Glacier No. 31 in the Suntar-Khayata Range, eastern Siberia, Russia was divided into two portions for UV treatment and untreated controls. Particle concentrations in the samples were measured using a Coulter counter (Multisizer 4e; Beckman Coulter, USA). Whereas the particle concentration in untreated samples increased, no obvious increase was observed over 53 days in the samples subjected to UV treatment. In addition, the original particle concentrations were unaffected by UV treatment. These findings indicate that the antimicrobial effect of UV radiation is effective for long-term sample storage of melted water samples. A detailed analysis of the particle size distribution for untreated samples indicated that particles of 0.7–1.2 μm appeared within the first 7–14 days. Measurements using a viable particle counter (XL-10BT2 and XL-28A1; RION Co. Ltd., Japan) confirmed that these were biological particles, suggesting that microbial growth occurs during this period. Subsequently, the particles shifted to a smaller size and a higher concentration, suggesting that the decomposition of microorganisms occurred in the water samples. Therefore, the size distribution of particles in untreated samples reflected the growth and decomposition of microorganisms over time.

Keywords: biological particle, glacier, snow, sterilization, culture

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The origin of moisture inferred from water stable-isotopes of an ice-core drilled in the Pamir-Alay Mountains in Central Asia

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Central Asia is located in the central part of the Eurasia Continent and is characterized by arid climate. Precipitation occurs mostly in the alpine area and forms glaciers, which are important water resources in this region. To evaluate the mass balance of such alpine glaciers, understanding of the moisture sources of the central Asia is important. In this study, water stable isotopes of ice-core drilled in the Pamir-Alay Mountains in western Central Asia were analyzed to assess the origin and its variations of the moisture transported to this region.

An ice-core was drilled in August 2016, at the top of an ice cap in the Pamir-Alay Mountains at the elevation of 5300 m a.s.l. The mean of $\delta^{18}O$, δD, and d-excess of the ice core were -10.0‰, -58.0‰ and 22.3‰, respectively. The stratigraphy of the ice-core suggests that significant melting and refreezing occurred in the most of layers, and thus the stable isotope records of this ice-core appear to be disturbed. The mean stable isotope of the upper parts of the ice-core (above 15 m) was higher than those of the lower part (below 25 m), suggesting the recent warming trend. As the mean isotopes of ice-core was compared with those of river water and precipitation around the mountain range, the isotope of ice-core cannot be explained by elevation effect of river water and precipitation of the southern side of the mountains, while it is close to the isotope of river water and precipitation of the northern side of the mountains. The mean isotope of the ice-core was further compared with those of other ice cores obtained in Central Asia. The isotope of this ice-core is significantly higher than that of the ice-core from Pamir located in the southern side of the mountains, but is close to those of ice-cores from Tien Shan located in the northern side of the study site. Results suggest that the water vapor transported to the Pamir-Alay mountains is different from that of the southern side of Pamir-Alay mountains, which is originally from Indian Ocean, but is similar to that of the Tien Shan Mountains, which is transported from the Mediterranean.

Keywords: Central Asia, Pamir-Alay mountains, ice-core, stable isotope, moisture

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Analyses of pollen grains and insoluble particles in an ice core drilled in the Pamir-Arai Mountains in central Asia

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1. Chiba University, 2. Nagoya University, 3. National Institute of Polar Research, 4. University of Idaho

We analyzed pollen grains and insoluble particles in an ice core drilled in the Pamir-Arai Mountains in central Asia. The ice core was drilled in August of 2016 on an ice cap of elevation 5300 m a.s.l. The length of the ice core was 36 m from the surface to the bedrock. Microscopy revealed that the ice core contained mainly three morphological types of pollen grains, which are likely to correspond the genus of Juniperus, Artemisia, and Ephedra. Using the variations in these pollen concentrations in the ice core, annual layers were determined from the surface to the depth of 15 m for 21 years. In the section between the depths of 15 m and 26 m, little pollen grains were found in the ice core. The lack of pollen grains in the section is probably due to refrozen ice originated from water filled in a crevasse. Below the depth of 26 m, the pollen grains appeared again down to the bottom of the ice core. We found the charcoal particles in several layers in the deeper part of the core, suggesting that forest fires occurred in the past in this region. We also found pure calcite particles in some layers, which appeared not to be derived from terrestrial surface, but from a geyser because silicate mineral particles were not contained in the layers. Although this ice core did not appear to preserve a continuous past climate information, particle analyses could reveal unique environment events in this region of central Asia.

Keywords: ice core, pollen, central asia

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.12 Zoom Room 12

[A-GE27] Subsurface Mass Transport and Environmental Assessment

convener:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Chihiro Kato(Faculty of Agriculture and Life Science, Hirosaki University), Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo), Chairperson:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Zi feng Wu (Guangzhou University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo),Yuki Kojima(Department of Civil Engineering, Gifu University)



This session covers the topics on fluid flow and mass transport in geological media. Subjects related to laboratory testing, subsurface characterization, theoretical analysis and numerical modeling will be discussed. Presentations on geo-pollution, remediation, geological disposal of hazardous wastes, mass transport in vadose zone, and environmental assessment from any fields, such as earth science, engineering, and agriculture, are welcome.

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

[AGE27-01] Numerical simulation of soil moisture dynamics using physics-informed neural networks

★Invited Papers

*Toshiyuki Bandai[1], Teamrat A. Ghezzehei[1] (1.The University of California, Merced)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AGE27-02] Improvement of contaminant plume estimation by a geostatistical method considering groundwater flow and non-negativity

*Shizuka Takai[1], Taro Shimada[1], Seiji Takeda[1], Katsuaki Koike[2] (1.Japan Atomic Energy Agency, 2.Graduate School of Engineering, Kyoto-University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[AGE27-03] [Comparison of experiments and model calculations on the capillary rise of water and the air entrapment in rock pores]

*Ryoto Nomura[1], Tadashi Yokoyama[2], Naoki Nishiyama[3] (1.Graduate School of Advanced Science and Engineering, Hiroshima University, 2.Graduate School of Integrated Arts and Sciences, Hiroshima University, 3.University of Tsukuba)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[AGE27-04] Open-Loop System Ground Source Heat Pump on the Nagara River Alluvial Fan: An Assessment of Thermal Environmental Impact

*Randa Permanda[1], Tomoyuki Ohtani[1] (1.Gifu University)

11:50 AM - 12:15 PM JST | 2:50 AM - 3:15 AM UTC

[AGE27-05] Discussion

Numerical simulation of soil moisture dynamics using physics-informed neural networks

*Toshiyuki Bandai[1], Teamrat A. Ghezzehei[1]

1. The University of California, Merced

Water flow in soils can be described by the Richardson-Richards equation (RRE), which is a nonlinear partial differential equation. Because its analytical solution is not available in practical situations, it has been solved by numerical methods, such as the finite difference method, finite element method, and finite volume method. We here introduce an alternative numerical method called physics-informed neural networks (PINNs), where the solution to the RRE is approximated by neural networks based on their universal approximation capability. Although PINNs require more computational resources to solve the forward problem of the RRE compared to the other numerical methods, the PINNs approach is expected to be effective for the inverse problem. This is because the PINNs approach does not need repetitive solutions of the forward problem as in other numerical methods. Here, we introduce the PINNs solver for the RRE, and its solution was compared with the analytical and other numerical solutions to the RRE for homogeneous and layered soils. To demonstrate the potential of the PINNs approach for the inverse problem, the PINNs approach was applied to the estimation of surface flux from near-surface soil moisture measurements.

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Improvement of contaminant plume estimation by a geostatistical method considering groundwater flow and non-negativity

*Shizuka Takai[1], Taro Shimada[1], Seiji Takeda[1], Katsuaki Koike[2]

1. Japan Atomic Energy Agency, 2. Graduate School of Engineering, Kyoto-University

For underground contamination by such as radioactive nuclides and chemicals, the contaminant plume distribution needs to be clarified accurately for effective remedy. Existing methods for plume estimation can be divided in two categories. The first one is simulation of groundwater flow and contaminant transport. However, if the history of pollution is unknown, the calculation condition cannot be set properly. The second one is spatial interpolation and extrapolation of measurement data, such as Kriging. However, once a pollutant reaches an aquifer, the transport will be affected by groundwater (advection, dispersion, adsorption and retardation). In such case, spatial modeling of measurement data without considering of physical/chemical law may be unable to estimate the contaminant plume accurately.
In this study, we considered the estimation method integrated transport information into geostatistical analysis. In this method, release history from a known source is estimated inversely using the measurement concentration. Then, the entire plume distribution is calculated by the release history. However previous method does not impose any limitations on the results; therefore, the negative value can be estimated. To gain physically feasible solution, we considered the non-negativity constraint by Gibbs-sampling, which is based on Bayes' rule and statistically rigorous. The applicability of the method for underground contamination was confirmed for both hypothetical model and actual contamination case (Gloucester landfill, Canada). The groundwater flow and solute transport for porous media was calculated using 3D-SEEP code.
As the hypothetical model, the radioactive nuclide transport (^{3}H) in 2-dimensional and homogeneous media (300×60 m^2) was considered. The pollutant was assumed to be leaked for 300 days with 2 peaks. We used the concentration data taken after 330 days at 18 points placed at equal intervals. By spatial interpolation (Kriging with a Trend), the two peaks of plume could not be reproduced. However, the plume was reproduced well by the geostatistical method considering groundwater flow with the mean average error (MAE) of 1.0×10^{-4}. By considering non-negativity constraint, the MAE was reduced to 2.7×10^{-9}.
As the case study, we considered the pollution at the Gloucester landfill by 1,4-dioxane, which is highly soluble in water and resistant to biodegradation. The release history of 1,4-dioxane is almost unknown (beginning in 1969 and until 1980), but it is known that large spill is occurred sometime in 1978. We estimated the three-dimensional plume in the area of 300×300×40 m^3 using analytical solution for uniform flow, whose parameters are based the investigation at the site. We used concentration data at 69 points measured in 1982. By the geostatistical method considering groundwater flow and nonnegativity constraint, the large spill in 1978 could be reproduced well compared to previous research by other methods (minimum relative entropy approach and a geostatistical approach with Metropolis-Hasting). The plume was also evaluated well with the MAE of 2.8×10^{-2}.
This study includes the results of contract work funded by the Secretariat of the Nuclear Regulation Authority, Japan.

Keywords: Underground contamination, Geostatistical analysis, Groundwater flow, Gibbs sampling

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[Comparison of experiments and model calculations on the capillary rise of water and the air entrapment in rock pores]

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A rock usually has pores of various sizes. Pore diameter distribution is widely measured as a fundamental information on pore structure. When a rock contacts water, water infiltrates into pores by capillary rise. In many cases, a certain amount of air is trapped in the pore and the pores are not completely filled with water. As a conventional concept that can be used to predict the extent to which the pore of each diameter is filled with water, one assumption is that the pores are filled with water in order from narrow to wide pores (van Genuchten, 1980), and the other assumption is that each pore is filled with water at the same ratio (the same ratio as whole rock water saturation) (Parker and Lenhard, 1987). Below, the former is referred to as VG model and the latter as PL model. In both the models, the amount of water in each pore diameter can be predicted based on the pore diameter distribution using a known water saturation. In this study, we are working on creating a new model that can predict the amount of water in each pore diameter in the presence of entrapped air even if the water saturation is unknown.

Our model built upon the models of Tsunazawa et al. (2016) and Yokoyama et al. (2020). The model considers a situation in which water rises from the bottom of the Y-shaped tube (radius r_{supply}), the tube is separated to narrow tube (radius r_{narrow}) and wide tube (radius r_{wide}) at the branching point, and then merges again in an inverted-Y-shape tube at the top. When water moves in such a tube, after the branching point, water first advances only inside the narrow tube because the capillary pressure in the narrow tube is greater than that in the wide tube (Mehrabian et al. 2011; Sadjadi et al. 2015). However, when water in the narrow tube advances by a certain distance of L, the advantage of pressure in the narrow tube is lost due to the viscous resistance in the tube, and water starts to advance in the wide tube. This L value is a criterion for evaluating in which of wide tube and narrow tube the air entrapment occurs, and can be calculated theoretically by setting the values of r_{supply}, r_{narrow}, r_{wide}, and grain size. By performing such calculations for various combinations of pore radii in the rock, the amount of water in each pore diameter in the presence of entrapped air can be predicted.

The amount of water in each pore diameter inside a water-bearing rock can be measured directly by experiments (for example, water expulsion method; Nishiyama et al., 2012; Yokoyama et al., 2020). The data of water volume in each pore diameter determined after the capillary rise experiments using various rock samples were compared with the values predicted by each of the VG model, PL model, and our model. The experimental results showed that in many cases not only narrow pores but also wide pores contained a certain amount of water. This feature can be better reproduced by the PL model and our model, compared with the VG model which predicts that narrower pores are fully filled with water whereas wider pores are kept vacant.

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Open-Loop System Ground Source Heat Pump on the Nagara River Alluvial Fan: An Assessment of Thermal Environmental Impact

*Randa Permanda[1], Tomoyuki Ohtani[1]

1. Gifu University

Ground Source Heat Pump (GSHP) are renewable energy technologies that use thermal energy from the ground for heating and cooling purposes. GSHP has gained attention to benefits such as low costs of running costs and low emissions of CO_2. Many residential areas in Japan are located on alluvial deposits, where groundwater flow is usually present. An open-loop GSHP system or groundwater heat pump (GWHP) is potentially feasible in areas where abundant groundwater is available. Open-loop GSHP systems use groundwater as a heat source. Groundwater is extracted from a pumping well and passed through a heat exchanger or a heat pump before being discharged back into the aquifer through an injection well.

Apart from the advantages, open-loop GSHP has a potential thermal environmental impact resulting from groundwater pumping and injection activities in the surrounding area. Therefore, this study aims to simulate groundwater flow and heat transport in the alluvial fan and assesses the thermal environmental impact of pumping and injecting the open-loop system from the wells. The study area is located on an alluvial fan of the Nagara River, Gifu City, central Japan, with a size of 12 km (NS) ×12 km (EW). It is bounded by mountains ranging from north to northeast side, and the plain area remains. The underground temperature in the alluvial fan is influenced by rapid groundwater flow recharged from the Nagara River. This alluvial fan is composed of sand and gravel and often intercalates thin fine sand and silt layers.

In this study, groundwater flow and heat transport were modeled by DHI FEFLOW to understand regional groundwater flow and heat transport in the Nagara River alluvial fan. Based on the regional groundwater flow and heat transport simulation, a local scale model of an open-loop GSHP was constructed to assess the thermal environmental impact of the open-loop geothermal heat pump system. The operation mode was applied for heating from January to March, and cooling from July to September. The simulation was performed for ten years. Injection temperature is assumed to be three variant values: 3, 5, and 10 ˚C higher and lower than the temperature of pumping well for the heating and cooling periods, respectively. The flow rate of pumping and injection was 3.33 ×10−3 m^3/s.

The calculated results were compared with measured data of the hydraulic head and groundwater temperature to validate the regional groundwater flow and heat transport simulation. Hydraulic heads in the observation wells show that almost all calculated results match the measured data. This result indicates that the calculated result well represented the distribution of the hydraulic head in the study area. Nevertheless, some discrepancies (approximately 1 −2 m) occur in 2 wells located near the recharge area. This suggests that the hydraulic conductivity within an alluvial fan is not homogeneous and that in the upper fan area, including the recharge area, is higher than that of the other area. Comparison of the annual underground temperature change between the calculated and measured values are almost consistent with the measured data. However, there are noticeable differences between the measured and calculated data on an average of 1 −2 ˚C. The calculated phase differences of annual groundwater temperature change against annual river water temperature change are almost equal to the measured ones. In the local scale model of open-loop simulation, it can be found that there are changing

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groundwater temperatures around the injection well caused by heat/cold injection. In this study, the temperature change was defined by a change of more than 1 ˚C at groundwater temperatures. The thermal plume size would have a length of about 10 m in summer and 20 m in winter when water reinjected is at 3 ˚C of the temperature difference between pumping and injection. These thermal plumes' size becomes further when the temperature difference between pumping and injection gets higher. Injection activities by an open-loop GHP system do not cause a severe temperature change in the areas of 100 m and 200 m from the injection well. The thermal environmental impact and interference effect is avoidable from another open-loop GHP system according to regulation by other countries.

Keywords: Ground Source Heat Pump, Open-Loop System, Thermal Environmental Impact, FEFLOW

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[E] Oral | A (Atmospheric and Hydrospheric Sciences) | A-GE Geological & Soil Environment

[A-GE27] Subsurface Mass Transport and Environmental Assessment

convener:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Chihiro Kato(Faculty of Agriculture and Life Science, Hirosaki University), Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo), Chairperson:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Zi feng Wu (Guangzhou University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo),Yuki Kojima(Department of Civil Engineering, Gifu University)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.12 (Zoom Room 12)

This session covers the topics on fluid flow and mass transport in geological media. Subjects related to laboratory testing, subsurface characterization, theoretical analysis and numerical modeling will be discussed. Presentations on geo-pollution, remediation, geological disposal of hazardous wastes, mass transport in vadose zone, and environmental assessment from any fields, such as earth science, engineering, and agriculture, are welcome.

11:50 AM - 12:15 PM

[AGE27-05]Discussion

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.05_1

[A-GE27] Subsurface Mass Transport and Environmental Assessment

convener:Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Chihiro Kato(Faculty of Agriculture and Life Science, Hirosaki University), Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo)



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[AGE27-P01] Chemical and Biological Properties of Apple Orchard Soils under Natural, Hybrid, and Conventional Farming Methods

★Invited Papers

*Takamitsu Kai[1], Motoki Kubo[2] (1.Meiji University, 2.Ritsumeikan University)

[AGE27-P02] **Impact of Macropore structure and water management on greenhouse gas emissions, total soil carbon and nitrogen, and soil mineral distribution in agricultural field**

*Thanh Long Bui[1], Yasushi Mori[1], Morihiro Maeda[1] (1.Graduate School of Environmental and Life Science, Okayama University)

[AGE27-P03] Evaluation of radioactive cesium-bearing microparticles discharged with suspended solids from a small forested watershed

Satoshi Hadano[1], Shoichiro Hamamoto[1], Taiga Okumura[2], Toshihiro Kogure[2], *Taku Nishimura[1] (1.Deptartment of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

[AGE27-P04] Evaluating effects of plant roots on soil thermal properties with a thermo-TDR sensor

*Nanae Oda[1], Yuki Kojima[1], Kohji Kamiya[1] (1.Gifu University)

[AGE27-P05] Quantifying in-situ fine bubble concentration in water and soil with thermo-TDR

*Ryunosuke Tanigawara[1], Yuki Kojima[1], Shoichiro Hamamoto[2], Kohji Kamiya[1] (1.Faculty of Engineering, Gifu University, 2.Graduate School of Life and Agricultural Sciences, University of Tokyo)

[AGE27-P06] A laboratory test of heavy metal accumulation by using soil cooling and heating technique inducing dynamic soil water freezing and evaporation

*Yuki Kojima[1], Hayata Terada[2], Kohji Kamiya[1] (1.Department of Civil Engineering, Gifu University, 2.Graduate School of Natural Science and Technology, Gifu University)

[AGE27-P07] Effect of the gravity differences on early stage water movement in soils.

*Ryoki Ihara[1], Yasushi Mori[2] (1.Faculty of Environmental Science and Technology, Okayama University, 2.Graduate School of Environmental and Life Science, Okayama University)

[AGE27-P08] Neural network estimation of soil organic matter contents and its relation to other soil components.

Masaki Kiyohiro[1], *Yasushi Mori[1], Takayuki Shuku[1] (1.Graduate School of Environmental and Life Science, Okayama University)

[AGE27-P09] Water and Mass Transfer in Soils and Optimal Farmland Management in the Rice Terraces of the Philippine Cordillera

Tomoyo Kurozumi[1], *Yasushi Mori[1], Hiroaki Somura[1], Pearl Basilio Sanchez[2], Gina Villegas-Pangga[2] (1.Graduate School of Environmental and Life Science, Okayama University, 2. University of the Philippines Los Baños)

[AGE27-P10] Estimation of Soil Water Retention Parameters by Ground Penetrating Radar Reflection Wave Inversion

*Hiroki Kawasumi[1], Hirotaka Saito[2], Koki Oikawa[2] (1.Department of Ecoregion Science, Tokyo University of Agriculture and Technology, 2.Department of Ecoregion Science, Tokyo University of Agriculture and Technology)

[AGE27-P11] Effects of elevated air temperature and CO_2 concentration on soil CO_2 dynamics in an apple orchard

*Chihiro Kato[1], Akira Endo[1], Daiyu Ito[2], Sachinobu Ishida[3] (1.Faculty of Agriculture and Life Science, Hirosaki University, 2.Teaching and Research Center for Bio-coexistence, Faculty of Agriculture and Life Science, Hirosaki University, 3.Graduate school of Science and Technology, Hirosaki University)

[AGE27-P12] Effect of soil air on pore network properties and mass transport in porous media

Yushi Ohko[1], *Shoichiro Hamamoto[1], Yutaka Ohtake[2], Taku Nishimura[1] (1.Graduate School of Agricultural and Life Sciences, the University of Tokyo, 2.Graduate School of Engineering, the University of Tokyo)

[AGE27-P13] Monitoring of soil gas environment in soybean fields under different fertilizer managements

*Ayato Nishimura[1], Shoichiro Hamamoto[1], Naoto Nihei[2], Toshinobu Taira[3], Katsuo Tanji[3], Yasunori Ichihashi[4], Taku Nishimura[1] (1.Graduate School of Agricultural and Life Sciences, the University of Tokyo, 2.Faculty of Food and Agricultural Sciences, Fukushima University , 3.Fukushima Agricultural Technology Centre, 4.RIKEN BioResource Research Center)

[AGE27-P14] Effects of Cation Exchange on Colloid Transport in Saturated Porous Media

*Rikutaro Higashi[1], Shoichiro Hamamoto[1], Taku Nishimura[1] (1.Graduate School of Agricultural and Life Sciences, the University of Tokyo)

[AGE27-P15] Seasonal Variation of the Effect of Ridge Orientation on Water and Temperature Distribution Inside Ridges

*Keito MASUMOTO[1], Shintaro Kubota[2], Hirotaka Saito[3] (1.Department of Ecoregion Science, Tokyo University of Agriculture and Technology, 2.Graduate School of Agriculture, Tokyo University of Agriculture and Technology, 3.Institute of Agriculture, Tokyo University of Agriculture and Technology)

Chemical and Biological Properties of Apple Orchard Soils under Natural, Hybrid, and Conventional Farming Methods

*Takamitsu Kai[1], Motoki Kubo[2]

1. Meiji University, 2. Ritsumeikan University

Apples in Japan are generally cultivated under management systems that use chemical fertilizers and synthetic chemical pesticides. However, the continuous use of these fertilizers and pesticides damages the soil environment and reduces the number of soil microorganisms. In this study, we compared the chemical and biological properties of 12 soils from apple orchards in Aomori and Nagano Prefectures under four types of management systems, namely, natural conditions, with no cultivation, fertilizers, or pesticides; organic farming methods, using organic materials and pesticides approved by the Japanese Agricultural Standard organic certification system; hybrid farming methods, using a mix of organic and chemical fertilizers; and conventional farming, using chemical fertilizers and pesticides. Soil total carbon (TC), total nitrogen (TN), total phosphorus (TP), nitrate-nitrogen (NO_3^-), and available phosphoric acid (SP) contents were generally found to be the highest where organic farming methods were used. Similarly, bacterial biomass, nitrification (N) circulation activity, ammonia (NH_4^+) oxidation activity, nitrite (NO_2^-) oxidation activity, and phosphoric (P) circulation activity were the highest under organic farming, especially in comparison with conventional farming. This study indicated that the differences in apple sugar content, acidity, and sugar/acidity ratio between different orchard management systems were due to different soil conditions, and soil conditions under organic farming management system in apple cultivation increased bacterial biomass while enhancing N and P circulation activity and high TC. On the other hand, the soil of conventional farming has the lowest total number of bacterial biomass and lowest material cycle such as N and P circulation activity. Analysis of the chemical and biological properties of these orchard soils indicated that soil conditions under organic farming management are the most suitable for increasing microbial numbers and enhancing N and P circulation activity.

Keywords: Soil fertility, Organic farming, Soil Microorganisms

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Impact of Macropore structure and water management on greenhouse gas emissions, total soil carbon and nitrogen, and soil mineral distribution in agricultural field

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Greenhouse gas (GHG) emissions generated from soils have become the prevailing concern due to their contribution to global warming. Several studies have been conducted under the diversity of objectives, methods, and disciplines recently. The emissions generated from soil are significantly influenced by soil factors, such as water content, soil organic matter, redox potential, hydraulic conductivity, and pore structure.

In this study, a preliminary experiment was conducted to observe the effects of macropore structure and water management on agricultural soil GHG emissions, total soil carbon, nitrogen, and mineral distributions under different management practices. Masa soil was prepared with/without macropores and with/without compost application under unsaturated/saturated conditions, while paddy soil was examined the same preparation under with/without drainage.

The results for the Masa soil with macropores showed that CO_2 gas emissions were more extensive due to an increased pathway for gas emission. There was no clear trend in total carbon (TC) and total nitrogen (TN). However, Ca and Mg were larger at the surface of soils without macropore because of the salt accumulation process. Paddy soil with macropores also showed larger CO_2 gas emissions but CO_2 and CH_4 gas emissions were smaller with drainage application in soils with macropores and compost application. CH_4 gas concentration was negatively correlated with infiltration rate, which meant that freshwater or oxygen supply was available within macropore pathways and drainage application. TC and TN were significantly smaller at the bottom than at the top of the soil sample, showing the development of the reductive conditions with no drainage. The findings showed that macropores act as pathways for gas emission while reducing reductive conditions, leading to lower CH_4 emissions.

Keywords: GHG, Macropore, Soil total carbon, Total nitrogen, Soil mineral, Drainage

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Evaluation of radioactive cesium-bearing microparticles discharged with suspended solids from a small forested watershed

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Introduction

A large amount of radionuclides were released to the environment by the accident at the Fukushima Daiichi Nuclear Power Plant (FDNPP). After the accident, in Fukushima Prefecture, forest area which accounts for 70% of the total area of the prefecture was excluded from the decontamination work. However, it is still important to understand dynamics of ^{137}Cs in forests. ^{137}Cs deposited on the forest floor is considered to move slowly downward. It adsorbs to the surface soil and discharged into rivers by surface runoff during rainfall. Previous studies estimated the annual discharge of ^{137}Cs from forests to rivers as about 0.2% of the initial deposition.

Various types of radioactive particles have been isolated from forest. One of them is a weathered biotite adsorbed ^{137}Cs and another is a radioactive Cs-bearing micropaticle (CsMP). Previous studies reported that CsMP is composed mainly of the silicate and its radioactivity concentration (Bq g^{-1}) is approximately 10^{5-6} times of the weathered biotites. While weathered biotites can desorb ^{137}Cs by acidic compounds, CsMP is thought to have low solubility in acid solutions due to its chemical composition. It was also reported that CsMP dissolves by heating in artificial seawater. Therefore, quantification of CsMP based on the selective dissolution with acid solution and artificial seawater is expected to be utilized.

Thus, we aimed to eavluate discharge of ^{137}Cs and CsMP from a forest to a river by using acid and artificial seawater treatment.

Methods

Our study site was a small forest watershed in Iitate Village, Fukushima Prefecture, located about 30 km northwest from FDNPP. Initial deposition of ^{137}Cs in the area was about 1 MBq m^{-2}. We installed an automatic water sampler, a turbidity meter, and a water level gauge with a system that sampled river water when the water level exceeded a certain level.

Each water sample was filtrated through a 6 μm pore size filter paper and a 0.45 μm pore size membrane filter to separate suspended solids (SS). After each filtration, we passed the filtrate through a zinc substitute prussian blue cartridge to adsorb dissolved ^{137}Cs and measured the radioactivity of particulate ^{137}Cs from suspended solids and dissolved ^{137}Cs from the cartridge with a germanium semiconductor detector.

After filtrations, the filter paper was cut into pieces and immersed in 250 mL of 10 mM HCl together with the suspended solids. They were heated at 90˚C for 48 hours. After the treatment, we separated solids and liquid, and measured the radioactivity of the liquid. Then, the solids were immersed in 250 mL of artificial seawater and heated at 90˚C for 48 hours. After the treatment, we measured the radioactivity of both of solids and liquid. We also conducted the same treatments against 0.25 g of forest soils collected at 5 cm on the surface layer in the study site.

Results

We estimated the discharge of particulate ^{137}Cs by the regression equation between SS concentration (mg L^{-1}) and turbidity (NTU) of water samples, between SS concentration and particulate ^{137}Cs concentration

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(Bq L^{-1}), river water turbidities, and river water flow rates. We also estimated the discharge of dissolved ^{137}Cs by the average dissolved ^{137}Cs concentration (Bq L^{-1}). As a result, the total discharge of ^{137}Cs was 1.98 GBq (particulate ^{137}Cs: 1.89 GBq, dissolved ^{137}Cs: 82.6 MBq), which was 0.355% of the initial deposition. From the suspend solids in water samples, 12.7% of the total particulate ^{137}Cs were desorbed by the artificial seawater treatment. This was equivalent to the ratio of CsMP (R_{CsMP}) in suspended solids. Meanwhile, in the forest soils, R_{CsMP} was 12.3%. By SS concentration and R_{CsMP} of water samples, the discharge of CsMP was estimated to be 15.4 MBq. The deposition of CsMP was also estimated to be 685 GBq by R_{CsMP} in forest soils. Therefore, the ratio of CsMP discharged was calculated to be 0.0224% of the CsMP deposited.

Keywords: erosion, radioactive cesium, cesium ball, forest

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Evaluating effects of plant roots on soil thermal properties with a thermo-TDR sensor

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Plant roots have many effects on the surface soil properties. An interaction between soil thermal properties and plant root weight density has not been well understood. In this study, we aimed to evaluate the effects of plant roots on the soil thermal properties.

We hypothesized that the effect of plant roots on the soil thermal properties would differ depending on the soil and plant type, thus, we have performed an experiment with three types of plants (soybean, western grass, and guinea grass) and two soils (Gifu university experimental field soil and Andisol soil). The three plants were cultivated in the two soils, and thermal properties were measured with thermo-TDR periodically.

It was found that the plant root growth caused decrease in bulk density in Andisol soil while that of the field soil was relatively constant. Thermo-TDR sensor measurement showed that the soil thermal properties were affected by not only the root weight density but also various factors such as the soil bulk density and the root shape. In order to elucidate the phenomena in more detail, it is necessary to analyze the images of the rhizosphere soil by CT and to improve the model.

Keywords: plant root, thermal properties, thermo-TDR

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Quantifying in-situ fine bubble concentration in water and soil with thermo-TDR

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Application of Fine bubbles (FB) for de-contamination of soils has been attracting attentions recently. It is important to understand the behavior of FB in soils, however, effective in-situ measurements of FB concentration in both water and soil have been difficult. In this study, we investigated quantification of FB concentration in water and soil with thermo-TDR.

Two experiments were performed, one was for quantifying FB concentration in water, and the other was to quantify FB concentration in soils. In the first experiment, three differently sized thermo-TDR sensors were placed in a surfactant solution, and FB was produced. Dielectric permittivity of the solution was measured with each sensor. The thermo-TDR sensors were placed either horizontally or vertically to evaluate the effect of probe direction. In the second experiment, two thermo-TDR sensors were inserted into a completely saturated soil column and a quasi-saturated soil column. The FB solution was pumped into the both column, and deictic permittivity, volumetric heat capacity, and thermal conductivity were measured with the thermo-TDR sensors.

It was found that the FB concentration in water could be measured stably from the relative permittivity by using a large size sensor and with the probe placed vertically. The FB concentration in soil was found to be difficult to estimate with thermo-TDR in the case of completely saturated soil because the change in both dielectric constant and thermal properties was small. However, in the case of a quasi-saturated soil, there was a clear change in relative permittivity and thermal property values. It is guessed that the movement of FB was restricted by the enclosed air in the soil, and FB were trapped in the soil column. FB concentration was determined from these changes in dielectric permittivity and thermal properties by using empirical and theoretical equations that express the relative permittivity and thermal properties as a function of water content. Comparing the FB concentrations determined from the relative permittivity and thermal properties, the FB concentration estimated from the thermal properties was relatively large. It is because the thermal properties were affected by the water flow in the soil which was not complete steady-state. In conclusion, thermo-TDR sensor can measure the in-situ FB concentration in water and soil.

Keywords: fine bubble, thermo-TDR, dielectric permittivity, thermal properties

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A laboratory test of heavy metal accumulation by using soil cooling and heating technique inducing dynamic soil water freezing and evaporation

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Soil contamination by heavy metals has been recognized as a critical issue in recent years. A new technique to accumulate heavy metal in a thin soil layer and an adsorbent layer using an artificial soil cooling and heating cycle was proposed. Soil cooling causes soil freezing that dynamic liquid and solute transfer to the cooling plane occurs due to the low matric potential of frozen soil. Soil heating induces soil water evaporation and the solute is left in the heating plane. Given that, the soil a number of cooling and heating cycle results water soluble heavy metals accumulated near the cooling/heating plane and the adjacent adsorbent layer. In this study, we evaluated the possibility of the new technique, and influence of soil type, texture, initial water content, and addition of chelating solution on the efficiency of the technique with laboratory experiments.

30 cm height, 10 cm diameter PVC columns were filled with soils (Silica sand No. 7 or No. 9) contaminated by lead nitrate artificially. The lead concentration of the soils were 1000 mg kg^{-1}. A heat exchanger was installed at both ends of the column to control the temperature, which represented a cooling and heating cycle. The cooling and heating temperatures were -10˚C and 60˚C. The duration of cooling and heating was set to 36 hours and 12 hours, respectively. Apatite was used as an adsorbent. The initial volumetric water content of the soil was either 0.15 m^3 m^{-3} or 0.30 m^3 m^{-3}. Chelating agents (0.05 M and 0.15 M) were added as a substitute for water for some cases. TDR sensors were inserted to measure temperature and volumetric water content, and lead concentration was analyzed after the experiments.

The results of the laboratory tests showed that water and solutes tended to accumulate on the cooling and heating plane, indicating the feasibility of this technique. The amount of lead in soils decreased with the installation of the adsorbent layer, and the lead content in the adsorbent layer was 5.7 times higher than the initial value of the contaminated soil. The lead accumulation in the adsorbent increased when the moisture content was low and the particle size was fine. It is due to in part liquid water flux near the freezing front. The addition of chelating agent improved the mobility of lead and increased the accumulation of lead both on the cooling and heating plane and on the adsorbent. This indicates that the addition of chelating agent increases the accumulation efficiency of solute in this method. It was also found that low concentrations of chelating agents were sufficient to achieve the desired effect.

These results indicated that the effectiveness of the new technique in laboratory. Furthermore, the effect of changes in the soil environment on the accumulation efficiency of solutes was clarified. The findings obtained in this study are important information for the practical in-situ application of the new technique.

Keywords: Soil cooling and heating cycle, heavy metal, soil freezing, liquid water and vapor transfer

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Effect of the gravity differences on early stage water movement in soils.

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When considering the expansion of human activity to other planets, food production is one of the major issue. For plants growth, the dynamics of water in the soils are very important. Especially on other planets, the surface layers contains only primary weathering objects called regolith, and because of their low gravity, infiltration is unlikely to occur, and a lot of water is lost due to evaporation. Therefore, we investigated the initial water movement accompanied by the differences of gravity and soil structure. Standard sand, aggregate soil, macropore soils, and clayey soils were assumed as tested materials. Glass capillaries were used for the macropores.

The centrifugal force was used to generate the pseudo-gravity differences by rotating the tube rotator horizontally. For infiltration experiments, a 2ml centrifuge tube with a small hole at the bottom as water supply is placed on the soil surface in 15ml centrifuge tubes, then the tube was drained by applying the pseudo gravity. In the evaporation experiment, 2 ml of water was first supplied to the soil sample and placed in an incubator at a constant temperature of 40˚C. In this experiment, gravity differences were made by changing the inclination of the sample.

Changes in gravity did not affect the infiltration depth as expected. In addition, although there was no significant difference in infiltration depth in all soils, macropore infiltration tended to be greater in standard sand than in clay soil, which was considered to be due to the influence of inertial force when the particle size was large. In the evaporation experiment, the gravity did not affect the amount of evaporation, but the soil structure did. The amount of evaporation of standard sand with macropore and aggregates was significantly higher than that of bare standard sand. Because the exposed surface area increases as the soil structure develops, the vapor exchange might be accelerated.
The results of this study indicate that soil moisture is easily lost due to the aggregate structure with organic matter and the macropore structure in which vascular plants grow. However, on the current 1G earth, the macropore soils have more organic matter and shows higher water retention capacity, and are advantageous for plant growth. We need to consider long-term experiment.

Keywords: Micro-gravity, Regolith, Soil, Infiltration, Water conservation

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Neural network estimation of soil organic matter contents and its relation to other soil components.

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Soil is the largest carbon pool on land and plays an important role in supplying nutrients to animals and plants and improving the physical properties of soil. Currently, various SOC dynamic prediction models have been proposed, but most of them have been developed in Europe and the United States, and the application examples are biased toward temperate field soils. Until now, the human side has narrowed down the parameters and pursued the functional type, but if the optimum relationship can be derived from the data itself, we might clarify the phenomenon in the natural world. The objectives this study were to create a SOC prediction model using a neural network (NN) model, and to consider the relationship between SOC and other soil components in the target area.

Soil data for Europe, Southeast Asia, Australia, North America and South America were extracted from the Harmonized world soil database v1.2. In this study, in addition to using all features, model-based feature selection (Lasso (alpha = 1), Lasso (alpha = 10), Random Forest, and recursive feature selection (Random Forest parameters 8 to 1) are used as feature selection methods. In addition, 7 types of regularization strength (Penalty lambda=10, 1, 0.1, 0.01, 0.001, 0.0001, 0) in the objective function were prepared, models were created 5 times each, and accuracy verification was performed by cross-validation. 100 models were created by combining parameters with high prediction accuracy, and then the selected features were evaluated. In addition, hydraulic parameters were derived from the HWSD particle size data using ROSETTA, which is a Pedotransfer Function model, and the selected features were evaluated.

The features commonly selected in the models were silt content, dry density, cation exchange capacity, and base saturation. The development of soil pore structure and the adsorption of high-valence ions are cited as factors in the amount of organic matter, which are consistent with conventional knowledge. In addition, when hydraulic parameters are added to the features, they are selected as the features at each target site, thus, we could say the infiltration or water retention properties is a factor related to organic matter conservation.

Keywords: Neural Network, Soil Organic Carbon, Hydraulic properties, pedo-transfer function

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Water and Mass Transfer in Soils and Optimal Farmland Management in the Rice Terraces of the Philippine Cordillera

Tomoyo Kurozumi[1], *Yasushi Mori[1], Hiroaki Somura[1], Pearl Basilio Sanchez[2], Gina Villegas-Pangga[2]

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In the Rice Terraces of the Philippine Cordilleras, the World Heritage Site, soil-related problems such as the collapse of rice terraces and low productivity are becoming more serious. The rice terraces in the study area are characterized by the fact that the entire mountain slope is terraced, that there are villages within the terraced rice paddy basin, and that farming has been conducted using indigenous knowledge such as constant flooding and application of rice straw as a fertilizer. Therefore, in this study, we evaluated how these farming and environmental factors affect the soil environment, and discussed farmland management methods to improve the soil environment.

Field surveys and sampling were conducted in Bangaan and Batad in Ifugao Province to determine the amount of organic matter, total nitrogen, and minerals such as exchangeable cations, available phosphorus, and available trace elements in the soil. In addition, the drainage of paddy fields may cause cracks in the dry rice field surface and the collapse of terraced rice field. Therefore, we examined the effect of soil drying on permeability; samples were prepared using 100 cc samplers, dried, and saturated permeability experiments were conducted. The degree of drying (water content ratio) and dry density were used as parameters.

The field survey revealed that there is no unified knowledge about soil in the region, and the agricultural extension system is not functioning, so there are no opportunities to acquire agricultural knowledge. Soil analysis showed that the soil was generally deficient in nutrients, but on the other hand, the plots located directly under the village had excessive amounts of organic matter, which was thought to be mainly due to domestic wastewater from the village. On the other hand, in the field directly under the village, the amount of organic matter was excessive. In addition, the application of raw rice straw with high C/N ratio may have caused nitrogen starvation. The plots with excess organic matter were reported to have stunted rice growth and poor workability, and it was also confirmed that the plots were abandoned.

The results of the hydraulic conductivity tests showed that even when the samples were dried to quite low water content at 0.07, at dry densities of 1.0 and 1.2 g/cm3, the hydraulic conductivity when the samples were re-saturated was similar to that when the samples were flooded without drying. Regardless of the drying density, the lowest permeability was observed in the range of 0.25-0.40 at water content. In the experiment with different dry densities, permeability decreased due to clogging at dry densities below 0.9 g/cm3 . These results suggest that hydraulic conductivity can be stably maintained at dry densities of 1.0 g/cm3 or higher.

From all results, drainage in the field was desirable to mitigate soil reduction and decompose organic matter, and permeability of terraced fields could be stably maintained if the dry density was 1.0 g/cm3 or higher. Drying up to a water content ratio of 0.25-0.40 was considered to stabilize the functioning of the tillers because the shrinkage reduced the permeability.

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Keywords: the Rice Terraces of the Philippine Cordillera, the world heritage, rice terrace, ponding management, cracks

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Estimation of Soil Water Retention Parameters by Ground Penetrating Radar Reflection Wave Inversion

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1. Department of Ecoregion Science, Tokyo University of Agriculture and Technology, 2. Department of Ecoregion Science, Tokyo University of Agriculture and Technology

Surface ground penetrating radar (GPR) is often used to measure groundwater levels and to determine soil moisture conditions by recording reflected and refracted pulse electromagnetic (EM) waves emitted from the transmitter. When a soil profile with a shallow groundwater table is at hydrostatic equilibrium, the distribution of soil water content within the profile is determined by water retention property of the soil. As a result, the pulse EM wave emitted from the ground surface can be reflected at a point within a so-called capillary fringe, not at a depth where the pressure head is equal to zero.

In this study, we aimed to investigate numerically if such reflected waveforms can be used to inversely estimate soil water retention parameters. We developed an inverse analysis scheme with two software packages, gprMax, an open-source software package to simulates EM wave propagation, and PEST, a model independent parameter estimation software package as shown in Fig. 1. In this scheme, soil water retention parameters were optimized by fitting to waveforms simulated with known retention parameters.

In this study, we used the well-known van-Genuchten (VG) model to compute soil water distribution in a soil profile in hydrostatic equilibrium with a known groundwater table depth. We tested our scheme with a homogeneous sandy soil layer with a width of 2 m, a height of 2 m. To reduce the computational load, among the VG model parameters, we optimized the shape parameters, n and α, which strongly control the water distribution of the capillary fringe zone.

In this study, the depth to the groundwater table was set to 1.5 m. A ricker waveform with a central frequency of 400 MHz was used as a transmitted wave. The offset between the transmitter and the receiver was kept at 20 cm.

The inverse analysis scheme was first executed independently for the two parameters n and α. We found that when the initial values are below a certain value, the objective function did not converge and the optimization hardly progressed. On the other hand, the optimization proceeded to obtain parameters with an error less than 0.2 % even when an initial value that was several times larger than the true value. When an initial value above a certain value was used, while the objective function decreased significantly and optimization proceeded, it converged to a local minimum value.

When the two parameters n and a were optimized simultaneously, it was difficult to define clear limits. In some trials, even an initial value close to the true value was given, the parameter was optimized in the direction away from the true value especially when one of the parameters was way off from the true value.

With a scheme developed in this study, the inverse analysis resulted in an accurate estimation of the VG parameters for sand with an appropriate initial value. It is necessary to investigate the effectiveness of the proposed inverse scheme for different soil types and for the experimental data.

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Rererences
Saintenoy, A., andHopmans, J. (201: IEEE J. Selec. Top. Appl. Earth Obs. Remote Sens., 4(4), 748– 753.
Nemes, A, Schaap, M. G., Leij, F. J., Wösten (2001): J. of Hydro., 251 (3-4), 151-162.

Keywords: GPR(Ground Penetrating Radar), Water Retention, Parameter Estimation

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Figures

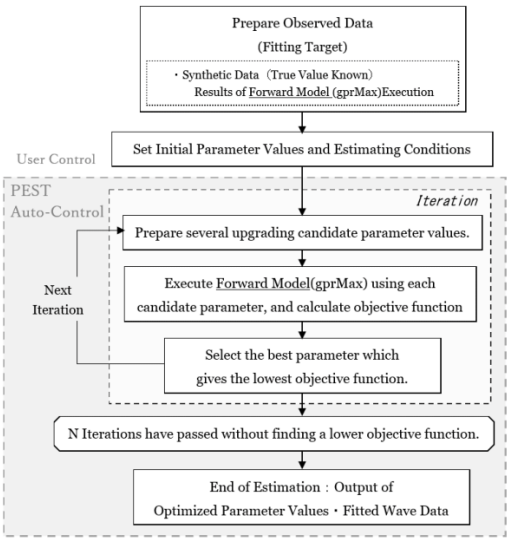


Figure 1 Flow Chart of Inversion Scheme

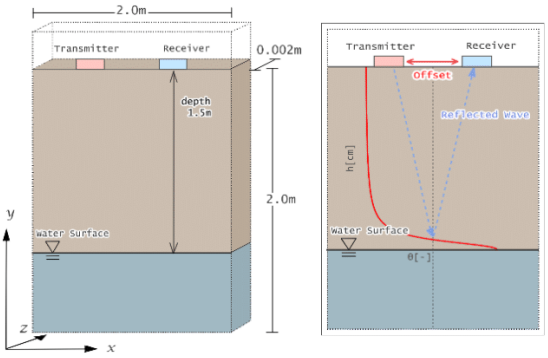


Figure 2 Simulation Domain

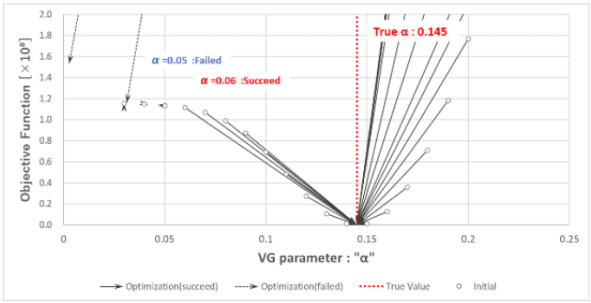


Figure 3 Optimization results of n:
① Estimating n

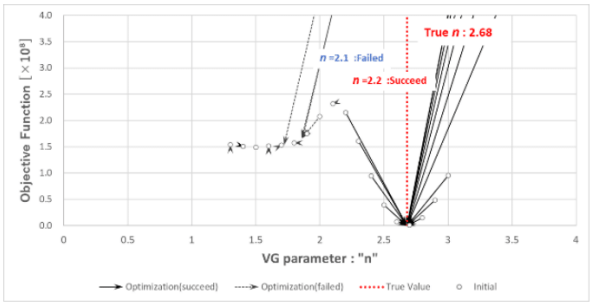


Figure 4 Optimization results of α:
② Estimating α

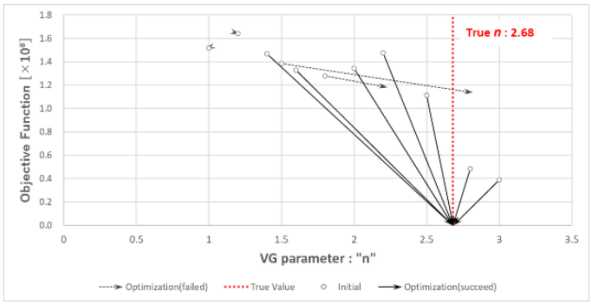


Figure 5 Optimization results of n:
③ Simultaneous Estimation of n and α

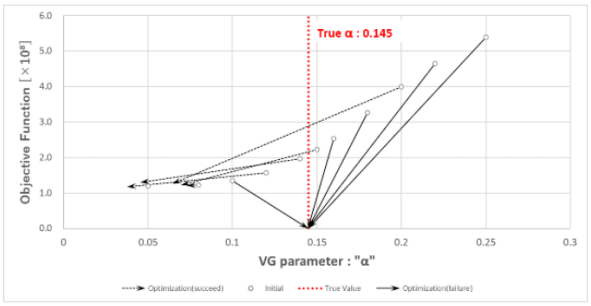


Figure 6 Optimization results of α:
③ Simultaneous Estimation of n and α

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Effects of elevated air temperature and CO_2 concentration on soil CO_2 dynamics in an apple orchard

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As global warming mitigation, carbon capture and storage by soil has been recognized as a function of agricultural field, and capacity of carbon storage in arable land has been discussed. Therefore, it is important to understand the soil CO_2 dynamics which results in soil CO_2 profile and CO_2 efflux from the surface in agricultural lands for maintaining carbon storage by proper agricultural practices. Increase of air temperature and atmospheric CO_2 concentration will affect soil environment such as soil moisture, temperature and the distribution of soil organic matter. In apple orchards, not only apple trees but also undergrowth weeds are distributed and thus soil organic matters are often input by cultivation management such as undergrowth mowing and branch pruning, thus changes in soil environment under global warming will be complex. The objective of this study is to evaluate the changes in soil CO_2 dynamics under elevated air temperature and CO_2 concentration in an apple orchard.

This study was conducted in Fujisaki Farm of Hirosaki University, Fujisaki Town, Aomori, northeast Japan. Three plastic greenhouses of 17m-long, 7m-wide, 5m-high were used for the experiment. In each house 16, 5-year-old apple trees were cultivated. Atmospheric condition of each house was regulated as follows; (A) Control (both sides opened), (B) High temperature (3℃ higher than ambient), (C) High temperature and high CO_2 (3℃ and 200 ppm higher than ambient). Irrigation of 4 ~ 7 mm/day was conducted twice a week and additional 50 mm/day irrigation was also conducted once in two months in accordance with average rainfall pattern of the study site. In each greenhouse, soil CO_2 concentrations at depths of 15 cm and 40 cm from the soil surface were continuously monitored by using CO_2 probes (GMP 252, Vaisala Co., Ltd.), which were connected with datalogger, and the data was collected every 30 minutes from April 2020 to November 2020. Soil gas samples at depths of 15 cm and 40 cm were also obtained with gas samplers (DIK-5212, Daiki Rika Kogyo Co., Ltd.) once or twice a month and CO_2 concentrations of the sampled soil gas were analyzed with gas chromatography. Soil moisture and temperature at depths of 15 cm and 40 cm from the soil surface were measured every 30 minutes by using 5TE sensors (METER Co., Ltd). Soil respiration rate, or CO_2 efflux from the surface, was measured with automated open/closed chamber system on Oct. 2020.

Under all three conditions, soil CO_2 concentrations at depth of 15 cm was lower than that at depth of 40 cm since the gas at the shallower layer were easily diffused to the soil surface. Monitored soil CO_2 concentrations increased from April to August accompanied with rise of soil temperature and then gradually decreased from autumn to winter.

Soil temperature of (B) “High temperature” and (C) “High temperature and CO_2” were two to three ℃ higher than that of (A) “Control” during the whole experiment period. The soil CO_2 concentration at depth of 15 cm of (C) was the highest and that of (A) was the lowest among three conditions. Soil respiration rate was also the highest at (C) and the lowest at (A) ((A) 520.5, (B) 606.2 and (C) 643.3 mg CO_2 m^{-2} $hour^{-1}$). The difference of soil respiration rate among three condition at a distance of 50 cm from a tree ((A) 650.5, (B) 889.2 and (C) 979.3 mg CO_2 m^{-2} $hour^{-1}$) was more conspicuous than that away from

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the trees at a distance of 150 cm from a tree ((A) 307.3, (B) 323.1 and (C) 347.2 mg CO_2 m^{-2} $hour^{-1}$). Under high temperature and CO_2 condition, increase of dry matter production of both undergrowth and apple trees was confirmed in 2019. Therefore, increase of soil temperature as well as increase of soil carbon input such as mown grass might affect the soil CO_2 production rate by plant roots and microorganisms.

Acknowledgement: This work was supported by JSPS KAKENHI Grant Numbers JP18H03964 and JP19K15934.

Keywords: Soil carbon dioxide, Global warming, Apple orcahrd

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Effect of soil air on pore network properties and mass transport in porous media

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Soil is a three-phase structure consisting of solids, liquids (water), and air. Volume and geometry soil air phase in soils affects network of water and air filled pores, then mass transport through the network. X-ray CT device is a strong tool for characterizing water-filled and air-filled soil pore networks, i.e., pore network properties such as pore size distributions, connectivity, or tortuosity in liquid and air phases. The purpose of this study is to clarify the effect of volume and geometry of soil air (entrapped or continuous air) on the pore network properties and mass transport.
Toyoura sand (mean dia. *D50*: 240 μm), Mikawa silica sand No. 7 (Mikawa-S, *D50*: 180 μm), and Mikawa silica sand No. 56 mixed with Mikawa-S (Mikawa-L, *D50*: 290 μm), were repacked to the acrylic or stainless column to make porous medias. Fully-saturated samples were prepared by repacking the sands under water saturation. Two different quasi-saturated samples were prepared either by repacking the sands in hydrogen peroxide solution (H_2O_2 samples) or re-saturating the samples after draining fully-saturated samples with -70 cm H_2O water pressure (re-saturated samples). Unsaturated samples containing continuous air phase were prepared by stepwise drying or wetting.
The saturated and quasi-saturated hydraulic conductivity were measured by falling-head method, and the unsaturated hydraulic conductivity was measured by pressure control method. For unsaturated samples, gas diffusion coefficient was measured by diffusion chamber method and air permeability was calculated from the applied air pressure difference and flow rate to the soil sample by ventilating the samples.
The X-ray CT device (Carl Zeiss METROTOM 1500, voxel size: 10 μm) was used to take X-ray CT images of each sample for fully- and quasi-saturated and unsaturated conditions. The tortuosity (τ), pore coordination number (*C*), and pore size distribution in the gas or liquid phase were calculated from X-ray CT image analysis using of EX Fact Analysis (Nihon Visual Science, Japan).
Lower hydraulic conductivity was obtained for the H_2O_2 sample than for the re-saturated sample for the same volumetric water content. As results of X-ray CT image analysis, finer entrapped air existed in the liquid filled pore space for the H_2O_2 samples, resulting in the reduction on the liquid-phase pore connectivity. For the unsaturated samples with the presence of continuous air phase, no hysteresis was found in the relationship between hydraulic conductivity and volumetric water content, but hysteresis was found in the relationships between air permeability and gas diffusion coefficient and volumetric air content. Higher air permeability and gas diffusion at the wetting process were obtained than those at the drying process especially for the fine samples (Toyoura sand and Mikawa-S). The X-ray CT image analysis suggested that small pores located between large pores are active for air transport in the wetting process, creating continuous large pore networks in continuous air phases.

Keywords: pore network, mass transport, X-ray CT

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Monitoring of soil gas environment in soybean fields under different fertilizer managements

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It is known that significant amount of CO_2 is released from the soil to the atmosphere. Previous studies showed that applied fertilizer influences the CO_2 emissions from soils based on the field monitoring of soil gas environment. However, there are a few investigations about continuous monitoring of soil gas at minutes to hourly time interval. Therefore further understandings on effects of fertilizer managements on soil gas environment and GHG emission are required, eg., the response of soil respiration to rainfall events, and emission rate in response to type of the applied fertilizer. This study aims to clarify the effect of different fertilizer managements on the soil gas movement during the cultivation period.
Field monitoring was conducted at soybean fields in Koriyama City, Fukushima prefecture with 4 different treatments: no fertilizer (NF), cow manure (CM), chemical fertilizer (CF), and without crop (WC). The CO_2 and O_2 concentration at different depths (10, 25 cm) were monitored at every 1hr interval and recorded with data loggers (CR1000, Campbell Scientific). The CO_2 concentration was measured using NDIR type CO_2 concentration transducers (GMM221, Vaisala) and O_2 concentration was measured using Galvanic oxygen sensors (CAP-SO-210, Apogee), respectively. Water content, soil temperature, and electrical conductivity at different depths (10, 18, 25 cm) were monitored at every 30 min interval using 5TE sensors (METER Group). The monitoring has been done from June 29 till November 12, when the soybeans were grown. Soil hardness profile was also measured using a digital penetration type soil hardness tester (DIK-5532, Daiki) during flowering and harvesting period. The soil samples were taken at 5, 10, 18 and 25 cm deep. Basic physical properties, gas diffusion coefficient, air permeability and amount of microbial biomass were measured using the soil samples. The monitored gas concentrations and gas diffusion coefficients were used to calculate gas fluxes at 0-10 cm and 10-25 cm deep.
The CO_2 fluxes at each depth of the CM plot were smaller than those at the NF plot. This was because deeper layer of CM plot was more compacted and the soil water content was higher than the NF plot, inducing the reduction on the soil respiration. Similar behavior was observed at the CF plot where lower CO_2 flux at 10-25 cm deep after September were observed than at the NF plot. This was also thought to be because shallower layer of the soil at CF plot was compacted and generally wet. The CO_2 concentration at the WC plot were larger than those at NF plot. The soil hardness measurements showed that the surface soil of the WC plot was highly compacted, which inhibited CO_2 emission to the atmosphere. Cumulative CO_2 emission after August was well correlated to mean water content regardless of different fertilizer managements. In the comparison of soil gas dynamics between plots, the effects of water contents among the plots were more significant than effects of applied fertilizer. There were cases where the gas concentrations were different under wetting and drying processes before and after rainfall events even at the same soil water content condition. Hysteresis of soil gas diffusivity during wetting and drying and activation of microbial respiration induced by increase of soil water content were considered as possible reasons for these phenomena.

Keywords: Soybean, Soil gas environment, Monitoring, Soil respiration

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Effects of Cation Exchange on Colloid Transport in Saturated Porous Media

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1. Graduate School of Agricultural and Life Sciences, the University of Tokyo

Many studies on the transport of various colloids transports in natural soils have been reported. There are different findings about retention and release of colloidal particles induced by cation exchange reactions at the surface of collector particles. Torkzaban et al. (2013) showed that quantum dot nanoparticles (diam. 1~10 nm) injected to a sand repacked column were released during the cation exchange reaction between calcium ion (Ca^{2+}) and sodium ion (Na^{+}). On the other hand, Bradford and Kim (2010) have indicated that soil colloids (diam. 360 nm) were retained on repacked quartz sand during the Ca^{2+}-Na^{+} cation exchange reaction. This study investigates the transport behavior of colloidal particles during Ca^{2+} -Na^{+} cation exchange reaction in the repacked saturated porous media.
One-dimensional column experiments with carboxyl latex (CL) as a model colloid were conducted using repacked Toyoura sand. Experimental procedure for the experiments was as follows. First, a colloidal suspension (2 mmol L^{-1} $CaCl_2$ solution) with 10.25 mg L^{-1} was injected to the column (diam. 5 cm, height 6 cm), followed by a colloid-free $CaBr_2$ solution. Then pure water, 10 mmol L^{-1} NaCl solution, and pure water were sequentially injected. In the experiments, CLs with 500 nm were used as injected colloids. Experiments using NaCl solution with higher concentration (50 mmol L^{-1}) to increase the amount of exchanged cation, and using CLs of smaller particle size (200 nm) were also conducted. Effluents were collected at two minutes interval to determine pH, EC, CL concentration, and ion concentrations. Interaction energies between colloidal particle and sand particle at different solution chemistry were analyzed based on DLVO (Derjaguin-Landau-Verwey-Overbeek) theory.
In all experiments, the effluent concentration remained low when NaCl solution was injected, but it increased rapidly when pure water was introduced. The DLVO calculations suggested that the CLs deposited at the secondary minimum in the total potential energy even when cation exchange occurred. In addition, based on the DLVO calculations, it was suggested that repulsive force between CLs and Toyoura sand surface was dominant during pure water injection and deposited CLs will be released from the Toyoura sand surface.The obtained effluent concentrations of CL showed that even when the extent of exchanged cation was increased (i.e., experiments using 50 mmol L^{-1} NaCl) or colloid’ s particle size was reduced (i.e., experiments using CLs with 200 nm) , colloids did not detach from the sand surface with the cation exchange reaction.

Keywords: Colloidal Particle, Porous Media, Cation Exchange, DLVO Theory

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Seasonal Variation of the Effect of Ridge Orientation on Water and Temperature Distribution Inside Ridges

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1. Department of Ecoregion Science, Tokyo University of Agriculture and Technology, 2. Graduate School of Agriculture, Tokyo University of Agriculture and Technology, 3. Institute of Agriculture, Tokyo University of Agriculture and Technology

The recent rapid climate change in Japan and globally, as well as the declining birthrate, aging population, and rapid increase in population, have required changes in the production environment of agriculture, which is the foundation of our lives. For example, sustainable development of agriculture in arid and semi-arid regions is required, and optimization of water use efficiency is essential for its establishment.

In the energy balance of the land surface, the radiation from the sun to the surface is divided into evaporation, atmospheric temperature rise, and subsurface temperature rise, respectively. Moisture transfer can be classified into two major categories: transfer as liquid water and transfer as water vapor (Philip and de Vries, 1957). As for the calculation of moisture and heat balance considering water vapor transfer under non-isothermal conditions, the unsaturated soil water flow and solute transport program HYDRUS-1D (Šimůnek, *et al.*, 2005) has been used to analyze liquid water, water vapor, and heat transfer in one dimension (Saito *et al.,* 2006).

For more practical analysis, it is necessary to consider the external environment in terms of topographical and meteorological conditions. However, there is a lack of quantification of the effects of topographical conditions on the couple movement of liquid water, water vapor, and heat through the soil. In addition, there is a need for research on the land surface balance, moisture, and heat transfer that considers land surface structures and solar movement.

The purpose of this study was to investigate the seasonal variation in the effects of topographical conditions, such as the direction of ridges and other structures, on the moisture and temperature distribution in a soil profile.

In this study, we set up a test site at FM Fuchu (35.68˚N, 58m above sea level) in the TUAT campus. Three rows of ridges were made so that the slopes of the ridges faced north-south and east-west directions. Thermocouples, soil moisture sensors, potential sensors, and heat flux panels were inserted in the ridges. The temporal changes of soil temperature, volumetric water content, water pressure, and heat flux were recorded from each sensor. Various soil hydraulic and thermal parameters were determined based on the basic soil experiment. Numerical analysis was performed using modified HYDRUS 2D (Šimůnek, *et al.*, 2014).

In terms of moisture distribution, the entire ridge was drier in summer than in winter, with rapid drying occurring in a smaller area near the surface of the slope that was exposed to the sun for a longer period of time. In summer, the soil temperature was higher in the whole rows, although there were differences depending on the orientation of the rows. The effect of topographical conditions such as the orientation of ridges and other structures on the moisture and temperature distribution varies seasonally. The moisture and temperature distribution in the rows did not fluctuate in winter when seasonal radiation is

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lower suggesting that because of the lack of exposure to the sun, the orientation of the rows is likely to affect the moisture and temperature distribution inside the rows.

Keywords: HYDRUS 2D, surface energy balance, vapor flux, ridge orientation

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.12 Zoom Room 12

[A-GE28] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Yonghong Hao(Tianjin Normal University), Jet-Chau Wen(National Yunlin University of Science and Technology), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Chairperson:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University)

This session provides a broad platform for discussion and presentation of fundamental and up-to-date scientific results related to clean energy production, environmental remediation and restoration, waste management, water cycle, monitoring of water quality, management of water resources and interconnections among them for sustainable development. Presentations on the topics associated with social science that enhance public awareness, stakeholder empowerment and involvement, and policy decisions regarding the management of water, energy and the environment are also encouraged.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[AGE28-01] Introduction

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[AGE28-02] **Investigate the Benefit of Micro-hydropower Generation on Water-energy-food Nexus : A case study in Linnei channel**

★Invited Papers

*Shih Jen-Chieh[1], Fu-Yuan Lin[2], Ming-Der Hong[2], Hong-Ru Lin [3], Jet-Chau Wen[4,5] (1.Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology., 2.Irrigation and Engineering, Council of Agriculture, Executive Yuan., 3.Graduate School of Engineering Science and Technology, National Yunlin University of Science and Technology., 4.Research Center for Soil and Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science and Technology., 5.Department and Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology.)

2:10 PM - 2:25 PM JST | 5:10 AM - 5:25 AM UTC

[AGE28-03] Preliminarily environmental magnetic results from packed snow along the roadside at Mt. Tateyama, Toyama, Japan.

*Kazuo Kawasaki[1] (1.School of Sustainable Design, University of Toyama)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[AGE28-04] **Gas Transport and Pore Structural Parameters of Granulated Bentonite Mixtures at Varied Densities**

*Mazhar Nazir[1], Akihiro Matsuno[1], Ken Kawamoto[1], Sakaki Toshihiro[2] (1.Graduate School of Science and Engineering, Saitama University, Japan, 2.Environmental Science and Engineering Consulting, Japan)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[AGE28-05] **Exploring the Spatial and Temporal Variability of the Hydraulic Tomography Estimates**

*Si-Xian Liu[1], Jyun-Lin Chen[2], Hong-Ru Lin[2], Tian-Chyi Jim Yeh[3], Jet-Chau Wen[2,4] (1.Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology., 2.Research Center for Soil and Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science and Technology., 3.Department of Hydrology and Atmospheric Sciences, The University of Arizona., 4.Department and Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[AGE28-06] **Characterization of particle breakage of recycled concrete aggregates with different fines contents under different compaction energies**

*Thai Hong Nam[1], Akira Kato[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University, Saitama, Japan)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

[AGE28-07] Discussion

[E] Oral | A (Atmospheric and Hydrospheric Sciences) | A-GE Geological & Soil Environment

[A-GE28] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Yonghong Hao(Tianjin Normal University), Jet-Chau Wen(National Yunlin University of Science and Technology), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Chairperson:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.12 (Zoom Room 12)

This session provides a broad platform for discussion and presentation of fundamental and up-to-date scientific results related to clean energy production, environmental remediation and restoration, waste management, water cycle, monitoring of water quality, management of water resources and interconnections among them for sustainable development. Presentations on the topics associated with social science that enhance public awareness, stakeholder empowerment and involvement, and policy decisions regarding the management of water, energy and the environment are also encouraged.

1:45 PM - 1:50 PM

[AGE28-01]Introduction

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Investigate the Benefit of Micro-hydropower Generation on Water-energy-food Nexus : A case study in Linnei channel

*Shih Jen-Chieh[1], Fu-Yuan Lin[2], Ming-Der Hong[2], Hong-Ru Lin [3], Jet-Chau Wen[4,5]

1. Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology., 2. Irrigation and Engineering, Council of Agriculture, Executive Yuan., 3. Graduate School of Engineering Science and Technology, National Yunlin University of Science and Technology., 4. Research Center for Soil and Water Resources and Natural Disaster Prevention (SWAN), National Yunlin University of Science and Technology., 5. Department and Graduate School of Safety Health and Environmental Engineering, National Yunlin University of Science and Technology.

Micro-hydropower is necessary renewable energy to provide baseload, and it has the advantages of sustainable development and reduction of greenhouse gas emissions.There is an interrelationship between irrigation water and energy from micro-hydropower with the development of micro-hydropower in agricultural irrigation systems. Li et al. (2019) mentioned that in the agricultural system estimate the water supply-demand, energy supply-demand, land demand, as well as food production, were quantitatively analyzed under different scenarios. However, the study water for electricity generation was neglected in the agricultural system. Zhou et al., (2019) apply small-hydropower into water supply systems to lift renewable power output and uplifting the synergistic benefits of the Water-Food-Energy (WFE) Nexus steered by the optimal water allocation and small-hydropower installation, but the adjustment of the water source by the reservoir makes the flow of the water supply system unstable, which leads to unstable electricity generation of small hydropower. Gaudard et al., (2018) research that in the relationship between water and energy of hydropower plants is set upstream. The results show that seasonality slightly affect hydroelectric power generation
Therefore, the study set up a micro-hydropower generation system in Linnei channel of the Zhuoshuixi river watershed in the middle of Taiwan. Collected channel background information and use Doppel (Teledyne StreamPro ADCP) to measure the water level, velocity and discharge of the study site analyzes potential power generation, and evaluate the profit and payback period of micro hydropower generation and the impact of micro- hydropower systems in agriculture. In order to investigate the relationship nexus of WFE, in addition, evaluate the effectiveness of micro- hydropower in reducing carbon dioxide emissions. According to the results of this study, it can be used as a reference basis for setting up other micro-hydropower systems in the future.

Keywords: Micro-hydropower, Water-energy-food Nexus, Irrigation Channel

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Preliminarily environmental magnetic results from packed snow along the roadside at Mt. Tateyama, Toyama, Japan.

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Environmental magnetic techniques have been shown to be useful for investigating roadside pollution. There are several reports that show a positive correlation between the distance from a road and magnetic susceptibility. Only a few studies have been reported for such magnetic monitoring using packed snow along a roadside. Here, environmental magnetic studies are reported for the Bijyodaira area of Mt. Tateyama in Toyama. The Tateyama Kurobe sightseeing Alpine route is the only available road through the area and only authorized vehicles are allowed to drive on it. Four profiles were set up with a length away from the roadside that depended on the available space beside the roadside, with maximum length of 30 m. Uppermost packed snow was collected along the Tateyama Kurobe Alpine road using a plastic scraper and 7 cc plastic cubes. The collected snow melt to water at room temperature and then it was solidified using a superabsorbent polymer. Rock magnetic measurements of these solidified specimens indicate that the major magnetic mineral in the snow is maghemite and its composition is nearly the same at different distances from the roadside. The observed saturation isothermal remanent magnetization intensity curves against distance from the roadside show rapid decay patterns near the roadside in three profiles although there are some abnormal peaks along the profiles. The results show that environmental magnetic techniques can be applied to packed snow by using a superabsorbent polymer and this is an effective method for monitoring pollution associated with vehicle traffic.

Keywords: Environmental magnetism, Snow, Roadside pollution

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Gas Transport and Pore Structural Parameters of Granulated Bentonite Mixtures at Varied Densities

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Granulated bentonite mixtures (GBM) are being evaluated as a candidate buffer material in the deep geological disposal of radioactive waste owing to ease of installation and good compaction characteristics. Various gases are generated in the repository by several mechanisms, and the transport of these gases through GBM occur by advection and diffusion. Understanding gas diffusion coefficient, air permeability and their dependence on pore structural parameters such as air-filled porosity, pore size distribution and pore tortuosity-connectivity is essential to characterize the diffusive and advective transport of gases through GBM. In this study, GBM prepared from OK Bentonite (Kunimine Industries, Japan) were used to measure the gas transport parameters by direct and indirect observations. First, air-dried OK bentonite grains (T = 20º C, RH = 60%) were sieved and graded to obtain a grain size distribution between 0.075 mm and 9.5 mm. The samples were then packed, in 100 cm^3 acrylic cylindrical cores at varied densities ranging from 1.09 ~ 1.75 g/cm^3, using a hand compaction. Gas transport parameters such as air permeability (k_a) and gas diffusion coefficient (D_p) were measured in the laboratory and the pore structural parameters such as equivalent pore diameter for gas flow and diffusion-based tortuosity were estimated (indirect approach). The pore network and structure of the tested samples were also visualized and analyzed by using a Microfocus X-ray computed tomography (MFXCT) system (direct approach). Finally, correlations of the pore structural parameters evaluated from indirect and direct approaches were examined to discuss the effect of packed densities on the gas transport parameters of air-dried GBM.

Keywords: Radioactive waste disposal, granulated bentonite mixtures (GBM), gas transport parameter, pore structural parameters, Microfocus X-ray computed tomography (MFXCT)

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Exploring the Spatial and Temporal Variability of the Hydraulic Tomography Estimates

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In the past few decades, hydraulic tomography (HT) has been developed and successfully applied to many field sites to delineate the spatial distributions of hydraulic properties (e.g., transmissivity (*T*) and storage coefficient (*S*)). Numerous studies used HT to investigate hydraulic properties, only using the test data of the current year for analysis when discussing the same study area hydraulic properties distribution. There is no comparison of test data collected using the same test method for multiple years in the same study area to estimate the hydraulic properties. Therefore, the purpose of this study is to (1) use multiple annual pumping test data to investigate the reproducibility of the drawdown-time data; (2) use multiple annual pumping test data to characterize the reproducibility of the heterogeneous hydraulic properties and (3) Whether the distribution of hydraulic properties will change over time.
The study used four sequential pumping tests (SPT) to collect pumping rates and drawdown data at the National Yunlin University of Science and Technology in 2010, 2012, 2013, and 2018. Using 4 SPTs with different pumping rate and drawdown data to analyze normalized time (time divided by the square of the distance between the pumping well and the observation well) and normalized drawdown (drawdown divided by per unit pumping rate). Then, use the HT to delineate four years 2-dimensional heterogeneous hydraulic properties distribution field and analyze the relationship between the spatial distribution characteristics of the reproducibility of heterogeneous hydraulic properties and time.

Keywords: Hydraulic Tomography, Sequential Pumping Test, Heterogeneous, Reproducibility

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Characterization of particle breakage of recycled concrete aggregates with different fines contents under different compaction energies

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Many factors affect the mechanical properties of granular materials including recycled concrete aggregates (RCA). Among them, particle size distribution is one of the most important factors. However, the particle size distribution usually changes after specimens are compacted due to particle breakage. The comparison between particle size distribution after compaction and original particle size distribution of RCA aggregates shows the particle breakage of samples, and the particle breakage index (B_g) normally use to characterize the particle breakage. The particle breakage depends on many factors such as compaction energy (E_c), the single-strength of particle, particle shape, particle size, etc. This study concentrates on the characterization of particle breakage under different compaction energies and different particle size condition [i.e. different fine content fines content (F_c; typically, the particle size of fines < 0.075 mm), and different maximum particle size]. Samples were prepared with two different maximum diameters (D_{max}) of 25 and 37.5mm, and four different F_c of 0, 5, 10 and 20%. Modified proctor method (E_c = 2631 kJ/m^3) was used to compact samples for measurement maximum dry density, optimum water content, and compare the particle breakage with different water content. Three different compaction energies, E_c = 580, 2631, 5262 kJ/m^3 were applied to compact samples with optimum water contents to measure the effect of compaction energy on particle breakage. The results of this study showed that the maximum dry densities of RCA samples were highest with F_c = 5-10% regardless D_{max}, and optimum water contents were around 9.5-10.5%. The dry densities of RCA samples were dropped to minimum values when “bulking” occurred with water contents were around 6-7%. B_g increased with the increase of E_c, and B_g decreased when F_c increased because of the cushioning effect. Besides, regardless D_{max}, E_c and water content, the fraction of 25-37.5 mm gave the highest % decrement (i.e., the most breakage) and the fraction of 0.475-2.36 mm gave the highest % increment.

Keywords: Recycled concrete aggregate, Compaction, Fines content, Particle breakage

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[E] Oral | A (Atmospheric and Hydrospheric Sciences) | A-GE Geological & Soil Environment

[A-GE28] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Yonghong Hao(Tianjin Normal University), Jet-Chau Wen(National Yunlin University of Science and Technology), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Chairperson:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.12 (Zoom Room 12)

This session provides a broad platform for discussion and presentation of fundamental and up-to-date scientific results related to clean energy production, environmental remediation and restoration, waste management, water cycle, monitoring of water quality, management of water resources and interconnections among them for sustainable development. Presentations on the topics associated with social science that enhance public awareness, stakeholder empowerment and involvement, and policy decisions regarding the management of water, energy and the environment are also encouraged.

3:10 PM - 3:15 PM

[AGE28-07]Discussion

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.05_2

[A-GE28] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Research Promotion Division, Geological Survey of Japan, AIST), Yonghong Hao(Tianjin Normal University), Jet-Chau Wen(National Yunlin University of Science and Technology), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University)

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[AGE28-P01] Assessment of Hydrophobicity/Oleophilicity for Artificially Coated Autoclave Aerated Concrete Grains

*Muhammad Junaid Zafar[1], Akihiro Matsuno[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University, Japan)

[AGE28-P02] Measurements unsaturated hydraulic property of recycled concrete aggregates for a road -base layer

*Ryohei ITO[1], Akira Kato[1], Akihiro Matsuno[1], Ken Kawamoto[1,2] (1.Graduate School of Science and Engineering, Saitama University, Japan, 2.National University of Civil Engineering, Vietnam)

[AGE28-P03] Characterization of Physical and Chemical Properties for CDW Fine Residues of Dumped CDW in Hanoi,Vietnam

*NINGNING HAO[1], Akihiro Matsuno[1], Ken Kawamoto[1], Akira Kato[1] (1.Saitama University)

[AGE28-P04] Effects of Silicic Acid on Arsenite Leaching from Spent Magnesium-based Arsenic Adsorbents

*Hajime Sugita[1], Terumi Oguma[1], Ming Zhang[1], Junko Hara[1], Yoshishige Kawabe[1] (1.National Institute of Advanced Industrial Science and Technology)

[AGE28-P05] Identifying glacier sensitive zones based on mass balance anomaly and its linkage to climate change

*Yonghong Hao[1], Huiqing Hao[1], Yan Liu[1], Tian-Chyi Jim Yeh[2], Ming Zhang[3] (1.Tianjin Normal University, 2.The University of Arizona, 3.AIST)

[AGE28-P06] Tidal Method for the Estimation of Coastal Aquifer Properties Based on Theoretical Solutions: Advantages and Limitations

*Ming Zhang[1], Yonghong Hao[2], Zhixue Zhao[2], Tongke Wang[2], Ling Yang[2] (1.Research Promotion Division, Geological Survey of Japan, AIST, 2.Tianjin Normal University)

Assessment of Hydrophobicity/Oleophilicity for Artificially Coated Autoclave Aerated Concrete Grains

*Muhammad Junaid Zafar[1], Akihiro Matsuno[1], Ken Kawamoto[1]

1. Graduate School of Science and Engineering, Saitama University, Japan

Insufficient treatment of oily-wastewater generated from domestic sources and industries such as petrochemicals, food, textiles, and metal industries, biopharmaceutical, and oil/gas refineries cause serious water pollution and endanger aquatic-life, which affects human health and living nature. Due to economic and technical constraints, however, general advanced treatment systems for oily-wastewater are not common, especially in developing countries. The applicable system with cost-effective and high-performance are highly required. Moreover, most of industrial by-products (IBPs) are not fully recycled and stored/dumped without a suitable treatment in most of those countries.

In this study, therefore, with the viewpoints of utilization of, the potential use of hydrophobized porous grains made from IBPs were examined to develop a suitable oily-wastewater treatment technology. Especially, this study aims to assess porous grains of autoclave aerated concrete (AAC) grains coated by hydrophobic agents (HAs) and discuss the applicability to the oil/water separation technique. The AAC grains (0.106–0.250 mm) were prepared from waste-scrap along with the manufacturing process of AAC blocks that stored at stocking yard without reuse and recycling in Vietnam. They were coated with two types of hydrophobic agents (HAs), Oleic acid (OA) and Stearic acid (SA), at different concentrations ranging from 0 to 750 (g of HA / kg of AAC grains; hereafter, g/kg) based on a solvent-aided method. The degree of hydrophobicity/oleophilicity was assessed in the laboratory, by measuring contact angles of water in air (CA_a) and soybean oil in water (CA_o). Results showed that the measured CA_a for both OA–and SA–coated AAC grains rapidly increased with increasing HA concentrations with $CA_a(max) = 135–145^o$ at HA $\geq$100 g/kg, while CA_o decreased with increasing HA concentrations with $CA_o(max) = 130–140^o$ at HA < 10 g/kg. Finally, a simple gravity-driven oil/water separation experiment was performed showing that the hydrophobized AAC grains have good separation efficiency/capacity. Thus, this novel and cost-effective AAC grains coated with suitable HAs concentrations have a high prospective as filtration media in the oil/water separation system.

Keywords: Oily-wastewater, Oil/water separation, Autoclave aerated concrete, Hydrophobicity/Oleophilicity, Contact angle (deg)

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JpGU-2021

Assessment of Hydrophobicity/Oleophilicity for Artificially Coated Autoclave Aerated Concrete Grains

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Insufficient treatment of oily-wastewater generated from domestic sources and industries such as petrochemicals, food, textiles, and metal industries, biopharmaceutical, and oil/gas refineries cause serious water pollution and endanger aquatic-life, which affects human health and living nature. Due to economic and technical constraints, however, general advanced treatment systems for oily-wastewater are not common, especially in developing countries. The applicable system with cost-effective and high-performance are highly required. Moreover, most of industrial by-products (IBPs) are not fully recycled and stored/dumped without a suitable treatment in most of those countries.

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Keywords: Oily wastewater; Oil/water separation; Autoclave aerated concrete; Hydrophobicity/Oleophilicity; Contact angle (°).

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Measurements unsaturated hydraulic property of recycled concrete aggregates for a road -base layer

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Not only characterization of saturated hydraulic property but also unsaturated hydraulic properties such as water retention and unsaturated hydraulic conductivity are necessary to evaluate an accurate water movement process and the design of water drainage in the road pavement system. Till now, only limited data is available for the unsaturated hydraulic properties for unbound roadbed materials due to the difficulty of measurement. This study carried out the measurements of water retention capacity (WRC) and unsaturated hydraulic conductivity for recycled concrete aggregates (RCA) that typically used for the road base and subbase materials. After grading particle size distribution of RCA adjusted to Japanese technical specification, the tested sample was compacted in a cylindrical mould following the modified Proctor method and then used to measure WRCs and unsaturated hydraulic conductivity. The WRC was measured under the main drying process by a combinational technique with a hanging water, pressure chamber, and a dew-point potentiometer and the unsaturated hydraulic conductivity was measured by an evaporation method. Besides, Toyoura sand was used as a reference material. Results showed the graded RCA gave a smaller water retention capacity compared to Toyoura sand at saturation, however, its water retention became higher than Toyoura sand at the suction range exceeding 10 kPa. As well as water retention property, the saturated hydraulic conductivity of graded RCA became smaller than Toyoura sand at saturation, however, the measured unsaturated hydraulic conductivities of graded RCA at the suction range of 10~100 kPa ranged in the orders of 10^{-6}~10^{-8} cm/s and became higher than those of Toyoura sand. It was found that the fitted *l* values of RCA became approximately -3.5 to -14, implying that l = 0.5, commonly used in VG-Mualem model, did not capture well the unsaturated hydraulic conductivities for graded RCA.

Keywords: Recycled road base aggregates, Water retention curves, Unsaturated hydraulic conductivity

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Characterization of Physical and Chemical Properties for CDW Fine Residues of Dumped CDW in Hanoi,Vietnam

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1. Saitama University

INTRUDUCTION

Due to rapid urbanization and population increase, the generation of Construction and Demolition Waste (CDW) is increasing in urban areas and industrial zones in developing countries.In developing countries, most of the CDW generated is currently reused on/off-site without any material quality control and dumped in treatment sites along with urban clean-up waste (e.g. sludge and soil). The treatment plant lacks quality control and management of the accepted CDW, hazardous waste containing heavy metals, etc., is also mixed in with the potential risk. Therefore, it is important to determine the environmental status of the clean waste dump site based on an appropriate monitoring program. In order to examine the potential reuse and recycling of fine residues (typically < 2mm) that generate from various construction and demolition activities, this study investigated physical and chemical properties for fine residues including soil-like materials taken from building demolition sites and CDW landfills in Hanoi, Vietnam and the grounded and sieved fines prepared from waste concrete and clay brick debris taken from CDW landfills. Three properties such as i) surface morphology and element composition, ii) thermal property, and iii) environmental safety were analysed in the laboratory using a Scanning Electron Microscopy (SEM) with Energy Dispersive Spectroscopy (EDS), Thermogravimeter (TG)-Differential Thermal Analyzer (DTA), and leaching and content tests.

OBJECTIVES Characterize the physical and chemical properties for fine residues including soil-like materials to examine the potential reuse/recycling of fine residues. Examine the connection between the different experiments and discuss the most appropriate experimental Methodology for the subsequent study of the properties of CDW Assessment of the surrounding environment to evaluate the environmental safety of the CDW landfill. **METHOTHOGIES**

The main experimental methods were TG-DTA, SEM-EDS, and leaching test (Water extractable ions) and content test (Acid extractable ions). Through these different experiments, the chemical composition, thermal reaction, and surface properties of fine residue had been summarized, and the physical and chemical properties of fine residue were discussed in a comprehensive manner. The experimental methods, equipment used, and main experimental objectives parameter are summarized in Table 1.:SEM image and EDS spectrum are shown in figure 1,and the examples of sample after treatment are shown in figure 2

RESULTS

(1) Compared to a reference mortar sample, the measured Ca/Si of waste concrete samples from CDW landfills gave a opposite trend: the waste concrete from Thanh Tri CDW landfill became approximately 30% lower and the waste concrete from Vinh Quynh CDW landfill became 30% higher. It is noted that Ca/Si vales of the fine residues from building demolition sites became similar to the value of the reference mortar sample. Basically, the measured Ca/Si values for waste clay bricks and soil-like materials became small and some samples gave zero values of Ca/Si because the measured Ca % was zero.the result shown in Figure 3.

(2) The tested results of Ca/Si ratio from EDS and TG were summarized in Table 2. It could be understood that the higher Ca/Si samples gave higher TG values. In the previous section Ca/(Si+Al) was also mentioned as an important object, so the results for Ca/(Si+Al) are also summarised in the graph below. In the elemental content, it can be clearly seen, that the clay brick contains about twice as much

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aluminium as the other samples. The aluminium content of waste concrete is very limited, being only 2.6% in Thanh Tri landfill and 3.78% in Vinh Quynh landfill. The correlation with Tg reduction, on the other hand, is the same as for Ca/Si. The higher Ca/(Si+Al) samples gave higher TG values.

CONCLUSION

The combinational results of Ca/Si ratio and TG might give an effective approach to quantify the cementitious amount in fine residues. The tested results from environmental safety indicated the water- and acid-extractable heavy metals should be examined especially for soil-like materials from CDW landfill sites. But, the tested results shown in this study would give a goof insight to characterize physical and chemical properties of fine residues and to examine the potential reuse/recycling of fine residues in future.

Keywords: CDW, SEM-EDS, TG-DTA, Thermal property, Element composition, Environmental safety

Property	Methods	Major target parameters
Surface morphology and element composition	Scanning Electron Microscopy(SEM) with Energy Dispersive Spectroscopy(EDS)	Ca, Si, Al, O
Thermal analysis	Thermogravimeter(TG) - Differential Thermal Analyzer(DTA)	TG,DTA
Environmental safety	Leaching test (Water extractable ions) Content test (Acid extractable ions)	Pb, Cd, Al, Fe, Cr, Cr(∇I)

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Effects of Silicic Acid on Arsenite Leaching from Spent Magnesium-based Arsenic Adsorbents

*Hajime Sugita[1], Terumi Oguma[1], Ming Zhang[1], Junko Hara[1], Yoshishige Kawabe[1]

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The spent adsorbents after arsenic removal in arsenic contaminated water itself contain a large amount of arsenic. If they are discarded without appropriate treatment, there is a concern that secondary arsenic pollution may occur due to arsenic leaching from them. In our previous studies, it was suggested silicic acid greatly affects leaching behavior of arsenate from the spent adsorbents. In this study, in order to examine the effects of silicic acid on arsenite leaching from the spent adsorbents, leaching tests with silicic acid solution and 2 kinds of spent magnesium-based adsorbent (MgO and $Mg(OH)_2$) were carried out. From the experimental results, the arsenite leaching from spent Mg-based adsorbents was found to be inhibited by silicic acid present in the solution. In our previous study on the spent Mg-based adsorbents adsorbed with arsenate, it has been reported that the leaching amount of arsenate was higher as the initial silicic acid concentration in the solution was higher. The leaching behavior of arsenite is significantly different from that of arsenate. Therefore, under the presence of silicic acid, the leaching-precipitation mechanisms of arsenite are considered to be different from those of arsenate.

Keywords: Arsenite Leaching, Spent Adsorbent, Magnesium Oxide, Magnesium Hydroxide, Silicic Acid

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Identifying glacier sensitive zones based on mass balance anomaly and its linkage to climate change

*Yonghong Hao[1], Huiqing Hao[1], Yan Liu[1], Tian-Chyi Jim Yeh[2], Ming Zhang[3]

1. Tianjin Normal University, 2. The University of Arizona, 3. AIST

Glaciers have been considered as a key indicator of climate change. Taking the Urumqi River Glacier No.1 in the Chinese Tienshan Mts., China as an example, this paper analyzed the responses of glacier mass balance at different elevations to climate changes. First, we collected the glacier mass balance data of Tienshan Mts. during the observation periods of 1979-2018. The glacier mass balance data were classified into seven groups based on an elevation interval of 100m (i.e., 3700-3800, 3800-3900, 3900-4000, 4000-4100, 4100-4200, 4200-4300 and 4300-4400 m a.s.l.). Then, the anomaly periods of mass balance in the seven groups were identified by the Mann-Kendall (MK) anomaly test. The results showed that the frequency of anomaly in the equilibrium zone (3900-4200 m a.s.l.) was high. Subsequently, by defining an anomaly coefficient that describes the degree of the anomaly, the sensitive zones of Tienshan Mts. were detected (i.e., 4100-4400m a.s.l.). For confirming the sensitive zones, we analyzed the responses of the glacier mass balance of the seven groups to climate teleconnections, which included El Niño-Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), and Arctic Oscillation (AO). We figured out positive and negative phases for each of the climate mode, and then calculated the percent deviation of glacier mass balance in the positive and negative phases, respectively. Based on the percent deviations, one can see that the glacier mass balance in the zones between the elevation of 4100-4400m a.s.l. were sensitive to climate anomaly. Moreover, the NAO cold period and La Niña are the most dominant factor that controls the mass balance of Urumqi River Glacier No.1 compared with others. The impact of La Niña mainly concentrated on the low and middle elevation zones. While NAO cold phase mainly influenced high elevation zones.

Keywords: La Niña, North Atlantic Oscillation, heterogeneity, Mann-Kendall (MK) anomaly test

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Tidal Method for the Estimation of Coastal Aquifer Properties Based on Theoretical Solutions: Advantages and Limitations

*Ming Zhang[1], Yonghong Hao[2], Zhixue Zhao[2], Tongke Wang[2], Ling Yang[2]

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Determination of the hydraulic properties of coastal aquifer systems has practical implications that are related to the many important issues such as seawater intrusion, submarine groundwater discharge, migration of contaminants, assessment of water resources, and geotechnical engineering. Compared with conventional well techniques such as the pumping test performed in a localized area, the hydraulic properties obtained by the tidal method are more representative of the large-scale hydrogeological characteristics. This is because the results are derived from the signals of hydraulic heads transmitted from the coastline where ocean tides are imposed across a long distance to the observation well at which the hydraulic head fluctuations are measured. In addition, the tidal method is more cost effective as it requires fewer wells compared to the pumping test method, and uses natural waves as input signals, thus eliminating the need for producing hydraulic signals such as water flow or changes in hydraulic pressure for the measurements.

Over recent decades, many analytical solutions that consider different types of coastal aquifer systems or models have been developed. Major models include single-layer perfectly confined coastal aquifer; single-layer unconfined coastal aquifer; two-layer island aquifer; three-layer with different boundary conditions; L-shaped boundary single-layer; L-shaped boundary three-layer; and U-shaped boundary non-leaky aquifer. Theoretical solutions to these models can be used as a theoretical basis for the tidal method that characterizes the hydraulic properties of a coastal aquifer system using hydraulic response measurements in an observation well or wells induced by tidal waves in the ocean.

The hydraulic properties of an aquifer can in principle be estimated through fitting a series of time-dependent changes of hydraulic head detected in an observation well to those calculated based on theoretical solutions. For simplicity, however, most theoretical solutions only consider one tidal component and idealized boundary conditions, although in reality multiple tidal components exist simultaneously and boundary conditions can be more complicated. For practical applications of the tidal method and to increase its reliability, multiple tidal components should be considered and models considering more complicated boundary conditions should be developed. In addition, methods that can determine both the hydraulic conductivity and storage coefficient, rather than only the hydraulic diffusivity, i.e., the ratio of hydraulic conductivity to storage coefficient of coastal aquifer, should be developed. Cautions should be taken into account when using the tidal method because earth tides and changes in local atmospheric pressure may induce similar tidal fluctuations in the hydraulic head within inland observation wells.

In this presentation, we overview the advantages of the tidal method, currently available theoretical

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models, limitations and future perspective associated with the tidal method.

Keywords: coastal aquifer, tidal method, theoretical model, Overview

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.12 Zoom Room 12

[A-CG31] Aircraft and UAV Observations for Earth-planetary sciences

convener:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University), Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Toshinobu Machida(National Institute for Environmental Studies), Taro Shinoda(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

The global climate change, especially for global warming is a big issue throughout the Earth and planetary sciences. To confront this problem, progresses of the observations both for continuous monitoring of the Earth and for the process studies as well as the numerical climate modeling become more important. Aircraft observation has the great advantages on the promptness/timeliness and direct (in-situ) observation which cannot be achieved by Earth observing satellites or ground-based observations. Recently, the importance of aircraft observation is increasing in "in-situ measurements" such as concentration of greenhouse gases, aerosol and cloud particle size distribution, and chemical composition, and "remote sensing" such as three-dimensional observation typhoons and observation on forests and vegetation for better understanding of the detailed process of the global warming and its impacts on the global climate and weather. In addition, the application of aircraft observation including the unmanned aerial vehicle (UAV) to geodesy, studies on earthquakes and volcanos are also progressing. However, operational and/or extensive aircraft observations to fulfill the requirements in Japan are not realized at the present time even though the aircraft observations technologies in Japan has been leading the world. Under this situation, the Science Council of Japan selected the proposal "Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts" as a high priority program. In order to promote more comprehensive/extensive researches by the aircraft observations, it is necessary to have close collaborations among researchers. In this session, we will discuss the future promotion of aircraft and UAV observation through the latest research results using aircraft.

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

[ACG31-01] Aircraft observation of typhoon environments using dropsondes of the Taiwan ASTRA jet

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

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

[ACG31-02] Large Eddy Simulation on Horizontal Rolls in Atmospheric Boundary Layer at Narita Airport and its Evaluation

*Junshi Ito[1], Hiroshi Niino[2], Katsumi Yoshino (1.Tohoku University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[ACG31-03] Remote Sensing of Atmospheric Composition using Commercial Flights between Tokyo-Haneda and Fukuoka-city

*Akihiko Kuze[1], hiroshi Suto[1], Seiya Kosaki[1], Kei Shiomi[1], Ayako Matsumoto[2], YaYasuhiro Tubakihara[2], Fumie Kataoka[3], Tetsuya Kaku[3], Shigetaka Mori[4] (1.Japan Aerospace Exploration Agency, 2.ANA HD, 3.RESTEC, 4.JASTECS)

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

[ACG31-04] Arctic black carbon during PAMARCMiP 2018 and previous aircraft experiments in spring

*Sho Ohata[1,2], Makoto Koike[3], Atsushi Yoshida[3], Nobuhiro Moteki[3], Kouji Adachi[4], Naga Oshima[4], Hitoshi Matsui[5], Oliver Eppers[6,7], Heiko Bozem[6], Marco Zanatta[8,9], Andreas B. Herber[8] (1.Institute for Space-

Earth Environmental Research, Nagoya University, 2.Institute for Advanced Research, Nagoya University, 3.Graduate School of Science, The University of Tokyo, 4.Meteorological Research Institute, 5.Graduate School of Environmental Studies, Nagoya University, 6.Johannes Gutenberg University of Mainz, 7.Max Planck Institute for Chemistry, 8.Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, 9.Université Paris-Est-Créteil)

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

[ACG31-05] Observation of red tide in an estuary by a fixed-wind type unmanned aircraft

*Soichi Yamaguchi[1], Shota Koide[1], Takayuki Mine[2], Takuya Iwanaga[2] (1.Kyushu university, 2.Saga Ariake Fisheries Promotion Center)

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

[ACG31-06] Understory biomass estimation based on Structure from Motion data by Multi-layered forest drone survey

*Yupan Zhang[1], Yuichi Onda[1], Hiroaki Kato[1], Takashi Gomi[2] (1.University of Tsukuba, 2.Tokyo University of Agriculture and Technology)

Aircraft observation of typhoon environments using dropsondes of the Taiwan ASTRA jet

*Kazuhisa Tsuboki[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

The T-PARCII (Tropical cyclone-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts) project has been performing in situ aircraft observations of typhoons since 2017. We observed supertyphoon Lan on 21-22 October 2017 and supertyphoon Trami on 25-28 September 2018 using the Japanese jet aircraft in collaboration with the Taiwan DOTSTAR team. The observed dropsonde data were transmitted to GTS (Global Telecommunication System) in real time and were used for typhoon forecasts in 2018. However, the dropsonde system of the Japanese aircraft has no longer been available since the jet aircraft was replaced by new one. Consequently, T-PARCII asked the Taiwan DOTSTAR team to help for typhoon observations and Taiwan kindly provided us the ASTRA jet equipping dropsonde facility.

A test flight of ASTRA was performed over the Taiwan-Okinawa region on 8 November 2019 and highly humid region adjoining a dry region was observed by the ASTRA dropsonde system. A moist layer to the southeast of the Okianwa main island and a dry region to the north of Ishigaki were observed. The dropsonde observations were made to the south and north of Ishigaki and the observed data were compared with the JMA balloon sonde observation at Ishigaki at 00 UTC 8 November.

The first flight of the ASTRA observation was made for 03-09 UTC 31 August 2020 to observe Typhoon Maysak (2020). The purpose of the flight was to observe the environment of the typhoon. Maysak developed to the east of the Philippines on 29 August and moved northward with intensifying. The aircraft observation was made in the region to the south of the Okinawa main island when Maysak was intensifying. Seven dropsondes were launched around the typhoon and the observed data were transmitted to the JMA through GTS. Unfortunately, the observed data were limited in the upper layer because of a trouble of the Vaisala dropsonde receiving system. The limited data were used for data assimilation by the JMA.

The second flight was made for 03-08 UTC 8 October 2020 to observe the environment of Typhoon Chan-Hom (2020). The typhoon was generated to the east of Okinawa and moved northwestward. Although Chan-Hom was less intense typhoon with a lifetime-minimum central pressure of 965 hPa, it caused a severe landslide in Mie Prefecture and a heavy rainfall over Izu islands. Eleven dropsondes were launched in the surrounding region of the typhoon center and atmospheric data were obtained throughout the troposphere from 200 hPa to the surface. An important characteristic of Chan-Hom is an accompanied corridor of large water vapor on its east side named an atmospheric river. The easternmost point of dropsonde observation was almost the edge of the atmospheric river and a highly humid layer below 300 hPa was observed at 134.343˚E and 27.454˚N.

In addition, Taiwan DOTSTAR team observed a weak tropical cyclone which approached Taiwan with an expecting disaster on 5 November 2020. They also provided us the observed dropsonde data. These data have been used for studied of typhoons and data assimilation experiments. In 2020, a supertyphoon Haishen passed along the west coast of Kyushu and a huge disaster was expected. This was an important case to be observed. However, The ASTRA jet was not available for the typhoon observation and we had

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to give up an aircraft observation of the typhoon. This impressed strongly that Japan should have its own observation aircraft.

Keywords: typhoon, aircraft observation, dropsonde observation, atmospheric river

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Large Eddy Simulation on Horizontal Rolls in Atmospheric Boundary Layer at Narita Airport and its Evaluation

*Junshi Ito[1], Hiroshi Niino[2], Katsumi Yoshino

1. Tohoku University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

Fronts and downbursts are known to be severe threats to airplanes during takeoff and landing. However, it is less known that there is another type of danger under fair weather conditions. An aircraft landing at Narita International Airport, Japan, encountered rapid changes of wind and turbulence in the afternoon of 20 June 2012 when south-westery winds prevailed. It causes a hard-landing, resulting in several injuries and damage to the fuselage. A Doppler lidar for monitoring low-level winds at the airport observed alternating regions of strong and weak winds aligned southwest--northeast, perpendicular to the runway.

In order to clarify the detailed structure and mechanism of these disturbances, numerical simulations using a fine-resolution (horizontal resolution: 100 m) nested in a coarse-resolution (horizontal resolution: 1 km) are made. The simulations show that horizontal convective rolls, which occur in convective boundary layers with strong vertical shear, were prevailing. These rolls are associated with the rapid changes in wind speed and turbulence similar to those observed by the Doppler lidar and flight recorder.

The present study demonstrates that the large eddy simulation is useful for clarifying the structure and mechanisms of horizontal convective rolls and forecasting them. We will also show on-going research in a case with northwesterly winds.

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Remote Sensing of Atmospheric Composition using Commercial Flights between Tokyo-Haneda and Fukuoka-city

*Akihiko Kuze[1], hiroshi Suto[1], Seiya Kosaki[1], Kei Shiomi[1], Ayako Matsumoto[2], YaYasuhiro Tubakihara[2], Fumie Kataoka[3], Tetsuya Kaku[3], Shigetaka Mori[4]

1. Japan Aerospace Exploration Agency, 2. ANA HD, 3. RESTEC, 4. JASTECS

Local flux estimations using existing satellite data such as GOSAT include large uncertainties due to too large footprint, lack of proper upwind reference observation, and lack of wind information. To contribute to the global stocktake of the Paris Agreement, we need an observation system to estimate local flux from individual source sectors. We have developed imaging spectrometer suites with optimized spectral resolution and coverage for air borne observations. They which consist of oxygen (O_2) A band, methane (CH_4) and carbon dioxide (CO_2) bands at 1.6 μm and UV-visible spectrometers. We flew between Tokyo Haneda and Fukuoka-City. The flight route covers mega cities such as Nagoya, Osaka, Kobe, Okayama, Hiroshima, Kita-Kyusyu and industry areas. Since October 2020, we have acquired imaging data of O_2, CO_2, CH_4 and nitrogen dioxide (NO_2). The NO_2 image can identify point sources such as power plants and steel plants with plume. These information will improve the CO_2 local emission estimation from individual source sectors.

Keywords: CO2, NO2, commercial flight, imaging spectrometer , greenhouse gases

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Arctic black carbon during PAMARCMiP 2018 and previous aircraft experiments in spring

*Sho Ohata[1,2], Makoto Koike[3], Atsushi Yoshida[3], Nobuhiro Moteki[3], Kouji Adachi[4], Naga Oshima[4], Hitoshi Matsui[5], Oliver Eppers[6,7], Heiko Bozem[6], Marco Zanatta[8,9], Andreas B. Herber[8]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Institute for Advanced Research, Nagoya University, 3. Graduate School of Science, The University of Tokyo, 4. Meteorological Research Institute, 5. Graduate School of Environmental Studies, Nagoya University, 6. Johannes Gutenberg University of Mainz, 7. Max Planck Institute for Chemistry, 8. Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, 9. Université Paris-Est-Créteil

Vertical profiles of the mass concentration of black carbon (BC) were measured at altitudes up to 5 km during the PAMARCMiP 2018 aircraft experiment (PAM2018) conducted around the Northern Greenland Sea (Fram Strait) during March–April 2018. Median BC mass concentrations in individual altitude ranges were 7–18 ng m^{-3} at standard temperature and pressure at altitudes below 4.5 km. These concentrations were systematically lower than previous observations in the Arctic in spring conducted by ARCTAS-A in 2008 and NETCARE in 2015, whereas they were similar to those observed during HIPPO3 in 2010. Vertically integrated BC mass concentrations for altitudes below 5 km in the Arctic (>60˚N, C_{BC}), observed during the ARCTAS-A and NETCARE experiments were higher by factors of 5.3 and 2.5, respectively, than those of the PAM2018 experiment. These differences could not be explained solely by the different locations of the experiments. The year-to-year variation of C_{BC} values generally corresponded to that of biomass burning activities in northern high latitudes over western and eastern Eurasia. Furthermore, numerical model calculations estimated the year-to-year variation of contributions from anthropogenic sources to be smaller than 20–30%. These results suggest that the year-to-year variation of biomass burning activities likely affected BC amounts in the Arctic troposphere in spring, at least in the years examined in this study. These year-to-year variations in BC were also observed at the ground surface in Ny-Ålesund and Barrow, although their magnitudes were slightly lower than those in C_{BC}.

Numerical model calculations generally reproduced the observed C_{BC} values for PAM2018 and HIPPO3 successfully, whereas they markedly underestimated the values for ARCTAS-A and NETCARE by factors of 3.9–4.3 and 2.9-3.6, respectively. Because anthropogenic contributions account for nearly all of the C_{BC} (82 –98%) in PAM2018 and HIPPO3, the good agreements between the observations and calculations for these two experiments suggest that anthropogenic contributions were generally well reproduced. However, the significant underestimations of C_{BC} for ARCTAS-A and NETCARE suggest that biomass burning contributions were underestimated.

In this study, we also investigated plumes with enhanced BC mass concentrations, which were quite likely affected by biomass burning emissions, observed at 5 km altitude. Interestingly, the mass-averaged diameter of BC (core) and the shell-to-core diameter ratio of BC-containing particles in the plumes were generally not very different from those in other air sampled, which were considered to be mostly aged anthropogenic BC. These observations provide useful bases to evaluate numerical model calculations of the BC radiative effect in the Arctic region in spring.

Keywords: Aircraft observation, black carbon, Arctic

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Observation of red tide in an estuary by a fixed-wind type unmanned aircraft

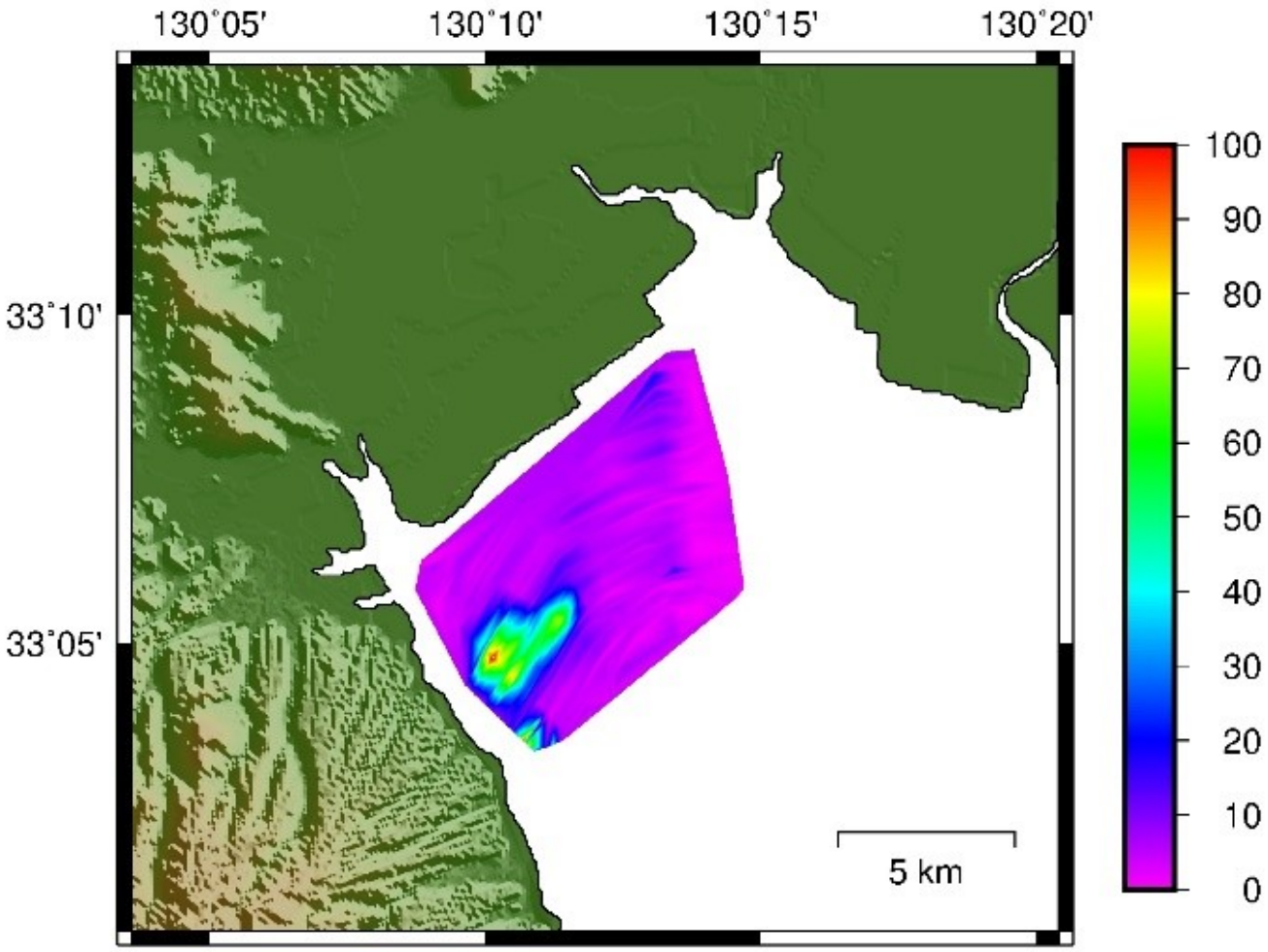
*Soichi Yamaguchi[1], Shota Koide[1], Takayuki Mine[2], Takuya Iwanaga[2]

1. Kyushu university, 2. Saga Ariake Fisheries Promotion Center

In order to elucidate the actual condition of red tide, it is important to observe the series of processes from the early stage of its development to the decay stage through the proliferation stage with high resolution in space and time. One of the methods for obtaining the concentration of sea surface chlorophyll a (Chl-a: an index of phytoplankton community) is observation by ship, but it requires a great deal of labor and cost to secure spatiotemporal resolution. Sea-color remote sensing using artificial satellites, which is another method, enables spatial monitoring, but in the orbit of the satellite, weather condition (clouds), and sea turbidity and seaweed aquaculture in the inner part of the Ariake Sea, which is the target sea area of this research, makes it difficult to obtain data with sufficient spatiotemporal resolution. Observations using unmanned aerial vehicles (UAVs) have been in the limelight in recent years because an aircraft observation has a high degree of freedom in observation such as immediacy and directness, and can perform observations with high spatiotemporal resolution that cannot be performed by satellite or ground observation. In this study, we aimed to establish a spatiotemporal high-resolution sea surface Chl-a concentration remote sensing method using a fixed-wing unmanned aircraft equipped with a spectroradiometer, and attempted to detect red tide in coastal waters. A handheld Spectra PAR Meter (PG200N by UPRtek corp.) was mounted on the UAV to estimate the Chl-a concentration in the sea surface. The PG200N can measure spectral data of light in the visible light region (350 nm to 800 nm) with a wavelength resolution of 1 nm, and can estimate the concentration using the optical characteristics of the Chl-a dye possessed by phytoplankton. It is small and lightweight, suitable for installation on UAV. In the observation, the irradiance incident on the sea surface from the sky and the radiance emitted from the sea surface were measured. In estimating the Chl-a concentration from the obtained spectral data, the reflectance of each wavelength (= upward radiance from the sea surface / downward irradiance from the sky) was calculated, and applied to a three-waveband model (Dall'Olmo, G. and Gitelson, A.A, 2003). Field observations were conducted on December 7 and 18, 2000 and January 5, 2021, and for fixed-wing type unmanned aircraft, OPTiM Hawk V2 (manufactured by OPTiM Corporation) has two PG200N sensors inside the aircraft body, so that it faced directly above and below and measured the spectral data of light from the sky and the sea. The flight speed of OPTiM Hawk V2 was set to 70km / hour, and the spectral data was acquired every 5 seconds, resulting in the spatial resolution of the data to about 100 m. A high correlation was obtained as a whole between the Chl-a concentration estimated by the 3-waveband model and the measured value by the field observation. However, the estimation error tended to increase in the sea area where the Chl-a concentration was high. Generally, when the concentration of phytoplankton is increased, the "packaging effect" that change in the light absorption coefficient per unit Chl-a concentration due to the overlapping of pigments occurs, and the Chl-a concentration estimated by sea color remote sensing is underestimated or overestimated. Therefore, analysis of covariance was performed to estimate the threshold of Chl-a concentration at which the packaging effect appears. Based on this threshold value, we succeeded in developing an algorithm that can estimate Chl-a concentration with high accuracy even in the high Chl-a concentration sea area. In the three observations, a high-concentration local region, which is considered to be the initial occurrence of red tide, was detected. Therefore, this observation using UAV has sufficient performance to grasp the spatiotemporal high resolution of red tide in the coastal area.

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Keywords: red tide, fixed-wind type unmanned aircraft, spectral radiation, Ariake Sea



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Understory biomass estimation based on Structure from Motion data by Multi-layered forest drone survey

*Yupan Zhang[1], Yuichi Onda[1], Hiroaki Kato[1], Takashi Gomi[2]

1. University of Tsukuba, 2. Tokyo University of Agriculture and Technology

Understory vegetation is an important part of evapotranspiration from forest floor. Forest management changes the forest structure and then affects the understory vegetation biomass (UVB). Quantitative measurement and estimation of UVB is a step cannot be ignored in the study of forest ecology and forest evapotranspiration. However, large-scale biomass measurement and estimation is challenging. In this study, Structure from Motion (SfM) was adopted simultaneously at two different layers in a plantation forest made by Japanese cedar and Japanese cypress to reconstruct forest structure from understory to above canopy: i) understory drone survey in a 1.1h sub-catchment to generate canopy height model (CHM) based on dense point clouds data derived from a manual low-flying drone under the canopy; ii) Above-canopy drone survey in whole catchment (33.2 ha) to compute canopy openness data based on point clouds of canopy derived from an autonomous flying drone above the canopy. Combined with actual biomass data from field harvesting to develop regression models between the CHM and UVB, which was then used to map spatial distribution of UVB in sub-catchment. The relationship between UVB and canopy openness data was then developed by overlap analysis. This approach yielded high resolution understory over catchment scale with a point cloud density of more than 20 points/cm^2. Strong coefficients of determination (R-squared = 0.75) of the cubic model supported prediction of UVB from CHM, the average UVB was 0.82kg/m^2 and dominated by low ferns. The corresponding forest canopy openness in this area was 42.48% on average. Overlap analysis show no significant interactions between them in a cubic model with weak predictive power (R-squared < 0.46). Overall, we reconstructed the multi-layered structure of the forest and provided models of UVB. Understory survey has high accuracy for biomass measurement, but it’s inherently difficult to estimate UVB only based on canopy openness result.

Keywords: Structure from Motion, Plantation, Understory biomass, Drone survey

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.06_1

[A-CG31] Aircraft and UAV Observations for Earth-planetary sciences

convener:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University), Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Toshinobu Machida(National Institute for Environmental Studies), Taro Shinoda(Institute for Space-Earth Environmental Research, Nagoya University)

The global climate change, especially for global warming is a big issue throughout the Earth and planetary sciences. To confront this problem, progresses of the observations both for continuous monitoring of the Earth and for the process studies as well as the numerical climate modeling become more important. Aircraft observation has the great advantages on the promptness/timeliness and direct (in-situ) observation which cannot be achieved by Earth observing satellites or ground-based observations. Recently, the importance of aircraft observation is increasing in "in-situ measurements" such as concentration of greenhouse gases, aerosol and cloud particle size distribution, and chemical composition, and "remote sensing" such as three-dimensional observation typhoons and observation on forests and vegetation for better understanding of the detailed process of the global warming and its impacts on the global climate and weather. In addition, the application of aircraft observation including the unmanned aerial vehicle (UAV) to geodesy, studies on earthquakes and volcanos are also progressing. However, operational and/or extensive aircraft observations to fulfill the requirements in Japan are not realized at the present time even though the aircraft observations technologies in Japan has been leading the world. Under this situation, the Science Council of Japan selected the proposal "Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts" as a high priority program. In order to promote more comprehensive/extensive researches by the aircraft observations, it is necessary to have close collaborations among researchers. In this session, we will discuss the future promotion of aircraft and UAV observation through the latest research results using aircraft.

[ACG31-P01] The drone techniques for earth science research operated by high school students and applying for efficiency environmental survey education

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

[ACG31-P02] Vegetation Monitoring by Aircraft Observation: Review and Requirement

*Kazuhito Ichii[1] (1.Chiba University)

[ACG31-P03] Cloud seeding experiment for precipitation augmentation with aircraft in-situ measurements

*Narihiro Orikasa[1], Masataka Murakami[2,1], Atsushi Saito[3], Takuya Tajiri[1], Yuji Zaizen[1], Taro Shinoda[2] (1.Meteorological Research Institute, 2.Nagoya University, ISEE, 3.Japan Meteorological Agency)

[ACG31-P04] Simulation of airborne dual-polarization phased array radar observation of a typhoon

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

The drone techniques for earth science research operated by high school students and applying for efficiency environmental survey education

*Ryo S Nakamura[1]

1. Miyagi Rifu high school

It is not easy for not only researchers but also ordinary people to grasp the shape of the earth from a broad perspective, as represented by ancient Greece Eratosthenes's view of the size of the earth by expanding its imagination. That is even more so for young people who will be responsible for science in the future. At the end of the 20th century, small unmanned aerial vehicles (drones) became cheaper for the public and it became easier that their interest in earth science and its research methods could vivid.

I will introduce how to expand the possibilities in school education by using drone researches for teens, and what we have been able to practice by utilizing the recent world situation of keeping social distance.

(1) The drone techniques in the high school activities

Taking pictures and videos in order to train control skill.

Learning with drone pilot certification for level 3 (DPJ) and safety education for operating apparatus. For safe operation, needed to operate both by visually and out of sight at the radio controller. And make it more safety, also needed face-to-face flight training.

(2) Tracking of inorganic components in the seashore

We have monitored long-term transition and coastal distance tendency for saline components in Matsushima bay.

I will show the flying back water sampling system constructed by students.

(3) Statistical processing of ground-soil conditions using drone imaging and aerial photography software

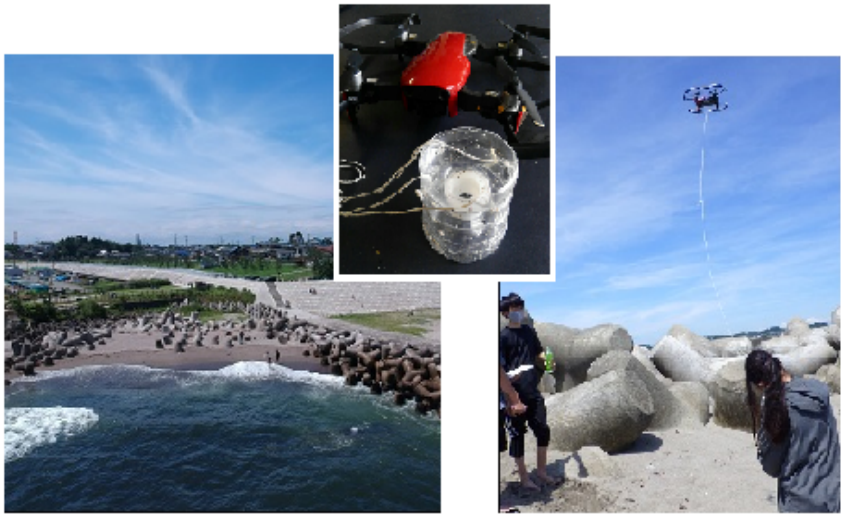
We are trying to measure the vegetation and soil distribution from aerial images. We hope to statistically process soil heat reflexes and green coverage by using drone-related applications (now planning), and to consider the correlation between soil conditions and atmospheric conditions in the future.

Keywords: Drone techniques, earth science education, Inquiry learning, environmental education

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High school activities

Teaching materical for environmental & social study



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Vegetation Monitoring by Aircraft Observation: Review and Requirement

*Kazuhito Ichii[1]

1. Chiba University

Air-craft observation is one of the approaches to accurately monitor the terrestrial vegetation. In this study, I review aircraft observation activities and community requirements. So far, many researchers have been conducted for (a) LiDAR observation, and (b) optical sensor observations at several JapanFlux sites. I will report the survey of other activites, reviews, and community requests.

Keywords: Vegetation Monitoring, Near Remote Sensing, Terrestrial environment

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Cloud seeding experiment for precipitation augmentation with aircraft in-situ measurements

*Narihiro Orikasa[1], Masataka Murakami[2,1], Atsushi Saito[3], Takuya Tajiri[1], Yuji Zaizen[1], Taro Shinoda[2]

1. Meteorological Research Institute, 2. Nagoya University, ISEE, 3. Japan Meteorological Agency

As one of the physical evaluation techniques of cloud seeding effects, we have conducted several field campaigns for cloud seeding experiment utilizing an instrumented aircraft in Japan and in the United Arab Emirates. The seeding agents used were dry-ice pellets and silver iodide flares in cold clouds and hygroscopic flares and salt micro-powders in warm clouds.

We demonstrate from the in-situ measurements that dry-ice pellet seeding of mixed-phase orographic clouds were effective, based on the comparison of estimated radar reflectivity factor, ice water content, or precipitation intensity from the 2D images of ice particles between seeded regions and their surroundings.

The observational results we obtained so far showed that hygroscopic seeding of warm clouds might be effective under limited conditions. The size distributions of cloud droplets near the cloud base were compared between seeded cloud regions and unseeded regions.

The flare seeding plumes generated in midair were sampled and measured with the instrumented aircraft. The size distributions and CCN and INP abilities of those particles in different types of flares are presented.

Keywords: Cloud Condensation Nuclei (CCN)/Ice Nucleating Particles (INP), Hygroscopic Seeding, Hygroscopic Flare and Salt Micro-powder, Glaciogenic Seeding, Silver Iodide Flare and Dry-ice Pellet

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Simulation of airborne dual-polarization phased array radar observation of a typhoon

*Nobuhiro Takahashi[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

In this study, dual-polarization phased array radar observation is simulated by considering the electrical scan of the radar and flight path as well as the polarimetric observables aiming for the typhoon observation which has horizontal dimension of > 300 km and vertical extent of >10 km. Assuming that the aircraft flies about 13 km in height where are the cloud-free height except for the eye-wall region and aircraft flies circular path centered the eye of typhoon or straight path cross the eye region, the radar specifications are set as follows: scan angle is -90 degree to + 10 degrees, 1 degree intervals, scan direction is cross-track direction of the aircraft, and the observables are Zh, ZDR, ϕDP, ρHV and Doppler velocity. First of all, simple typhoon model is simulated by the radar, especially for Zh and Doppler velocity in order to check the geolocation of the aircraft and beam locations. The polarimetric simulation is based on the scattering characteristics of non-spherical particles of rain and ice by using T-matrix method. For the ice precipitation, several types of particles with different shape (oblate/prolate) and different refractive indices (various air and ice mixture).

Keywords: airborne radar, phased array

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.08 Zoom Room 08

[A-CG33] Terrestrial monitoring using new-generation geostationary satellites

convener:Yuhei Yamamoto(Center for Environmental Remote Sensing, Chiba University), Tomoaki Miura(Univ Hawaii), Kazuhito Ichii(Chiba University), Chairperson:Tomoaki Miura(Univ Hawaii)

The third-generation geostationary satellites, such as Himawari 8/9, GOES-16/17, Fengyun-4, and GeoKompsat-2A are recently launched, and earth observation is in a new phase. These sensors are equipped with new spectral bands suitable for terrestrial monitoring used in polar-orbiting satellite sensors, enabling detailed land observations such as land surface temperature, surface albedo, and land cover and vegetation dynamics. Furthermore, by utilizing the advantages of hypertemporal (e.g. 10 min) and moderate spatial resolution, various new land dynamics can be observable. By combining these satellites and polar-orbiting satellites/sensors such as Terra/MODIS and GCOM-C/SGLI, a new generation monitoring data covering Asia, Oceania and North and South America will become possible. This would allow for a consistent comparison of a variety of phenomena across continents. To this end, there are many issues to be discussed, such as the standardization of the estimation algorithms of physical quantities, calibration and verification using GEO-(LEO)-GEO satellites, and application of these new datasets to various phenomena.
In this session, we will discuss the retrieval algorithms of land surface parameters, inter-satellite calibration, validation efforts using in-situ data, and novel applications to various phenomena. Studies on atmospheric parameters in relation to land surface phenomena, such as cloud cover and aerosols, are highly welcomed.

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

[ACG33-01] Using the Diurnal Variability in GeoNEX TOA Reflectances for Earth Monitoring

★Invited Papers

*Weile Wang[1,2], Hirofumi Hashimoto[1,2], Andrew Michaelis[1], Taejin Park[1,5], Ramakrishna Nemani[1], Yujie Wang[3,4], Alexei Lyapustin[3], Tsengdar Lee[6], Satya Kalluri[7] (1.NASA Ames Research Center, 2.California State University Monterey Bay, 3.NASA Goddard Space Flight Center, 4.University of Maryland Baltimore, 5.Bay Area Environment Research Institute, 6.NASA Headerquarter, 7.NOAA NESDIS Center for Satellite Applications and Research)

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

[ACG33-02] Uncertainty quantification in operational algorithms to retrieve land surface temperature from Himawari-8/AHI data

*Yuhei Yamamoto[1], Kazuhito Ichii[1] (1.Center for Environmental Remote Sensing, Chiba University)

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

[ACG33-03] Himawari-8 based near-real time meteorological drought monitoring and early warning system in Asia

★Invited Papers

*Wataru Takeuchi[1], Rizatus Shofiyati[2], Khiem Mai Van[3], Kei Oyoshi[4], Tanita Suepa[5] (1.Institute of Industrial Science, The University of Tokyo, 2.Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD), 3.National Center of Hydro-Meteorology Forecasting (NCHMF), Vietnam, 4.Japan Aerospace Exploration Agency (JAXA), 5.Geo-Informatics & Space Technology Development Agency (GISTDA), Thailand)

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

[ACG33-04] Validation of HIMAWARI-8 AHI Aerosol Products with SKYNET and AERONET Measurements

*Hirokazu YAMAMOTO[1], Hitoshi Irie[2] (1.Geological Survey of Japan, AIST, 2. Center for Environmental Remote Sensing, Chiba University)

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

[ACG33-05] On the relationship between photosynthesis measures from OzFlux tower sites and Himawari-8 geostationary observations

★Invited Papers

*Alfredo R Huete[1], Qiaoyun Xie[1], Ngoc Nguyen Tran[1,2] (1.University of Technology Sydney, 2.School of Information and Communication Technology, Hanoi University of Science and Technology)

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

[ACG33-06] Seasonal variations in photosynthesis activities across Southeast Asia detected by a new geostationary satellite, Himawari-8

*Kazuhito Ichii[1], Kodai Hayashi[1], Yuhei Yamamoto[1] (1.Chiba University)

Using the Diurnal Variability in GeoNEX TOA Reflectances for Earth Monitoring

*Weile Wang[1,2], Hirofumi Hashimoto[1,2], Andrew Michaelis[1], Taejin Park[1,5], Ramakrishna Nemani[1], Yujie Wang[3,4], Alexei Lyapustin[3], Tsengdar Lee[6], Satya Kalluri[7]

1. NASA Ames Research Center, 2. California State University Monterey Bay, 3. NASA Goddard Space Flight Center, 4. University of Maryland Baltimore, 5. Bay Area Environment Research Institute, 6. NASA Headerquarter, 7. NOAA NESDIS Center for Satellite Applications and Research

Observations from the third-generation geostationary satellite instruments (GOES 16/17 ABI, Himawari 8/9 AHI, and etc.) have spatial resolution and spectral band configurations comparable to flagship LEO sensors (e.g., MODIS/VIIRS). More importantly, these data are acquired at very high temporal resolution, faithfully recording the variations of the full disk of Earth at every 5-10 minutes. They thus provide unique information about Earth’ s atmosphere and surface. In order to explore the unique information content of geostationary data, this study systematically analyzes the diurnal variability in the GeoNEX L1G TOA reflectance products and compares them to simulated results by state-of-the-art radiative transfer codes. Our results show that

The smoothness of the TOA reflectance diurnal cycle provides a convenient and reliable way to identify stable atmospheric conditions and filter out passing clouds/shadows.

The diurnal variability of the blue band (0.47 μm) reflectance is regulated mainly by atmospheric optical conditions over a majority of land cover types. As such, the diurnal variability of the blue band data allows us to retrieve AOD without invoking the use of spectral band ratios (SRC) as in previous algorithms.

In comparison, the diurnal variability of the short-wave infrared band (2.2 μm) BRFs is mainly regulated by surface reflectance and the sun-target-satellite geometry. This information allows us to test and, if suitable, retrieve surface BRDF parameters.

Spectral band ratios, especially those between the 2.2 μm and 0.47 μm bands, are not constant but vary by locations and sun-target-satellite geometries.

Our analysis clearly demonstrates that the information provided in high-frequent geostationary observations is unique and complementary to LEO sensors. Therefore, a synergy of GEO and LEO (and other) sensors has the great potential to improve existing remote sensing models and algorithms for better Earth monitoring.

Keywords: GeoNEX, Remote Sensing, Geostationary Satellites, Diurnal Variabilty, Surface Reflectance, Aerosol Optical Depth

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Uncertainty quantification in operational algorithms to retrieve land surface temperature from Himawari-8/AHI data

*Yuhei Yamamoto[1], Kazuhito Ichii[1]

1. Center for Environmental Remote Sensing, Chiba University

Land surface temperature (LST) is a key parameter of land–atmosphere interaction on various scales. Therefore, the LST has potential applications in environmental studies, such as the surface energy balances and vegetation monitoring. Himawari-8, a new generation of Japanese geostationary satellite, began the observation from July 2015. The Advanced Himawari Imager (AHI) onboard Himawari-8 features high spatial (about 2 km) and temporal resolution (10 min), and three thermal infrared bands (band 13, 14, and 15 centered at 10.4, 11.2, and 12.4 μm, respectively). The observation area of Himawari-8 has many islands, complex terrains, and megacities, causing a large spatial variation in LST. Therefore, it is important to compare the performance of the different LST algorithms and evaluate the reliabilities of the LSTs in various land covers and atmospheric environments.
In this study, we compared the sensitivities to their input data between three different LST retrieval algorithms; a nonlinear split-window algorithm proposed by Sobrino and Raissouni (2000) (*NSW_sob*), a NSW proposed by Wan (2014) (*NSW_wan*), and a nonlinear three-band algorithm developed by Yamamoto et al. (2018) (*NTB_yam*). In addition, the LST algorithm, which was selected as the most accurate of the three, was validated in various land covers and seasons by *in-situ* LST. The sensitivity analysis of the LST algorithms were performed using the data simulated by the MODTRAN6 radiative transfer code. Inputs of MODTRAN6 were atmospheric profiles of SeeBor (7204 profiles), surface emissivities from ASTER spectral library (70 types), response functions of AHI three thermal infrared bands, and satellite zenith angle ranging 0–70 °. The *in-situ* LST were estimated from the upward longwave radiation data provided by AsiaFlux and OzFlux.
The sensitivity analysis showed that the *NTB_yam* has the highest robustness to the uncertainties of input data and highest accuracies under hot, humid, and high view-zenith angle situations. Regarding validation, we are waiting for the results of the analysis.

Keywords: Himawari-8, Land surface temperature

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Himawari-8 based near-real time meteorological drought monitoring and early warning system in Asia

*Wataru Takeuchi[1], Rizatus Shofiyati[2], Khiem Mai Van[3], Kei Oyoshi[4], Tanita Suepa[5]

1. Institute of Industrial Science, The University of Tokyo, 2. Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD), 3. National Center of Hydro-Meteorology Forecasting (NCHMF), Vietnam, 4. Japan Aerospace Exploration Agency (JAXA), 5. Geo-Informatics & Space Technology Development Agency (GISTDA), Thailand

This research focuses on a development of satellite-based drought monitoring warning system for croplands in Asian countries. Drought condition of cropland is evaluated by using Keeth-Byram Drought Index (KBDI) computed from rainfall measurements with GSMaP product, land surface temperature and vegetation index by Himawari-8 at daily basis. The derived information is disseminated as a system for an application of space based technology (SBT) in the implementation of the Core Agriculture Support Program. The benefit of this system are to develop satellite-based drought monitoring and early warning system in Asian counties using freely available data, and to develop capacity of policy makers in those countries to apply the developed system in policy making. A series of training program has been carried out since 2013 to officers and researchers of ministry of agriculture and relevant agencies in Greater Mekong Subregion countries including Cambodia, China, Myanmar, Laos, Thailand, Vietnam and Indonesia. This system is running as fully operational and can be accessed at http://wtlab.iis.u-tokyo.ac.jp/DMEWS/.

Keywords: KBDI, land surface temperature, rainfall

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Satellite-based drought monitoring and warning system

Institute of Industrial Science, The University of Tokyo, Japan

About this site

This is system is an application of space based technology (SBT) in the implementation of the Core Agriculture Support Program.
The benefit of this system are to develop satellite-based drought monitoring and early warning system (DMEWS) for Asian Pacific counties using freely available data, and to develop capacity of policy makers in those countries to apply the developed system in policy making.

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Validation of HIMAWARI-8 AHI Aerosol Products with SKYNET and AERONET Measurements

*Hirokazu YAMAMOTO[1], Hitoshi Irie[2]

1. Geological Survey of Japan, AIST, 2. Center for Environmental Remote Sensing, Chiba University

Atmospheric correction over land is an essential process for ground surface reflectance products, which are derived from space-borne optical remote sensing data. Surface reflectance is very important for environmental research using higher accurate biophysical parameter estimations. General algorithm consists of Rayleigh scattering, absorption by atmospheric gases, and aerosol effects. Especially, removal of the aerosol effects is difficult because of spatial variability, time variation, and so on.

Himawari-8 was developed by the Japan Meteorological Agency (JMA) and launched on October 7, 2014, and the official operation started on July 7, 2015. JAXA provides Himawari-8 AHI aerosol products processed by the retrieval algorithms, which are very useful for high-frequency land surface reflectance processed by the atmospheric correction algorithm.

The instruments, Skyradiometer POM02, have been installed to measure the aerosol parameters over three validation sites, Tsukuba, Takayama, and Fuji in Japan. Obtained data are transferred to the SKYNET (http://atmos3.cr. chiba-u.jp/skynet/), which provides the aerosol parameters retrieved by using SKYRAD.PACK software package. Additionally, we also installed a CIMEL instrument (CE318TS9) at Tsukuba, that retrieved atmospheric profiles are available from the AERONET.

This research shows the validation and evaluation of Himawari-8 AHI L2ARP, L3ARP Hourly, and L3ARP Monthly products using SKYNET and AERONET data for all three validation sites.

Keywords: Himawari-8 AHI, Atmospheric Correction, Validation, SKYNET, AERONET

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On the relationship between photosynthesis measures from OzFlux tower sites and Himawari-8 geostationary observations

*Alfredo R Huete[1], Qiaoyun Xie[1], Ngoc Nguyen Tran[1,2]

1. University of Technology Sydney, 2. School of Information and Communication Technology, Hanoi University of Science and Technology

Estimations of gross ecosystem production (GEP) and photosynthetic capacity (Pc) are crucial to understanding the global carbon cycle and the impact of climate change. Eddy covariance (EC) flux towers from the OzFlux network in Australia, provide in-situ, sub-daily and seasonal measurements of photosynthetic fluxes across a wide range of ecosystem types, encompassing both meteorology-driven and phenology-driven plant productivity, as well as combinations of the two drivers. Further, Australia’s extreme climate variability present many challenges for satellite remote sensing to accurately capture vegetation dynamics, particularly given their ecohydrologically sensitivity. In this study, we used GEP and Pc estimates from eight OzFlux sites, encompassing arid grasslands and woodlands; dry and wet savannas; and dry to wet sclerophyll evergreen forests. The sub daily, daily, and seasonal flux measures were related to geostationary Himawari-8 satellite measures of vegetation at equivalent temporal scales. The advanced Himawari imager (AHI) provides unparalleled high-temporal imagery over Australian ecosystems to better understand how they function by tracking important sub-daily and daily processes over multiple years. In addition to cross-temporal scale comparisons between satellite and in-situ measures of productivity, we further wished to assess the role and extent to which plant phenological and meteorologic processes can be related with tower flux photosynthesis measures under climate variability.

Our results show great potential of Himawari-8 data in providing continuous temporal estimations of vegetation dynamics. Wet pulse events in arid regions were more clearly represented in the Himawari-8 data. Phenology-driven savanna dynamics, depicted from Himawari-8 and tower fluxes were strongly synchronised, and meteorologically driven flux tower measures of GEP in wet sclerophyll evergreen forests were completely out of phase with satellite measures of vegetation. Enhancing our biophysical understanding of vegetation dynamics will enable better predictions of how ecosystems will respond to simultaneous stressors such as climate change (warming, extreme events, flash droughts) and other disturbance regimes. These processes govern Australia’s ecosystems and heavily influence the ecosystem services they provide.

Keywords: Himawari-8, geostationary satellites, OzFlux, phenology, climate variability, ecosystems

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Seasonal variations in photosynthesis activities across Southeast Asia detected by a new geostationary satellite, Himawari-8

*Kazuhito Ichii[1], Kodai Hayashi[1], Yuhei Yamamoto[1]

1. Chiba University

Satellite-based monitoring of terrestrial vegetation over tropical forests is challenging due to the frequent cloud cover. In particular, vegetation activities in southeast Asia is one of the most unknown regions due to severe cloud cover and heavy precipitation. Polar-orbiting satellites which were traditionally used for terrestrial vegetation monitoring were New geostationary satellites, such as Himawari-8/AHI (H8-AHI) are expected to observe better due to its high observation frequency (every 10 minutes). In this study, we quantified how much more cloud-free observations can be obtained using H8-AHI data in Southeast Asia, compared to using polar-orbiting satellite data, Terra and Aqua/MODIS. First, we confirmed that cloud detection rates are similar between H8-AHI and MODIS cloud masks. Then, we found that H8-AHI observation substantially increased cloud-free observation compared with those of MODIS at monthly scale. Finally, we compared resulting cloud free vegetation index time-series between AHI and MODIS and only H8-AHI tracks seasonal plant phenology over tropical forests.

Keywords: Himawari-8, Vegetation Monitoring, Southeast Asia

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.06_2

[A-CG33] Terrestrial monitoring using new-generation geostationary satellites

convener:Yuhei Yamamoto(Center for Environmental Remote Sensing, Chiba University), Tomoaki Miura(Univ Hawaii), Kazuhito Ichii(Chiba University)

The third-generation geostationary satellites, such as Himawari 8/9, GOES-16/17, Fengyun-4, and GeoKompsat-2A are recently launched, and earth observation is in a new phase. These sensors are equipped with new spectral bands suitable for terrestrial monitoring used in polar-orbiting satellite sensors, enabling detailed land observations such as land surface temperature, surface albedo, and land cover and vegetation dynamics. Furthermore, by utilizing the advantages of hypertemporal (e.g. 10 min) and moderate spatial resolution, various new land dynamics can be observable. By combining these satellites and polar-orbiting satellites/sensors such as Terra/MODIS and GCOM-C/SGLI, a new generation monitoring data covering Asia, Oceania and North and South America will become possible. This would allow for a consistent comparison of a variety of phenomena across continents. To this end, there are many issues to be discussed, such as the standardization of the estimation algorithms of physical quantities, calibration and verification using GEO-(LEO)-GEO satellites, and application of these new datasets to various phenomena.
In this session, we will discuss the retrieval algorithms of land surface parameters, inter-satellite calibration, validation efforts using in-situ data, and novel applications to various phenomena. Studies on atmospheric parameters in relation to land surface phenomena, such as cloud cover and aerosols, are highly welcomed.

[ACG33-P01] Introduction

[ACG33-P02] Himawari-8 AHI NDVI Temporal Signature Variability of Broadleaf Deciduous Forests Along Temperature, Elevation, and Latitudinal Gradients in Northern Japan

*Tomoaki Miura[1,2], Shin Nagai[2], Narumasa Tsutsumida[3], Yuhei Yamamoto[4] (1.University of Hawaii at Manoa, 2.JAMSTEC, 3.Saitama University, 4.Center for Environmental Remote Sensing, Chiba University)

[ACG33-P03] Geolocation accuracy assessment of CEReS released Himawari-8 gridded data

*Yuhei Yamamoto[1], Kazuhito Ichii[1], Atsushi Higuchi[1], Hideaki Takenaka[1] (1.Center for Environmental Remote Sensing, Chiba University)

[ACG33-P04] **Monitoring urban heat island of Jakarta using medium spatial resolution satellite data**

*Fitria Nucifera[1], Widiyana Riasasi[1], Da Wang[2], Yuhei Yamamoto[2], Kazuhito Ichii[2] (1.Universitas AMIKOM Yogyakarta, 2.Center for Environmental Remote Sensing (CeRES), Chiba University)

[ACG33-P05] Discussion

[E] Poster | A (Atmospheric and Hydrospheric Sciences) | A-CG Complex & General

[A-CG33] Terrestrial monitoring using new-generation geostationary satellites

convener:Yuhei Yamamoto(Center for Environmental Remote Sensing, Chiba University), Tomoaki Miura(Univ Hawaii), Kazuhito Ichii(Chiba University)

Thu. Jun 3, 2021 5:15 PM - 6:30 PM Ch.06

The third-generation geostationary satellites, such as Himawari 8/9, GOES-16/17, Fengyun-4, and GeoKompsat-2A are recently launched, and earth observation is in a new phase. These sensors are equipped with new spectral bands suitable for terrestrial monitoring used in polar-orbiting satellite sensors, enabling detailed land observations such as land surface temperature, surface albedo, and land cover and vegetation dynamics. Furthermore, by utilizing the advantages of hypertemporal (e.g. 10 min) and moderate spatial resolution, various new land dynamics can be observable. By combining these satellites and polar-orbiting satellites/sensors such as Terra/MODIS and GCOM-C/SGLI, a new generation monitoring data covering Asia, Oceania and North and South America will become possible. This would allow for a consistent comparison of a variety of phenomena across continents. To this end, there are many issues to be discussed, such as the standardization of the estimation algorithms of physical quantities, calibration and verification using GEO-(LEO)-GEO satellites, and application of these new datasets to various phenomena.

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5:15 PM - 6:30 PM

[ACG33-P01]Introduction

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Himawari-8 AHI NDVI Temporal Signature Variability of Broadleaf Deciduous Forests Along Temperature, Elevation, and Latitudinal Gradients in Northern Japan

*Tomoaki Miura[1,2], Shin Nagai[2], Narumasa Tsutsumida[3], Yuhei Yamamoto[4]

1. University of Hawaii at Manoa, 2. JAMSTEC, 3. Saitama University, 4. Center for Environmental Remote Sensing, Chiba University

Himawari-8 Advanced Himawari Imager (AHI), one of new-generation geostationary satellite sensors, is equipped with a red and near-infrared bands and has been imaging an Earth’s hemisphere at 10 min intervals since July 2015. This new-generation geostationary satellite sensor provides the potential to generate higher-temporal resolution vegetation index (VI) time series data than the conventional polar-orbiting satellite sensors even in cloud-prone areas and seasons. In this study, we assessed how AHI NDVI higher-temporal signatures varied for deciduous broadleaf forests (DBFs) along temperature, elevation, and latitudinal gradients in the northern Japan. AHI 10-min data were obtained for a three-year period of 2016-2018 and reduced into daily NDVI time series. Two temperature-driven indices, the warmth and coldness indices (WI and CI, respectively), were obtained from mean monthly temperature. A land cover map derived from Advanced Land Observing Satellite (ALOS) data was used to identify DBF areas along three transects drawn from Japan Sea to Pacific Ocean. AHI NDVI temporal signatures had one growth cycle/season per year, but were different along temperature, elevation, and latitudinal gradients. The start of growth season (SGS) metric derived from AHI NDVI was positively, but weakly correlated with the latitude (r = .47) and elevation (r = .47). In contrast, the AHI NDVI-derived end of growth season (EGS) metric significantly correlated to the latitude (r = .73), but extremely weakly to the elevation (r = .07). The highest correlations were obtained with the WI and CI for these metrices (r = .86 between the SGS and WI, and r = .75 between the EGS and CI). It was found that AHI-derived NDVI temporal data were useful for regional-scale analysis of DBF phenology.

Keywords: Advanced Himawari Imager, NDVI, Phenology

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Geolocation accuracy assessment of CEReS released Himawari-8 gridded data

*Yuhei Yamamoto[1], Kazuhito Ichii[1], Atsushi Higuchi[1], Hideaki Takenaka[1]

1. Center for Environmental Remote Sensing, Chiba University

Geolocation accuracy is an essential issue due to the refinement of the terrestrial and meteorological scales accompanying the improvement of observation functions of new generation geostationary satellites. In the case of the Himawari-8, the Center for Environmental Remote Sensing (CEReS) at Chiba University released lat-lon coordinated and geometrically corrected processed data using a visible band with 500 m spatial resolution (CEReS data) from Himawari Standard Data provided by the Japan Meteorological Agency (JMA data). We evaluated the spatiotemporal variation characteristics of the geolocation errors of the two datasets and their stability against large unexpected misalignments when assuming terrestrial monitoring.

The results showed that the long-term stability of CEReS data from the start of operation of Himawari 8, and improvements of systematic geolocation errors, especially west-eaast direction from JMA data. As CEReS data are processed during the daytime due to the availability of visible bands, we suggest the use of CEReS data for effective terrestrial monitoring during the daytime (4 hours before and after noon).

Keywords: Himawari-8, geometric correction

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Monitoring urban heat island of Jakarta using medium spatial resolution satellite data

*Fitria Nucifera[1], Widiyana Riasasi[1], Da Wang[2], Yuhei Yamamoto[2], Kazuhito Ichii[2]

1. Universitas AMIKOM Yogyakarta, 2. Center for Environmental Remote Sensing (CeRES), Chiba University

Rapid urbanization in developing countries has been triggering numerous environmental problems such as air pollution, ecological degradation, and urban heat island. Urban heat island (UHI) is the most common phenomenon that occurs in urban areas where the temperature of urban areas is higher than its surroundings. Satellite remote sensing data have been widely used to analyze UHI in many countries. So far, high spatial resolution data such as Landsat were commonly applied. However, only very few images are available for urban monitoring across humid tropical regions due to heavy and frequent cloud cover. In this study, we attempted to use multiple medium resolution satellite data which have better temporal observation frequency. MODIS satellite data have a medium spatial resolution and high temporal resolution which is capable of monitoring the development of urban heat island over time. Using multiple MODIS products such as land cover and land surface temperature from 2000 to 2019, we monitored urban expansion and UHI in Jakarta, the capital of Indonesia. MODIS land cover data (MCD12Q1) were applied to quantify urban expansion, while MODIS land surface temperature (MOD11A2) were used to analyze UHI. The Gaussian fitting method was performed to determine UHI magnitude and UHI pattern. The results show that the Jakarta urban area has expanded more than 20% larger from 2000 to 2019. Land surface temperature in Jakarta was likely to increase during that time. The expansion of the high LST area during the day and night had different characteristics. We also discuss the capability of hyper-temporal data by geostationary satellites such as Himawari-8.

Keywords: land surface temperature, urban heat island, urban expansion, MODIS, Jakarta

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[E] Poster | A (Atmospheric and Hydrospheric Sciences) | A-CG Complex & General

[A-CG33] Terrestrial monitoring using new-generation geostationary satellites

convener:Yuhei Yamamoto(Center for Environmental Remote Sensing, Chiba University), Tomoaki Miura(Univ Hawaii), Kazuhito Ichii(Chiba University)

Thu. Jun 3, 2021 5:15 PM - 6:30 PM Ch.06

The third-generation geostationary satellites, such as Himawari 8/9, GOES-16/17, Fengyun-4, and GeoKompsat-2A are recently launched, and earth observation is in a new phase. These sensors are equipped with new spectral bands suitable for terrestrial monitoring used in polar-orbiting satellite sensors, enabling detailed land observations such as land surface temperature, surface albedo, and land cover and vegetation dynamics. Furthermore, by utilizing the advantages of hypertemporal (e.g. 10 min) and moderate spatial resolution, various new land dynamics can be observable. By combining these satellites and polar-orbiting satellites/sensors such as Terra/MODIS and GCOM-C/SGLI, a new generation monitoring data covering Asia, Oceania and North and South America will become possible. This would allow for a consistent comparison of a variety of phenomena across continents. To this end, there are many issues to be discussed, such as the standardization of the estimation algorithms of physical quantities, calibration and verification using GEO-(LEO)-GEO satellites, and application of these new datasets to various phenomena.

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5:15 PM - 6:30 PM

[ACG33-P05]Discussion

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.08 Zoom Room 08

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Hiroshi Murakami(Earth Observation Research Center, Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies)

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

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

[ACG36-01] Earth environment in 2020 observed by GCOM-C “SHIKISAI”

*Hiroshi Murakami[1], Kazuhisa Tanada[1], Rigen Shimada[1], Toshiyuki Kobayashi[1], Kazunori Ogata[1], Tomoko Koyama[1], Yukio Kurihara[1] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency)

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

[ACG36-02] **Validation of SGLI/GCOM-C cloud products using surface and MODIS observation data**

*Pradeep Khatri[1], Tadahiro Hayasaka[1], Hitoshi Irie[2], Tamio Takamura[2] (1.Center for Atmospheric and Oceanic Studies,Tohoku University, 2.Center for Environmental Remote Sensing, Chiba University)

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

[ACG36-03] Development of Above Ground Biomass estimation method by combined use of GCOM-C / SGLI and Space LiDAR observation data

*REI MITSUHASHI[1], Koji Kajiwara[2], Yoshiaki HONDA[2] (1.Japan Aerospace Exploration Agency, 2.Chiba University)

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

[ACG36-04] Spatial and Temporal Variations of XCO_2 and XCH_4 observed by GOSAT and GOSAT-2 in 2019 - 2020

★Invited Papers

*Tsuneo Matsunaga[1], Isamu Morino[1], Hirofumi Ohyama[1], Jiye Zeng[1], Hibiki M Noda[1], Makoto Saito[1], Yukio Yoshida[1], Akihide Kamei[1], Fumie Kawazoe[1], Tazu Saeki[1] (1.Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies)

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

[ACG36-05] Global high-resolution inverse model for application to space-based CO_2 observations

*Shamil Maksyutov[1], Tomohiro Oda[2], Jiye Zeng[1], Rajesh Janardanan[1], Yukio Yoshida[1], Johannes W Kaiser[3], David Crisp[4], Tsuneo Matsunaga[1] (1.National Institute for Environmental Studies, 2.Universities Space Research Association, 3.Deutscher Wetterdienst, 4.Jet Propulsion Laboratory/California Institute of Technology)

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

[ACG36-06] Observing anthropogenic emissions of greenhouse gases and air pollutants with the GOSAT-GW satellite: Scientific targets and policy contributions

*Hiroshi Tanimoto[1], Tsuneo Matsunaga[1], Nobuko Saigusa[1], Takafumi Sugita[1], Hisashi Yashiro[1], Isamu Morino[1], Makoto Saito[1], Hirofumi Ohyama[1], Kohei Ikeda[1], Yu Someya[1], Tamaki Fujinawa[1], Yousuke Yamashita[1], Tazu Saeki[1], Yugo Kanaya[2], Takashi Sekiya[2], Yasuko Kasai[3], Tomohiro Sato[3] (1.National Institute for Environmental Studies, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Institute of Information and Communications Technology)

Earth environment in 2020 observed by GCOM-C “SHIKISAI”

*Hiroshi Murakami[1], Kazuhisa Tanada[1], Rigen Shimada[1], Toshiyuki Kobayashi[1], Kazunori Ogata[1], Tomoko Koyama[1], Yukio Kurihara[1]

1. Earth Observation Research Center, Japan Aerospace Exploration Agency

JAXA polar-orbit satellite, GCOM-C called “SHIKISAI” has been launched on 23 Dec. 2017, and continued global observation since 1st January 2018 with Second-generation Global Imager (SGLI). The key characteristics of SGLI are 250-m spatial resolution with 1150-1400 km swath and nineteen bands in 0.38-12 um including two polarimetry bands. The version 2 standard products have been released in the end of June 2020, the reprocessing of previous years data is on-going, and the next version 3 products will be open in the next winter.
In 2020, GCOM-C has captured several characteristic environment events: (1) heavy aerosols caused by wildfires in Australia, Siberia, California and Amazon, (2) weak unstable Kuroshio current, (3) upwelling of suspended sediment by typhoons in the East China Sea, (4) significant decrease of short wave radiation and (5) increase of coastal suspended sediment by long continued rain band around East Asia in July, and so on. The zonal mean of the SGLI near-ultraviolet channel was decreased corresponding to the aerosol events of (1). The SGLI 250-m resolution could reveal fine structure of the ocean surface current by comparing with Sentinel-3 OLCI images observed before 20-60 minutes. The upwelling of suspended sediment (3) could be analyzed with geophysical data by GCOM-W.
The accumulating data products are expected to be used in both researches and monitoring of the environmental change such as phenology and spectral characteristics, e.g., seasonal change of the land vegetation and the ocean phytoplankton, reflectance spectra of red tides, near-UV absorption of the aerosols, and so on.

Keywords: GCOM-C, SHIKISAI, SGLI, remote sensing

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Validation of SGLI/GCOM-C cloud products using surface and MODIS observation data

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The recent version 2.0 cloud properties (cloud optical thickness COT and cloud-particle effective radius CER) of both water and ice clouds obtained from the Second-generation Global Imager (SGLI) aboard the Global Change Observation Mission-Climate (GCOM-C, “Shikisai” in Japanese) were validated using sky radiometer cloud properties and global radiative flux data observed at different SKYNET sites within Japan (Chiba, Hedo-misaki, Fukuejima, Miyakojima, and Sendai) for the period of January-November, 2020. Accuracies of SGLI cloud properties were further confirmed by comparing them with MODIS cloud properties observed for the period of June-July, 2020 over the region of 20^0N-40^0N and 106^0E-156^0E. The SGLI COTs agreed quite well with sky radiometer (r = 0.73 and MBE = 1) and MODIS (r >= 0.97 and MBE < 2 over land and ocean) values by further reproducing global radiative fluxes modeled using SGLI cloud properties comparable to observed values (r = 0.85 and MBE = 25 Wm^{-2}), where r and MBE are correlation coefficient and absolute value of mean bias error, respectively. The comparison between SGLI and sky radiometer based CER is relatively poor (r=0.12, MBE = 1.5 μm), possibly due to the effect of inhomogeneous vertical profile of CER. But, MODIS and SLGI CERs agreed very well (r >= 0.93 and MBE < 0.5 μm). On the other hand, the agreement for ice cloud is relatively poor: r = 0.5 and MBE = 4.5 for comparison with sky radiometer COTs; r >=0.97 and MBE < 1 for comparison with MODIS COTs over land and ocean; r >=0.73 and RE < 8 μm for comparison with MODIS CERs over land and ocean; r =0.89 and RE = 16 Wm^{-2} for comparison of modeled and observed global radiative fluxes at SKYNET sites. The relatively poor agreement for ice cloud properties is likely due to the difference in cloud phase detection method and single scattering properties for ice cloud in different cloud retrieval methods, suggesting the necessity of more validation studies for ice clouds in future.

Keywords: SGLI, validation , sky radiometer, global radiative flux, MODIS

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Development of Above Ground Biomass estimation method by combined use of GCOM-C / SGLI and Space LiDAR observation data

*REI MITSUHASHI[1], Koji Kajiwara[2], Yoshiaki HONDA[2]

1. Japan Aerospace Exploration Agency, 2. Chiba University

The SGLI sensor onboard the GCOM-C, launched in December 2017, provides observation data from nadir and slant observation in the Red and NIR regions. An algorithm has been proposed that uses a set of these observation data to estimate biomass using the observed reflectance change caused by the 3D structure of the vegetation canopy, and the biomass product created by this algorithm, currently available from JAXA.

In the current algorithm, the parameters of the biomass estimation formula are selected according to the forest type of the observed area. these parameters are adjusted by regression analysis using in-situ data from literature and existing biomass digital data.

Therefore, the abundance and accuracy of the biomass data used as the true value at that time are important. Currently, the data used as true values in regression analyzes are literature data collected in the past and existing digital biomass data. However, these data were collected and observed more than 10 years ago and are becoming less valid considering the growth of trees during that period.

On the other hand, biomass estimation technology from Space LiDAR observation data that can collect vegetation tree height information from space is developing. Currently, observation data is being collected by NASA's GEDI onboard the ISS from the end of 2019. In addition, JAXA is planning a new space LiDAR, MOLI which will be equipped with an optical imager. And it is considered that the biomass data estimated from these space LiDAR observation data can be used globally as the latest true biomass value. However, the LiDAR biomass estimation value has the following problems in incorporating it into the SGLI biomass estimation method.
It is necessary to verify the accuracy of the biomass estimate itself by LiDAR. A biomass product of NASA's GEDI is not available. JAXA is currently developing a biomass estimation algorithm for MOLI. The estimated biomass value by LiDAR is in the narrow area of footprint, and it is necessary to develop an algorithm that gives spatial representativeness in order to use it as the true biomass value in the observation area of a mediumresolution optical sensor.

In view of the above background, the purpose of this study is as follows.
The results of applying the biomass estimation algorithm for MOLI under development at JAXA to the fullwave data of the observation spot based on GEDI observation data will be verified by field measurement, and the estimation accuracy and validity will be examined. For GEDI data, generate global biomass estimates for observation spots using the above algorithm. Considering the data in 2) above as the true biomass value, perform SGLI biomass estimation and examine the superiority over the current algorithm. At that time, we will develop an algorithm for making the biomass of narrow area spots by LiDAR correspond to SGLI resolution.

Regarding 1), the validity and estimation accuracy of the algorithm were shown by conducting field observations on the already observed GEDI fullwave data and comparing it with the measured biomass.

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Regarding 2), typical land cover (using land cover classification data specialized for use in biomass estimation created using SGLI observation data), and the current biomass estimation algorithm by LiDAR for each region. Created a dataset to which. Regarding 3), the biomass estimation value by Space LiDAR created. Regarding 3), the land cover data created in 2) is created at SGLI's 250 m resolution. Since SGLI biomass products are created with a resolution of 1 km, there are actually 16 pixels of land cover data within one pixel of the biomass product. The results of calculating the weighted average for the biomass estimated from the GEDI data using the area ratios of these land covers within the 1 km resolution were used for the regression analysis of the SGLI algorithm to create the biomass estimation data from SGLI.

Keywords: GCOM-C/SGLI, GEDI, Above Ground Biomass

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Spatial and Temporal Variations of XCO_2 and XCH_4 observed by GOSAT and GOSAT-2 in 2019 - 2020

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1. Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies

Fourier transform spectrometers (FTS) onboard GOSAT (launched in 2009) and GOSAT-2 (launched in 2018) have been observing the Earth's atmosphere in the short wavelength infrared region for about 12 and 2 years respectively. The column-averaged dry-air mole fractions of CO_2 (XCO_2) and CH_4 (XCH_4) were calculated from these FTS data and distributed to general public from GOSAT Data Archive Service (https://data2.gosat.nies.go.jp/index_en.html) and GOSAT-2 Product Archive (https://prdct.gosat-2.nies.go.jp/en/index.html) as GOSAT and GOSAT-2 Level 2 standard products. Their latest versions are V02.90/V02.91 and V02.95/V02.96 (bias corrected) for GOSAT and V01.03 (proxy) and V01.04 (full physics) for GOSAT-2, respectively.

It is already found that the current GOSAT-2 full physics XCO_2 and XCH_4 products have significant biases which are spatially and temporally variable. To investigate such characteristics of GOSAT-2 data, following comparisons are being conducted.

(1) Comparison between GOSAT-2 Level 2 products and ground-based data

(2) Comparison between GOSAT and GOSAT-2 Level 2 products

(3) Comparison of whole-atmosphere monthly mean CO_2 and CH_4 concentrations derived from GOSAT and GOSAT-2 L2 products independently.

Comparison results and suggestions for future product improvements will be discussed in the presentation.

Keywords: Greenhouse gas, Carbon Dioxide, Methane

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Global high-resolution inverse model for application to space-based CO_2 observations

*Shamil Maksyutov[1], Tomohiro Oda[2], Jiye Zeng[1], Rajesh Janardanan[1], Yukio Yoshida[1], Johannes W Kaiser[3], David Crisp[4], Tsuneo Matsunaga[1]

1. National Institute for Environmental Studies, 2. Universities Space Research Association, 3. Deutscher Wetterdienst, 4. Jet Propulsion Laboratory/California Institute of Technology

We report revision of the global inverse model NTFVAR (NIES-TM-FLEXPART-variational) towards its application to estimating the regional carbon dioxide fluxes using data by GOSAT and OCO-2 satellites. To improve CO_2 simulation, the interhemispheric and vertical mixing rates in the transport model NIES-TM uses ERA-5 reanalysis winds, interpolated to 42 hybrid-pressure levels with a horizontal resolution of 2.5 and 3.75 degrees, and revised 3rd order upwind scheme for advection in the transport model and its adjoint. The validation of the transport model shows an improved match with the observed interhemispheric gradient of SF_6 and vertical gradient of radon. In CO_2 simulations, land biosphere fluxes are provided by the global upscaling product based on tower flux data at the spatial resolution of 0.1 degrees and temporal resolution of 10 days. Fossil emissions are provided by ODIAC, fire emissions by GFAS, and oceanic fluxes by the upscaling product based on surface ocean pCO_2 observations (Landschü tzer et al. 2015). The respiration and oceanic fluxes are scaled to match the global CO_2 growth rate. The corrections to the prior fluxes are estimated on a bi-weekly time step. With this set of prior fluxes, the model is close to reproducing the observed seasonal cycle at most global monitoring sites even before the inversion. Another problem to address is the data size. Recent space-based observations of the greenhouse gases produce a large number of data leading to a need to input into an inverse model an even larger volume of surface flux sensitivity matrixes prepared by the high-resolution Lagrangian transport model. In the revised model, storing the matrixes out of core leads to a significant reduction of memory demand, at the expense of a need to reread the data from disk on each iteration, but allowing the use of general-purpose computer systems for satellite data inversion. To test the system, inversions of 1.3 sec averaged OCO-2 (version b10) data were performed for a period of 2015-2019. The CO_2 retrieval data by GOSAT (v.02.95) and OCO-2 were compared with forward simulation driven by fluxes optimized with surface data inversion and showed a good match with model data, typically within 0.5 ppm for monthly average data over 5-degree latitudinal bands.

Landschützer, P., et al. The reinvigoration of the Southern Ocean carbon sink, Science, 349, 1221-1224, 2015.

Keywords: carbon dioxide, inverse modeling, satellite

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Observing anthropogenic emissions of greenhouse gases and air pollutants with the GOSAT-GW satellite: Scientific targets and policy contributions

*Hiroshi Tanimoto[1], Tsuneo Matsunaga[1], Nobuko Saigusa[1], Takafumi Sugita[1], Hisashi Yashiro[1], Isamu Morino[1], Makoto Saito[1], Hirofumi Ohyama[1], Kohei Ikeda[1], Yu Someya[1], Tamaki Fujinawa[1], Yousuke Yamashita[1], Tazu Saeki[1], Yugo Kanaya[2], Takashi Sekiya[2], Yasuko Kasai[3], Tomohiro Sato[3]

1. National Institute for Environmental Studies, 2. Japan Agency for Marine-Earth Science and Technology, 3. National Institute of Information and Communications Technology

Following the GOSAT satellite launched by Japan in 2009, several satellites observing greenhouse gases (GHGs) including carbon dioxide (CO_2) and methane (CH_4) were launched by the United States, Europe and China and are successfully in operation. There are several plans to launch additional GHG-observing satellites in near future. In Japan there is an ongoing plan to launch the third satellite in the GOSAT series. This mission is named “Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW)”, with an objective to observe CO_2, CH_4, and nitrogen dioxides (NO_2) with the Total Anthropogenic and Natural emissions mapping SpectrOmeter-3 (TANSO-3) sensor, providing the data at a horizontal resolution of 3 km or less. The missions of GOSAT-GW include (1) monitoring of whole atmosphere-mean concentrations of GHGs, (2) validation of nationwide anthropogenic emissions of GHGs, and (3) detection of GHGs emissions from large sources. We will brief an overview of its objectives and current status, with a focus on scientific targets and approaches, and implications for international climate change abatement strategies.

Keywords: carbon dioxide, nitrogen oxides, climate change, air pollution, methane

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.08 Zoom Room 08

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Naoto Ebuchi(Institute of Low Temperature Science, Hokkaido University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

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

[ACG36-07] Present Status of GCOM-W/AMSR2 and Outlook for GOSAT-GW/AMSR3

★Invited Papers

*Naoto Ebuchi[1,2], Misako Kachi[2], Marehito Kasahara[2], Hideyuki Fujii[2], Rigen Shimada[2], Keiichi Ohara[2], Takashi Maeda[2], Kazuya Inaoka[2], Yasushi Kojima[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.JAXA)

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

[ACG36-08] Examining possibility of cloud/rain/ice water path partitioning over land using passive microwave observations

*Rie Seto[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

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

[ACG36-09] Improvement in the GSMaP histogram matching algorithm for middle and lower level clouds

*Hitoshi Hirose[1], Tashima Tomoko[1], Takuji Kubota[1], Tomoaki Mega[2], Tomoo Ushio[2] (1.Japan Aerospace Exploration Agency, 2.Department of Engineering, Osaka University)

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

[ACG36-10] Current status of Level-2 algorithm for dual-frequency precipitation radar onboard GPM satellite

*Nobuhiro Takahashi[1], GPM International DPR L2 algorithm team - (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

[ACG36-11] Improvement of precipitation judgement by the GPM dual-frequency precipitation radar

*Kaya Kanemaru[1], Hiroshi HANADO[1], Katsuhiro Nakagawa[1] (1.National Institute of Information and Communications Technology)

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

[ACG36-12] Correction of path integrated attenuation estimates by considering soil moisture effect for the GPM Dual-frequency Precipitation Radar

★Invited Papers

*Shinta Seto[1] (1.Nagasaki University)

Present Status of GCOM-W/AMSR2 and Outlook for GOSAT-GW/AMSR3

*Naoto Ebuchi[1,2], Misako Kachi[2], Marehito Kasahara[2], Hideyuki Fujii[2], Rigen Shimada[2], Keiichi Ohara[2], Takashi Maeda[2], Kazuya Inaoka[2], Yasushi Kojima[2]

1. Institute of Low Temperature Science, Hokkaido University, 2. JAXA

The Global Change Observation Mission-Water (GCOM-W) satellite was launched by the Japan Aerospace Exploration Agency (JAXA) in May 2012. It carries the Advanced Microwave Scanning Radiometer 2 (AMSR2), which is a 7-band multi-frequency, dual-polarization microwave radiometer with a 2-m aperture antenna. JAXA provides the sea surface wind speed, vertically-integrated water vapor, cloud liquid water, precipitation, sea surface temperature (SST), sea ice concentration, snow depth, and soil moisture, as the AMSR2 standard product via the JAXA G-portal (https://gportal.jaxa.jp/gpr/). The GCOM-W/AMSR2 completed its 5-year designed mission life in May 2017 and has transferred to post-mission phase. At present, the satellite and sensor are very healthy and expected to continue the observation. Besides the 10-month gaps between AMSR-E and AMSR2, the AMSR series provide long-term global observation data for studies of the global water cycle, air-sea interactions, and polar environments.

JAXA is currently developing a follow-on mission, named AMSR3, which will be carried by the Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW). In December 2019, the GOSAT-GW/AMSR3 mission was officially approved. At present, it is expected to be launched in the Japanese Fiscal Year of 2023. AMSR3 succeeds all the frequency channels and polarization combinations of AMSR2. In addition, three high-frequency channels (165.5 GHz, 183±3 GHz and 183±7 GHz, V-pol) and 10.25-GHz channels (V- and H-pol) with improved Noise Equivalent Delta Temperature (NEDT) are added for observations of solid precipitation, humidity sounding, and high accuracy measurement of sea surface temperature. Main targets of the AMSR3 mission are producing long-term continuous data record from AMSR, AMSR-E and AMSR2 and enhancing operational utilizations of near-real time data (e.g., weather forecast including typhoon and hurricane analysis, fishery near the coasts, navigational assistance on arctic shipping route).

Keywords: AMSR series, GCOM-W, Microwave radiometer, GOSAT-GW, Global water cycle

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Examining possibility of cloud/rain/ice water path partitioning over land using passive microwave observations

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1. Tokyo Institute of Technology

For the monitoring of water and energy cycles, satellite-based cloud water estimations provide valuable information. However, most existing methods estimate cloud water with emphasis on one category of hydrometeor type. Because the features of the rainfall carried by a cloud system can vary depending on the particle type distribution within the cloud system, even with the same total water content. Thus, water contents must be estimated separately. Moreover, applying those methods to estimations over land is a widely recognized challenge. This study developed a 36.5 GHz method of estimating total liquid water path, and partitioning it into liquid cloud and rain water paths over land using the difference between horizontal and vertical polarizations at 36.5 GHz. The method was validated by satellite cloud radar products and the results show that liquid water paths over land can be estimated reasonably well using 36.5 GHz. Furthermore, based on comparison between the features of estimation results of 36.5 GHz method and 89.0 GHz method, the possibility of cloud–rain–ice partitioned estimation was assessed. Assessment results showed that the 36.5 GHz method of this study can reduce information needed for total liquid water path estimation and save high-frequency microwave observations, which indicates the possibility to partition liquid and ice water path using the difference between 36.5- and higher-frequency measurements.

Keywords: liquid cloud and rain partitioning, passive microwave observations, over land

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Improvement in the GSMaP histogram matching algorithm for middle and lower level clouds

*Hitoshi Hirose[1], Tashima Tomoko[1], Takuji Kubota[1], Tomoaki Mega[2], Tomoo Ushio[2]

1. Japan Aerospace Exploration Agency, 2. Department of Engineering, Osaka University

In Southeast Asia, where the use of ground-based rain observation is limited, there have been many attempts to utilize global satellite precipitation products for predicting the flow rate of water-related disasters. The Global Satellite Mapping of Precipitation (GSMaP; Kubota et al. 2020) combines data from microwave instruments (PMW) aboard polar-orbiting satellites and infrared (IR) radiometers aboard geostationary meteorological satellites to observe global precipitation hourly. However, the IR product are less accurate than the PMW product because they provide information only from cloud tops, and spatial heterogeneity has been reported in the precipitation estimation accuracy of GSMaP (Utsumi and Kim 2018). Therefore, we introduced a histogram matching method to correct the precipitation rate histogram of the IR product to match that of the PMW product (Hirose et al. 2021). Implementation of the histogram matching over the tropical oceans was successful in improving rain the overestimation of the IR product for upper level clouds, but not enough to improve the underestimation for middle and lower level clouds. Therefore, we used classification data of convective or stratiform rain derived from the Ku-band precipitation radar of the Global Precipitation Measurement (GPM) core satellite to classify the tropical ocean into three zones: warm-pool, subtropical subsidence zone and transition zone in between. Histogram matching was applied to each region. In addition, since the IR product tended to estimate a slightly larger precipitation area than the PMW product, the particularly weak rain sample in the IR product was excluded from the correction to eliminate the difference in precipitation area between IR and PMW products. The effect of the histogram matching will be explained in detail for each region and season.

Keywords: Satellite precipitation measurement, algorithm, Rain type classification

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Current status of Level-2 algorithm for dual-frequency precipitation radar onboard GPM satellite

*Nobuhiro Takahashi[1], GPM International DPR L2 algorithm team -

1. Institute for Space-Earth Environmental Research, Nagoya University

The Global Precipitation Measurement (GPM) core observatory was launched in February 2014. The dual-frequency precipitation radar (DPR) onboard GPM core observatory scans cross-track direction with a swath width of 245 km for Ku-band radar (KuPR) and 125 km for Ka-band radar (KaPR). The KaPR is consist of matched beam with KuPR centered nadir direction (MS) and interlaced scan with higher sensitivity (HS). The swath width of HS of KaPR has changed in June 2018 to match with outer swath of the KuPR.

The DPR product consist of three types of algorithms: single frequency (Ku only and Ka only) and dual frequency algorithms. The single frequency algorithm for KuPR is common with the Precipitation radar (PR) onboard the Tropical Rainfall Measuring Mission (TRMM) satellite product after its version 7 of PR. The level-2 algorithm consists of several modules: Preparation module (PRE), Vertical profile module (VER), Classification module (CSF), Surface reference technique module (SRT), Drop size distribution module (DSD) and Solver module (SLV). The level-2 algorithm for DPR was prepared before the launch (Version 3) and revised in March 2016 (Version 4), May 2017 (Version 5) and October 2018 (Version 6). An experimental version (Version 6X) for full swath observation by both KuPR and KaPR after the scan pattern change in June 2018 is also developed. New version (Version 7) will be released June 2021. Recent papers explaining the DPR algorithm are listed below:

Seto, S., T. Iguchi, R. Meneghini, J. Awaka, T. Kubota, T. Masaki, and N. Takahashi, 2021: The Precipitation rate retrieval algorithms for the GPM Dual-frequency Precipitation Radar. *J. Meteor. Soc. Japan*, 99.

Meneghini, R., H. Kim, L. Liao, J. Kwiatkowski, and T. Iguchi, 2021: Path attenuation estimates for the GPM Dual-Frequency Precipitation Radar (DPR). *J. Meteor. Soc. Japan*, 99.

Le, M. and V. Chandrasekar, 2021: Graupel and hail identification algorithm for the Dual-Frequency Precipitation Radar (DPR) on the GPM core satellite. *J. Meteor. Soc. Japan*, 99.

Liao, L., R. Meneghini, A. Tokay, and H. Kim, 2020: Assessment of Ku- and Ka-band Dual-frequency radar for snow retrieval. *J. Meteor. Soc. Japan*, 98, 1129-1146.

Awaka, J., M. Le, V. Chandrasekar, N. Yoshida, T. Higashiuwatoko, T. Kubota, and T. Iguchi, 2016: Rain Type Classification Algorithm Module for GPM Dual-Frequency Precipitation Radar, J. Atmos. Oceanic Technol., 33, 1887–1898.

Awaka, J. and S. Brodzik, 2019: Improvements of GPM DPR rain type classification algorithm, IGARSS 2019, 4470–4472, doi: 10.1109/IGARSS.2019.8898365

Iguchi, T., N. Kawamoto and R. Oki, 2018: Detection of intense ice precipitation with GPM/DPR. J. Atmos. Oceanic Technol., 35, 491–502, DOI: 10.1175/JTECH-D-17- 0120.1.

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Kubota, T., T.Iguchi, M. Kojima, L. Liao, T Masaki, H. Hanado, R. Meneghini, R. Oki, 2016: A statistical method for reducing sidelobe clutter for the Ku-band precipitation radar onboard the GPM Core Observatory, J. Atmos. Oceanic Technol., 33 (7), 1413-1428.

Kubota, T., T. Iguchi, T. Masaki, N. Yoshida, and R. Oki, 2018: Development of a statistical method for reducing sidelobe clutter in high sensitivity mode of GPM/KaPR, Proc. IGARSS2018, 8347-8348.

Kubota, T., S. Seto, M. Satoh, T. Nasuno, T. Iguchi, T. Masaki, J. M. Kwiatkowski, and R. Oki, 2020: Cloud assumption of Precipitation Retrieval Algorithms for the Dual-frequency Precipitation Radar, J. Atmos. Oceanic Technol.. *37*(11), 2015-2031

Keywords: Precipitation, Satellite

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Improvement of precipitation judgement by the GPM dual-frequency precipitation radar

*Kaya Kanemaru[1], Hiroshi HANADO[1], Katsuhiro Nakagawa[1]

1. National Institute of Information and Communications Technology

The Dual-Frequency Precipitation Radar (DPR) onboard the Global Precipitation Measurement (GPM) mission's core satellite measures the 3-D structure of global precipitation within latitudinal coverage (65S to 65N). The GPM DPR can detect light rainfall of about 15 dBZ. However, the sensitivity of the DPR is not enough to measure high-latitude snowfall smaller than 15 dBZ that occupies the majority of both frequent and amount. Although it is difficult to improve the DPR's sensitivity because the sensitivity is directly constrained by the designed radar performance, a possible improvement of the precipitation detection is expected with data processing. The precipitation judgement in the DPR's standard algorithm employs detection of successive certain signal in vertical direction (1D judgement) so that thin precipitation layer cannot be detected even if the precipitation echoes are higher than 15 dBZ. Since the top height of high-latitudes precipitation is not taller than that of tropical precipitation, the detection of thin precipitation layer is required to improve detection of high-latitude snowfall. The current study aims to improve the precipitation judgement by using 3-D information of precipitation signals.

In this study, we count up the successive signals higher than the certain level not only in the vertical direction but also the cross-track and along-track directions. The standard algorithm (1D judgement) detects as precipitation when the successive count in the vertical direction is greater than 5. Moreover, the proposed method (3D judgement) also detects precipitation when the successive count in the 3D direction is greater than 10 even if the successive vertical count is smaller than 5. This additional condition enables the improvement of precipitation detection for thin precipitation layer such as low-level storms and the edge of precipitating clouds.

The DPR (Ku-band channel) data in 2020 March were processed with the 3D judgement to quantify the improvement of precipitation detection. Analyzing the precipitation frequency using near-nadir angles data, the 3D judgment increased the precipitation detection by 20% relative to the original 1D judgement. Over high-latitude regions, about 60% increase was obtained because the detection of the low-level storms was effectively improved. Note that a change in precipitation amount due to the increase in the precipitation detection were limited.

Keywords: Precipitation, Spaceborne radar, Algorithm

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Correction of path integrated attenuation estimates by considering soil moisture effect for the GPM Dual-frequency Precipitation Radar

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1. Nagasaki University

Spaceborne precipitation radars, the Tropical Rainfall Measuring Mission's Precipitation Radar (PR; 13.8GHz) and the Global Precipitation Measurement mission's Dual-frequency Precipitation Radar (DPR), continue measurements for more than 23 years. They can measure not only precipitation echoes but surface echoes, the latter of which are used to estimate path integrated attenuation (PIA) in surface reference technique (SRT; Meneghini et al. 2004; 2021).

Seto and Iguchi (2007) analyzed the measurements by PR, and found that attenuation-free surface backscattering cross section (denoted by σ^0_e) becomes higher during precipitation over land. This can be considered as a result of an increase in surface soil moisture, then it is called soil moisture effect. SRT may underestimate PIA if it does not consider this effect. In the PR standard algorithm (Iguchi et al. 2009), a constant offset of 0.5 dB is given to the PIA estimates by SRT (denoted by PIA_{SRT}) for the precipitation rate retrieval over land.

In this study, the measurements by KuPR (13.6GHz) and KaPR (35.5GHz) radars, which compose the DPR, are analyzed to examine if KuPR and KaPR show soil moisture effect as well as PR. Based on the analysis, a method to correct for PIA_{SRT} is developed and is implemented in the DPR standard algorithm (version 06A; Seto et al. 2021). The effect of the PIA_{SRT} correction on the precipitation rate estimates is introduced.

The average of measured surface backscattering cross section at no-rain pixels is calculated for each 1 degree by 1 degree grid, month, and angle bin (the value is denoted by σ^0_{NR}). At rain pixels, measured surface backscattering cross section (denoted by σ^0_m) is investigated. The anomaly of σ^0_m from the σ^0_{NR} is denoted by $\Delta\sigma^0_m$. Figure shows the relation between the average of $\Delta\sigma^0_m$ and the surface precipitation rate estimated by KuPR (denoted by R) at the grid (100-95W, 30-35N) and for angle bin numbers 21-29. R (mm/h) is classified into 9 categories; Category 1 is for $R < 0.5$, Category k is for $2^{k-3} < R < 2^{k-2}$ ($k = 2 \cdots 8$), and category 9 is for $R > 64$. For KuPR, $\Delta\sigma^0_m$ increases with R up to category 4, and is higher than 0 up to category 5, though σ^0_m is subject to precipitation attenuation. This suggests the existence of soil moisture effect in KuPR. The anomaly of σ^0_e from σ^0_{NR} (denoted by $\Delta\sigma^0_e$) should be higher than $\Delta\sigma^0_m$. PIA estimated by Hitschfeld-Bordan method (PIA_{HB}), which is independent of SRT, is used to estimate $\Delta\sigma^0_e$ as $\Delta\sigma^0_m + PIA_{HB}$. $\Delta\sigma^0_m + PIA_{HB}$ increases with R up to category 5, and is higher than 0 for categories 7 and lower. PIA_{HB} is consider to be underestimated for heavy precipitation. On the other hand, $\Delta\sigma^0_m + PIA_{SRT}$ is not clearly dependent on R and is slightly higher than 0. $\Delta\sigma^0_m + PIA_{SRT}$ is lower than $\Delta\sigma^0_m$ for categories 5 and lower and is lower than $\Delta\sigma^0_m + PIA_{HB}$ for categories 7 and lower. This reveals the necessity for the correction of PIA_{SRT}.

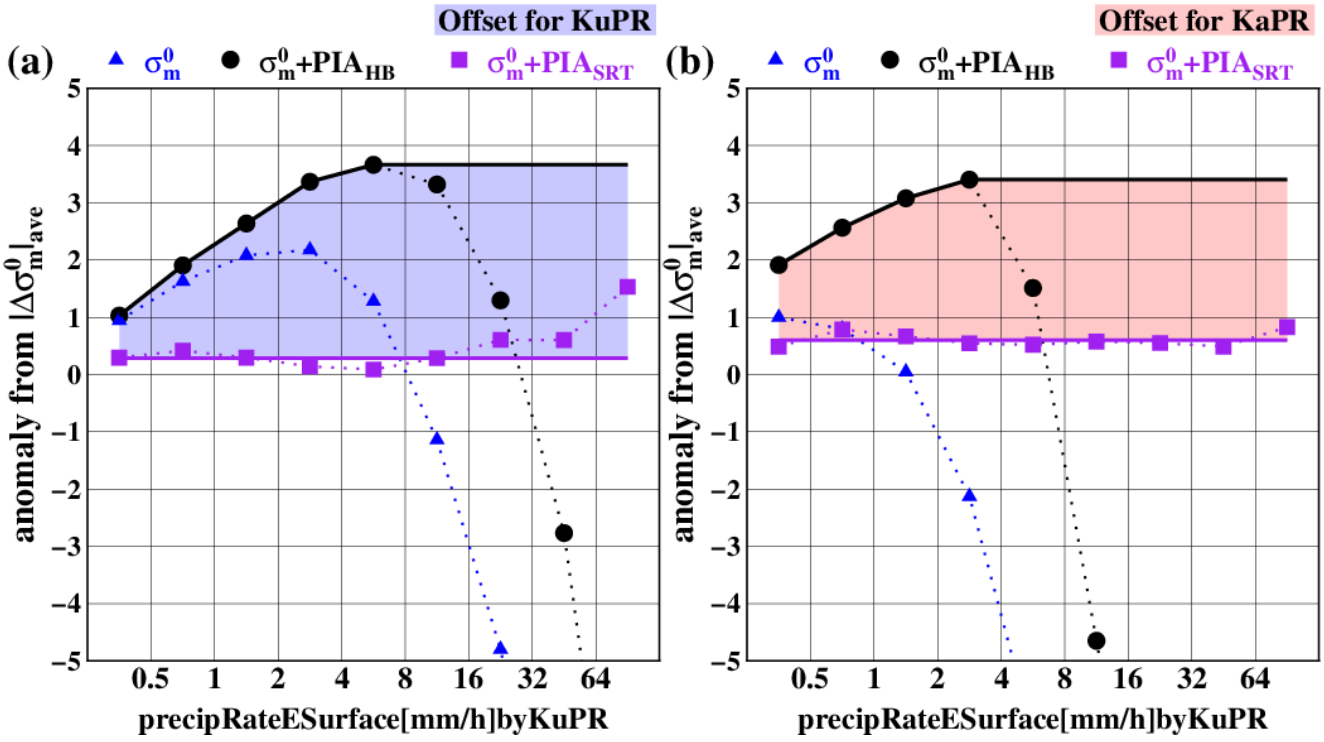
The offset can be regarded as $\Delta\sigma^0_m + PIA_{HB} - (\Delta\sigma^0_m + PIA_{SRT})$. However, as PIA_{HB} is likely to be underestimated for heavy precipitation, the maximum value of $\Delta\sigma^0_m + PIA_{HB}$ among 9 categories is searched. In this case for KuPR, it is found at category 5, then the maximum value replaces $\Delta\sigma^0_m + PIA_{HB}$ for categories 6 and higher (as shown by black solid line in the figure). Also as $\Delta\sigma^0_m + PIA_{SRT}$ does not show clear dependence on R, the value is averaged regardless of R and the average value replaces $\Delta\sigma^0_m + PIA_{SRT}$ (as shown by purple solid line). So as shown in the figure, the difference between the black solid

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line and purple solid line becomes offset value. If the value is negative, it is replaced by 0.

In the single-frequency algorithms of DPR, the retrieval processes are iterated twice. In the first loop, no offset is given to PIA_{SRT} and *R* is estimated. In the second loop, the offset is determined by *R*, then PIA_{SRT} is corrected and *R* is finally estimated. This correction is implemented into the DPR standard algorithms version 06A, and is tested for June 2016. In KuPR (inner swath only), the unconditional average of surface precipitation rate for over land is 2.55 mm/day with a 18.3% increase from 2.16 mm/day in the original product. In KaPR, the average of surface precipitation rate for over land increases by 15.1 % from 1.35 mm/day to 1.55 mm/day. The offset value is not very different between for KuPR and for KaPR. The same change of PIA leads to larger change in *R* for KuPR than for KaPR, but SRT is less reliable for KuPR and the change of PIA_{SRT} does not affect the final estimates of PIA and *R*. Then, the change ratio of *R* of KaPR is slightly lower than that for KuPR.

Keywords: precipitation radar, attenuation correction, soil moisture



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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.08 Zoom Room 08

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Kozo OKAMOTO(Meteorological Research Institute), Takemasa Miyoshi(RIKEN)

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

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

[ACG36-13] Statistical analysis of precipitation system characteristics observed by GPM/DPR over high-latitude land

*Atsushi Hamada[1], Rei Kawabata[1], Kazuaki Yasunaga[1] (1.University of Toyama)

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

[ACG36-14] Enhancement of Integrated Satellite Simulators for Data Assimilation

*Yasutaka Ikuta[1] (1.Japan Meteorological Agency/Meteorological Research Institute)

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

[ACG36-15] Addition of microwave humidity sounder radiance data to all-sky assimilation in the JMA global NWP system

*Hiroyuki Shimizu[1], Masahiro Kazumori[1], Hidehiko Murata[1] (1.Japan Meteorological Agency)

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

[ACG36-16] Improving Precipitation Prediction by Data Assimilation of GPM and Other Satellite Observations

*Takemasa Miyoshi[1], Shunji Kotsuki[2,1], Koji Terasaki[1], Shigenori Otsuka[1], Ting-Chi Wu[1], Hirofumi Tomita[1], Ying-Wen Chen[3], Kaya Kanemaru[4], Masaki Satoh[3], Hisashi Yashiro[5], Keiichi Kondo[6], Kozo OKAMOTO[6], Eugenia Kalnay[7], Takuji Kubota[8] (1.RIKEN, 2.Chiba University, 3.University of Tokyo, 4.NICT, 5.NIES, 6.Meteorological Research Institute, 7.University of Maryland, 8.JAXA)

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

[ACG36-17] Ensemble-Based Data Assimilation of GPM DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

★Invited Papers

*Shunji Kotsuki[1,2], Koji Terasaki[2], Masaki Satoh[3], Takemasa Miyoshi[2] (1.Center for Environmental Remote Sensing, Chiba University, 2.RIKEN Center for Computational Science, 3.Atmosphere and Ocean Research Institute, The University of Toky)

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

[ACG36-18] Recent progress in impact assessment of hyperspectral sounder for a Himawari follow-on satellite

*Kozo OKAMOTO[1], Hiromi OWADA[2], Tadashi Fujita[1], Masahiro Hayashi[1], Kotaro Bessho[2]
(1.Meteorological Research Institute, 2.Japan Meteorological Agency)

Statistical analysis of precipitation system characteristics observed by GPM/DPR over high-latitude land

*Atsushi Hamada[1], Rei Kawabata[1], Kazuaki Yasunaga[1]

1. University of Toyama

A statistical analysis of precipitation system characteristics is conducted, using three-dimensional precipitation measurements by the dual-frequency precipitation radar (DPR) onboard the Global Precipitation Measurement (GPM) core observatory. The main focus of this study is to find a globally uniform method that efficiently describe the difference in the precipitation characteristics for different types of precipitation systems, and efficiently classify them.

We use the 2AKu version 06A product of GPM/DPR. The analysis period is July and January 2015-2020 for Northern and Southern Hemispheres, respectively, corresponding to the summertime of each hemispheres. The analysis domain is 65S-65N, and we especially focus on two land regions over 45N-65N and 20S-0S to compare the precipitation characteristics between the high-latitudes and tropics. Meso-scale boxes with 20 and 21 pixels (~100 km x 100 km) in along-track and cross-track direction, respectively, are set in the DPR swath, and several statistics for precipitation characteristics are calculated: Area, total precipitation, mean precipitation-top height, and so on.

Among many possible combinations of these statistics, we found that two statistics, stratiform area ratio (SAR) and stratiform precipitation efficiency (SPE), are efficiently describe the difference among the observed precipitation systems. The SAR is defined as the ratio of stratiform precipitation area to the total precipitation area in the box. The SPE is defined as the ratio of mean stratiform precipitation rate to the sum of it and mean convective precipitation rate. While organized precipitation systems such as squall-lines tend to have broad range of SAR but low SPE, precipitation systems partially related to extratropical cyclones tend to have high values of both SAR and SPE. Such difference in SPE between the two system types probably reflects the difference in precipitation production processes.

Precipitation systems can be classified into four categories by setting globally constant thresholds for SAR and SPE. Geographical distributions of dominant precipitation categories classified by the SAR-SPE plane clearly illustrates regional precipitation characteristics.

Keywords: precipitation system, spaceborne radar, Global Precipitation Measurement (GPM)

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Enhancement of Integrated Satellite Simulators for Data Assimilation

*Yasutaka Ikuta[1]

1. Japan Meteorological Agency/Meteorological Research Institute

In order to data assimilate the GPM/DPR, it is necessary to simulate the KuPR and KaPR from the results of the forecast model and compare them with the observation. The accuracy of the DPR simulation is directly related to the accuracy of data assimilation. To improve the accuracy of data assimilation, we enhanced the Integrated Satellite Simulators (I-Simulator). The I-Simulator is based on the radar simulator used for DPR data assimilation in the Meso-scale Analysis at JMA. In addition, it can also simulate microwaves using RTTOV-SCATT, and it is also possible to simulate ground-based radar.

In this study, the DPR is simulated using the predictions of the Meso-Scale Model at JMA. The hydrometeors of targets to simulate are cloud water, rain, cloud ice, snow, and graupel. The particles of snow and cloud ice are assumed to be non-spherical particles. The attenuation by the hydrometeors is taken into account in the calculation of the reflectivity. The observation error characteristics are discussed by comparing the simulation and the observation. We will show not only the observation error characteristics of KuPR and KaPR, but also the error characteristics of DFRm, which includes the outer swath KaPR in DPR-L2 V06X. The effects of DPR data assimilation expected from the Jacobian of the observation operator will be shown in the presentation.

Keywords: GPM, DPR, Data assimilation

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Addition of microwave humidity sounder radiance data to all-sky assimilation in the JMA global NWP system

*Hiroyuki Shimizu[1], Masahiro Kazumori[1], Hidehiko Murata[1]

1. Japan Meteorological Agency

Microwave radiance data from space-based observation contain a variety of information on geophysical parameters relating to the atmosphere and the earth's surface (e.g., atmospheric temperature and water vapor profiles, cloud, precipitation, surface wind and surface temperature). In this context, microwave radiance over ocean areas in clear-sky conditions has been assimilated in JMA's global numerical weather prediction (NWP) system. By properly considering microwave radiance data relating to cloud and precipitation, assimilation of all-sky (including clear-sky, cloud and precipitation) microwave radiance contributes to better forecasting of atmospheric phenomena associated with severe weather conditions. JMA developed an all-sky microwave radiance assimilation scheme for microwave imagers and microwave humidity sounders. It was introduced into JMA's operational global NWP system in December 2019. Currently, the all-sky assimilation scheme is applied to several microwave humidity sounders (GMI/GPM, MHS/NOAA-19, Metop-A, -B) and microwave imagers (AMSR2/GCOM-W, GMI/GPM, SSMIS/DMSP F-17, F-18, WindSat/Coriolis, MWRI/FY-3C).

To apply the all-sky microwave assimilation scheme to the other microwave humidity sounders (e.g., ATMS/Suomi-NPP, NOAA-20, SSMIS/DMSP F-17, F18, SAPHIR/Megha-Tropiques, MWHS-2/FY-3C), several evaluations of the data quality and data assimilation experiments were carried out. The results showed better fit of first guess to radiosonde observations and clear-sky infrared radiance observations. The details of the experiment results are presented in the conference.

Keywords: Microwave, Data assimilation

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Improving Precipitation Prediction by Data Assimilation of GPM and Other Satellite Observations

*Takemasa Miyoshi[1], Shunji Kotsuki[2,1], Koji Terasaki[1], Shigenori Otsuka[1], Ting-Chi Wu[1], Hirofumi Tomita[1], Ying-Wen Chen[3], Kaya Kanemaru[4], Masaki Satoh[3], Hisashi Yashiro[5], Keiichi Kondo[6], Kozo OKAMOTO[6], Eugenia Kalnay[7], Takuji Kubota[8]

1. RIKEN, 2. Chiba University, 3. University of Tokyo, 4. NICT, 5. NIES, 6. Meteorological Research Institute, 7. University of Maryland, 8. JAXA

This presentation summarizes the recent progress of the project started in 2013 to explore data assimilation methods for GPM and other satellite observations. The details of the project are described in the latter part of this abstract. The achievements are highlighted by successful data assimilation of GPM DPR reflectivity and a new development of an efficient data-driven (DD) method for a satellite simulator a.k.a. an observation operator in data assimilation. By assimilating DPR reflectivity, we estimated a model microphysics parameter corresponding to snowfall terminal velocity and successfully reduced the gap between the model-produced and observed CFAD (Contoured Frequency by Altitude Diagram). The results showed improvements in radiation budgets (OSR and OLR biases) and overall numerical weather prediction skill. As for the DD method for a satellite simulator, we developed a new approach using neural networks to simulate satellite microwave radiances without a need for a bias correction treatment. We applied machine leaning with model forecast data and corresponding actual satellite observations and built a bias aware simulator for satellite radiances. The results showed that the satellite simulator worked properly although slightly worse than the case with a radiative transfer model and bias correction. The early results are encouraging since we do not need a bias correction method to build a generally complex system to assimilate satellite radiance data.

In precipitation science, satellite data have been providing precious, fundamental information, while numerical models have been playing an equally important role. Data assimilation integrates the numerical models and real-world data and brings synergy. We have been working on assimilating the GPM data into the Nonhydrostatic ICosahedral Atmospheric Model (NICAM) using the Local Ensemble Transform Kalman Filter (LETKF). We continue our effort on “Enhancing Precipitation Prediction Algorithm by Data Assimilation of GPM Observations” funded by JAXA, following successful completion of the 3-year project titled “Enhancing Data Assimilation of GPM Observations” from April 2016 to March 2019. The project first started in April 2013 on “Ensemble-based Data Assimilation of TRMM/GPM Precipitation Measurements”, where we developed a global data assimilation system NICAM-LETKF from scratch. This presentation highlights the most recent achievements.

Keywords: Numerical Weather Prediction, Data Assimilation, Satellite Observation, GPM, DPR, PMM

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Ensemble-Based Data Assimilation of GPM DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

*Shunji Kotsuki[1,2], Koji Terasaki[2], Masaki Satoh[3], Takemasa Miyoshi[2]

1. Center for Environmental Remote Sensing, Chiba University, 2. RIKEN Center for Computational Science, 3. Atmosphere and Ocean Research Institute, The University of Toky

This study aims to improve the precipitation forecasts from numerical weather prediction models through effective assimilation of satellite-observed precipitation data. The assimilation of precipitation data is known to be difficult mainly due to highly non-Gaussian statistics of precipitation-related variables. We have been developing a global atmospheric data assimilation system NICAM-LETKF, which comprises the Nonhydrostatic ICosahedral Atmospheric Model (NICAM) and Local Ensemble Transform Kalman Filter (LETKF). Using the NICAM-LETKF system, Kotsuki et al. (2017, JGR) successfully improved the weather forecasts by assimilating the Japan Aerospace eXploration Agency (JAXA)’ s Global Satellite Mapping of Precipitation (GSMaP) data into the NICAM at 112-km horizontal resolution. However, assimilating space-borne precipitation radar data remains to be a challenging issue.

This study pioneers to assimilate radar reflectivity measured by the Dual-frequency Precipitation Radar (DPR) onboard the Global Precipitation Measurement (GPM) core satellite into the NICAM. We conduct the NICAM-LETKF experiments at 28-km horizontal resolution with explicit cloud microphysics of a single-moment 6-class bulk microphysics scheme. To simulate GPM DPR reflectivity from NICAM model outputs, the Joint-Simulator (Hashino et al. 2013; JGR) is used. Our initial tests showed a better match with the observed reflectivity by assimilating GPM DPR reflectivity into NICAM forecasts. However, the results from a 1-month data assimilation cycle experiment showed general degradation by assimilating GPM DPR reflectivity. For better use of GPM DPR reflectivity data, we estimated a model cloud physics parameter corresponding to snowfall terminal velocity by data assimilation. Parameter estimation reduced the snowfall terminal velocity, and successfully mitigated the gap between simulated and observed Contoured Frequency by Altitude Diagram (CFAD). The estimated parameter also improved temperature and humidity fields in the mid- to lower troposphere, and precipitation forecasts.

Keywords: Precipitation, GPM DPR, Data Assimilation, NICAM-LETKF, Parameter Estimation

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Recent progress in impact assessment of hyperspectral sounder for a Himawari follow-on satellite

*Kozo OKAMOTO[1], Hiromi OWADA[2], Tadashi Fujita[1], Masahiro Hayashi[1], Kotaro Bessho[2]

1. Meteorological Research Institute, 2. Japan Meteorological Agency

Potential impacts on numerical weather prediction of a hyperspectral infrared sounder (HSS) on Himawari-8/-9 follow-on geostationary satellite (GeoHSS) have been investigated using an observing system simulation experiment (OSSE) approach. Hypothetical GeoHSS observations were simulated by using the fifth generation of European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis (ERA5) and assimilated in global and regional data assimilation systems of the Japan Meteorological Agency (JMA). The global data assimilation experiments showed that assimilation of hourly clear-sky radiances of GeoHSS improved the prediction of large-scale atmospheric field and typhoon track. The assimilation of three hourly GeoHSS synthetic observations still demonstrated improvements although with smaller magnitude. Assimilation of temperature and humidity profiles in the reginal data assimilation system resulted in better prediction of moisture flow and then large-scale heavy rain. However, some experiments revealed that GeoHSS did not improve a localized convective rain system, suggesting the necessity of further development of data assimilation system and forecast model. We also developed a one-dimensional variational (1D-Var) scheme to derive temperature and humidity profiles from GeoHSS radiances. The profileswill be used for nowcasting and more realistic impact assessment in the regional data assimilation for GeoHSS.

Keywords: satellite data assimilation, Himawari follow-on program, Hyperspectral infrared sounder, Observing System Simulation Experiment (OSSE)

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.06_3

[A-CG36] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies)

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

[ACG36-P01] Evaluation of GCOM-C/SGLI L2 aerosol products: aerosol over the ocean, land aerosol by near-ultraviolet

*Tomoko Koyama[1], Kazuhisa Tanada[1], Hiroshi Murakami[1], Mayumi Yoshida[2] (1.JAXA, 2.RESTEC)

[ACG36-P02] The field campaign of DRAGON/J-ALPS in the mountain area of Japan for validation of satellite data

*Makiko Nakata[1], Itaru Sano[1], Sonoyo Mukai[2] (1.Kindai University, 2.The Kyoto College of Graduate Studies for Informatics)

[ACG36-P03] Advantages of GCOM-C/SGLI for characterization of biomass burning aerosols

*Makiko Nakata[1], Itaru Sano[1], Sonoyo Mukai[2] (1.Kindai University, 2.The Kyoto College of Graduate Studies for Informatics)

[ACG36-P04] Retrieval of aerosol properties from GOSAT-2/TANSO-CAI-2 and comparison with ground-based observations

*Makiko Hashimoto[1], Hideaki Takenaka[2], Chong Shi[3], Teruyuki Nakajima[3] (1.Japan Aerospace Explortion Agency, 2.Chiba University, 3. National Institute for Environmental Studies)

[ACG36-P05] Remote sensing of three-dimensional clouds from multispectral measurements using deep learning

*Hana Kato[1], Hironobu Iwabuchi[1] (1.Center for Atmospheric and Oceanic Studies, Graduate School of Science, Tohoku University)

[ACG36-P06] Long Term Analysis of TPW (total precipitable water vapor) product

*Ohara Keiichi[1], Takuji Kubota[1], Misako Kachi[1], Masahiro Kazumori[2] (1.Japan Aerosrpace Exploration Agency, 2.Japan Meteorological Agency)

[ACG36-P07] Evaluation of Himawari estimated precipitation product compared with GSMaP and JMA radar analysis

*Koichi Toyoshima[1], Hitoshi Hirose[2], Atsushi Higuchi[1] (1.Center for Environmental Remote Sensing, Chiba University, 2.Japan Aerospace Exploration Agency)

[ACG36-P08] Heavy orographic rainfall in Taiwan missed by the GPM Dual-Frequency Precipitation Radar (DPR) algorithm

*Riku Shimizu[1], Shoichi Shige[1], Toshio Iguchi[2], Cheng Ku Yu[3] (1.Graduate School of Science, Kyoto University, 2.University of Maryland, ESSIC, 3.National Taiwan University)

[ACG36-P09] Comparative analysis of the GSMaP and quantitative precipitation estimation based on surface observation by radars and gauges in heavy rainfall events over Vietnam

*Masato I. Nodzu[1], Jun Matsumoto[1,2], Hoa Khanh Thi Bui[3], Thanh-Hoa Pham-Thi[1], Thanh Ngo-Duc[4], Thu Nguyen-Vinh[3] (1.Tokyo Metropolitan University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Viet Nam Meteorological and Hydrological Administration, 4.University of Science and Technology of Hanoi, Vietnam Academy of Science and Technology)

[ACG36-P10] Improvement of cloud mask algorithm of CALIPSO lidar

*Eiji Oikawa[1], Hajime Okamoto[1], Kaori Sato[1] (1.Research Institute for Applied Mechanics, Kyushu University)

[ACG36-P11] Simultaneous retrieval of aerosols and ocean color parameters using GCOM-C/SGLI data

*Miho Sekiguchi[1], Makiko Hashimoto[2], Hideaki Takenaka[3], Chong Shi[4], Teruyuki Nakajima[4] (1.Tokyo University of Marine Science and Technology, 2.Japan Aerospace Exploration Agency/Earth Observation Research Center, 3.Chiba University, 4.National Institute for Environmental Studies)

[ACG36-P12] Verification of satellite-observed surface temperature in water areas and application to meteorological simulations

*Kanato Mano[1], Shozo Yamane[1] (1.Department of Environmental Systems Science, Doshisha University)

[ACG36-P13] Sampling simulation of spaceborne precipitation radar

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

[ACG36-P14] Comparative analysis between precipitation measurement by a satellite and meteorological observation by a high density ground surface observation network

*Hisato Iwashita[1] (1.Meisei Electric Co.,Ltd)

[ACG36-P15] **Comparison between random forest and multiple linear regression algorithms for digital soil mapping in the Thung Kula Ronghai region, Thailand**

*Sasirin Srisomkiew[1,2], Masayuki Kawahigashi[1], Pitayakon Limtong[2] (1.Department of Geography, Tokyo Metropolitan University, Tokyo 192-0397, Japan , 2.Land Development Department, Ministry of Agriculture and Cooperatives, Bangkok 10900, Thailand)

[ACG36-P16] Wildfire watch using SWIR data from SGLI/GCOM-C

*Yukio Kurihara[1], Hiroshi Murakami[1] (1.Japan Aerospace Exploration Agency / Earth Observation Research Center)

[ACG36-P17] Evolution of Global Satellite Mapping of Precipitation (GSMaP) Product version 05

*Takuji Kubota[1], Kazumasa Aonashi[1], Tomoo Ushio[2], Shoichi Shige[3], Tomoko Tashima[1], Munehisa Yamamoto[4], Moeka Yamaji[1], Hitoshi Hirose[1], Tomoaki Mega[2], Atsushi Hamada[5], Yukari Takayabu[6] (1.Earth Observation Research Center,Japan Aerospace Exploration Agency, 2.Osaka Unviersity, 3.Kyoto University, 4.RESTEC, 5.Toyama University, 6.University of Tokyo)

[ACG36-P18] Soil Moisture and Plant Water Content estimate in Pilot areas of the Mediterranean basin through multitemporal analysis of AMSR-E/2 images

*Giuliano Ramat[1], Fabrizio Baroni[1], Emanuele Santi[1], Simonetta Paloscia[1], Simone Pettinato[1] (1.CNR-IFAC, Earth Observation, Florence, Italy)

[ACG36-P19] GOSAT calibration activities and observation plans for advanced GHG measurements

*Kei Shiomi[1], Akihiko Kuze[1], Hiroshi Suto[1], Nobuhiro Kikuchi[1], Fumie Kataoka[2] (1.Japan Aerospace Exploration Agency, 2.Remote Sensing Technology Center of Japan)

[ACG36-P20] How can SAR small-satellite constellation potentially monitor flood area?

*Rie Seto[1], Natsumi Kitajima[1], Dai Yamazaki[2], Xudong Zhou[2], Wenchao MA[2], Shinjiro Kanae[1] (1.Tokyo Institute of Technology, 2.The University of Tokyo)

Evaluation of GCOM-C/SGLI L2 aerosol products: aerosol over the ocean, land aerosol by near-ultraviolet

*Tomoko Koyama[1], Kazuhisa Tanada[1], Hiroshi Murakami[1], Mayumi Yoshida[2]

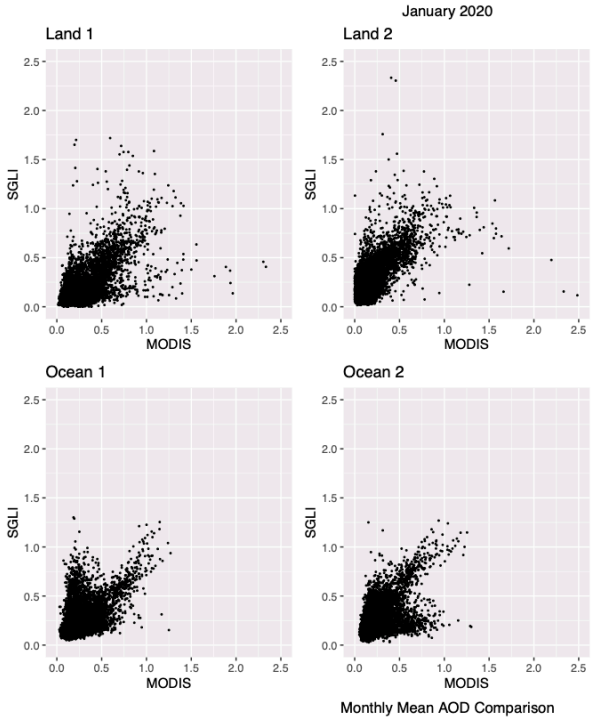
1. JAXA, 2. RESTEC

Atmospheric aerosol significantly impacts the Earth in multiple ways, such as its radiative effect, climate processes, chemical reactions, and air pollution. While Aerosol Optical Depth (AOD) shows how much aerosols prevent light transmission in the atmosphere, the retrievals from Second-generation Global Imager (SGLI) observations are available among other Atmospheric data products. SGLI is a payload sensor onboard the Global Change Observation Mission Climate (GCOM-C) satellite for monitoring global climate change.

JAXA disseminates three types of SGLI Level 2 (L2) aerosol products: aerosol over the ocean, land aerosol by near-ultraviolet, and aerosol by polarization. We evaluated the first two products, retrieved with the second version algorithm released in June 2020, over different regions in this research. Conventional statistical parameters, such as the linear correlation coefficient, root mean square error, and mean bias error, are calculated. The error of estimation, given by the Moderate Resolution Imaging Spectroradiometer (MODIS) science team through their validations, is utilized, too. The biases with respect to ground truth measurements are analyzed as functions of the truth and retrievals. These diagnostic and prognostic error dependencies can be useful for the algorithm developers and users. We also perform comparisons with MODIS AODs, which have been produced over two decades. The results can be utilized to advance aerosol retrieval algorithms and to support the interpretation of the SGLI L2 AODs.

Keywords: GCOM-C, SGLI, aerosol, remote sensing

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	mbe	cor.	rmse	ee
Land 1	0.08	0.63	0.19	0.45
Land 2	0.11	0.62	0.21	0.38
Land 3	0.12	0.71	0.20	0.37
Ocean 1	0.01	0.61	0.10	0.77
Ocean 2	0.01	0.61	0.10	0.77

MODIS AOD algorithms

1. "Dark Target"
2. DT/DB merged
3. "Dark Blue"

Evaluation Matrices

- *Mean Bias Error*
- *Correlation Coefficient*
- *Root Mean Square Error*
- *Error of Estimation*

$EE = \pm(0.05 + 20\%\, AOD)$
within $AOD_{MODIS} \pm|EE|$

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The field campaign of DRAGON/J-ALPS in the mountain area of Japan for validation of satellite data

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NASA/AERONET (Aerosol Robotics Network) field campaign named DRAGON/J-ALPS (Distributed Regional Aerosol Gridded Observation Networks/Joint work to the AerosoL Properties and process Simulations) have been carried out since the spring of 2020 in mainly Nagano prefecture. One of the objectives of the campaign is understanding the spatial distribution of aerosol properties both horizontally and vertically in the mountainous environments. A dense sun photometer network help us understand the spatial distribution both horizontally and vertically to be able to assess the limits of satellite and model retrievals of aerosol properties, especially under varying conditions that would be encountered in mountainous environments. It is of interest to mention that the Japanese missions GCOM-C is equipped with high resolution sensors as SGLI.

The effect of topography on aerosol concentration in the atmosphere motivated our ground observations. In addition to AERONET sun photometer network, we conducted ground observations using portable sun photometers, a $PM_{2.5}$ measuring instrument, and a ceilometer in the Ina basin, which is surrounded by high mountains in March 2020. The Microtops-2 portable sun photometer is easy to carry and adds mobility to our observations. These Microtops-2 photometers were calibrated with a standard AERONET-Cimel radiometer. The P-Sensor $PM_{2.5}$ measuring instrument operates via the light scattering method and is developed by the Nagoya University and Panasonic Corporation. This instrument is small enough to be portable. Additionally, we used the compact and lightweight Vaisala ceilometer CL31, which can be used for detection of cloud-base height and vertical visibility measurements.

The values of aerosol optical depth (AOD) at J-ALPS sites tend to be lower than the values of AOD at AERONET site on the Sea of Japan and the $PM_{2.5}$ concentration levels around J-ALPS sites are usually not too high. It is one of the possible reason that aerosol advection may had been blocked by the high mountains. However, there are days when the concentration becomes high. The morning of March 19, 2020 showed higher than usual concentrations of $PM_{2.5}$. Also, The Microtops-2 instrument detected a high AOD. These features were consistent with the ceilometer measurements. Notably, the ceilometer also measured the vertical distribution of the atmospheric aerosols. One of the factors is the contribution of local sources. On the time when the concentration was high, visual observation confirmed very high emission from a factory near the observation site. The meteorological conditions are another factor that increases the concentration. On the high concentration day, when the boundary layer squeezes, the atmospheric environment tends to stabilize, which is conducive to the formation of aerosol.
The Japanese satellite GCOM-C was launched on December 23, 2017 and mounted with only the SGLI multispectral sensor, which contains 19 channels encompassing near-UV (380 nm) and violet (412 nm) wavelengths, and two polarization channels PL1 and PL2 in red (674 nm) and near-IR (869 nm) wavelengths. The instantaneous field-of-view (IFOV) of the SGLI is extremely fine, i.e., 250 m from near UV to short IR wavelength range, and 1km for polarization measurements. It is worth noting that fine resolution images from SGLI are available to validate the ground-based measurements, and vice versa. This work reports on the field campaign and comparison of observed AOD and satellite derived AOD.

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Advantages of GCOM-C/SGLI for characterization of biomass burning aerosols

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The wild fires has increased owing to global warming and climate change, thereby large-scale forest fires have occurred worldwide since 2019. The 5th IPCC report mentions the warming effect of black carbon aerosols as opposed to the cooling effect of other aerosol types (https://www.ipcc.ch/report/ar5/wg1/). Accurate detection of aerosol types has become critical for understanding global climate problems. Carbonaceous aerosols such as smoke, soot, and black/brown carbon should be rigorously defined though, the carbonaceous aerosols generated by wild fires are collectively referred to as biomass burning aerosols (BBAs) hereinafter.
The Japanese mission JAXA/GCOM (Global Change Observation Mission-Climate)-C (SHIKISAI in Japanese) launched in 2017 loads only the second generation global imager. The SGLI (Second generation GLobal Imager) is a multispectral sensor including near-UV and two polarization channels. It contains 19 channels from near-UV to thermal IR, including red (674 nm named PL1 band) and near-IR (869 nm; PL2 band) polarization channels. This study demonstrates the advantages of the SGLI feature in the detection and characterization of BBAs in wildfire events. It has been shown previously that the ratio of near-UV data at 412 to that at 380 nm, named absorption aerosol index (AAI), revealed absorbing aerosols such as BBAs or dust. Figure 1 presents the AAI distribution from SGLI measurements over Kalimantan, Indonesia on Sept.15, 2019, when severe wild fires have happened. The values of AAI greater equal 0.83 indicates BBA type aerosols.
Furthermore, in order to demonstrate such advantage of SGLI that has observation channels in the short wavelength, color composite images are shown in Figure 2. The left image is compiled from JMA/Himawari-8/AHI observations in terms of usual (R, G, B) channels, and the right from SGLI data using shorter (443, 412, 380nm) channels for three primary color than usual. It is clear that the dark yellow color spreading in the center of the figure clearly visualizes the smoke due to biomass burning events according that three primary colors are shifted to shorter wavelengths than usual.
Polarization measurements by SGLI is useful for retrieval of BBAs. Figure 3 provides the distribution of the retrieved aerosol optical thickness (AOT) and measurements at Palang Karaya NASA/AERONET station on 15 September, 2019 in the left and right, respectively.

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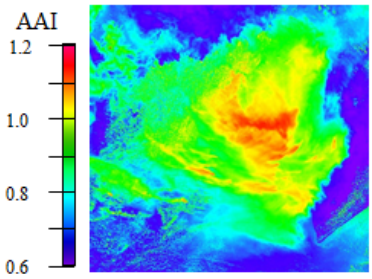


Fig.1 AAI distribution over Kalimantan, Indonesia on Sept.15, 2019.

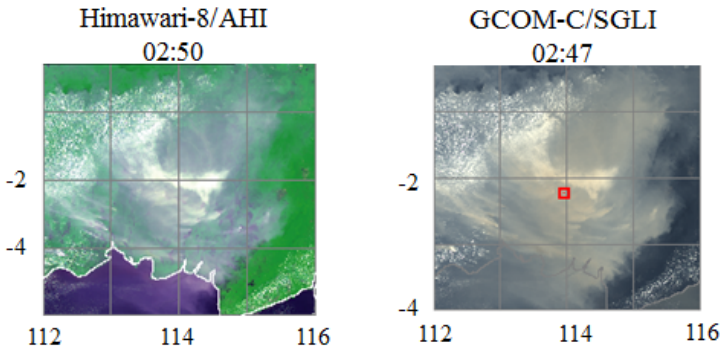


Fig.2. Color composite images by Himawari-8/AHI at 02:50 and SGLI at 02:47 on Sept.15, 2019. In the case of SGLI, shorter wavelength channels (443, 412, 380nm) are used for three primary color (R, G, B) than such a usual as AHI. The open red square in the right image indicates a station Palangkaraya (lat:2.22°S, lon:113.95°E) of NASA/AERONET.

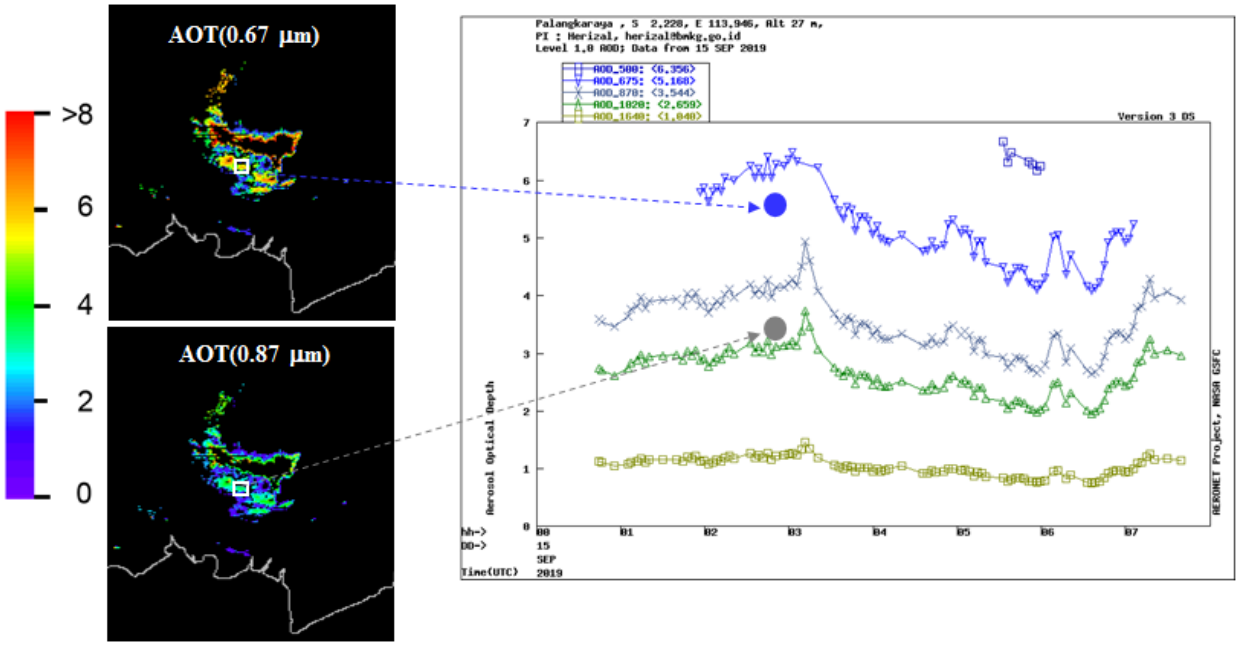


Fig.3. Aerosol optical thickness (AOT) retrieved from SGLI and measurements at Palangkaraya NASA/AERONET station on 15 September, 2019 in the left and right, respectively.

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Retrieval of aerosol properties from GOSAT-2/TANSO-CAI-2 and comparison with ground-based observations

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Aerosol particles in the atmosphere scatter and absorb sunlight and affect Earth’ s climate. Satellite remote sensing is one of useful way to monitor the global distribution of aerosol particle. We have developed aerosol retrieval algorithm called MWPM (Multiple wavelengths and pixels method) (Hashimoto and Nakajima, 2017). The method simultaneously retrieves fine and coarse mode AOT and single scattering albedo (SSA) by using several wavelengths and spatial difference of surface reflectance. The method is useful for aerosol retrieval over spatially inhomogeneous surface region like an urban area.
The Greenhouse Gases Observing Satellite-2 (GOSAT-2) called “Ibuki-2” was launched on October 29th, 2019 for monitoring greenhouse gases in the atmosphere from space. GOSAT-2 has two sensors, TANSO-FTS-2 (Thermal And Near-infrared Sensor for carbon Observation, Fourier Transform Spectrometer 2) and TANSO-CAI-2 (Cloud and Aerosol Imager 2). CAI-2 makes an observation at ten bands composed of seven wavelengths at 340, 380, 443, 550, 674, 869 and 1630 nm and performs two-directional observation in forward and backward directions. CAI-2 is characterized by having two ultraviolet (UV) bands that have sensitivity to light absorption by aerosol particles. The spatial resolution (IFOV) is 460 m other than a wavelength at 1630nm which resolution is 920 m.
We have applied our algorithm, MWPM, to CAI-2 data, and deriving and calculating aerosol properties such as fine and coarse mode of AOT, soot volume fraction in fine mode particles, SSA, Angstrom exponent (AE) and an equivalent value of PM2.5. The results were compared with aerosol properties of ground-based observations at sites in SKYNET and AERONET which are famous ground-based networks for aerosol monitoring.
We also have investigated biases on the products by input data and assumed aerosol models in the algorithm such as ground surface albedo, relative humidity and aerosol size distribution and so on. Aerosol particle size and these light absorption properties are different in different regions. It is important to know a bias occurred by assumed aerosol models when we validate the aerosol products by ground-based observations and modify the algorithm. We show the results of the comparisons and discuss about the results and algorithm to improve the aerosol retrieval and the algorithm.

Keywords: Aerosol, Satellite Remote sensing

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Remote sensing of three-dimensional clouds from multispectral measurements using deep learning

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Clouds are an important factor in determining the Earth's radiation budget, and those properties such as cloud optical thickness (COT) are globally retrieved by satellite observations. A standard COT retrieval method is the bispectral method based on 1D radiative transfer model neglecting horizontal radiative transfer. In addition, this method is based on the independent pixel approximations which assumes that clouds are plane-parallel and homogeneous within each pixel of the satellite image. However, it has been pointed out that not taking into account 3D radiative transfer and cloud inhomogeneity can lead to large errors in retrieval of cloud properties. Here we present a deep neural network (DNN) approach for the retrieval of COT from multispectral satellite observation. In order to account for 3D radiative transfer and cloud inhomogeneity, the training and test data of the DNN are made by a Monte Carlo 3D radiative transfer model whose input is 3D cloud fields from large-eddy simulations. The DNN structure consists of a convolutional neural network which is good at learning spatial features of cloud imprinted in satellite image. When we compare our method with pixel-by-pixel retrieval trained by a 1D radiative transfer model, our retrieval method can represent 3D radiative transfer effects, utilizing spatial features and data from 3D radiative transfer models. We will also report on results of application to the SGLI (Second generation GLobal Imager) measurement data onboard GCOM-C.

Keywords: satellite remote sensing, cloud , deep learning, machine learning

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Long Term Analysis of TPW (total precipitable water vapor) product

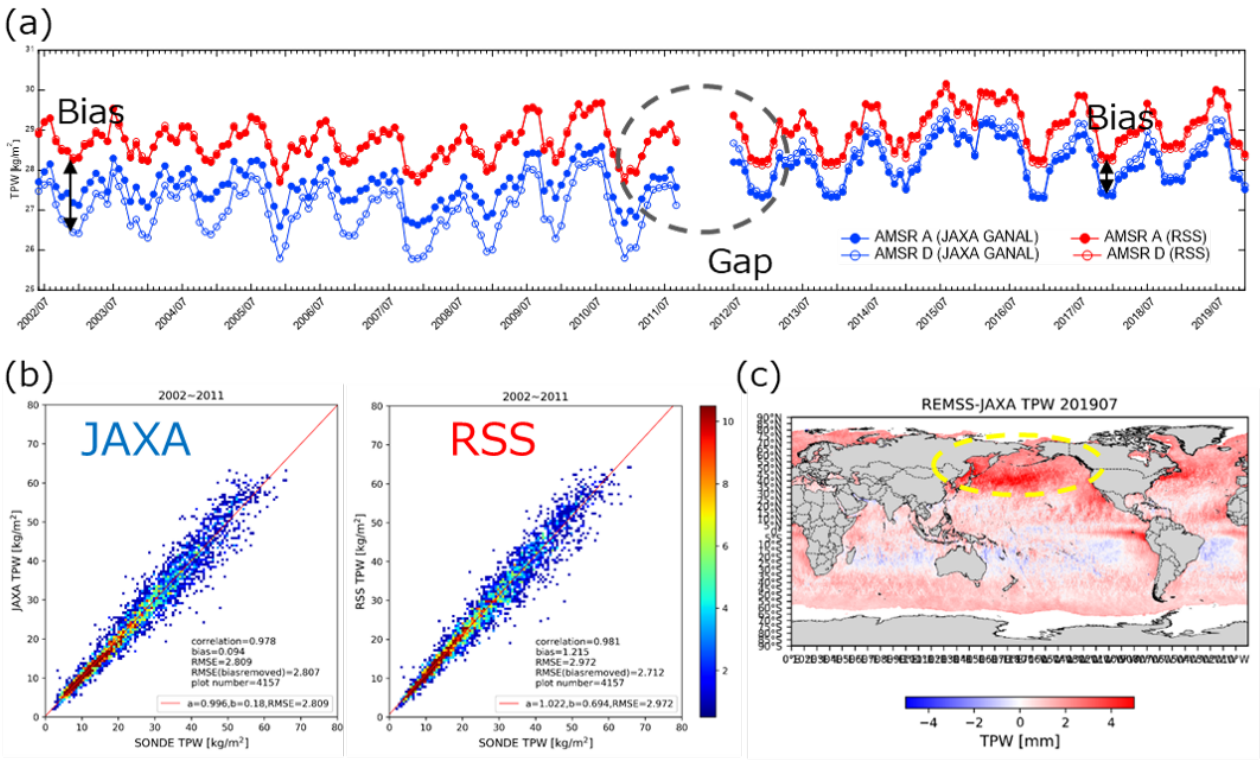
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Global climate and water cycle changes become social issues that have attracted more attention in recent years. It is critical to observe geophysical parameters (essential climate variables) on a long-term, continuous, and global scale to understand the global climate and water cycle changes mechanism. The amount of water vapor in the atmosphere is vital information for forecasting meteorological phenomena such as heavy rains and typhoons and understanding global climate and water cycle changes.
JAXA's Advanced Microwave Scanning Radiometers (AMSR-E and AMSR2) continuously provide various hydrological parameters, including Total Precipitable Water (TPW) over ocean, since June 2002. The next generation sensor AMSR3 will be on the Global Observing Satellite for Greenhouse gases and Water cycle (GOSAT-GW), and the launch is scheduled for 2023. Since the sensor specifications and observation conditions of AMSR-E and AMSR2 are almost the same, it is possible to generate a consistent long-term data set for AMSR-E and AMSR2 (and AMSR3 in the future). However, there is an approximately 8-month data missing period between the AMSR-E and AMSR2, and JAXA's TPW product shows different trends before and after the gap. It is uncertain if they are the actual TPW trend: the difference might be due to the sensors' calibration in AMSR-E and AMSR2.
In this study, to clarify the cause of the gap between AMSR-E and AMSR2, we analyzed not only TPW products of JAXA but also that of Remote Sensing Systems (RSS). RSS performs retrieval TPW from AMSR brightness temperature data with its own algorithm. We analyzed the long-term trend of the TPW products of AMSR-E and AMSR2 from 2002 to the present. Fig. a shows the long-term trend analysis of TPW, and we compares in-situ observations such as radiosonde and ground-based GPS occultation observations (Fig. b). These analyses allow us to verify the accuracy of the respective TPW products for JAXA and RSS. The comparison is analyzed by varying region, QC flag, sea surface temperature, and other conditions (Fig. c). We discuss each product's trend's characteristics and the main factors of the difference between JAXA and RSS products.

Keywords: AMSR-E, AMSR2, Total Precipitable Water, water vapor, long-term

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(a) Latitude-weighted global monthly mean of ASMR TPW are plotted in time series separately for Ascending (●) and Descending (○). (JAXA: blue point, RSS: red point). (b) Match Up AMSR-E TPW L3 Ascending data with SONDE observation at clear sky condition. (c) TPW bias between RSS and JAXA products (RSS-JAXA).

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Evaluation of Himawari estimated precipitation product compared with GSMaP and JMA radar analysis

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The Global Satellite Mapping of Precipitation (GSMaP) uses geostationary satellite infrared band data to estimate precipitation to fill the gap in microwave radiometer (MWR) observations. However, the precipitation estimation that depends only on the cloud top temperature (altitude) information shows a remarkable tendency to overestimate precipitation around the anvil cloud in the tropical region, and the accuracy of the infrared (IR) area is lower than that of MWR. Himawari-8 has IR multi-band observations available in the Asian monsoon region. A product that can estimate rainfall with higher accuracy than the conventional method using only a single IR band observation using random forest machine learning using the Global Precipitation Measurement (GPM) Mission Ku band precipitation radar (PR) observations (Hirose et al. 2019) was created. To evaluate this product, we created annual Himawari Rainfall Analysis (HRA) products for 2019 and compared them with GSMaP MVK version 7. The satellite information flag of GSMaP was used to distinguish the observation area of MWR. Since HRA adjusts the hyperparameters of the machine learning model based on the root mean square error (RMSE), it has the problem that the estimation accuracy decreases for extreme rainfall, which is rarely observed. To solve this problem, we introduced a method to correct the HRA observational rainfall intensity histogram based on the MWR observational rainfall intensity histogram and compared the results before and after the correction was applied.
In the product applied with histogram correction, the part that tended to be excessive in the tropical ocean area became smaller, but the excessive amount in the coastal area became conspicuous. A one-year long-term analysis revealed that the histogram correction improved the intensity distribution to a level comparable to that of MWR. However, focusing closely on land and sea, it did not match. It does not have a real rainfall intensity distribution. As a result of the histogram correction, the excessive tendency of the tropical ocean area and the coastal area's excessive tendency were corrected.
In addition, the product is compared with the Japan Meteorological Agency Radar (JMARAD) over the Japan area. Rainfall accumulation is compared for each rainfall event period. The precipitation distributions of frontal precipitation in the mid-latitudes and during the rainy season are similar to those of JMARAD, and the differences in the accumulation values are small. Although the reproducibility of the partial accumulation of localized rainfall areas during the occurrence of a line-shaped rainfall system is low, the precipitation distribution is relatively consistent. We focused on the precipitation accumulation during typhoons approaching and crossing Japan, and the rainfall distribution is consistent between them. However, the rainfall tends to be underestimated in the rainfall associated with the unique topography of Shikoku and the southern coast of the Kii Peninsula. In the case of the Japan Sea snowfall cases, it is not easy to find the characteristics of the snowfall streaks as seen in JMARAD. On the other hand, we find the precipitation accompanied by rapidly developing of isolated cumulonimbus clouds unaffected by radar shielding due to topography in the summer season because of the high temporal resolution of Himawari-8 observation.

Keywords: satellite precipitation observations, geostational satellite

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Heavy orographic rainfall in Taiwan missed by the GPM Dual-Frequency Precipitation Radar (DPR) algorithm

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1 Introduction

Because precipitation in orographic areas is difficult to observe with rain gauges or microwave radiometers, spaceborne precipitation radar observations are important. However, spaceborne precipitation radar observations also have a drawback: in orographic areas, shallow precipitation cannot be captured due to the strong influence of the ground surface clutter. The orographic areas of northern Taiwan are unique in the world in that they are equipped with a high density of rain gauges (Cheng and Yu 2019, J. Atmos. Sci.). In this study, we examined the spaceborne precipitation radar data by comparing with rain gauge data and ground-based radar data.

2 Data and Method

The Global Precipitation Measurement (GPM) mission’ s Dual-frequency Precipitation Radar (DPR) was used as the spaceborne precipitation radar data. Although DPR contains two different frequencies, Ku-band radar (KuPR) is more sensitive to precipitation than Ka-band radar (KaPR). Therefore, KuPR Near Surface Rain (NSR) data was used in this study. NSR data is the rainfall intensity data at the lowest altitude that is not affected by surface clutter. The data was extracted from orbits passing through the analysis area from March 2014 to February 2020. For the rain gauge data, one-minute interval data from 22 Da-Tun rain gauge network (DTRGN) units installed in mountainous areas in northern Taiwan (Cheng and Yu 2019) were used. Data from the S-band ground-based Doppler radar on Wu-Fen-San (WFS) was also used to compare the vertical distribution of precipitation.

As a method to compare KuPR data and the rain gauge data, we compared a set of KuPR observation data within a radius of 3.5 km from each rain gauges, referring to Terao et al. (2017, SOLA).

3 Results

We found several cases which KuPR did not capture any rain at all, though rain gauges caught the rain. In particular, there were three cases which the rain gauges captured very strong rainfall of 10 mm/h or more, but the KuPR did not. The WFS radar also observed the rain for all the three cases.

The radar reflectivity profile of the WFS radar revealed that the heavy rainfall of 10mm/h or more is associated with shallow orographic rainfall systems below clutter free bottom (CFB) altitude estimated from KuPR. Although the effect of surface clutter is small near the nadir, one of the three cases was found to have a precipitation-top height lower than the near nadir CFB altitude (about 2300m).

Cheng and Yu (2019) showed that atmospheric stability tends to be higher in shallow precipitation in the orographic region of Taiwan. Also, Shige and Kummerow (2016, J. Atmos. Sci.) showed that there is a negative correlation between static stability and precipitation top height in Asian monsoon precipitation. The ERA5 reanalysis data revealed that the static stability around Taiwan became high. In these three

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cases, shallow precipitation was considered to have occurred more easily. In addition, in all three cases, moist air flowed into Taiwan from the cooler northern regions through the ocean, which might make rainfall in the orographic area.

Reducing the vertical extent of clutter region is important to capture the shallow rain lower than the CFB altitude. CFB altitude is estimated by using received power and could be estimated higher than it actually is (Iguchi et al. 2020, https://www.eorc.jaxa.jp/GPM/doc/algorithm/ATBD_DPR_202006_with_Appendix_a.pdf). The magnitude of the ground surface clutter is different between Ku-band and Ka-band. Therefore, the difference in radar reflectivity values of Ku-band and Ka-band, dual-frequency ratio (DFRm), jumps at the ground surface clutter. Using this fact, we examined that the CFB altitude could be set lower. As a result, we found that the DFRm value actually jumped at an altitude lower than the CFB altitude. By using this result, we may be able to broaden the clutter free region and capture the shallow rain at a lower altitude.

Keywords: GPM/DPR, Precipitation, Orographic rainfall

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Comparative analysis of the GSMaP and quantitative precipitation estimation based on surface observation by radars and gauges in heavy rainfall events over Vietnam

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1. Introduction

It is necessary to grasp the horizontal distribution of precipitation to forecast fluvial floods, inland flooding, and landslides. The Viet Nam Meteorological and Hydrological Administration (VNMHA) has implemented their automatic observation network of surface weather radars and rain gauges covering the whole country and built the quantitative precipitation estimation (QPE) system from these observations. This might improve the ability to forecast the pluvial disasters in Vietnam, although the performance of this system is still not clear. Moreover, the horizontal distribution of hourly precipitation can be optimized by combining surface observations and satellite data. In the present study, we compared surface and satellite rainfall observations to find out about consensus and inconsistency between them.

2. Data

Version 7 of the GSMaP (Aonashi et al. 2009, Ushio et al. 2009; Kubota et al. 2020) was adopted as a precipitation dataset based on satellite observation. We used four products including MVK, NRT, Gauge, and Gauge_NRT (Mega et al. 2019). Their resolution is horizontally 0.1 degrees and temporarily one hour. The QPE data provided by the VNMHA was used as a precipitation dataset based on surface observations. Their resolution is horizontally one kilometer and temporarily one hour. The QPE data were horizontally binned as fitting to the GSMaP's resolution. We chose 11 rainfall events in 2019 and 2020 for the analysis.

3. Results

3.1 Horizontal distribution

Figure 1 shows one heavy-rainfall case concerning the Tropical Cyclone ETAU on 9 November 2020. Scattering diagrams indicate a high correspondence between the QPE and GSMaP data with correlation coefficients exceeding 0.5 in three snapshots. Especially, both data show a higher agreement over the sea. This result implies that the surface and satellite observations can be complementarily useful in a forecast of a typhoon which often approaches from the eastward ocean in Vietnam, by providing horizontally continuous observations. Whereas, over the land, the GSMaP had heavier precipitation and an unnatural overestimating spot. Such a discrepancy should be overcome in the next step.

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3.2 Synthetic analysis

We statistically compared the two datasets in all horizontal points and hours for each case in 2019.

In analyses for hourly precipitation, the GSMaP MVK had heavier precipitation than the QPE data in 8 out of 10 cases in 2019 (Fig. 2). Most of the selected cases were observed over lowlands relatively close to the coast. This characteristic roughly agreed with the previous study (Nodzu et al. 2019). The GSMaP relatively overestimated in light-rain cases and underestimated in heavy-rain cases if we regard the QPE as ground truth data. The GSMaP Gauge (Gauge_NRT) modified by gauge data has a higher similarity with the QPE than the GSMaP MVK (NRT) without modification in the analyses including root mean square difference, biases, and probability of detection (not shown).

The correspondence between the GSMaP and the QPE was assessed by varying accumulation time of precipitation (ATP) from one hour to 12 hours. Hourly or 2-hourly precipitation had a lower correspondence between the two datasets than precipitation with longer ATP. On the other hand, in the longer ATP, normalized RMSD and POD for 6-hourly precipitation had similar values with those for 12-hourly precipitation.

4. Summary

The GSMaP and the QPE precipitation datasets showed a high agreement in their horizontal distribution, especially over the ocean. The GSMaP often had larger values compared to the QPE. This could be a shared feature over lowlands relatively close to the coast observed in the previous studies. It seems that the adjustment algorithm with rain gauge data in the GSMaP successfully works judging from the analyses on the Gauge and Gauge_NRT products. Two common features could be seen in the comparison between the GSMaP and the QPE data: (1) the GSMaP had larger values in light-rain cases and smaller values in heavy-rain cases; (2) the GSMaP and the QPE had a higher correspondence for the precipitation with a longer ATP. Discussion based on the above comparison is helpful in the construction of an optimized and integrated precipitation dataset from the satellite and surface observations.

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Keywords: satellite precipitation observation, radar precipitation observation, Asian monsoon, data validation

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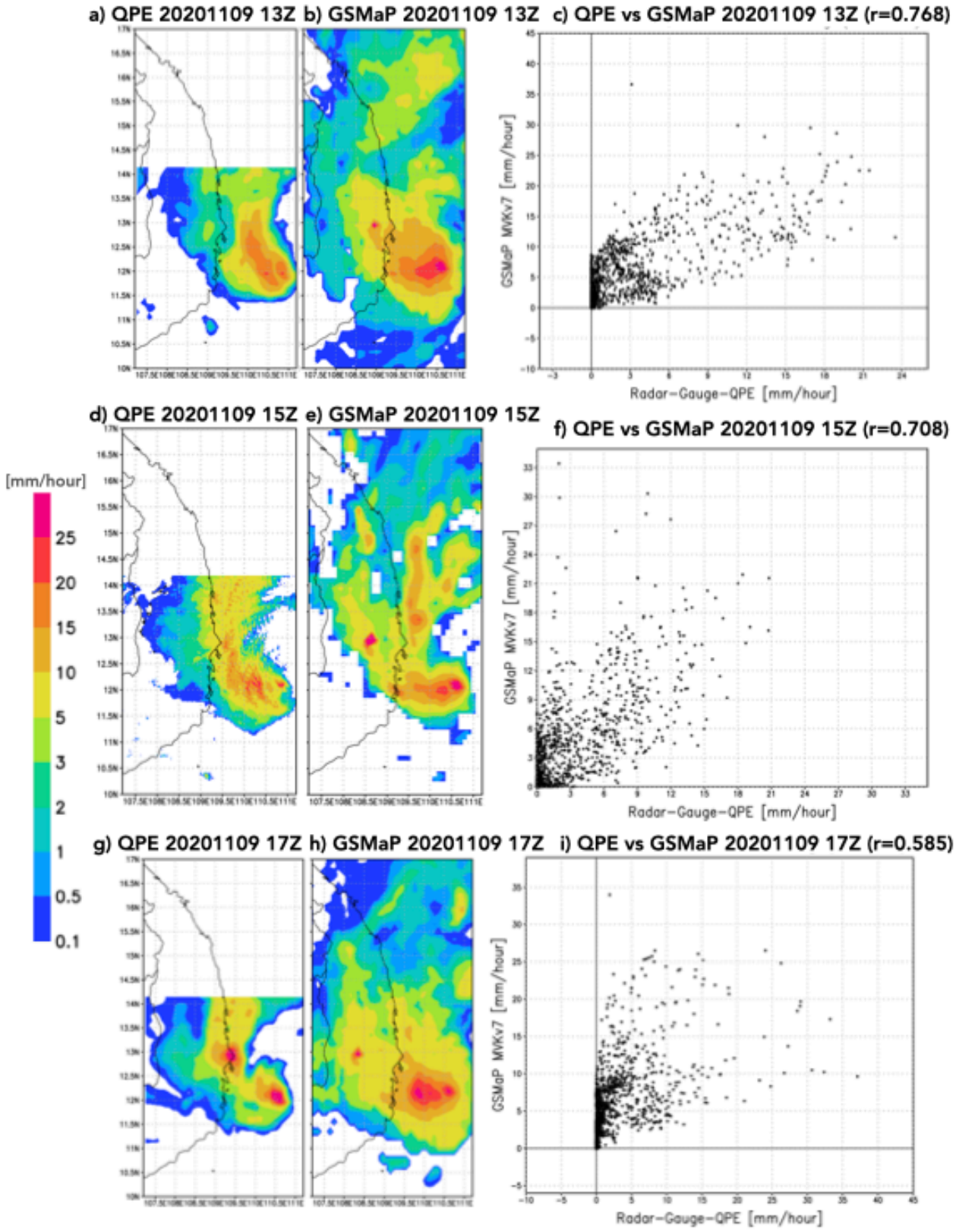


Fig. 1: Comparison of horizontal distribution in hourly precipitation between the GSMaP MVKv7 and the QPE based on surface weather radars with modification by gauge observation in (a–c) 13Z, (d–f) 15Z, and (g–i) 17Z on 9th November 2020 around Nha Trang in central Vietnam. Horizontal distribution of hourly precipitation in (a, d, and g) the QPE data and (b, e, and h) the GSMaP MVKv7. (c, f, and i) Scattering diagrams comparing the two data. One outlier case is not displayed in the panel (f), exceeding 60 mm hour^{-1} in the GSMaP.

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Improvement of cloud mask algorithm of CALIPSO lidar

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The cloud mask algorithm at 532 nm had been developed for the CALIPSO satellite lidar retrieval (Hagihara et al., 2010). In the cloud mask scheme, the threshold value of attenuated backscattering coefficient to discriminate between clouds and aerosols was set to the fixed value, $10^{-5.25}$ $m^{-1}sr^{-1}$. Clouds near cloud base tend to be undetected in this cloud mask scheme, because attenuated backscattering coefficient affected by the attenuation of the upper cloud layers becomes lower than the threshold value of clouds and aerosols. Therefore, the threshold value between clouds and aerosols changes depending on cloud and molecule attenuation in the new cloud mask scheme. In this study, we use the CALIPSO level 1b product version 4.1 and the effects of the CALIPSO lidar receiver’s transient response on attenuated backscattering coefficient are corrected using the transient response function (Lu et al., 2014, 2020). In the new cloud mask scheme, clouds near cloud base are detected more frequently and the low-level cloud fraction increases.

Keywords: CALIPSO, lidar, cloud

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Simultaneous retrieval of aerosols and ocean color parameters using GCOM-C/SGLI data

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Atmospheric aerosols have a significant impact on the global climate through direct and indirect climate effects. Emissions of anthropogenic aerosols are said to be increasing year by year, and more accurate estimates are needed to suppress them. In remote sensing of land and ocean, aerosols are contaminants that cause serious errors, and it is important to remove them for better satellite analysis.

In this study, we performed an analysis of atmospheric aerosol by the new satellite analysis algorithm, the multi-wavelength multi-pixel method (MWP method)(Hashimoto and Nakajima, 2017), and an analysis of atmospheric aerosol and chlorophyll concentrations by the simultaneous method (Shi and Nakajima, 2017). The MWP method is a solution method in which observation values of multiple channels are used for multiple pixels at once, and the aerosol distribution is limited and derived to be smooth. The spatial distribution of the AOT obtained even in an urban area that is complicated in the horizontal direction, which is a superiority of this method. The simultaneous method is that enables simultaneous estimation by considering the radiative transfer process in the ocean under the conflicting situations where the effect of ocean color needs to be considered when analyzing aerosols, and aerosols need to be considered when analyzing ocean color. Both methods can estimate more parameters at once by using a large number of observation data at once. The problem of high computational cost has been overcome by using the Neural Network method (Takenaka et al., 2011) as the radiative transfer model.

In this presentation, we apply GCOM-C / SGLI observation data to these methods and show the results of atmospheric aerosols and ocean color analysis in the Ariake and Yellow Sea areas. Also, the validation results are shown with AERONET.

Keywords: Satellite observation, aerosol, ocean color

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Verification of satellite-observed surface temperature in water areas and application to meteorological simulations

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It is well known that urban rivers have a moderating effect on the surrounding climate. In order to investigate such an effect using a regional climate model, numerical simulations with a high-resolution are required, and initial and boundary conditions with a high resolution are also required for these simulations. Water temperatures in major rivers are measured by the River Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, and the hourly measured data are open to the public, but these observations do not cover the entire river. The Earth observation satellite Terra passes over the same area at 16 day intervals at the same time, and the surface kinetic temperature is measured with a high resolution of about 90 m by the Thermal Infrared Radiometer (TIR) of the mounted Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). In a large river with a width of 200-300 m, the surface temperature observed by this satellite seems to be available as the river water temperature. In this study, at first, we compare the surface temperature observed by Terra/ASTER (TASTER) with the water temperature measured at River Bureau in Yodogawa River and at water quality monitoring points in Osaka bay. Next, we try to create boundary conditions for the surface temperature of water bodies in Weather Research and Forecasting (WRF) model from the TASTER surface temperature. Then, the effect of incorporating TASTER surface temperature is investigated with the WRF simulations.

The TASTER surface temperature data (AST_08) at 10:52 JST on April 8, 2019 is used, of which the cloud cover rate is 2% and the observation area includes Osaka Bay and Yodogawa River. The accuracy of the TASTER surface temperature is verified by comparing this surface temperature with the water temperature observed at 11:00 on the left bank of Hirakata Bridge at the Yodogawa River Bureau and at four water quality monitoring points in Osaka Bay. The surface temperature of the water area, which is one of the boundary conditions for a WRF simulation, is produced by fitting in the surface temperature of the satellite observation point with the nearest model grid point. Numerical experiments are carried out for the case using the boundary conditions of the surface temperature of water bodies produced from the meso-scale land surface analysis of the Japan Meteorological Agency (JMA), and the case produced from the TASTER surface temperature. We compare the results of these calculations with those of the surface meteorological observations by the JMA and the Atmospheric Environment Measurement Bureau.

The TASTER shows lower surface temperatures in water areas, such as Osaka Bay and the Yodogawa River, than in land areas at this time. The TASTER surface temperatures around the five monitoring points in the Yodogawa River and Osaka Bay are all higher than the water temperatures measured at the monitoring points. Compared with the surface temperature of the water bodies in the JMA meso-scale land surface analysis, the TASTER surface temperature is lower in the ocean and higher in the land water area. Since the observations at the River Bureau and the water quality monitoring points in Osaka Bay show higher surface temperature in the Yodogawa River than in Osaka Bay, the TASTER surface temperature reasonably represents the realistic land water temperatures. The WRF simulations with two different boundary conditions show that the surface wind converges over the Osaka Plain from 13:00 to 18:00, and that there is a relatively large difference in the air temperature, mixing ratio, and relative

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humidity of the two simulations in the region where the wind converges.

Keywords: rivers, surface temperature, ASTER, WRF

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Sampling simulation of spaceborne precipitation radar

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Precipitation radar observation from space started by Tropical Rainfall Measuring Mission (TRMM) launched in 1997 with the inclination angle of 35 degrees and 350 km of height followed by Global Precipitation Measurement (GPM) core satellite launched in 2014 with inclination angle of 65 degrees and 402.5 km of orbit altitude. When the satellite inclination and orbit height is determined, global sampling efficiency and diurnal sampling are evaluated. For the future precipitation measurement mission, several possibilities of the satellite orbit were discussed such as the inclination of higher than 65 degrees with the satellite altitude of about 450km and sun-synchronous orbit with the altitude of 450 km. In this study, global and diurnal sampling efficiency is evaluated for various inclination angle and satellite altitude. The swath width of the precipitation radar is assumed as 250 km. The satellite orbit is calculated by the method of Crisp et al. [1]. The global sampling is evaluated by counting the days for complete the sampling on the equator with the given swath width. The diurnal sampling is evaluated by counting the days to complete at least one time for all 1x1 degree boxes in the orbit range for 3-, 4-, and 6-hour intervals. The result indicates that the global sampling and diurnal sampling are similar height and inclination dependency. Also, global sampling maps against the observation days (e.g., 1, 1.5 and 2 month) are shown.

Reference

[1] Crisp, N. H., Livadiotti, S., and Roberts, P. C. E., “A Semi-Analytical Method for Calculating Revisit Time for Satellite Constellations with Discontinuous Coverage”, arXiv e-prints, 2018.

Keywords: satellite orbit, global sampling, diurnal sampling

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Comparative analysis between precipitation measurement by a satellite and meteorological observation by a high density ground surface observation network

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It is generally said that the meteorological observation data by ground surface observation equipment is very few. On the other hand, the calibration / validation by ground truth are essential in order to maintain the high accuracy of precipitation observation technology by a satellite. The ground meteorological observation data is by no means the ground truth. But, the existence of ground meteorological observation data is very valuable.

POTEKA(POint TEnki KAnsoku in Japanese) equipment can observe the eight meteorological variables such as temperature, relative humidity, sea-level pressure, wind speed, wind direction, sunshine, rain and precipitation. The five variables of temperature, relative humidity, sea-level pressure, wind speed and precipitation are certificated by JMA. As of 2020, approximately 900 POTEKA points have installed in the whole of Japan. Although it is not uniform such as AMeDAS observation network, the localized but high density ground surface meteorological observation network can be consisted of these POTEKAs. We have some cases that POTEKA has a high density network in the mountain area where AMeDAS observation point is relatively few. POTEKA started around 2013 at the earliest observation point. Therefore, POTEKA history is very short compared with AMeDAS history of more than 40 years. But, some POTEKA points have the history of multiple years.

We have performed the comparative analysis of precipitation observation data between the satellite such as GPM(Global Precipitation Measurement)/DPR(Dual-frequency Precipitation Radar), GSMaP(Global Satellite Mapping of Precipitation), etc. and the ground surface of POTEKA. The analysis realm is a pinpoint in the both spatial and temporal aspects. Therefore, it is by no means universal analysis. But, we have confirmed some cases of the precipitation underestimation of satellite observation technology on the mountain area or on the torrential rainy season which has the occurrence of a linear precipitation zone.

We will continue to perform the comparative analysis of precipitation observation data between satellite and POTEKA in the future. Particularly, we will concentrate on the comparative analysis for the precipitation underestimation of satellite observation technology in order to acquire the knowledge to maintain the high accuracy. Moreover, in the observation case of the rare and localized meteorological change such as downburst and tornado, we will also perform the same comparative analysis in order to acquire the new knowledge for a rare meteorological phenomenon.

Keywords: high density, ground surface observation, ground truth, GPM, DPR, GSMaP

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Comparison between random forest and multiple linear regression algorithms for digital soil mapping in the Thung Kula Ronghai region, Thailand

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Digital soil mapping (DSM) increases use of machine learning (ML) algorithms to identify appropriate relationships between soil properties and environmental variables, enabling to predict the soil nutrient levels. Over the past decades, many studies have been employed the multiple linear regression (MLR) algorithm to estimate the spatial distribution of soil chemical properties in various landscapes. The TKR region is an essential agricultural field to produce a good quality jasmine rice and the rice has been successfully registered as a Protected Geographical Indication (PGI) by the European Union. However, the rice yield in this region is lower than those in other regions in the country. In this study, we compare the random forest (RF), which is the most popular ML algorithm for digital soil mapping, with multiple linear regression algorithm to map the spatial distribution of soil chemical properties in the Thung Kula Ronghai (TKR) region, Thailand. These algorithms were compared on the basis of three factors: (1) accuracy of the models, (2) predictor variables selection, and (3) the spatial distribution characteristics of soil properties. The dataset consisted of 186 soil samples collected from surface layer 0-30 cm and analyzed for nutrients. Landsat-8 images collected at bare land conditions with 30 m resolution were used to calculate the spectral indices. A digital elevation model with 5 m resolution was used to derive the terrain variable of the study area. Soil properties were estimated using predictor variables by multiple linear regression as a simple model and random forests as a complex model. Ten-fold cross-validation was used to determine model accuracy. Developed models using RF and MLR were evaluated in terms of the coefficient of determination, root mean square error and normalized root mean square error. The results demonstrated that the RF and MLR models successfully produced digital soil maps of various soil properties. The spectral indices of brightness, saturation, coloration, normalized difference water and moisture stress were the important predictor variables and were significantly correlated with various soil properties. The random forest predictions showed higher accuracy than those of MLR for most of the soil properties. The RF model produced more realistic results in terms of the correlation between predicted and measured soil data, indicating that random forests were more appropriate to make digital maps of soil chemical properties in the TKR region.

Keywords: Predictor variables, Remote sensing, Spatial distribution, Spectral and terrain indices, Soil property

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Wildfire watch using SWIR data from SGLI/GCOM-C

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The Second-generation Global Imager (SGLI) is an optical sensor onboard the GCOM-C satellite. SGLI has eleven channels for visible to near-infrared wave range, six channels for short-wavelength to thermal infrared wave range, and two polarization channels for visible and near-infrared wavelength. The spatial resolution is switchable between 250 m and 1 km. In terms of watching wildfire, the spatial resolution of 250 m is an advantage of SGLI. Although lack of mid-infrared (MIR) channels is a disadvantage, SGLI has channels in a short-wavelength infrared (SWIR) range where data is sensitive to high temperatures.

We examined the SWIR data for its performance of watching wildfire. We introduced a threshold-based test for detecting hotspots and a single-channel method to estimate fire radiative power (FRP). The single-channel method followed Wooster et al. 2003. Preliminary results show good agreements with those retrieved from Himawari-8 data. Meanwhile, some of the SWIR data were saturated probably by some wildfire flaming in a wide area. That suggests the upper limit of the dynamic range of SWIR channels is too low for estimating FRP; this is likely to be originated from a mismatch between the high spatial resolution and the narrow dynamic range. However, SWIR can capture signs from wildfire behind the clouds and has detected hotspots that Himawari-8 could not, suggesting wildfire data from SGLI is worthy.

Keywords: Wildfire, SGLI, GCOM-C

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Evolution of Global Satellite Mapping of Precipitation (GSMaP) Product version 05

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Global Satellite Mapping of Precipitation (GSMaP) has been developed as a standard product of Japan's Global Precipitation Measurement (GPM) mission. Merged satellite precipitation products such as GSMaP are particularly effective for monitoring in regions where ground-based observation is not available. The GSMaP has been continuously improved, and the product version 03 (algorithm version 6) was released in September 2014, and the product version 04 (algorithm version 7) in January 2017. Product version 05 (algorithm version 8) is scheduled to be released in May 2021. Product version 05 will be available for reprocessing from March 2020 onwards, and we are currently investigating whether it will be available for reprocessing from January 1998 onwards. In this presentation, we will introduce contents of the product version 05.

The new sensors, MHS(Metop-C) & ATMS (Suomi-NPP/ATMS, NOAA-20/ATMS), will be added to the product version 05 to improve the observation coverage of the passive microwave radiometer (PMW). In addition, the PMW precipitation algorithm will be improved to extend the estimation range to the poles. However, this does not include the application of the combined PMW-IR algorithm at this time, and only PMW sensor estimations are planned for regions of the polar to 60 degrees latitude.

We will also improve the database of precipitation physical models. We will introduce the use of longer term GPM/DPR data and the use of dual frequency information from DPR. We will also incorporate improvements to the orographic heavy rainfall estimation method (Yamamoto et al. 2017). We will improve the scattering algorithm based on frozen precipitation depths (Aonashi et al. 2021). Improvements to the ground rain gauge adjustment method (Mega et al. 2019) were developed to correct artificial patterns found in the previous version.

In addition, one of the major improvements in the product version 05 is to improve the sensor-induced heterogeneity of GSMaP. The heterogeneity often occurs at the boundary between the PMW observation area and the geostationary infrared radiometer (IR) estimation area. The heterogeneity among different types of PMWs is corrected based on Yamamoto and Kubota (2020), based upon cumulative distributions of precipitation for PMW sensors. For the heterogeneity between PMW and IR, the histogram matching method of Hirose et al. (2021) is applied. Furthermore, a gap reduction method based upon an image processing is also expected to be effective in reducing the heterogeneity between PMW and IR.

Keywords: Global Precipitation Measurement, Global Satellite Mapping of Precipitation

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Soil Moisture and Plant Water Content estimate in Pilot areas of the Mediterranean basin through multitemporal analysis of AMSR-E/2 images

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This study aims contributing to the analysis of climatic change evaluation on regional scale in sensible areas like the Mediterranean basin. Two target areas have been identified in North-Africa in the framework of a European project devoted to the analysis of drought conditions and climate change impacts (ERANET-MED OptiMed-Water). The selected areas are the Nile Delta region in Egypt and two areas in Eastern Tunisia, whose main land use is represented by agriculture both rainfed and irrigated.

The goal of this research was to carry out a multi-temporal analysis on soil moisture content (SMC, in cm^3/cm^3) and vegetation biomass, expressed as Plant Water Content (PWC, in Kg/m^2), through large spatial resolution microwave images. The scarce ground resolution (about 10Km at all frequencies) of microwave radiometers from satellite platforms (AMSR-E and AMSR2) can be considered a limit for in-depth analysis related to drought/water waste phenomena at local scale. However, the availability of long-term series of data starting from 2002 makes the investigation of climate change cycles possible through the observation of the seasonal variations of brightness temperatures (Tb) at C, X and Ku bands and the corresponding polarization differences, the latter expressed as polarization indices (PI). Both Tb and PI are related to SMC and PWC. In addition to the frequent revisit time, the possibility of two daily passages (night/day) may also provide useful information on the evapotranspiration processes.

As a preliminary investigation, the temporal trends of Tb and PI at C, X and Ku bands collected on these areas have been analyzed from 2002 to today, pointing out the occurred seasonal variations. Successively, these microwave parameters have been processed through an inversion algorithm (HydroAlgo) implemented at IFAC-CNR, which is able to estimate both SMC and PWC. HydroAlgo is based on neural network approach and is trained using both experimental and model data derived from the tau-omega model. The model, which was validated in the entire Italian territory by using the SMC product derived from a hydrological model as a comparison, provided an overall Pearson's correlation coefficient between the estimated and the target SMC higher than 0.8 and the corresponding root mean square error less than 0.055 m^3/m^3. Slightly different results were obtained using ascending or descending overpasses. Comparisons with MODIS products have been carried out to identify spatial correlations during the analyzed period and validate the PWC products.

Keywords: Microwave radiometry, Soil Moisture, Vegetation Biomass

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GOSAT calibration activities and observation plans for advanced GHG measurements

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JAXA’s GOSAT has been operating since 2009 and GOSAT-2 since 2018 to monitor the greenhouse gases (GHGs) carbon dioxide (CO_2) and methane (CH_4) by a Fourier Transform Spectrometer. The total column-average dry air mole fractions of CO_2 (XCO_2), and CH_4 (XCH_4) are measured from space using surface-reflected sunlight at near-IR wavelengths. Additionally, the partial column fractions of CO_2 and CH_4 in troposphere are retrieved together with thermal-IR wavelengths radiated from atmosphere. The partial column fraction in tropospheric lower altitude has an advantage to take local emissions before mixing rather than the total column-average fraction. The observation pattern over urban city area would be further optimized for taking local emissions efficiently. The GOSAT and the other GHG missions, NASA OCO and ESA TROPOMI are collaborated in calibration activities to improve GHG observation accuracy. We will present updated GOSAT calibration activities and observation plans for detecting local emissions by using tropospheric partial column fraction.

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How can SAR small-satellite constellation potentially monitor flood area?

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1. Tokyo Institute of Technology, 2. The University of Tokyo

Synthetic aperture radar (SAR) is an observation technology that is effective for flood detection at night or in bad weather conditions, and the operation of a constellation of small satellites equipped with SAR is becoming increasingly possible. In this study, we invsetigated how a flood inundation area is observed by a small SAR satellite constellation using a newly developed method that integrates satellite orbit design and flood simulation. The results of virtual experiments of two flood cases in Japan showed specific changes in observation behavior with the change in number of satellites and orbital planes. In addition, a performance evaluation in the inundation area observation suggested that the amount of temporal change was a more dominant factor than the spatial range of the flood area.

Keywords: SAR small-satellite constellation, flood area monitoring, virtual experiment

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.10 Zoom Room 10

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Makoto Yamada(Faculty of Economics, Ryukoku University), Chairperson:Masahiko Fujii(Faculty of Environmental Earth Science), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Makoto Yamada(Faculty of Economics, Ryukoku University)

Substances from land which are brought by river and/or submarine groundwater discharge are important for the process of biological production in coastal areas. This session focuses on land-ocean interactions through water cycle. The aim of this session is to create interdisciplinary discussions on the research of connectivity of ecosystems, water cycles in terrestrial and coastal areas, fishery resources and biodiversity. Comprehensive discussion on the mechanisms that promote productivity and biodiversity in coastal ecosystems will be made from the viewpoint of land-ocean interactions. Presentations on water-material cycle in terrestrial and coastal areas, fishery resources, biodiversity and connectivity of the ecosystems are encouraged.
A companion session proposed as "Coastal Ecosystems - 2. Coral reefs, seagrass meadows, and mangroves" focuses on benthic communities in shallow-water ecosystems such as coral reefs, seagrass meadows and mangroves and is dedicated to promote researches on comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration. Main focuses of these two sessions are different. However, there are much of information that covers both sessions. Scientists who work on the related field will be able to obtain information and share them with other scientists if they attend to both of these sessions.

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

[ACG40-01] Submarine groundwater discharge from Mt. Fuji in Suruga Bay(Ⅷ)

*Yasuhide Muranaka[1], Tomohide Kaneko[1], Tetsuhiro Watano[1], Tomoya Oka[1], Akira Ito[1], Masahiko Ono[2], Atsunao Marui[2] (1.Shizuoka Institute of Environment and Hygiene, 2.National Institute of Advanced Industrial Science and Technology)

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

[ACG40-02] Influence of groundwater-surface water exchange on riverine nutrient export to coastal seas: a comparative study at the six tide-less rivers in Wakasa Bay

*Toshimi Nakajima[1], Ryo Sugimoto[1] (1.Fukui Prefectural University)

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

[ACG40-03] Quantifying flux of groundwater-derived nutrients and phytoplankton assimilation rate of nutrients in a volcanic sandy beach

*Ryo Sugimoto[1], Ryoma Yagi[1], Toshimi Nakajima[1], Tatsuhiro Ishida[1], Makoto Yamada[2] (1.Faculty of Marine Biosciences, Fukui Prefectural University, 2.Faculty of Economics, Ryukoku University)

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

[ACG40-04] **Spatial and Temporal Patterns of the Physical and Biogeochemical Properties in the Nearshore Waters of Toyama Bay**

*Eligio de Raus Maure[1], Genki Terauchi[1], Yasuyuki Harada[1] (1.Northwest Pacific Region Environmental Cooperation Center)

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

[ACG40-05] The relationship between the timing and scale of *Karenia mikimotoi* bloom and environmental factors in the western Bungo Channel of Seto Inland Sea, Japan

*Yuma Hayashi[1], Naoki Yoshie[1], Goh Onitsuka[2] (1.Center for Marine Environmental Studies , Ehime University, 2.Japan Fisheries Research and Education Agency)

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

[ACG40-06] Continuous monitoring and future projection of ocean warming, acidification, and deoxygenation on the subarctic coast of Hokkaido, Japan

*Masahiko Fujii[1,2], Shintaro Takao[3], Takuto Yamaka[2], Tomoo Akamatsu[2], Yamato Fujita[2], Masahide Wakita[4], Akitomo Yamamoto[5], Tsuneo Ono[6] (1.Faculty of Environmental Earth Science, 2.Graduate School of Environmental Science, Hokkaido University, 3.National Institute for Environmental Studies, 4.Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology, 5.Japan Agency for Marine-Earth Science and Technology, 6.Japan Fisheries Research and Education Agency)

Submarine groundwater discharge from Mt. Fuji in Suruga Bay(Ⅷ)

*Yasuhide Muranaka[1], Tomohide Kaneko[1], Tetsuhiro Watano[1], Tomoya Oka[1], Akira Ito[1], Masahiko Ono[2], Atsunao Marui[2]

1. Shizuoka Institute of Environment and Hygiene, 2. National Institute of Advanced Industrial Science and Technology

Around the foot of Mt. Fuji, the main flow passages of groundwater are thought to be in the Younger Fuji volcano, which consists of the pervious basaltic lavas in new volcanic stage. Most of rainfall and melted snow have been considered to be percolating into underground, turning to groundwater, flowing down in the layers of the Younger Fuji volcano and partly discharging from seabed in Suruga Bay. Especially, the Fujikawa-kako fault zone, which stretches south to north in the southwestern side of Mt. Fuji, has a potentially effect on the local groundwater flow system into Suruga Bay. Therefore, precipitation at Mt. Fuji have been considered to be discharging partly from seabed in Suruga Bay and making a impact on the biological production at the coastal sea area.

For the purpose of contribution to make sense of the rich coastal ecosystem in Suruga Bay, we conducted a survey for submarine groundwater discharge (SGD) in Oku-Suruga Bay: from the mouth of the Fuji River, at which the fault is found, to Tagonoura, where the lavas of the Younger Fuji volcano are distributed from 100 to 200 m below sea level. We detected SGD in the top of the cliff in the west of Tagonoura using a remotely operated vehicle (ROV).This time, We used ROV for taking for the image of the spring points, sampled seawater containing a high percentage of sea bottom spring water and conducted water quality analyses. In this presentation, we introduce our works noted above.

Keywords: submarine groundwater discharge (SGD), Mt. Fuji, remotely operated vehicle (ROV), water sampling method

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Influence of groundwater-surface water exchange on riverine nutrient export to coastal seas: a comparative study at the six tide-less rivers in Wakasa Bay

*Toshimi Nakajima[1], Ryo Sugimoto[1]

1. Fukui Prefectural University

Groundwater-surface water exchange (GSE) has been increasingly recognized for its role in transferring water, heat, and chemicals across the land-ocean continuum. Although the magnitude of nutrient transport from surface rivers to coastal seas is crucial for the sustainability of coastal ecosystems, the effects of GSE in most downstream rivers and/or estuarine areas on nutrient flux have not still been clarified yet. Here, we assessed the quantitative effects on groundwater-surface water exchange on nitrogen and phosphorus transports at six tide-less rivers flowing into Wakasa Bay. We took river waters from five sites throughout the river continuum from the upstream site (< 3.7 km from the river mouth) to the most downstream site (river mouth) in each river and constructed the mass balance model for water, salt, and ^{222}Rn coupled with the direct measurement of river discharge. The water fluxes at the most downstream sites compared to the most upstream sites changed from 0.1 to 1.3 folds depending on surface water recharge into groundwaters or groundwater discharge to surface water. Export fluxes of total nitrogen (TN) and phosphorus (TP) at the most downstream sites were 0.1 −1.5 and 0.1 −3.0 folds compared to those at the most upstream sites, respectively. These changes of TN and TP fluxes between at the upstream sites and downstream sites were determined by those of dissolved inorganic nitrogen (DIN) and phosphorus (DIP), respectively. The higher contribution rates of GSE on the changes in DIN export fluxes indicated that GSE was crucial for riverine N export to coastal seas. A significant relationship for DIP was also found except for one river. We conclude that the surface water-groundwater exchange can alter net export rates of riverine nutrients to coastal seas, resulting in under- or overestimates of riverine nutrient fluxes.

Keywords: Groundwater-surface water exchange, Riverine nutrient export, Nitrogen, Phosphorus, Coastal sea, Wakasa Bay

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Quantifying flux of groundwater-derived nutrients and phytoplankton assimilation rate of nutrients in a volcanic sandy beach

*Ryo Sugimoto[1], Ryoma Yagi[1], Toshimi Nakajima[1], Tatsuhiro Ishida[1], Makoto Yamada[2]

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Volcanic coast is a hotspot occurring meteoric fresh groundwater discharge. Although groundwater supplies nutrients into the water column and contributes to primary productivity in nearshore coasts, there is little quantitative evidence concerning nutrient supply via groundwater discharge and nutrient assimilation by phytoplankton. In the study, we conducted the field survey at the sandy beach along the Chokai volcano coast in August 2020. Here we assessed (1) allochthonous nutrient fluxes via meteoric fresh groundwater (FGW), marine recirculated groundwater (RGW), and offshore seawater, and (2) the net primary productivity (NPP) of phytoplankton. The mass balance models of salt, ^{222}Rn, and ^{224}Ra showed that the total meteoric fresh groundwater discharge was 248 m^3 d^{-1} composed of two pathways: springs (~90%) and seeps (~10%). Recirculated marine groundwater discharge reached 2881 m^3 d^{-1}. Total allochthonous nutrient fluxes of dissolved inorganic nitrogen (DIN), phosphorous (DIP), and silica (DSi) were 25.0 mol d^{-1}, 1.4 mol d^{-1}, and 642.0 mol d^{-1}, respectively. RGW occupied 62% of total DIP flux and 78% of total DSi flux, while FGW occupied 49% of total DIN flux. The average NPP measured at six sites was 0.35±0.06 mg C L^{-1} d^{-1}, which equals 182.7 mol C d^{-1} on the beach scale. Based on the Redfield stoichiometric ratio, the assimilation rates of DIN, DIP, and DSi were 27.6 mol d^{-1}, 1.7 mol d^{-1}, and 25.9 mol d^{-1}, respectively. These results revealed that groundwaters could sustain a maximum of 74% (FGW=44%, RGW=30%) of DIN and 71% (FGW=22%, RGW=49%) of DIP assimilated by phytoplankton.

Keywords: Submarine groundwater discharge, Radioisotopes, Primary production

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Spatial and Temporal Patterns of the Physical and Biogeochemical Properties in the Nearshore Waters of Toyama Bay

*Eligio de Raus Maure[1], Genki Terauchi[1], Yasuyuki Harada[1]

1. Northwest Pacific Region Environmental Cooperation Center

Toyama Bay, located in the Japan Sea, has a very steep bottom topography with depths greater than 200 m confined to the narrow shelf. The outflow from rivers plays an important role in the physical and biological dynamics of coastal waters. Thus, it is important understand the influence of the river discharge on the spatial and temporal variations of material cycle and productivity in nearshore waters. Previous research using satellite observations of chlorophyll-a concentration suggested in the river discharge influenced waters, the phytoplankton bloom was characterized by a strong summer peak that correlated with river discharge. Although the river discharge can also be high or higher in seasons other than summer, it is not yet clear what is the influence on the spatial and temporal variations of phytoplankton during non-summer periods. In this study, we summarize the long-term in-situ observations collected by the Northwest Pacific Region Environmental Cooperation Center (NPEC) in Toyama Bay to gain insights of the influence of river discharge on the spatial and temporal patterns of physical and biogeochemical properties of the innermost waters. For this purpose, this presentation will discuss the spatial and temporal patterns obtained from monthly observations of temperature, salinity, chlorophyll-a concertation and dissolved inorganic nutrients (nitrogen and phosphorus), collected since 2004 to present in the Toyama Bay.

Keywords: Toyama Bay, Physical and Biogeochemical Properties , Nearshore Waters

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The relationship between the timing and scale of *Karenia mikimotoi* bloom and environmental factors in the western Bungo Channel of Seto Inland Sea, Japan

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1. Center for Marine Environmental Studies , Ehime University, 2. Japan Fisheries Research and Education Agency

In recent years, harmful algae bloom of *Karenia mikimotoi* has caused serious damage for aquaculture in the eastern part of the Bungo Channel in the Seto Inland Sea, and the damage of aquaculture has been more than a billion yen per year. To reduce the fisheries damage, we try to predict the dynamics of HAB of *K.mikimotoi* such as timing of the appearance and scale of HAB using the easily-obtainable environmental data. Previous studies suggested that intrusions of oceanic water from the Kuroshio affected the HAB (Kamada et al., 2010), and weather condition also affected the HAB (Onitsuka et al., 2021). However, these studies usually focused on the sporadic HAB events, and did not comprehensively analyze using the long-term HAB data in this region. We investigated the relationships among the HAB dynamics, the oceanic water intrusions and the weather conditions from 1997 to 2020, and considered whether the environmental factors can be used for the prediction of HAB dynamics.

We estimated the strength of the two types of the oceanic water intrusions (surface water intrusion: Kyucho, bottom water intrusion: Bottom intrusion) based on Takeoka et al., (2000) using the variabilities of the surface and bottom water temperatures at the Shiokojima monitoring station every ten days from April to September. For weather conditions, we used the daily hours of daylight and precipitation at the Uwajima AMEDAS station of Japan Meteorological Agency. For dynamics of HAB, we extracted the first appearance date and the maximum cell density of the year using the HAB report of the Seto Inland Sea, Fisheries Agency.

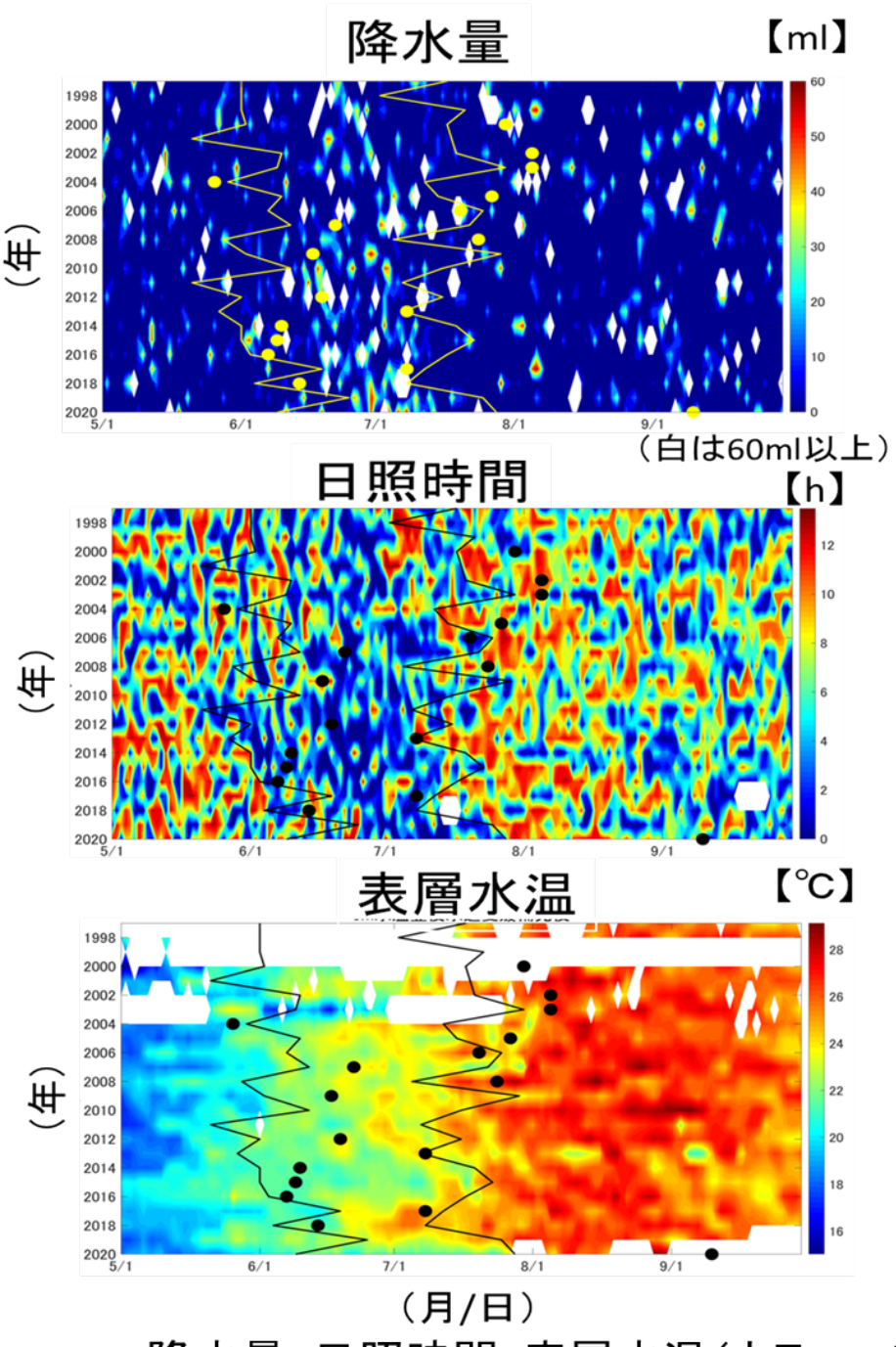
From the statistical analysis between the oceanic water intrusions and HAB dynamics, there was a significant correlation between the strength of Kyucyo in early May and the timing of appearance of HAB ($r = 0.60$, $p < 0.01$), while the strength of Bottom intrusion did not have any significant correlations. Focusing on the relationships between the weather condition and HAB dynamics, there was significant correlation between the precipitation in the early Jun and the maximum cell density of the year ($r = 0.58$, $p < 0.05$). However there was no clear relationship between the hours of daylight and the dynamics of HAB. From the view point of the growth condition for phytoplankton such as water temperature, the timing of water temperature rising in the spring has been getting faster from 2002 to 2016, and the timing of HAB also has become faster in this period. It was found the significant correlation between the arrival date of 20˚C at the surface water and the first appearance date ($r = 0.52$, $p < 0.05$), and the arrival date of 20˚C usually observed in May in this region. These results suggested that the strength of Kyucho in the early May and the arrival date of 20˚C at the surface water in May controlled the timing of appearance of HAB, and precipitation in early Jun affected the scale of HAB.

In this study, we found three important environment factors that can be used for prediction of the dynamics of HAB. First was the strength of Kyucho in early May, second was the arrival date 20˚C at the surface water in May, and third was precipitation in early Jun. These environmental factors are easily obtained from the website of Japan Meteorological Agency and the Uwa-Sea water temperature information system “*You see U-Sea*”. We suggest the step-by-step prediction of the dynamics of HAB of

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K. mikimotoi using the easily-obtainable environmental data from 1-2 months before the appearance of HAB.

Keywords: Karenia mikimotoi, Bungo Channel, open ocean water intrusion, weather condition, marine condition



降水量・日照時間・表層水温（カラーコンタ）
梅雨入り/終わりの時期（縦線）・赤潮発生日（点）の経年（縦軸）
及び時間変化（横軸）

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Continuous monitoring and future projection of ocean warming, acidification, and deoxygenation on the subarctic coast of Hokkaido, Japan

*Masahiko Fujii[1,2], Shintaro Takao[3], Takuto Yamaka[2], Tomoo Akamatsu[2], Yamato Fujita[2], Masahide Wakita[4], Akitomo Yamamoto[5], Tsuneo Ono[6]

1. Faculty of Environmental Earth Science, 2. Graduate School of Environmental Science, Hokkaido University, 3. National Institute for Environmental Studies, 4. Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology, 5. Japan Agency for Marine-Earth Science and Technology, 6. Japan Fisheries Research and Education Agency

As the ocean absorbs excessive anthropogenic CO_2 and ocean acidification proceeds, it is thought to be harder for marine calcifying organisms, such as shellfish, to form their skeletons and shells made of calcium carbonate. Recent studies have suggested that various marine organisms, both calcifiers and non-calcifiers, will be affected adversely by ocean warming anddeoxygenation. However, regardless of their effects on calcifiers, the spatiotemporal variability of parameters affecting ocean acidification and deoxygenation has not been elucidated in the subarctic coasts of Japan. This study conducted the first continuous monitoring and future projection of physical and biogeochemical parameters of the subarctic coast of Hokkaido, Japan. Our results show that the seasonal change in biogeochemical parameters, with higher pH and dissolved oxygen (DO) concentration in winter than in summer, was primarily regulated by water temperature. The daily fluctuations, which were higher in the daytime than at night, were mainly affected by daytime photosynthesis by primary producers and respiration by marine organisms at night. Our projected results suggest that, without ambitious commitment to reducing CO_2 and other greenhouse gas emissions, such as by following the Paris Agreement, the impact of ocean warming and acidification on calcifiers along subarctic coasts will become serious, exceeding the critical level of high temperature for three months in summer and being close to the critical level of low saturation state of calcium carbonate for two months in mid-winter, respectively, by the end of this century. The impact of deoxygenation might often be prominent assuming that the daily fluctuation in DO concentration in the future is similar to that at present. The results also suggest the importance of adaptation strategies by local coastal industries, especially fisheries, such as modifying aquaculture styles.

Keywords: ocean acidification, deoxygenation, subarctic, coasts, mitigation, adaptation

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.07_1

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Makoto Yamada(Faculty of Economics, Ryukoku University)

Substances from land which are brought by river and/or submarine groundwater discharge are important for the process of biological production in coastal areas. This session focuses on land-ocean interactions through water cycle. The aim of this session is to create interdisciplinary discussions on the research of connectivity of ecosystems, water cycles in terrestrial and coastal areas, fishery resources and biodiversity. Comprehensive discussion on the mechanisms that promote productivity and biodiversity in coastal ecosystems will be made from the viewpoint of land-ocean interactions. Presentations on water-material cycle in terrestrial and coastal areas, fishery resources, biodiversity and connectivity of the ecosystems are encouraged.
A companion session proposed as "Coastal Ecosystems - 2. Coral reefs, seagrass meadows, and mangroves" focuses on benthic communities in shallow-water ecosystems such as coral reefs, seagrass meadows and mangroves and is dedicated to promote researches on comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration. Main focuses of these two sessions are different. However, there are much of information that covers both sessions. Scientists who work on the related field will be able to obtain information and share them with other scientists if they attend to both of these sessions.

[ACG40-P01] Spatial extent of groundwater-derived heat in coastal area of volcanic sandy beach

*Makoto Yamada[1], Ryo Sugimoto[2], Toshimi Nakajima[2] (1.Faculty of Economics, Ryukoku University, 2.Faculty of Marine Biosciences, Fukui Prefectural University)

[ACG40-P02] Effects of fresh groundwater springs on phytoplankton primary productivity in a volcanic sandy beach

Kana Harada[1], *Ryo Sugimoto[1], Toshimi Nakajima[1], Osamu Tominaga[1] (1.Faculty of Marine Biosciences, Fukui Prefectural University)

[ACG40-P03] Spatial variation of ^{222}Rn concentration in river water and groundwater in the coastal area of Tokyo Bay

*Hiroya Kondo[1], Yu Umezawa[1], Misaki Ikari[1], Yosuke ONO[1], Shigeyoshi Otosaka[2], Muneoki Yoh[1] (1.Tokyo University of Agriculture and Technology , 2.Tokyo University)

Spatial extent of groundwater-derived heat in coastal area of volcanic sandy beach

*Makoto Yamada[1], Ryo Sugimoto[2], Toshimi Nakajima[2]

1. Faculty of Economics, Ryukoku University, 2. Faculty of Marine Biosciences, Fukui Prefectural University

Fresh groundwater from coastal areas provides nutrients to the sea and influences coastal ecosystems, but such fresh groundwater also provides thermal energy as well as chemical components. In contrast to seawater, groundwater has thermal characteristics that do not change significantly throughout the year. In other words, compared to seawater, cold water flows in during the summer and warm water flows in during the winter. However, the actual situation of the heat supplied by such groundwater is incompletely understood. In this study, we measured the surface temperature distribution of the sandy beach area and the sea area by a drone equipped with a thermal camera at the beach along the coast of Chokai Volcano in August 2020, and verified the spatial extent of groundwater-derived heat. In addition, the amount of heat flowing into the coastal zone was estimated from the freshwater inflow and temperature. Groundwater discharge in the sandy beach area was mainly observed on land, and no discharge from the seabed was observed. Groundwater from the land area flowed a few meters on the surface and then flowed into the sea. The groundwater temperature immediately after the discharge was about 9 deg. C, but it became about 12 deg. C while flowing on the surface and flowed into the sea. In the sea area, the sea water temperature range from 20 to 25 deg. C was extended to about 50 m off the shoreline. Since the actual seawater temperature measured offshore was about 28 deg. C, it is thought that a seawater temperature area of 20 to 25 deg. C was formed due to the low temperature water flowing in from the land. The area of the sea affected by groundwater-derived heat was about 13,000 m^2 (about 300 m north-south and 50 m east-west).The amount of heat flowing from the groundwater into the sea was estimated to be about -16 GJ/day. These results indicate that groundwater discharged at the sandy beach plays a role in lowering the seawater temperature in a certain range of coastal areas during the summer.

Keywords: Groundwater, Coastal Area, Heat Influx, Thermal Image, Drone

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Effects of fresh groundwater springs on phytoplankton primary productivity in a volcanic sandy beach

Kana Harada[1], *Ryo Sugimoto[1], Toshimi Nakajima[1], Osamu Tominaga[1]

1. Faculty of Marine Biosciences, Fukui Prefectural University

Research on how SGD nutrients impact marine biota has increased in recent years. The documented response of marine organisms to SGD is quite variable and site-specific, and can be positive or negative from a population or community perspective. Additionally, the response to SGD is sometimes unclear and could change depending on the specific location or time of the year. The most documented response to SGD-derived nitrogen and phosphorus loading is related to increasing the primary productivity of phytoplankton or microphytobenthos. However, in some cases, no response was found near sites receiving fresh groundwater springs, indicating SGD loading does not always induce an increase in primary productivity. Here, we present the phytoplankton primary productivity around fresh groundwater springs in the Chokai volcano coast assessed by the field experiments. Although fresh groundwater springs were significant nutrient sources, the primary productivity of phytoplankton decreased with increasing groundwater impact, possibly due to physical and physiological disturbances such as low salinity and temperature.

Keywords: Submarine groundwater discharge, 13C isotope tracer, Field experiment

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Spatial variation of ^{222}Rn concentration in river water and groundwater in the coastal area of Tokyo Bay

*Hiroya Kondo[1], Yu Umezawa[1], Misaki Ikari[1], Yosuke ONO[1], Shigeyoshi Otosaka[2], Muneoki Yoh[1]

1. Tokyo University of Agriculture and Technology , 2. Tokyo University

It is important to correctly assess the source and amount of freshwater-derived nitrogen and phosphorus that enter from the land to shallow coastal areas. However, it is not possible to distinguish the contributions of groundwater and river water based only on salinity changes, and the impact of groundwater inflow on shallow coastal ecosystems has not been evaluated in the Tokyo Bay. Therefore, we aimed to (1) investigate the spatial distribution of ^{222}Rn in groundwater and river water in the coastal area of Tokyo Bay, and to explore the factors causing its variation and (2) confirm the significant difference in ^{222}Rn concentration between river water and groundwater in the coastal area, and to show the effectiveness of ^{222}Rn as an indicator of groundwater discharge to Tokyo Bay. Groundwater, spring water, and river water were collected from September 2020 to January 2021 in the coastal area of Tokyo Bay from Miura Peninsula to Boso Peninsula. ^{222}Rn concentrations were analyzed using an radon detector based on electrostatic collection of alpha-emitters (RAD7), and general water quality was analyzed using ion chromatography. ^{222}Rn concentration in groundwater (dpm/L) was 43-477 in the innermost part of the bay, 9-1480 in the western part of the bay, and 134-386 in the eastern part of the bay. The concentrations of ^{222}Rn in river water (dpm/L) were 24-30 in the innermost part of the bay, 10-62 in the western part of the bay, and 21-50 in the eastern part of the bay. In all areas, the difference in ^{222}Rn concentrations between groundwater and river water was about one to two orders. The factor causing the difference in ^{222}Rn concentration in each location will be discussed in the viewpoint of geology, topography, groundwater residence time, soil porosity/crack, and underground redox state.

Keywords: ^{222}Rn, groundwater, coastal area

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.10 Zoom Room 10

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

Coastal marine ecosystems are complex open system interacting with surrounding watersheds, outer ocean, and the atmosphere, providing a wealth of various ecosystem services to human life. Simultaneously, they are also influenced strongly and often negatively by human activities. This session, together with a companion session dedicated for the water cycle and land-ocean interactions, aims to provide a platform for interdisciplinary discussion covering various aspects of frontiers in coastal ecosystem sciences. This session particularly focuses shallow-water benthic communities ranging from temperate to tropical regions, such as coral reefs, seagrass and macroalgal beds, mangroves, intertidal flats, and saltmarshes. All these communities are characterized by intrinsically high primary production, active material cycling, and biodiversity hot spots. However, increasing human demand for coastal marine resources and industrial development concentrating on coastal regions incur the risk of rapid degradation and diminishment. Comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration are urgently needed for such communities. This session is dedicated to organizing and promoting such research and management activities by sharing state-of-the-art science and technology among ecologists, geologists, geochemists, biogeographers, etc. Field-based and modeling studies concerning the following topics are especially welcome: material cycling and ecosystem functions; community connectivity; environmental changes such as global warming, ocean acidification, and sea-level rise; ecosystem services such as carbon sequestration, nutrient regulation, and fisheries production; broad-scale comparison; long-term ecological researches.

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

[ACG41-01] Introduction

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

[ACG41-02] Current status and future of ecosystem monitoring of seagrass beds in Japan and Asia: from basic field observation to the policy making and international planning.

★Invited Papers

*Takehisa Yamakita[1], Masakazu Hori[2], Yoshiyuki Tanaka[3], Misuzu Aoki[4], Masahiro Nakaoka[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Fisheries Research and Education Agency , 3.Hachinohe Institute of Technology, 4.Wetlands International Japan, 5.Hokkaido Univ)

11:10 AM - 11:30 AM JST | 2:10 AM - 2:30 AM UTC

[ACG41-03] Seagrass distribution and adaptation in a turbid tropical estuary (Brunei Bay, Borneo)

★Invited Papers

*Yasuaki Tanaka[1], Nadhirah Lamit[1] (1.Universiti Brunei Darussalam)

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

[ACG41-04] Detection of seagrass habitat in Himi, Toyama Bay using Google Earth Engine

*Genki Terauchi[1], Eligio de Raus Maure[1], Yasuyuki Harada[1], Wataru Matsumura[2], Tsuneo Maeda[3] (1.Northwest Pacific Region Environmental Cooperation Center, 2.Fisheries Research Institute, Toyama Prefectural Agricultural Forestry and Fisheries Research Center, 3.Toyama Prefectural Fisheries and Fishing Ports Division)

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

[ACG41-05] **Assessment of mangrove regeneration in abandoned aquaculture ponds using multi-temporal satellite imagery**

Kriselda Anna Delos Santos[2], Ram Avtar[1,2], *Masahiko Fujii[1,2] (1.Faculty of Environmental Earth Science, 2.Graduate School of Environmental Science, Hokkaido University)

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

[ACG41-06] Quantification of drag force and material trapping ability of a planted mangrove forest in the Philippines

*Yoshikai Masaya[1], Takashi Nakamura[1], Dominic Bautista[2], Eugene Herrera[2], Takuya Okamoto[1], Rempei Suwa[3], Kazuo Nadaoka[1] (1.School of Environment and Society, Tokyo Institute of Technology, 2.Institute of Civil Engineering, University of the Philippines, 3.Forestry Division, Japan International Research Center for Agricultural Sciences)

[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-CG Complex & General

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.10 (Zoom Room 10)

Coastal marine ecosystems are complex open system interacting with surrounding watersheds, outer ocean, and the atmosphere, providing a wealth of various ecosystem services to human life. Simultaneously, they are also influenced strongly and often negatively by human activities. This session, together with a companion session dedicated for the water cycle and land-ocean interactions, aims to provide a platform for interdisciplinary discussion covering various aspects of frontiers in coastal ecosystem sciences. This session particularly focuses shallow-water benthic communities ranging from temperate to tropical regions, such as coral reefs, seagrass and macroalgal beds, mangroves, intertidal flats, and saltmarshes. All these communities are characterized by intrinsically high primary production, active material cycling, and biodiversity hot spots. However, increasing human demand for coastal marine resources and industrial development concentrating on coastal regions incur the risk of rapid degradation and diminishment. Comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration are urgently needed for such communities. This session is dedicated to organizing and promoting such research and management activities by sharing state-of-the-art science and technology among ecologists, geologists, geochemists, biogeographers, etc. Field-based and modeling studies concerning the following topics are especially welcome: material cycling and ecosystem functions; community connectivity; environmental changes such as global warming, ocean acidification, and sea-level rise; ecosystem services such as carbon sequestration, nutrient regulation, and fisheries production; broad-scale comparison; long-term ecological researches.

10:45 AM - 10:50 AM

[ACG41-01]Introduction

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Current status and future of ecosystem monitoring of seagrass beds in Japan and Asia: from basic field observation to the policy making and international planning.

*Takehisa Yamakita[1], Masakazu Hori[2], Yoshiyuki Tanaka[3], Misuzu Aoki[4], Masahiro Nakaoka[5]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Fisheries Research and Education Agency , 3. Hachinohe Institute of Technology, 4. Wetlands International Japan, 5. Hokkaido Univ

With the increasing interest in the global environment in recent years, essential observation variables of ecosystems and environments have been examined in international frameworks such as GEO, GOOS, and MBON. There is growing momentum for monitoring and data integration. In Japan monitoring of coastal ecosystems has been conducted a couple of times around the 1990s as the nationwide Green Census conducted by the Ministry of the Environment. However nationwide surveys have not been conducted since then until recently. On the other hand, annual surveys to know temporal changes of ecosystems have been conducted as Monitoring sites 1000 program since 2008 and continuing. In the Asia-Pacific region, there have been a couple of surveys and monitoring programs from Japan, Europe, and the United States. In some countries, surveys also have been conducted by domestic organizations. These data are aggregated in recent years (Fortes et al. 2018; Sudo and Nakaoka 2020). In addition, new analysis and research methods such as deep learning, Drone, and environmental DNA are expected to be used. At the same time, the IPBES is considering the assessment of Nature's Contributions to People (NCP) and the assessment of future projection of such effects under socio-economic scenarios (such as SSP).

In this report, we will review the above situation and describe the current status under the monitoring site 1000 program and future plans of international monitoring (Takeuchi et al. 2021) by focusing on the eelgrass. Secondly, as an example of a new monitoring method applied in the Asia-Pacific region, we introduce an application of deep learning for the extraction of seagrass bed change in Thailand. Finally, estimation of carbon fixation and its changes due to scenarios are introduced as examples of the application of obtained monitoring data which may be more important than simply indication of the crisis of the ecosystem itself.

As a result of the first subject, 10 years monitoring of seagrass beds showed significant impact caused by Tsunami and ground subsidence by the Great East Japan Earthquake in 2011 on the Tohoku region. In addition, trends of increase or decrease of the seagrass area were recorded in several survey points. However, there was no nationwide trend of change and the trends differed from point to point and differed by the spatial resolution. We also identified signs of rapid changes in some regions. For example, a disappearance of seagrasses after a typhoon in Ibusuki, Kagoshima, and a sudden decrease after a heatwave in the intertidal zone of Futtsu, Tokyo Bay.

The classical monitoring by field survey can be conducted only at a limited number of sites. Remote sensing is an approach to detect changes through more extensive and long-term monitoring. As a result of this second subject, we analyzed past aerial photo images using deep learning and showed that even black and white (grayscale) images can be used to extract seagrass beds with higher accuracy than that previously possible. For example, in the Hat Chao Mai National Park, Trang, Thailand, our analysis detected that changes in the flow path of the small channels from the mouth of the river were a major factor in the changes of seagrass (Yamakita et al. 2019).

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Lastly, as an example of how to utilize and evaluate the results of such monitoring, an estimate of carbon fixation based on information on the nationwide distribution of seagrass/algal beds in Japan is presented. As a result, high values were found in narrow areas with a large area of the beds, and they were sparsely distributed throughout the country, mainly in bays.In addition, we examined future changes of the bed area by scenario. The results indicate that future changes are not only along climate gradients but may also be regionally different (Yamakita et al. 2020; Hori and Yamakita 2021). It is important to consider the regional features of these ecosystem services when planning for development or conservation.

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Keywords: Asia-Pacific Marine Biodiversity Observation Network (AP-MBON), Ecosystem Service, Nature's Contributions to people, Remote sensing, in-situ observation, Zostera marina

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Seagrass distribution and adaptation in a turbid tropical estuary (Brunei Bay, Borneo)

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Seagrass studies have been predominantly conducted in coastal marine environment such as coral reefs, but estuarine seagrass have been behind in research because of its lower abundance. However, the uniqueness of seagrass physiology or adaptation to the environment would be more exerted in estuaries, where water and sediment properties are not stable compared to marine environment. In order to get a better understanding of estuarine seagrass, recent studies on seagrass and water properties at the tropical estuary, Brunei Bay, Borneo are overviewed in this presentation. A total of eight species of seagrass have been recorded in this estuary during 2016-2019, and most of them were found at intertidal zones because the Brunei estuarine water is turbid and sufficient light is not available at subtidal zones. Among the eight species, *Halodule pinifolia* was most tolerant to muddy sediment conditions, while *Halophila minor*, *Halophila ovalis*, and *Thalassia hemprichii* preferred a relatively coarse sediment. Three species (*Halodule pinifolia*, *Halodule uninervis*, and *Halophila beccarii*) were found most upstream, where the surface water salinity fluctuated between 8.5-21. Laboratory experiments showed that *Halophila ovalis*, which is now found only in the downstream estuary, could also survive the conditions of this most upstream seagrass habitat. The spatial and temporal variations in basic water properties showed a wide range of salinity, pH, and dissolved oxygen from the upstream river to the downstream estuary. In particular, the upstream pH was lowest for the estuaries recorded in Southeast Asia. Because Brunei is covered with much more pristine forest than neighboring countries, surface and groundwater discharged from the abundant forest would be contributing to forming this unique gradient of water properties along the estuary. Seagrass has adapted to this environmental gradient using its species-specific physiological advantage. Amid continuing coastal disturbance such as dredging, upstream estuary may function as a shelter for seagrass and therefore needs to be carefully monitored for conservation of the ecosystem.

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Detection of seagrass habitat in Himi, Toyama Bay using Google Earth Engine

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Extent of seagrass habitat was mapped in coastal zone of Himi area in Toyama Bay using Seagrass Mapper, a web-based tool for mapping coastal habitats built upon Google Earth Engine (GEE). Results of field survey of sea floor conducted by an underwater video camera in June in 2018 were used to train satellite image of July 15, 2018 taken by Worldview-110 camera on board Worldview 2 satellite for its segmentation. The areas of seagrass beds in Himi were then estimated by the random forest supervised classification method. The estimated area of seagrass habitat was then compared with the report from the Fisheries Research Institute of Toyama Prefectural Agricultural Forestry and Fisheries Research Center published 2011. The study shows that removal of effects of water column by the Bottom Reflectance Index method better estimates area of seagrass habitats especially in deeper water.

Keywords: seagrass, Google Earth Engine, Mapping

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Assessment of mangrove regeneration in abandoned aquaculture ponds using multi-temporal satellite imagery

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Mangroves are highly productive forest ecosystems that can recolonize their habitat after a major disturbance, such as land use conversion. They provide vital ecosystem services, including shoreline protection and habitat for other organisms, that are dependent on their size and spatial arrangement. Globally, mangrove forests have decreased in area and have become fragmented, especially in Southeast Asian regions where aquaculture is a major driver of loss. This study conducted a spatiotemporal analysis of mangrove forest change in relation to aquaculture pond development in Panguil Bay, southern Philippines, using 30m spatial resolution satellite images. It also mapped abandoned aquaculture ponds that have been recolonized by mangroves. The study analyzed Landsat 5 and 8 images for 3 periods (1993-2000, 2000-2010, 2010-2020) and processed them on the Google Earth Engine cloud computing platform. Image classification was performed using a supervised random forest classification approach. Several water and vegetation indices, Grey Level Co-Occurrence Matrix (GLCM) texture measures, and shape metrics were tested as additional input features to the classifier. The area, perimeter, and number of patches of pond and mangrove classes were then computed to analyze their spatial pattern and determine the dominant land transformation process for each period. Based on a decision tree algorithm, the transformation processes of ponds and mangroves were identified.

A preliminary testbed result shows that the GLCM measures were useful in separating water from vegetation but did not add to the classification accuracy as this was already achieved by using the Automated Water Extraction Index (AWEI) and Enhanced Vegetation Index (EVI). AWEI and EVI were also effective in discriminating ponds from other water bodies. The Mangrove Vegetation Index (MVI) was effective in discriminating mangroves from other types of vegetation. Shape metrics did not improve the classification accuracy because of the low spatial resolution in relation to the objects being observed.

From 1993 to 2000, ponds lost 4km^2 in area while mangroves gained 12km^2. From 2000 to 2010, ponds gained 10km^2 while mangroves lost 4km^2. From 2010 to 2020, ponds lost 25km^2 while mangroves gained 17km^2. Mangroves that recolonized abandoned ponds made up 29 percent of the total mangrove area in the study site in 2020. The co-occurrence of pond retraction and mangrove expansion between 1993 and 2020 may be related to the enactment of Department Administrative Order 76 in 1987 which established mangrove buffer zone areas and Republic Act 7161 in 1991 which banned cutting of all mangrove species in the Philippines. During the 3 study periods, the sequence of landscape transformation processes for ponds was fragmentation (breaking up of area into separate patches), aggregation (patch mergence), and attrition (patch reduction). Meanwhile, mangroves underwent creation (patch formation), followed by attrition, and creation again. Despite the decrease in total pond area, pond aggregation and increase in the total volume of fish production from brackish water ponds indicates aquaculture pond system intensification. Intensive pond systems require less land but higher inputs of fertilizers and feed which can affect water quality in the area.

The study provides a workflow for mapping mangrove-recolonized ponds and spatial pattern change using open access data and a cloud-based platform. Since the workflow is implemented on Google Earth Engine, it can be replicated in other regions and used for mangrove scenario planning and policy making.

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The study’ s findings show that identifying spatial patterns can provide additional insight on the landscape dynamics. It also suggests the necessity of further studies on the conditions surrounding mangrove recolonization of ponds and the integration of spatial pattern analysis in mangrove monitoring.

Keywords: mangrove rehabilitation, aquaculture ponds, spatiotemporal change, remote sensing, Google Earth Engine

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Quantification of drag force and material trapping ability of a planted mangrove forest in the Philippines

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Mangrove forest is an important component of blue carbon ecosystem and plays a major role in climate change mitigation. The complex structures in mangroves' above-ground roots greatly attenuate flow and trap suspended materials on their surface which promote organic matter deposition in mangrove areas. This study aims to quantify the mangrove drag force and material trapping ability in a planted mangrove forest (Bakhawan Ecopark) in Panay Island, the Philippines. Field measurement was conducted in mono-specific stands of 17-year old *Rhizophora apiculata*. A precise measurement of water surface slope and velocity profiling were done to quantify the mangrove drag force from the momentum balance. We also measured the projected area of the above-ground roots of *R. apiculata* stands to estimate the value of drag coefficient (C_D). For quantification of the material trapping ability, trapping of floating mangrove leaf litter was monitored by a video camera. The results showed that the drag force by mangroves is much higher (around ten times) than the bed shear stress. While the estimated C_D values were close to those measured in other laboratory studies, the data suggested a water depth dependence of C_D which may be attributed to the vertical variations in the above-ground root projected area. Similarly, significant changes in the leaf litter dispersal patterns and the trapping efficiency with changing water depth were observed. The results may provide the first estimates of a set of field-derived drag coefficient, dispersion, and trapping ability of a planted mangrove forest.

Keywords: mangrove, drag, trapping, dispersion, blue carbon

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.10 Zoom Room 10

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

Coastal marine ecosystems are complex open system interacting with surrounding watersheds, outer ocean, and the atmosphere, providing a wealth of various ecosystem services to human life. Simultaneously, they are also influenced strongly and often negatively by human activities. This session, together with a companion session dedicated for the water cycle and land-ocean interactions, aims to provide a platform for interdisciplinary discussion covering various aspects of frontiers in coastal ecosystem sciences. This session particularly focuses shallow-water benthic communities ranging from temperate to tropical regions, such as coral reefs, seagrass and macroalgal beds, mangroves, intertidal flats, and saltmarshes. All these communities are characterized by intrinsically high primary production, active material cycling, and biodiversity hot spots. However, increasing human demand for coastal marine resources and industrial development concentrating on coastal regions incur the risk of rapid degradation and diminishment. Comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration are urgently needed for such communities. This session is dedicated to organizing and promoting such research and management activities by sharing state-of-the-art science and technology among ecologists, geologists, geochemists, biogeographers, etc. Field-based and modeling studies concerning the following topics are especially welcome: material cycling and ecosystem functions; community connectivity; environmental changes such as global warming, ocean acidification, and sea-level rise; ecosystem services such as carbon sequestration, nutrient regulation, and fisheries production; broad-scale comparison; long-term ecological researches.

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

[ACG41-07] Photoinhibition as a strategy for corals to mitigate heat stress and resulting ROS production

Reimi Terayama[1], *Agostini Sylvain[1], Takashi Nakamura[2], Tomihiko Higuchi[3], Ikuko Yuyama[5], Sung-Yin Yang[1], Toshihiro Miyajima[3], Hiroyuki Fujimura[4] (1.Shimoda Marine Research Center, University of Tsukuba, 2.Tokyo Institute of Technology, 3.AORI, University of Tokyo, 4.University of the Ryukyus, 5.Yamaguchi University)

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

[ACG41-08] Epizootiology of a temperate coral disease driven by thermal stress and macroalgal interactions

*Joshua Masataro Heitzman[1], Nicole Caputo[2], Sung-Yin Yang[1], Ben P Harvey[1], Sylvain Agostini[1] (1.Shimoda Marine Research Center, University of Tsukuba, 2.CIRI-FRAME, Alma Mater Studiorum, Università di Bologna)

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

[ACG41-09] Disease occurrence among various zonation: Status of Coral Reefs at Karimunjawa Island, Indonesia

*Dio Dirgantara[1], Rhesi Kristiana[2], Kuswadi bin Bunadi[3], Takashi Nakamura[1] (1.Faculty of Science, University of The Ryukyus, Nishihara, Okinawa 903-0213, Japan, 2.Marine Education and Research

Organisation, Karangasem, Bali 80853, Indonesia, 3.Karimunjawa National Park Office, Semarang, Central Java 50273, Indonesia)

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

[ACG41-10] Degraded turf algal systems are 'locked-in' by ocean acidification

*Benjamin Paul Harvey[1], Ro Allen[2,3], Sylvain Agostini[1], Linn J Hoffmann[2], Koetsu Kon[1], Tina C Summerfield[2], Shigeki Wada[1], Jason M Hall-Spencer[1,4] (1.Shimoda Marine Research Center, University of Tsukuba, 5-10-1 Shimoda, Shizuoka 415-0025, Japan, 2.Department of Botany, University of Otago, Dunedin, New Zealand, 3.The Marine Biological Association, Plymouth, Devon PL1 2PB, UK, 4.School of Biological and Marine Sciences, University of Plymouth, Plymouth PL4 8AA, UK)

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

[ACG41-11] Development of Numerical Model for Dynamics of Partial Pressure of CO_2 in Seawater Considering Effects of Stratification in the Yatsushiro Sea

*Naoki Saito[1], Bing Xiong[2], Hiroto Komori[2], Shinichiro Yano[2], Keisuke Nakayama[3], Katsuaki Komai[4], Hiroshi Yajima[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Kyushu University, 3.Kobe University, 4.Kitami Institute of Technology, 5.Shimane University)

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

[ACG41-12] Two-way nested blue carbon tracing simulation for elucidating fates of exported organic carbon from coastal ecosystems

*Takashi Nakamura[1], Faisal Amri[1], Lawrence Patrick Cases Bernardo[2], Kazuo Nadaoka[1], Masakazu Hori[3], Masami Hamaguchi[3], Toshihiro Miyajima[4] (1.School of Environment and Society, Tokyo Institute of Technology, 2.Graduate School of Environmental Science, Hokkaido University, 3. Japan Fisheries Research and Education Agency, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

Photoinhibition as a strategy for corals to mitigate heat stress and resulting ROS production

Reimi Terayama[1], *Agostini Sylvain[1], Takashi Nakamura[2], Tomihiko Higuchi[3], Ikuko Yuyama[5], Sung-Yin Yang[1], Toshihiro Miyajima[3], Hiroyuki Fujimura[4]

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Elevated water temperature due to climate change is causing massive bleaching events around the world. Two main factors that lead to coral bleaching are strong light and heat stress. Recent studies suggested that the bleaching response starting with a decrease in the carbon fixation due to heat damages of the Rubisco enzyme. Under strong light, this cause the photosystem electron transfer exceed the calvin cycle capacity. This excess in energy would cause ROS production. Photoprotective mechanisms such as photoinhibtion could mitigate the production of ROS, by restricting the electron transfer upstream carbon fixation. The loss of zooxanthellae could therefore be secondary protection mechanisms to reduce ROS production when other mechanisms are overwhelmed. Although both mechanisms reduce the photosynthesis rates of corals, photoinhibition could allow a more rapid recovery compare to the loss of zooxanthellae. We recently a theoretical model highlighting the dynamics of bleaching and the importance of photoinhibition as a protective mechanisms. However the lack of studies on the change in both photosystem efficiency and photosynthetic rates under natural diurnal cycle and temperature stress, limits the validity of the model. Here we present experimental data to validate and tune the theoritical model. Specimens of the corals *A. solitaryensis* and *P. heronensis* were incubated in the laboratory under diurnal cycle and three temperature treatment, 26ºC, 30ºC, and sustained 30ºC for one-week. In a first experiment we investigated the dynamics photosystem efficiency and, gross snd net photosynthesis using PAM fluorometry and microsensors techniques. Secondly we investigated the difference in oxygen and carbon based photosynthesis rates during bleaching under the same conditions of light and temperature. All corals bleached under the increased temperature treatment. Our results showed that high light intensity cause enhanced photoinhibition and in consequence, a reduction of the photosynthesis rates and electron transports rates in PSII. High temperature treatment enhanced photoinhibition and further decreased net and gross photosynthesis rates. The comparision of net photosynthesis rates in oxygen and carbon units showed a smaller difference under heat stress which was associated with enhanced photoinhibition. Our result suggests that photoinhibition can mitigate heat stress by reducing the difference between electron transfer rates from the photosystems and the capacity of the calvin cycles. Our observation mostly matches the previously develloped model, and will allow its tuning.

Keywords: coral bleaching, photoinhibition, reactive oxygen species

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Epizootiology of a temperate coral disease driven by thermal stress and macroalgal interactions

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Coral reefs are important marine ecosystems as they represent a large portion of global marine biodiversity. Increasing threats, including coral diseases, are resulting in their widespread loss. While coral diseases are well described in tropical and subtropical areas, none have been described in warm temperate areas. Here in Shimoda city, Japan, we report for the first time a coral disease outbreak in a warm temperate marginal coral community. The disease gross lesion is characterized by a white mat formation on the temperate coral species *Porites heronensis*, with infected coral tissue resulting in mortality. Based on its visual characteristics, we have tentatively named this disease “White Mat Syndrome” (WMS). Field surveys were conducted to determine disease incidence, the number of unique new disease occurrences weekly, and prevalence, the population of coral affected by WMS. Disease outbreaks were observed to only occur during the warm summer months from August to November, suggesting an association with high temperatures. The WMS microbial mat was analyzed, revealing a bacterial consortium mainly comprised of *Thiothrix* spp., a sulfide-oxidizing bacterium. During yearly disease outbreaks, the common macroalgae *Gelidium elegans* was associated with 75% (30/40) of WMS occurrences observed suggesting its role as a potential contributory factor. This macroalgae often overgrows corals and was observed to senesce and trap sediment during the warm summer months. Furthermore, we showed the presence of *Thiothrix* spp. within the microbial community of sediment-trapping *G. elegans*. Incubation experiments to test both the effect of seasonal temperature (winter and summer) and the pathogenicity of potential contributory factors (WMS microbial mat, sediment-trapping *G. elegans* and sediment) were conducted. These experiments confirmed that high temperature is required for disease proliferation, and that sediment-trapping *G. elegans* acts as a pathogen reservoir for WMS. As warming waters and increased macroalgal interactions contribute to WMS pathogenicity, future outbreaks may increase in duration and virulence. With tropical and subtropical coral reefs continuing to degrade into algal-dominant ecosystems, algal-mediated diseases like WMS may increase in number and spread. In this context, warm temperate marginal coral community may provide clues for future management strategies of both future algal dominated coral reefs and marginal coral communities.

Keywords: *Porites heronensis*, coral disease, warm temperate, marginal coral communities, *Gelidium elegans*, *Thiothrix* spp.

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Disease occurrence among various zonation: Status of Coral Reefs at Karimunjawa Island, Indonesia

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Coral reef ecosystems are known to have high rates of endemism and being considered as “biodiversity hotspots” (Roberts, 2002). However, coral reefs in the Anthropocene are also being subjected to global as well as local stressors. Local disturbances such as overfishing, habitat destruction, and pollution along with the impacts of climate change such as coral bleaching have been identified as major threats to coral reefs. Coral diseases have been recognized as important drivers to the coral decline worldwide (Weil et al., 2012) where the pathogenic diseases take advantage of the corals that are under other stressors to increase their abundance, becoming more prevalent in degraded environments (Muller et al., 2018). Located within the biodiversity hotspot, coral reefs in Karimunjawa,Indonesia has been surveyed to assess the status since 2000. Although different approaches were utilized to reveal the condition of Karimunjawa reefs, reports on coral disease incidence are scarce. Located in the northern part separate from the mainland Indonesia, Karimunjawa has been utilized for tourism and marine culture activity that may have been dragged down its pristine reef ecosystem. Additionally, there is almost no report available that clarify which of coral genera in Karimunjawa are susceptible to various diseases. To emphasize how far the Karimunjawa reef's current condition altered, disease prevalence; coral genus diversity and coral cover were assessed at 6 sites within three different zones (Tourism, Aquaculture and Protected zones) using two assessment methods (Point Intercept Transect method and Quadrat method with digital image analysis by Coral Point Count with Excel extension). Coral cover (CC) and disease prevalence (DP) results from all site shown strong similar trendline among methods with average PIT results 56.5%±7.89 (CC); 8.23%±3.11(DP) and CPCe results 43.21%±5.91(CC); 9.66%±4.55(DP) respectively. Thus, multivariate and ordination statistics were performed to construct comprehensive analysis on disease prevalence and zonation. Disease prevalence slightly differs from each zone while similar coverage on hard corals has been detected from all site. However, a strong correlation between genus diversity and disease prevalence has been detected in both tourism and aquaculture zones. There are several types of diseases that have not been reported previously from the Karimunjawa were found in these study sites. There are two types of coral killing sponges of *Terpios hoshinota* and *Chalinula nematifera* that haven’t been reported previously from the Karimunjawa were found in these study sites. These findings indicated Karimunjawa reefs may have been impacted by human activities. We suggest to continue periodical evaluation in order to keep comprehensive assessment-based on-site zonation as useful tools to guide a better conservation for Karimunjawa reefs in the future.

Keywords: Conservation, Disease Prevalence, Genus Diversity, Karimunjawa, Zonation

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Degraded turf algal systems are ‘locked-in’ by ocean acidification

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Human activities are rapidly changing the structure and function of coastal marine ecosystems. Large-scale replacement of kelp forests and coral reefs with turf algal mats is resulting in homogenous habitats that have less ecological and human value. Ocean acidification has strong potential to substantially favour turf algae growth, which led us to examine the mechanisms that stabilise turf algal states. Here we show that ocean acidification promotes turf algae over corals and macroalgae, mediating new habitat conditions that create stabilising feedback loops (altered physicochemical environment and microbial community, and an inhibition of recruitment) capable of locking turf systems in place. Such feedbacks help explain why degraded coastal habitats persist after being initially pushed past the tipping point by global and local anthropogenic stressors. An understanding of the mechanisms that stabilise degraded coastal habitats can be incorporated into adaptive management to better protect the contribution of coastal systems to human wellbeing.

Keywords: Regime Shifts, Feedback Loops, Hysteresis, CO2 Seeps, Turf Algae



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Development of Numerical Model for Dynamics of Partial Pressure of CO_2 in Seawater Considering Effects of Stratification in the Yatsushiro Sea

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About 55 % of the carbon fixed by living organisms on the Earth is that fixed by marine organisms, so-called "*blue carbon*". In particular, coastal areas with vegetation such as seagrass are considered to be important in reducing atmospheric CO_2.
On the other hand, estimates of the amount of CO_2 absorbed by coastal areas are currently uncertain. In general, the partial pressure of CO_2 in seawater (pCO_2) is used to calculate the amount of CO_2 absorbed from the atmosphere to seawater. However, pCO_2 in the coastal zone fluctuates greatly in space and time affected by flow, biological activities, *etc*. Therefore, in order to improve the accuracy of estimating the amount of CO_2 absorbed in coastal areas, it is necessary to accumulate data on pCO_2 based on various conditions such as flow and ecosystem (Macreadie *et al*., 2019).
It has also been reported by Kone *et al*. (2008) and others that pCO_2 fluctuates with the development of stratification. However, there are few examples of field studies and model development focusing on the relationship between stratification and pCO_2.
In this study, we conducted the following to obtain basic knowledge on CO_2 dynamics in coastal areas. First, we conducted a field survey on pCO_2 under three stratification conditions. Then, based on the survey results, a numerical model that can reproduce the pCO_2 dynamics under each stratification condition was developed. Furthermore, using the model, we made an attempted to elucidate the spatio-temporal variability of CO_2 absorption in coastal areas. The Yatsushiro Sea, the target area of this study, is characterized as a temperate area where both seagrasses and corals live.
The survey sites were selected near the mouth of the Kuma River, where strong stratification could develop. The survey dates were August 26, 2018 (weak stratification period), December 7, 2018 (mixed period), and August 2, 2019 (strong stratification period). Measured items were vertical distribution of water temperature, salinity, *etc*. from water quality measurement, and the dissolved inorganic carbon concentration (DIC) and total alkalinity (TA) from water samples. pCO_2 was calculated from water temperature, salinity, DIC, and TA from the chemical equilibrium relationship of the carbon system.
A numerical model of pCO_2 was developed using Delft3D, a general-purpose numerical model for coastal flow. The model consists of a flow model and an ecological model. The horizontal resolution is about 250 m, and the vertical resolution is 17 layers in the σ - coordinate system. The components of the ecological model were phytoplankton, nutrients, particulate organic matter, dissolved oxygen DO, DIC and TA. The main processes are photosynthesis, respiration, and death of phytoplankton, sedimentation and mineralization of organic matter, nitrification, and re-aeration.
The vertical fluctuation of pCO_2 with stratification development was revealed from the field survey. Based on the observations, a numerical model of pCO_2 dynamics was developed. The model was able to reproduce the vertical distribution of pCO_2 under each stratification conditions. The model results confirmed that the CO_2 sinks around the mouth of the river fluctuated significantly in space and time with the river discharge. In addition, the following two effects of saline stratification on CO_2 absorption in coastal areas were confirmed; (1) After a flood, the saline stratification develops and river water

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concentrates in the surface layer, which accelerates the release of CO_2 from seawater. (2) As mixing progresses and the saline stratification weakens, a large layer of phytoplankton appears on the surface, and CO_2 absorption into the seawater is promoted by photosynthesis.
In the future, it is necessary to investigate the effects of seagrass and coral inhabitation, through field observations and to incorporate these effects into the model. These studies are expected to contribute to the understanding of blue carbon dynamics in coastal areas.

Keywords: partial pressure of CO2 in seawater, air-sea CO2 flux, ecological model, blue carbon

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Two-way nested blue carbon tracing simulation for elucidating fates of exported organic carbon from coastal ecosystems

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A considerable amount of the organic carbon produced by coastal organisms such as seagrasses, mangroves, corals, is flushed out offshore, and may be potentially important for the global carbon cycles. However, the fates of the effused organic carbon of coastal origin are not well-known due to limited quantitative observation. In this study, a numerical simulation model for tracing the exported organic carbon was developed for elucidating the fates of the exported organic carbon.

The model composed of an ocean circulation model based on the Coupled-Ocean-Atmosphere-Wave-Sediment Transport (COAWST) Modeling System (Warner et al., 2010) and a newly developed low-trophic ecosystem model (modified from Nakamura et al., 2018). The low-trophic ecosystem model has the following compartments: dissolved inorganic carbon (DIC), total alkalinity (TA), dissolved oxygen (DO), ammonium (NH_4), nitrate (NO_3), phosphate (PO_4), labile dissolved organic carbon (LDOC), nitrogen (LDON), and phosphorus (LDOP), refractory organic carbon (RDOC), nitrogen (RDON), and phosphorus (RDOP), coarse particulate organic carbon (CPOC), nitrogen (CPON), and phosphorus (CPOP), detritus type particulate organic carbon (DPOC), nitrogen (DPON), and phosphorus (DPOP), three functional groups of phytoplankton (dinoflagellates, diatoms, coccolithophorids), one functional group of zooplankton, and particulate inorganic carbon (PIC; dead $CaCO_3$ shell of coccolithophorids). An additional carbon isotope module along with its compartments, such as DI^{13}C, RDO^{13}C, LDO^{13}C, CPO^{13}C, DPO^{13}C, and ^{13}C of the aforementioned phytoplankton, ^{13}C of zooplankton, and PI^{13}C, was incorporated into the model to trace the fates of the carbon. Isotope fractionations by all physical and biological processes were currently deactivated as the module was used for carbon tracing.

This model was applied to the Yaeyama Islands region, focusing on Nagura Bay, Ishigaki Island, for tracing organic carbon exported from the mangrove ecosystem around Nagura River. A two-grid nested configuration consisting of a coarser domain YAEYAMA1 (1.5 km grid resolution) covering the East-coast of Taiwan to Miyako Island and downscaled YAEYAMA2 (300 m grid resolution) covering the entire Ishigaki - Iriomote Island was used for the simulation. The dispersion process of the organic carbon from finer-scale to coarser-scale domain was tracked by applying two-way online nesting in the simulation.

In this simulation, completely 0% of carbon isotope is included in all compartments, and 100% of the CPOC as mangrove leaf carbon is marked as CPO^{13}C and released from the Nagura river mouth. Then the CPOC (CPO^{13}C) is dispersed by advection and diffusion. The carbon tracer model is able to capture the fates of the released CPOC including decomposition from CPOC to detritus to DIC, CPOC grazing and assimilation by zooplankton, detritus re-formation through organism mortality, and detritus deposition in ocean bottom sediment. This kind of carbon cycle was able to be chased and visualized by the carbon tracer. Simulation results also indicated a fraction of detritus that originated from mangrove leaves deposited into deeper water areas such as the Okinawa Trough after being dispersed from the Nagura

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River mouth. The amount of these mangrove-generated detritus, however, was much smaller than pelagic organism-generated detritus. Therefore, this modeling study suggests a challenge that might occur in detecting mangrove organic carbon from pelagic sediment core analysis by conventional techniques.

Keywords: blue carbon, exported organic carbon, numerical simulation

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.07_2

[A-CG41] Coastal Ecosystems -2. Coral reefs, seagrass and macroalgal beds, and mangroves

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

Coastal marine ecosystems are complex open system interacting with surrounding watersheds, outer ocean, and the atmosphere, providing a wealth of various ecosystem services to human life. Simultaneously, they are also influenced strongly and often negatively by human activities. This session, together with a companion session dedicated for the water cycle and land-ocean interactions, aims to provide a platform for interdisciplinary discussion covering various aspects of frontiers in coastal ecosystem sciences. This session particularly focuses shallow-water benthic communities ranging from temperate to tropical regions, such as coral reefs, seagrass and macroalgal beds, mangroves, intertidal flats, and saltmarshes. All these communities are characterized by intrinsically high primary production, active material cycling, and biodiversity hot spots. However, increasing human demand for coastal marine resources and industrial development concentrating on coastal regions incur the risk of rapid degradation and diminishment. Comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration are urgently needed for such communities. This session is dedicated to organizing and promoting such research and management activities by sharing state-of-the-art science and technology among ecologists, geologists, geochemists, biogeographers, etc. Field-based and modeling studies concerning the following topics are especially welcome: material cycling and ecosystem functions; community connectivity; environmental changes such as global warming, ocean acidification, and sea-level rise; ecosystem services such as carbon sequestration, nutrient regulation, and fisheries production; broad-scale comparison; long-term ecological researches.

[ACG41-P01] Skeleton microstructures and *in situ* colony morphometry analysis of the corals collected during Tara Pacific Expedition

*Guinther Hiromu Mitushasi[1], Yuko Kitano[2], Emilie Boissin[3], Serge Planes[3], Denis Allemand[4], Tara Pacific Consortium[1], Sylvain Agostini[1] (1.Shimoda Marine Research Center, University of Tsukuba, 2. National Institute of Environmental Science, Japan (Tsukuba), 3. CRIOBE, Universite de Perpignan (Perpignan), 4. Monaco Scientific Center (Monaco))

[ACG41-P02] Diversity of coral distributions and the difference in Sakiyamawan-Amitoriwan nature conservation area, Iriomote Island, Japan

*Shinya Shimokawa[1], Tomokazu Murakami[1], Hiroyoshi Kohno[2], Akira Mizutani[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Okinawa Reagional Research Center, Tokai University)

[ACG41-P03] Characteristics of water temperature changes and coral breaching in Amitori Bay, Iriomote Island, Japan

*Shinya Shimokawa[1], Tomokazu Murakami[1], Hiroyoshi Kohno[2], Akira Mizutai[2] (1.National Research Institute for Earth Science and Disaster Prevention, 2.Okinawa Reagional Research Center, Tokai University)

[ACG41-P04] Coral bleaching countermeasures by supplying metal-containing feed ~evaluation the effect at gene expression levels~

*Ikuko Yuyama[1], Naoko Yasuda[2], Sayaka Higa[2], Sung-Yin Yang[3], Sylvain Agostini [3], Tomihiko Higuchi[4], Toshihiro Miyajima[4], Takashi Nakamura[5], Hiroyuki Fujimura[2] (1.Yamaguchi University, 2.University of the Ryukyus, 3.University of Tsukuba, 4.The University of Tokyo , 5.Tokyo Institute of Technology)

[ACG41-P05] Linear and non-linear analysis for high temperature and acidification event in the Great Barrier Reef based on the observation in the Coral Sea

*Tatsuki Tokoro[1,2], Shin-ichiro Nakaoka[1], Shintaro Takao[1] (1.National Institute for Environmental Studies, 2.Port and Airport Research Institute)

[ACG41-P06] Stratigraphy of seagrass bed at Bise in Okinawa Island.

*Wataru Sano[1], Kazuhiko Fujita[2], Yoshikatsu Nakano[3], Shoko Hirabayashi[4], Yusuke Yokoyama[5], Yosuke Miyairi[5], Naoko Isomura[6], Hironobu Kan[1] (1.Kyushu Univ., 2.Univ. of the Ryukyus, 3.Okinawa Institute of Science and Technology Graduate University , 4.Rissho Univ., 5.Univ. of Tokyo, 6.National Institute of Technology, Okinawa College)

[ACG41-P07] **Applying DPSIR framework for blue carbon ecosystems assessment: The case of Busuanga Island, Palawan, Philippines**

*Jay Mar Dioquito Quevedo[1], Yuta Uchiyama[2], Ryo Kohsaka[2] (1.Tohoku University, 2.Nagoya University)

[ACG41-P08] Detecting mangrove- and seagrass-derived eDNA from deep-sea sediment around Yaeyama Islands: Implication for offshore blue carbon sequestration

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[ACG41-P09] Evaluation of the effect of differences in nitrogen loading on the chemical composition and decomposition characteristics of eelgrass(*Zostera marina*).

*Toru Miyata[1], Yu Umezawa[1], Takunari Ida[1], Yoshiki Horikawa[1], Makoto Watanabe[1], Shigeki Wada[2], Masahiro Nakaoka[3], Tomohiro Kuwae[4] (1.Tokyo University of Agriculture and Technology, 2.University of Tsukuba, 3.Hokkaido University, 4.Port and Airport Research Institute)

Skeleton microstructures and *in situ* colony morphometry analysis of the corals collected during Tara Pacific Expedition

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The taxonomy of scleractinian corals is still open to extensive debate due the high morphological variability among and within the numerous species. This variability can be associated with species plasticity and hybridization, phenotypic polymorphism, geographic variation and diverse environmental factors. Accurate and reproducible methods of taxonomic analysis are required for a better understanding of the distribution of coral communities and their response to climate change and anthropogenic stressors. Recent studies combining skeleton morphometry with genetic analysis have shown the relevance of landmark based skeleton morphometric analysis to identify coral species and the populations within. The Tara Pacific expedition collected more than 3000 samples from 30 different islands across two transects crossing the Pacific Ocean East-West and South-North. Three species, *Porites lobata*, *Pocillopora meandrina* and *Millepora platyphylla* were chosen for their relevance in the reef ecosystem and their presence across the whole Pacific. However, these species present great variations in their morphologies at both the colony and the skeleton levels making sampling and post-identification challenging. Here, we present the taxonomic identification of the corals collected during the Tara Pacific Expedition using morphometry landmark analysis of the coral colonies and their skeleton microstructures. The results will be further matched with the SNIPs based genotypes and linked with environmental and -omics data collected for the specimens.

Keywords: Tara Pacific, P. lobata, P. meandrina, skeleton morphometry, landmark analysis

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Diversity of coral distributions and the difference in Sakiyamawan-Amitoriwan nature conservation area, Iriomote Island, Japan

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The Sakiyamawan-Amitoriwan nature conservation area, Iriomote Island, is the only oceanic nature conservation area in Japan. The area has no access roads; therefore, it conserves a natural environment with very little human impact and various coastal marine ecosystems such as those containing reef-building corals and *Enhalus acoroides* (a kind of seagrass; its northern distribution limit is the ocean area surrounding the Yaeyama Islands, Japan). Sakiyama and Amitori bays are adjacent, but the coral distributions in both bays are largely different because of the difference of the geographical environmental gradients such as water depth, bay length and bay shape.
In this study, the difference of coral distributions between both bays are investigated from a view of diversity index (MacArthur and MacArthur, 1961, Clark & Warwick, 2001, McCune and Grace, 2002) and intermediate disturbance hypothesis (Connell, 1978) based on the results of coral distribution field survey, physical environmental observation such as wave height and soil particle number, and numerical simulations using the observation data that we have conducted since 2011 (e.g., Shimokawa et al., 2014, 2015, 2016, 2020).
In Amitori Bay, the diversity index (here, based on colony shapes) was at the maximum in the middle part of the bay, and intermediate disturbance hypothesis was realized by considering wave height and soil particle as external disturbance. Also, *Enhalus acoroides* is scarce and there is no large community. On the other hands, in Sakiyama Bay, the diversity index was at the maximum in the edge of coral reef and intermediate disturbance hypothesis was not realized. Also, *Enhalus acoroides* is distributed broadly from the inner part of the bay to the middle part of the bay. In the presentation, the reason of the difference between both bays is also stated from a view of the difference of the effect of soil particle inflow due to geographical environmental gradients between both bays.

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B2, 72, 1435-1440 (in Japanese with English abstract).
Shimokawa, S., T. Murakami and H. Kohno eds. (2020), Geophysical Approach to Marine Coastal Ecology -The Case of Iriomote Island, Japan, Springer, 273 pp.

Keywords: Reef building coral, Diversity index, Intermediate disturbance hypothesis

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Characteristics of water temperature changes and coral breaching in Amitori Bay, Iriomote Island, Japan

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Amitori Bay is located in the northeast region of Iriomote Island, Japan, and is a small bay but has a wide variety of environments with little human impacts and coastal ocean ecosystem such as reef building corals and mangrove forests. We have investigated the relationship between coral distributions and physical variables since 2011. In summer of 2016, a wide area breaching of the corals was caused also in the bay. The changes of water temperature in the bay are considered to have a large effect on the breaching.
In this study, the changes of water temperature in Amitori Bay are investigated from the observational data during 2014-2017. The results showed that no typhoon approached in this area in summer of 2016 caused high water temperature for a long term compared to the other years, and resulting the breaching of the corals. In the presentation, characteristics of seasonal changes of water temperature in Amitori Bay are also stated from the results of data analysis and numerical simulations.

Reference:

Shimokawa, S., T. Murakami and H. Kohno eds. (2020), Geophysical Approach to Marine Coastal Ecology -The Case of Iriomote Island, Japan, Springer, 273 pp.

Keywords: Reef building coral, Water temperature, Typhoon

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Coral bleaching countermeasures by supplying metal-containing feed ~evaluation the effect at gene expression levels~

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Under high temperature stress, the reactive oxygen species (ROS) generated from symbiotic algae triggers the coral bleaching response. There is a possibility that the antioxidant enzymes containing metal ions such as Fe, Mn, and Zn, have an effect on the mitigation of ROS stress. Therefore, we hypothesized that the supply of metal ions promotes antioxidant activity and mitigates the bleaching response. In this study, the corals were fed with a metal-containing diet, and investigated the effect on the bleaching response at gene expression level.

We used *Acropora hyacinthus* collected around Sesoko Island, and they were fed with Artemia and metal-fortified yeast. Furthermore, the coral was incubated at an increasing temperature, and physiological responses and gene expression change of coral and their symbiotic algae were investigated. Coral was fixed at the time point when the bleaching response was observed, and large-scale gene expression analysis by Next Generation Sequencing was performed. We identified 25,069 contigs derived from *Acropora hyacinthus* by de novo assembled of the short reads. Then, expression levels of each contigs were estimated, and the gene expression related to the physiological response of corals was investigated. Results showed that the expression level of genes related to proto-oncogene and CuZnSOD of corals was increased by temperature stress. [H1] These gene expression changes tended to be mitigated by feeding with artemia or yeast. Furthermore, a result of canonical correlation analysis (CCA) using the physiological data and the gene expression data showed that genes related to mucin metabolism and vitamin B12 were associated with the changes in symbiont density. Based on these gene expression levels, we discussed the effects of metal-containing diet on mitigating coral bleaching reactions.

Keywords: coral bleaching, feeding effect, RNA-seq

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Linear and non-linear analysis for high temperature and acidification event in the Great Barrier Reef based on the observation in the Coral Sea

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For predicting the health of coral reefs in the future, it is important to evaluate the impact of global fluctuations caused by the open ocean as well as the effect from the land area. For example, the widespread bleaching of the Great Barrier Reef (GBR) in 2016-2017 was attributed to the high temperature of seawater associated with El Nino event, but past El Nino events and GBR bleaching had not been necessarily linked. Therefore, the detailed analysis is required for future prediction of global fluctuation effects on coral reefs. In addition, the decrease in aragonite saturation state (Ω) due to the ocean acidification will lead to the inhibition of coral growth, but the study about the quantitative evaluation of Ωin coral reefs and the combined process with the high temperature event have not been enough at present.

In this study, we used the data in the Coral Sea, which corresponds to the oceanic endmember of GBR, from 2006 to 2018 observed by the National Institute for Environmental Studies (NIES) as the Volunteer Observation Ship program to identify the high temperature event and the Ωfluctuations in the GBR. In the analysis, the nonlinear analysis by machine learning (Random Forest and Gaussian Process) was applied to construct a regression model of the objective variables and extract the important explanatory variables. We used the Degree Heating Week (DHW; obtained from NOAA Coral Reef Watch), which is a high correlation index with the coral bleaching, and the Dissolved Inorganic Carbon concentration normalized to salinity of 35 (nDIC; calculated from the observation data of NIES), which is the main caution of the fluctuation of Ωas the objective variable of the high temperature event and the acidification, respectively.

The results of the regression model by Random Forest analysis are shown in Fig. 1. For the high temperature event, the atmospheric pressure on the Coral Sea was extracted as an important parameter in addition to the Southern Oscillation Index (SOI). This indicates that there are several meteorological patterns in the GBR during El Nino event, and that certain patterns, such as the increase in the amount of solar radiation, might cause the high temperature event in the GBR. It was also clarified that the fluctuation of Ωwas strongly influenced by the sea surface temperature and the concentration of atmospheric CO_2. However, the correlation with the former parameter is considered to be apparently significant because both the sea surface temperature and nDIC in the Coral Sea have increased by the recent global warming and acidification. No significant correlation was confirmed between the objective variables DHW and nDIC. This suggests that the high temperature and acidification in the GBR are independent phenomena each other. In the presentation, we will show the results of the linear regression analysis and will show more detailed analysis using the improved regression models.

Keywords: Great Barrier Reef, high temperature process, Acidification

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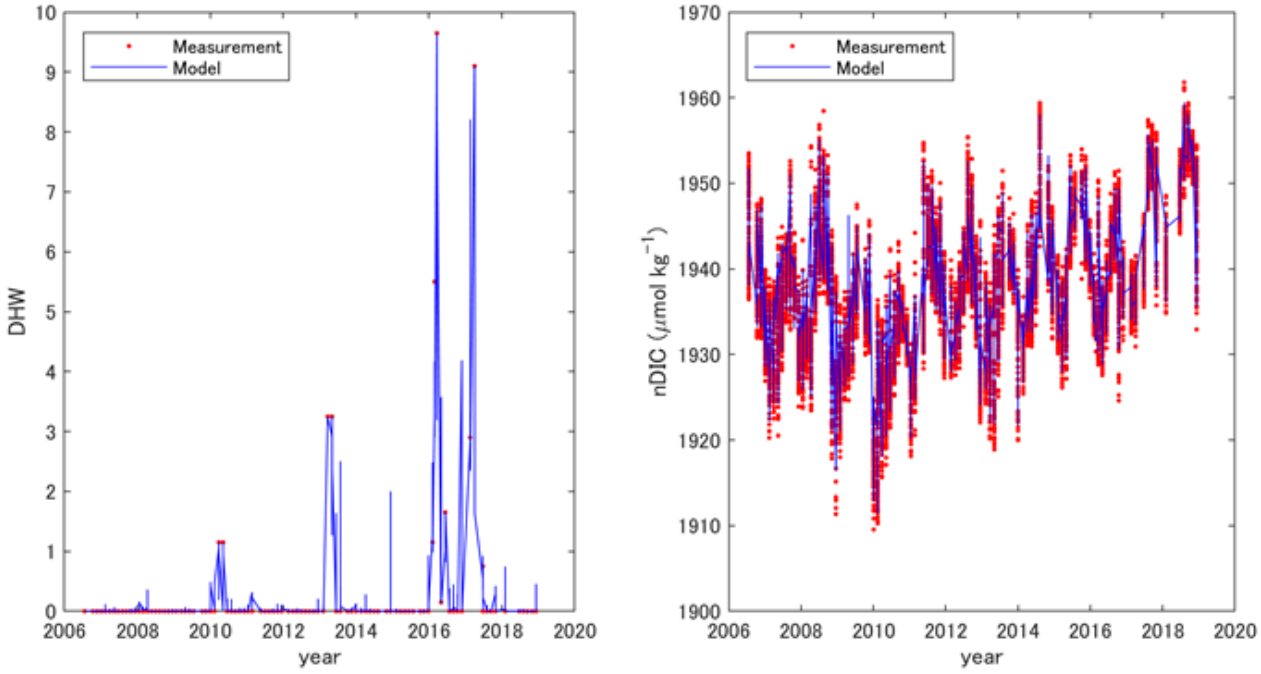


Figure 1
Results of regression model (blue) and the measurements (red);
DHW in GBR (left: r^2=0.98), nDIC in the Coral Sea (right: r^2=0.95).

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Stratigraphy of seagrass bed at Bise in Okinawa Island.

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Coral reef seagrass bed is a community of seagrass formed in the lagoon off the beach, where fish and benthic organisms live and spawn, and play a role in the carbon cycle in shallow coastal area (Nellemann et al., 2009; Unsworth et al., 2018).
The surface substrate of the seagrass beds in Bise, Okinawa Island, was muddy sand sediments and a living branch coral (*Montipora digitata*). It has been proposed that seagrass and coral are in a symbiotic relationship by the rhizome of *Thalasia hemprichii* is entwined with the underground part of Montipora digitata in this area (Ninomiya et al., 2016). In addition, past aerial photographs show that the almost seagrass beds in Bise was disappeared in the 1960s, but recovered rapidly after 1980s.
It is necessary to clarify how the seagrass beds, which is an ecologically highly unique place and is thought to be sensitive to environmental changes in the coral reef lagoon, has accumulated during the process of coral reef development in the Holocene. It is very important to conserve the seagrass beds and consider the factors that form the zonal trend of coral reefs including the seagrass beds.
In this study, we used the five sediment cores (maximum penetration depth 253 cm) collected from the seagrass beds in Bise by hand boring. We focused on coral fossils and large benthic foraminifera contained in the core sediments to clarify the sedimentary structure of the seagrass beds.
The top part of the core sediment (0-40 cm; 157 cm below MSL) was muddy sand sediments indicating seagrass bed. The bottom part below 86 cm was a coarse-graine sediment including many fossil corals (*Acropora* sp.), and 40-86 cm was a transition facies in which muddy sand including fossil *Acropora* fragments.
As a result, it was clarified that the habitat of branch coral (*Acropora* sp.) was buried by muddy sand sediments and gradually formed a modern seagrass beds.

Keywords: Seagrass beds, Coral reefs, Foraminifera, Intertidal flats, Ryukyus

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Applying DPSIR framework for blue carbon ecosystems assessment: The case of Busuanga Island, Palawan, Philippines

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Mangrove forests, seagrass meadows, and tidal marshes or collectively known as blue carbon ecosystems (BCEs) play important roles in reducing the risks and impacts of climate change through carbon sequestration and other essential ecosystem services. Despite this, records show that they are declining at various scales due to their vulnerability to natural and anthropogenic disturbances. Similar trends are observed at a local scale, particularly in the case of Busuanga Island, Palawan province in the Philippines, where BCEs along with other marine and coastal ecosystems are perceived to be threatened by a number of factors. To better understand and capture the state changes of coastal ecosystems with emphasis on BCEs, this study collected the drivers and pressures and their impacts on the coastal environments as well as existing management responses by interviewing 17 stakeholders representing community organizations, non-government organizations, and municipal level government units from the municipality of Busuanga. The interview results were analyzed by applying the Drivers-Pressures-State-Impact-Response (DPSIR) framework. The results of this study show that lack of institutional capacities (indirect driver) is the leading factor that hinders the progress or efficacy of coastal management. Most pronounced pressures caused by direct drivers to BCEs include overexploitation and coastal developments. The responses collected in the interviews can be grouped into ecosystems management, capacity building development, policies and implementation, and welfare and livelihood development. These results can be used to enhance or update existing management responses into more precise and contextualized measures in addressing specific impacts observed in the local areas.

Keywords: blue carbon ecosystems, DPSIR framework, stakeholders, Philippines

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Detecting mangrove- and seagrass-derived eDNA from deep-sea sediment around Yaeyama Islands: Implication for offshore blue carbon sequestration

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Coastal vegetated ecosystems (mangroves, salt marshes, seagrass beds) have been recognized as potential carbon dioxide (CO_2) sink due to their capacity to capture CO_2 and store organic carbon (OC) in anoxic sediment inside them. At the same time, these ecosystems are exporting OC (a.k.a. blue carbon) to outer ocean through tidal action, and the magnitude of OC export is believed to be as large as or even greater than that of OC burial within the ecosystems. Although the fate of exported OC has not been assessed due to technical difficulty, a part of exported OC may be transported across the pycnocline to deep ocean and isolated from the atmosphere for long term. For comprehensive evaluation of carbon sequestration capacity of coastal ecosystems, we need to clarify the fate of OC exported from these ecosystems, focusing on whether and to what extent OC may be sequestered in deep ocean.

In this study, we tested applicability of environmental DNA (eDNA) for detecting and estimating mangrove- and seagrass-derived OC in offshore sediments including those from the bathypelagic zone (>1000 m). As a case study, we focused OC export from mangroves and subtropical seagrass beds around Sekisei Lagoon, Okinawa, Japan, to the Lagoon and further to offshore area off Yaeyama Islands. Surface sediment samples were collected and analyzed for eDNA concentration by quantitative PCR, as well as OC, $\delta^{13}C_{OC}$, and specific surface area. Target species of the eDNA analysis include dominant plant species in this region, i.e., *Rhizophora stylosa*, *Bruguiera gymnorhiza*, and *Sonneratia alba* for mangroves, and *Thalassia hemprichii*, *Cymodocea rotundata*, and *Enhalus acoroides* for seagrasses.

Due to relatively high-energy conditions, shallow sediments of Sekisei Lagoon were mostly composed of coarse carbonate sand and often lacked any traces of mangrove and seagrass eDNA. However, significant concentrations of both mangrove and seagrass DNA fragments were detected from sediments of narrow nearshore area of Nagura Bay, where silty sediment supplied by the Nagura River prevailed. Offshore sediments commonly contained OC with the bulk $\delta^{13}C$ of -23‰ to -19‰, indicating that pelagic primary producers are the predominant source for OC stored in pelagic sediments. Nevertheless, DNA fragments of mangroves, but not seagrasses, could be detected in offshore sediments outside the Lagoon. Mangrove-derived eDNA was often detected significantly in bathypelagic sediments collected from northern area of Yaeyama Island. The concentration of bulk OC was also relatively high (>500 μmol C g^{-1}) in these sediments.

These observations suggest that: (i) organic detritus produced in coastal habitats such as mangroves and seagrass beds is exported by tidal action; (ii) exported OC is not accumulated significantly in shallow lagoon outside the habitats due to high-energy physical environment, but (iii) flushed away further to offshore water by tidal residual current, which usually flows from south to north across the lagoon; (iv) a

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part of OC then sinks down to bathypelagic zone and stored in deep-sea sediment. Thus, deep-sea sediment located downstream of major coastal vegetated habitats can serve as potentially important blue carbon sink.

Keywords: Coastal vegetated ecosystems, Organic carbon export, Carbon sequestration, Deep-sea sediment, Environmental DNA

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Evaluation of the effect of differences in nitrogen loading on the chemical composition and decomposition characteristics of eelgrass(*Zostera marina*).

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Nitrogen is one of the elements that can limit the primary production of plants, therefore nitrogen supply potentially affects coastal primary production. On the other hand, it is known that some secondary metabolites such as phenolic compounds that are not directly involved in growth and catabolism such as photosynthesis, respiration, and assimilation act as protective compounds against predators and pathogens. Some report that the abundance of these substances varies with the supply of nitrogen. Thus, differences in nitrogen supply may contribute not only to the growth of these plants, but also to the biodegradation properties of the plant.

In this study, we focused on the eelgrass (*Zostera marina*) widely distributed in the coastal area of Japan, and examined the followings, potential effects of the nitrogen supply in the coastal area on the function as “blue carbon”.

1) Possibility of measuring nitrogen content in eelgrass leaf using portable nitrogen meter

The measured values of multiple portable nitrogen meters for land herbs were compared with the chlorophyll content and actual nitrogen content of the eelgrass Z. marina. Conditions that enable us to effectively estimate the nitrogen content of eelgrass are discussed.

2) Relationship between nitrogen content and the amount of structural and repellent substances in the eelgrass leaves

The amount of structural substances and repellent substances of eelgrass plants were evaluated using chemical (KOH, $NaClO_2$, and NaOH) treatments and Folin-ciocalteu method, respectively, and compared with the nitrogen content.

3)Evaluation of the decomposition characteristics of eelgrass in the different environmental conditions

Effects of nitrogen load on the decomposition characteristics of eelgrass were evaluated by monitoring in the different environmental conditions.

Keywords: Blue carbon, Nitrogen load, Refractory organic carbon, Eelgrass(Zostera marina)

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.11 Zoom Room 11

[A-CG42] Water and sediment dynamics from land to coastal zones

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Chairperson:Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Yuko Asano(The University of Tokyo), Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University)

The dynamics of water and sediments from land to the ocean, such as hillslope runoff generation, river flow and flooding, sediment transport and geomorphology, and coastal river plumes, are inter-connected through processes with various spatial- and temporal-scales. As compound disasters and environmental changes often involve these processes occurring simultaneously at multiple scales, integrated understanding of the dynamics of water and sediments across hillslope, floodplain, river mouth, and coastal-zone are required. We welcome wide-range studies related to the dynamics of water and sediments from land to the ocean with theoretical, observational, and simulation-based approaches such as basic process understanding, in-situ and remote-sensing observations, big-data analysis and supercomputing.

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

[ACG42-01] The fate of riverine freshwater in the ocean

*Shinichiro Kida[1], Ryo Abe[2], Yosuke Alexandre Yamashiki[3] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Interdisciplinary Graduate School of Engineering Sciences, 3.Graduate School of Advanced Integrated Studies in Human Survivability)

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

[ACG42-02] Interpreting the sediment dynamics from mountains to the sea in the Saru River souce-to-sink system using radionuclide tracers

★Invited Papers

*Shigeru Mizugaki[1], Junichi Otsuka[1], Yasuhiro Murakami[1], Keiko Iwakura[1] (1.Civil Engineering Research Institute for Cold Region, Public Works Research Institute)

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

[ACG42-03] River survey using airborne laser bathymetry (ALB) and its applications

★Invited Papers

*Keigo Nakamura[1] (1.Public Works Research Institute)

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

[ACG42-04] How much suspended sediment is transported from land to oceans globally?

*Misako Hatono[1], Kei Yoshimura[2] (1.Hiroshima University, 2.The University of Tokyo)

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

[ACG42-05] Estimation of coastal freshwater discharge using surface salinity of Nanao Bay

*Shiho Kobayashi[1], Satoshi Nakada[2], Kei Senbokuya[3], Jun-ichi Okuno [3] (1.Kyoto University, 2.National Institute for Environmental Studies, 3.Ishikawa Prefecture Fisheries Research Center)

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

[ACG42-06] Storm runoff at hillslopes and channels in mountain catchment

*Yuko Asano[1], Taro Uchida[2], Mitsuhide Tomomura[3], Naoko Miura[1] (1.The University of Tokyo, 2.University of Tsukuba, 3.Meteorological Engineering Center)

The fate of riverine freshwater in the ocean

*Shinichiro Kida[1], Ryo Abe[2], Yosuke Alexandre Yamashiki[3]

1. Research Institute for Applied Mechanics, Kyushu University, 2. Interdisciplinary Graduate School of Engineering Sciences, 3. Graduate School of Advanced Integrated Studies in Human Survivability

Riverine freshwater is a buoyancy source for the ocean and spreads the coast as it mixes with oceanic water and establishes a river plume at the sea surface. Continental-scale rivers tend to create river plumes that are trapped along the coast and continue for a long distance. Regional-scale rivers, on the other hand, tend to create river plumes that mix close to the river mouth and are more short-lived. We investigated the fate of riverine freshwater after a heavy rain event for regional-scale rivers using a river-ocean seamless model. Model results show the formation of gravity-current like river plumes and that the roles of small-scale rivers are non-negligible for establishing the salinity distribution near the coast. We will also introduce recent high-resolution observations using drones which is becoming a convenient method to capture the behavior of river plumes.

Keywords: river plume

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Interpreting the sediment dynamics from mountains to the sea in the Saru River souce-to-sink system using radionuclide tracers

*Shigeru Mizugaki[1], Junichi Otsuka[1], Yasuhiro Murakami[1], Keiko Iwakura[1]

1. Civil Engineering Research Institute for Cold Region, Public Works Research Institute

Coastal erosion has been a nationwide problem in Japan since the 1950s, and there is a need for comprehensive sediment management in stream systems from mountains to coasts. In addition to understanding the sediment dynamics in the stream-sediment system, it is an extremely important basic issue to understand the source of sediment production. To clarify the sediment dynamics in the source to sink sediment transport system, we collected a variety of sediments such as suspended sediment, fluvial material, beach sand, and coastal sediment from the mountains to the sea in the Saru River basin in Hokkaido, and conducted the fingerprinting sources of those sediment using radioisotope tracers. The results show that coastal sand and sediment are mainly composed of sand, and that the contribution of accretionary sedimentary rocks, melange substrates, and plutonic rocks in the upstream region is high. On the other hand, suspended sediment is mainly composed of silt and clay, and sedimentary and metamorphic rock areas are the main sources of production. Since the riverbed material contains little silt and clay, the suspended sediment could be originated from the mountain slopes in the mid- and down-stream areas of the Saru River basin. Sand components may contribute to the coastal and littoral sediments not only from the mountain slopes but also from the re-migration of the fluvial materials. These results suggest that countermeasures against coastal erosion and beach loss require in-channel storage and continuity from the upper reaches of mountainous areas to the sea to supply sufficient quantities of sand to the sea.

Keywords: sediment fingerprinting, natural radionuclides, particle size

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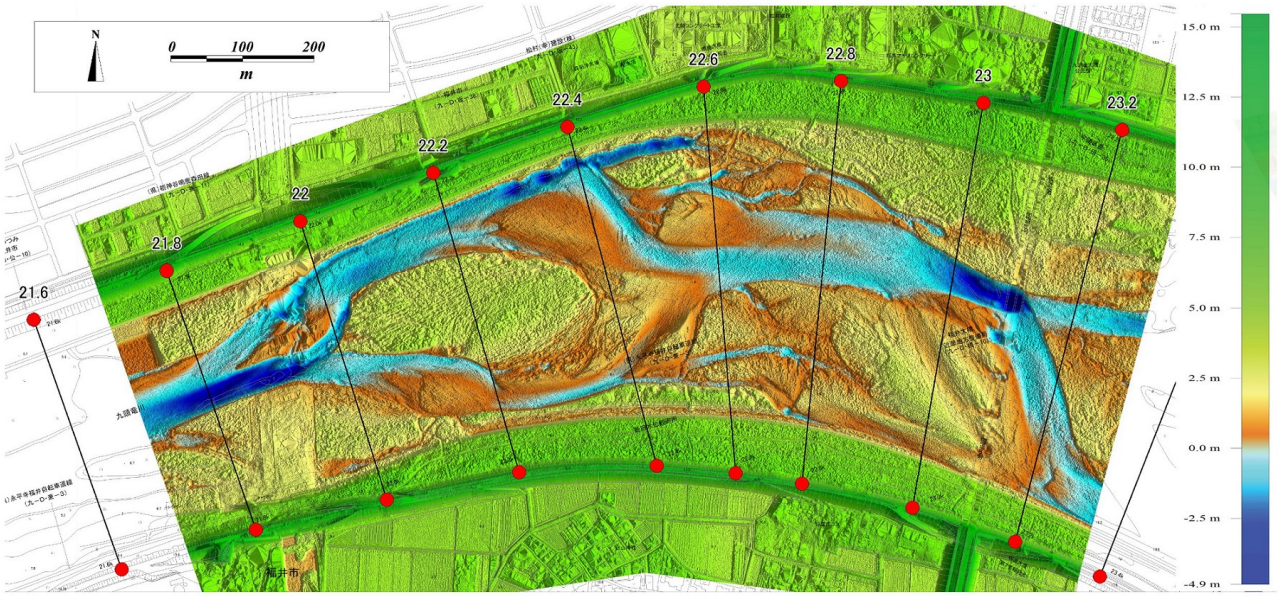
River survey using airborne laser bathymetry (ALB) and its applications

*Keigo Nakamura[1]

1. Public Works Research Institute

In the rivers throughout the country, periodic transverse survey by actual measurement is being carried out for the purpose of planning river management and river improvement. However, survey under the water has caused danger in working especially in a rapid river, and it takes a great deal of time to measure one survey line. To solve this problem, river survey was carried out by using ALB which is a recently-developed technique and can measure under the water surface. In this study, in order to create a cross section from point cloud data by using ALB which can perform underwater measurement in recent years, the accuracy verification with the actual measurement was carried out and the transverse map drawing was made in survey under the water surface. We also considered the application to river management that makes full use of the characteristics of aviation laser measurement.

Keywords: river survey, ALB, BIM



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How much suspended sediment is transported from land to oceans globally?

*Misako Hatono[1], Kei Yoshimura[2]

1. Hiroshima University, 2. The University of Tokyo

While fluvial suspended sediment plays a vital role in material transport through rivers, there are still large uncertainties in global scale estimates, partly due to its high regional dependency and lack of comprehensive observation networks. There have been several attempts to assess the global suspended sediment load to the oceans including regions with insufficient observation data by extrapolating the relationship between regional characteristics and suspended sediment load in data-rich regions. Milliman and Farnsworth (2011) compiled annual suspended sediment load data for over one thousand river basins globally, and combined various data such as elevation, precipitation, and geological features to estimate the annual suspended sediment load for river basins without observation data. The most significant are the rivers in the cluster of small islands in Oceania which is estimated to transport 6800 Mt/yr, approximately 35% of the global sum. This is significantly large considering the 13 rivers in this region included in the original database account for only 290 Mt/yr. To evaluate its validity, we used our global sediment dynamics model at 0.5 degree spatial resolution to compare the annual suspended sediment load to oceans. We found that the total suspended sediment load from this region in our model was less than a third of the previously estimated value even when calibrating model parameters to fit the annual suspended sediment load of the observed 13 rivers. Here we discuss the source of the large discrepancy in the region by comparing our model results with previous extrapolated estimates in river basins with insufficient data and its impact on the global suspended sediment load.

Keywords: Global sediment dynamics, Numerical modeling, Oceania

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Estimation of coastal freshwater discharge using surface salinity of Nanao Bay

*Shiho Kobayashi[1], Satoshi Nakada[2], Kei Senbokuya[3], Jun-ichi Okuno [3]

1. Kyoto University, 2. National Institute for Environmental Studies, 3. Ishikawa Prefecture Fisheries Research Center

Extremely heavy rainfall impacts on marine environment; it causes the significant decrease of surface salinity and intensifies density stratification in coastal seas, and might result in depletion of dissolved oxygen in the lower layer. The study area, Nanao Bay is a semi-enclosed bay in Noto Peninsula faced on Japan Sea. There is no public data of river discharge flowing into the bay, which is important to investigate the impacts of heavy rainfall on the marine environment. On the other hand, salinity in the bay has been monthly measured by Ishikawa Prefecture Fisheries Research Center and daily rainfall is publicized by Japan Meteorological Agency. This study employed a numerical model, FVCOM (Chen et al., 2003) for estimating the decrease of salinity in the surface layer of the bay associated with freshwater discharge which was estimated using the catchment area, rainfall data and runoff coefficients. The Green’s functions method was then applied for inverse estimation of the runoff coefficients using the simulated and the observed salinity in the bay.

Keywords: freshwater discharge, catchment area, surface salinity, coastal sea model, runoff coefficients

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Storm runoff at hillslopes and channels in mountain catchment

*Yuko Asano[1], Taro Uchida[2], Mitsuhide Tomomura[3], Naoko Miura[1]

1. The University of Tokyo, 2. University of Tsukuba, 3. Meteorological Engineering Center

It is important to clarify the dynamics of water and sediment in mountainous watersheds to understand the dynamics of water and sediment continuously from land to coastal zones. In Japan, about 70% of the land is mountainous, thus, water and sediment from mountain watershed transported to downstream plains and used for human activities, and the remaining will be brought to the coastal zones. Therefore, the amount of water and sediment transported from mountain watersheds is one of the most important conditions that determine the dynamics of water and sediment not only on land but also in coastal zones. However, information is still limited in mountain watershed because water and sediment dynamics changes dramatically between normal and storm condition and measurements during heavy storm is very difficult. In this study, we introduce the recent studies on flood flow from hillslopes and channels in mountainous watersheds based on field observations and literature review.

In mountainous watersheds, where the watershed area is steep and relatively small, it has been thought that the rainfall hyetographs transformed to discharge hydrographs mainly in hillslopes because water movement in hillslope soil should have greater effect on the waveform transformation and/or peak delay than that in the open channel flow. Researches have been conducted in hillslopes and the processes that control flood flow during small to middle sized storms have been clarified. However, responses and processes that occur during heavy storms have not been well understood. In addition, because mountain rivers have rough bed morphology consisting of gravels of various sizes, water depth and velocity distribution changes greatly during storms. However, even if the discharge is known, prediction of the water depth and velocity is still difficult.

To understand flood flow from hillslopes, we installed 16 water level recorders within a 4.5 km2 watershed in the University Forest of The University of Tokyo in Minami-Izu, Shizuoka and measured water levels for every minute. Because there were linear relationships between the channel flowpath length and the peak lag time during heavy storms, the peak propagation speeds in the channels were estimated from the slopes of these linear relationships, and the peak lag times in the hillslope flowpath were estimated from the intercepts. During heavy storms, that occur once every year to several years, the peak lag times in the hillslopes were -1 to 2 minutes, and the peak propagation speeds in the hillslopes were as fast as a few m/s. While the peak propagation speeds in the channels were 2.9 m/s at maximum. These small contributions of lateral flows in hillslopes on the catchment peak lag times have been demonstrated by other experimental and theoretical studies.

For flood flow in channels, we found the drastic changes in channel resistance during heavy storms. In practice, Manning's roughness coefficient has been used for flood analysis even in mountain rivers. The channel resistance decreased significantly as the water level rises, from more than 0.5 to less than 0.1 in terms of Manning's roughness coefficient. We also found that the change in the channel resistance with water depth became smaller when water depth increased to certain depth as most of gravel submerge, but that the measured minimum values of the channel resistance were often larger than the range that has been used as the reference.

In mountain watershed, when hillslopes become sufficiently wet during heavy storms, peak propagation

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speed in hillslopes increases and rainwater is expected to discharge to channel simultaneously and quickly from all hillslopes. While in mountain rivers with rough bed, the flow speed does not become very fast due to the high resistance. Therefore, the delay between the peak of rainfall and the peak of runoff during heavy storms is small on lateral water movement in hillslopes and occurs mainly in the channel.

Keywords: mountain river, peak propagation, velocity, celerity, hillslope, channel

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.11 Zoom Room 11

[A-CG42] Water and sediment dynamics from land to coastal zones

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Chairperson:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University)

The dynamics of water and sediments from land to the ocean, such as hillslope runoff generation, river flow and flooding, sediment transport and geomorphology, and coastal river plumes, are inter-connected through processes with various spatial- and temporal-scales. As compound disasters and environmental changes often involve these processes occurring simultaneously at multiple scales, integrated understanding of the dynamics of water and sediments across hillslope, floodplain, river mouth, and coastal-zone are required. We welcome wide-range studies related to the dynamics of water and sediments from land to the ocean with theoretical, observational, and simulation-based approaches such as basic process understanding, in-situ and remote-sensing observations, big-data analysis and supercomputing.

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

[ACG42-07] Sediment budget analysis and geomorphological evolution in alluvial river – Case study in the lower Yodo River –

★Invited Papers

*Ryoukei Azuma[1] (1.Osaka Institute of Technology)

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

[ACG42-08] Toward an improvement of river runoff in the Japanese Coastal Ocean Monitoring and Forecasting System

★Invited Papers

*Kei Sakamoto[1], Shogo Urakawa[1], Nariaki Hirose[1], Hideyuki Nakano[1], Takahiro Toyoda[1], Norihisa Usui[1], Goro Yamanaka[1] (1.Meteorological Research Institute)

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

[ACG42-09] Long river plume around Akkeshi Bay formed by snowmelt runoff

*Satoshi Nakada[1], Tomonori Isada[2] (1.National Institute for Environmental Studies, 2.Hokkaido University)

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

[ACG42-10] Application of suspended sediment and physical process interaction to river-plume simulations in the microtidal coastal region during a flood

*Yasuhiro Hoshiba[3], Yoshimasa Matsumura[2], Sachihiko Itoh[3], Hiroyasu Hasumi[1] (1.Division of Climate System Research, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Division of Marine Life Science, Atmosphere and Ocean Research Institute, University of Tokyo, 3.Center for Earth Surface System Dynamics, Atmosphere and Ocean Research Institute, University of Tokyo)

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

[ACG42-11] Experimental study on the effect of vegetation cover and location by a forest floor model on reducing sediment transport

*Ako YAMAMOTO[1], Akira Kojima[2], Ryusei Shiotsuki[2], Keita Kawaharada[3], Makjoto Sotoyama[3], Tsuyoshi Tada[2], Yoshinori Shigihara[2], Yo Fukutani[3] (1.Forest of Research and Management Organization Forestry and Forest Products Research Institute, 2.National Defense Academy, 3.Kanto Gakuin University)

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

[ACG42-12] Sediment transport and morphology change in coastal areas

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

Sediment budget analysis and geomorphological evolution in alluvial river –Case study in the lower Yodo River –

*Ryoukei Azuma[1]

1. Osaka Institute of Technology

This study starts with presenting field evidences that illustrate the occurrence of significant bank erosion in the lower section of the Yodo River. It then demonstrates that the resulting escarpments were not mere local adjustments, but are an indicator as to how extensively the Yodo River has undergone appreciable amounts of channel erosion over the entire 70km-long section. The datasets on which the discussion is based include: the cross-channel topographical data (200m intervals along the river course) in first half of 1970s, early 1990s and late 2000s made available from the Yodogawa Office, MLIT. A careful geomorphological analysis of the datasets in terms of GIS, permitted the determination of tempo-spatial changes of areal sediment storage in the Uji River, a tributary of Yodo River.
When integrated over the entire river course, the overall volume of sediment loss due to erosion proved to amount to 41.3 $\times 10^4$ tons a year in the period from first half of 1970s up to late 2000s. A discussion is made to identifying its practical implications for future riverine management. Furthermore, a discussion is made of the linkage between the extent of the channel erosion and the depositional environments of the sediment that constitutes the boundary of the river channel.

Keywords: Alluvial river, Sediment budget, Geomorphological evolution

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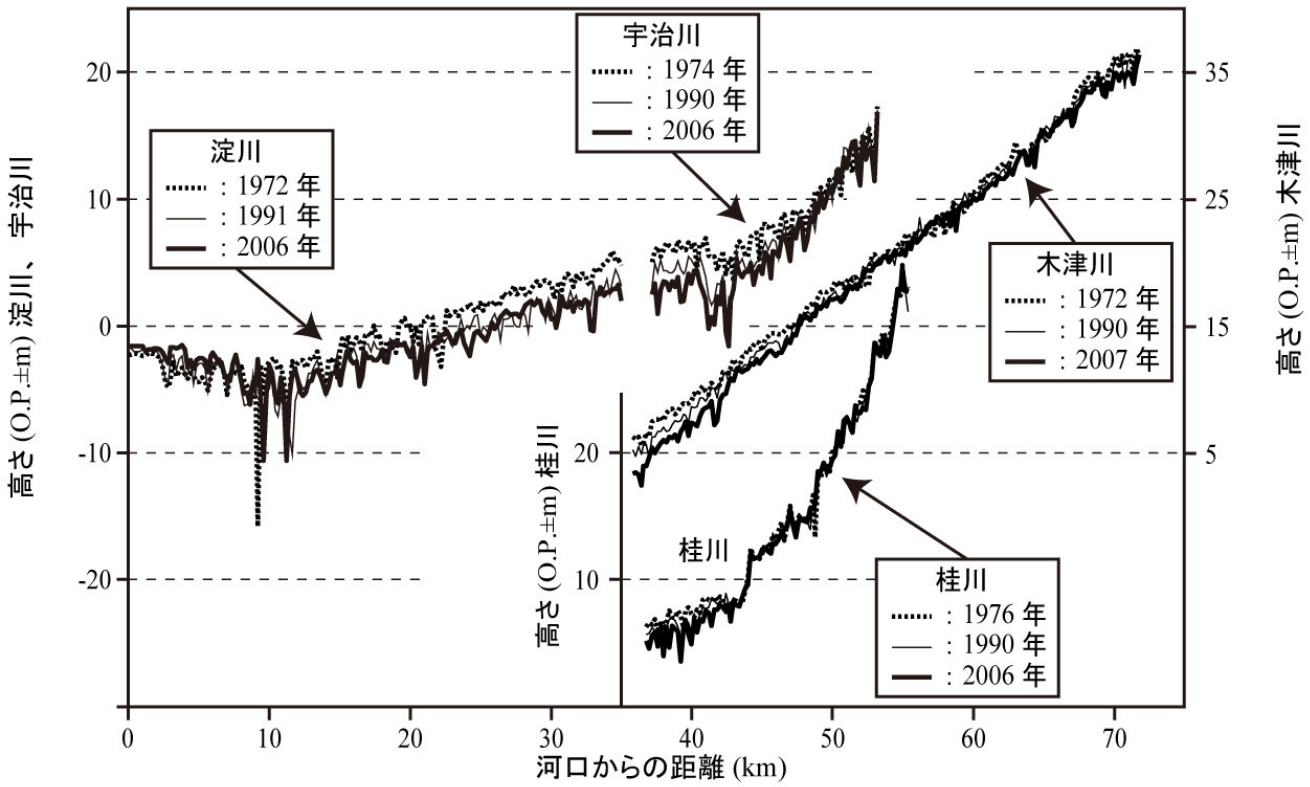


図　淀川中下流域における河床最深部の沿川縦断プロフィール

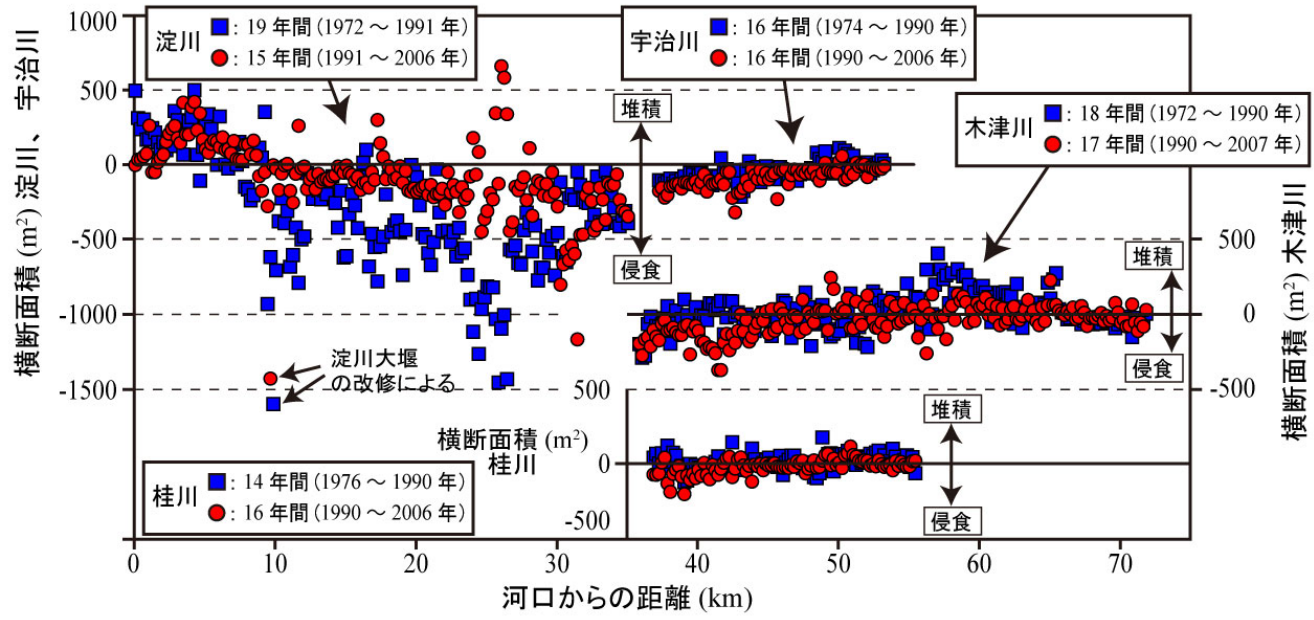
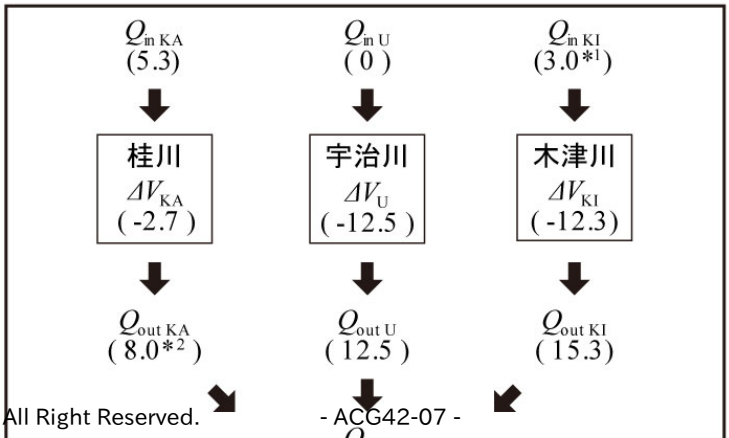


図　淀川中下流域における河道横断面積の変化量



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Toward an improvement of river runoff in the Japanese Coastal Ocean Monitoring and Forecasting System

*Kei Sakamoto[1], Shogo Urakawa[1], Nariaki Hirose[1], Hideyuki Nakano[1], Takahiro Toyoda[1], Norihisa Usui[1], Goro Yamanaka[1]

1. Meteorological Research Institute

The Japan Meteorological Agency (JMA) started the operation of the "Japanese Coastal Ocean Monitoring and Forecasting System" (JPN System) in October 2020 for the purpose of grasping ocean states around Japan in detail. This system was developed by the Meteorological Research Institute (MRI) and consists of an OGCM that covers a wide area around Japan with a horizontal resolution of about 2 km (JPN model) and a four-dimensional variational data assimilation system. The JPN model incorporates major coastal processes such as tidal and pressure response, enabling ocean simulations that can be directly compared to the real ocean. With the start of operation of the JPN system, new marine information such as detailed coastal current fields are being provided by the JMA, and we hope that it will be widely utilized by the ocean community across industry, government, and academia. The JPN quick analysis and prediction data can be obtained from the Japan Meteorological Business Support Center, and, in addition, a long-term reanalysis data from 2008 is also being provided by the MRI.
(https://mri-ocean.github.io/mricom/mri.com-user_jpn_start.html)
Although the JPN system has incorporated major coastal processes, there is still room for improvement in the system specifications. One of them is that daily climatology of Japanese first-class rivers is used for river runoff in the model, not taking the actual time variations into consideration. As a result, low-salinity plumes formed in estuaries during freshets due to heavy rain cannot be reproduced by the JPN system. Therefore, we conducted an experiment to introduce real-time river runoff data for the purpose of improving the JPN system in the future. Specifically, following Urakawa et al. (2016, Weather Service Bulletin), we made an hourly runoff dataset of 3986 rivers nationwide, based on the JMA Runoff Index, which has been used for flood warnings by the JMA, and we ran the JPN model under the new dataset. First, we executed a long-term free-run experiment, and confirmed that this dataset realistically reproduces seasonal changes in sea surface salinity in the Seto Inland Sea. Next, a hindcast experiment was conducted using an initial field by data assimilation, in order to reproduce coastal states after a typhoon passed in September 2011. In the inner part of the Osaka Bay, a low-salinity plume developed due to a freshet of the Yodo River, and surface salinity decreased by more than 5 psu there. This result is consistent with salinity observations along the coast of the Osaka Bay. These results indicate the possibility of improving river runoff in the JPN system. Now, we are planning an experiment to reproduce the low-salinity plume at the time of freshet using an Osaka Bay model, which is downscaled to a resolution of several hundred meters.

Keywords: coastal model, operational oceanograpy, river runoff, Japanese coastal seas

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Long river plume around Akkeshi Bay formed by snowmelt runoff

*Satoshi Nakada[1], Tomonori Isada[2]

1. National Institute for Environmental Studies, 2. Hokkaido University

This study investigated the seasonal variation in the river plumes formed in the coastal sea around Akkeshi Bay, Hokkaido, using a sea-surface salinity (SSS) map estimated from the colored dissolved organic matter (CDOM) product derived from the geostationary ocean color imager, GOCI-COMS. Focusing on the high correlation relationship between the CDOM and the SSS in the sea surface water, we developed a estimation method of the SSS maps from the CDOM data of high-resolution (500 m) and high-frequency (8 times a day) GOCI-COMS products in eight times a day based on the results of field observations and water sampling obtained in Akkeshi Bay. We analyzed the SSS maps created in 9 years from 2012 to 2020, and found that the remarkably large river plume was formed in the coastal sea around Akkeshi Bay during the snowmelt season from March to April every year. This river plume was a part of the long river plume that developed in coastal ocean and elongated from off Cape Erimo in the south to off Cape Nosappu in the east. This river plume shrank in the summer in phase with the increase of the SSS. This inferred that the snowmelt runoff occurred in the spring could form the river plumes in estuaries located along the coast, and coalesce into the long river plume.

Keywords: sea surface salinity, snowmelt runoff, river plume, colored dissolved organic matter, geostationary ocean color satellite

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Application of suspended sediment and physical process interaction to river-plume simulations in the microtidal coastal region during a flood

*Yasuhiro Hoshiba[3], Yoshimasa Matsumura[2], Sachihiko Itoh[3], Hiroyasu Hasumi[1]

1. Division of Climate System Research, Atmosphere and Ocean Research Institute, University of Tokyo, 2. Division of Marine Life Science, Atmosphere and Ocean Research Institute, University of Tokyo, 3. Center for Earth Surface System Dynamics, Atmosphere and Ocean Research Institute, University of Tokyo

Rivers transport freshwater, suspended sediment matter (SSM), and nutrients from land to coastal seas. In coastal seas termed as regions of freshwater influence (ROFIs), SSM is not only passively transported but also changes density of ambient water and influences physical characteristics especially in flood events, when a lot of SSM and nutrients are supplied to ROFIs. The interaction between SSM and water density in ROFIs can significantly change estuarine circulations and river plumes' mode such as hypopycnal (i.e. the riverine sediment-freshwater is not denser than the seawater) or hyperpycnal (i.e., the density of the riverine sediment-freshwater mixture exceeds that of the ambient seawater) plumes. In this study here, we investigate the interactive effects on salinity, nutrient, phytoplankton distributions in river plumes, and so on. We also discuss whether the interactive effects should be considered or not in ROFIs' simulations of various cases (e.g., changing riverine SSM-input flux, SSM particle diameter, and nutrient concentration). In order to quantitatively estimate the interactive effects of SSM, we employed a non-hydrostatic ocean model with Lagrangian particles, which represented SSM and affects the density and buoyancy of ambient water. A simple lower-trophic-level marine ecosystem model was also incorporated with the model. Many simulations (175 cases) reproducing river plumes during the developing stage initiated by a flood on a microtidal open bay were conducted to study the quantitative sensitivities of the interactive processes to the riverine SSM and nutrient flux, and SSM particle size. As a result, we strongly recommend that the interaction should be considered in hyperpycnal cases because the effects could make differences of the mean nutrient concentrations by 20 % or more in the river plumes. On the other hand, in hypopycnal cases, whether the interaction should be considered or not depends on the time scale (daily or not) and the substances (river originated or not) to focus on.

Keywords: Coastal region of river-water influence, River plume simulations, Interaction between suspended sediment and water density

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Experimental study on the effect of vegetation cover and location by a forest floor model on reducing sediment transport

*Ako YAMAMOTO[1], Akira Kojima[2], Ryusei Shiotsuki[2], Keita Kawaharada[3], Makjoto Sotoyama[3], Tsuyoshi Tada[2], Yoshinori Shigihara[2], Yo Fukutani[3]

1. Forest of Research and Management Organization Forestry and Forest Products Research Institute, 2. National Defense Academy, 3. Kanto Gakuin University

In coastal areas hit by the 2011 Tohoku Tsunami, coastal forests were reported to have mitigated the disaster and prevented some damage, including reducing water levels and flow velocities as well as trapping sediment. Coastal forests are being restored on embankments in the affected coastal areas. The embankments were created using soft engineering to maintain the deep root system of the trees. There is a concern that another tsunami may cause erosion and sediment runoff. To prevent the trees from being washed away, it is necessary to control sediment runoff at the ground surface. However, there is no method to evaluate the effect of vegetation cover on sediment transport at present. In this study, hydraulic experiments were carried out to clarify the effects of vegetation trapping and location on sediment transport. A two-dimensional wave-making tank was used for the experiments, consisting of a water storage tank, a 30-m long channel, and a drainage tank from the upstream side. The upstream gate was opened abruptly to generate a tsunami-like stepped wave. A forest floor model with different vegetation coverage and locations was set up in the sand bed section of the channel. We also conducted experiments using models with more complex vegetation patterns to simulate native coastal vegetation. The results confirmed that there was a decrease in the amount of sediment transported with an increase in the degree of cover when the location was the same. However, it was found that the amount of sediment transport was affected not only by the amount of vegetation cover, but also by the direction and density of the vegetation in relation to the flow. It was also confirmed from the image analysis that the effect of the waveform of the wave on the vegetation was very different. It is not clear whether these causes are due to the effect of vegetation trapping or location.

Keywords: Vegetation coverage, Hydraulic experiments, Tsunami

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Sediment transport and morphology change in coastal areas

*Keiko Udo[1]

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Future sea-level rise and wave climate change are projected to further increase the coastal erosion risk in Japan, where coastal erosion has already progressed due to rapid development after 1950s. Although there have been many studies on coastal erosion, the simplest one-dimensional equilibrium beach profile model is still used for long-term projection of future coastlines because of the difficulty in estimating coastal morphology change accurately. On the other hand, the risk may decrease if the heavy rainfall frequency increases because the heavy rainfall may increase the amount of sediment supply from rivers to the coasts. Knowledge of sediment supply from rivers to the coasts has not yet been sufficient, and further knowledge needs to be obtained.
In this presentation, existing studies on the characteristics of coastal morphology change and their models, as well as existing studies on sediment dynamics in rivers and sediment supply to the coast, which have been discussed separately, are introduced, the problems of the current coastal morphology change models are summarized, and future prospects are discussed.

Keywords: coastal erosion, sediment budget, sediment size

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.07_3

[A-CG42] Water and sediment dynamics from land to coastal zones

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Yuko Asano(The University of Tokyo), Keiko Udo(International Research Institute of Disaster Science, Tohoku University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo)

The dynamics of water and sediments from land to the ocean, such as hillslope runoff generation, river flow and flooding, sediment transport and geomorphology, and coastal river plumes, are inter-connected through processes with various spatial- and temporal-scales. As compound disasters and environmental changes often involve these processes occurring simultaneously at multiple scales, integrated understanding of the dynamics of water and sediments across hillslope, floodplain, river mouth, and coastal-zone are required. We welcome wide-range studies related to the dynamics of water and sediments from land to the ocean with theoretical, observational, and simulation-based approaches such as basic process understanding, in-situ and remote-sensing observations, big-data analysis and supercomputing.

[ACG42-P01] Representing terrestrial water dynamics within Earth system modelling framework

*Dai Yamazaki[1] (1.Institute of Industrial Sciences, The University of Tokyo)

[ACG42-P02] Breaching flood impact analysis of landslide dams in the Yarlung Tsangpo River Basin

*Danyi Shen[1,2], Zhenming Shi[1,2], Ming Peng[1,2] (1.Key Laboratory of Geotechnical & Underground Engineering of Ministry of Education, Tongji University, Shanghai 200092, China, 2.Department of Geotechnical Engineering, Tongji University, Shanghai 200092, China)

[ACG42-P03] Sediment transport analysis from the Abukuma river to the sea by typhoon No.19 in 2019

Makoto Kobayashi[1], *Daisuke Nakahara[1], Keiko Udo[1], Hiroshi Takebayashi[2] (1.International Research Institute of Disaster Science, Tohoku University, 2.Disaster Prevention Research Institute, Kyoto University)

[ACG42-P04] Structural characteristics of airflow and blown sand flux over fine-grained gravel surfaces in wind tunnel

*Jiaqi Liu[1], Reiji Kimura[1], Jing Wu[1] (1.Arid Land Research Center, Tottori University)

[ACG42-P05] Predictive simulations of redeposition and seawater transportation after a tsunami in Osaka Bay where bottom sediments were disturbed by tsunami

*Mitsuru Hayashi[1,2], Satoshi Nakada[4], Soichi Hirokawa[2], Shuto Fujisawa[3] (1.Research Center for Inland Seas, Kobe University, 2.Graduate School of Maritime Sciences, 3.Faculty of Maritime Sciences, 4. National Institute for Environmental Studies)

[ACG42-P06] Application of an isopycnal-layered model to islands

*Hiroaki Sato[1], Yosuke Alexandre Yamashiki[2] (1.Kyoto University, 2.Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University)

Representing terrestrial water dynamics within Earth system modelling framework

*Dai Yamazaki[1]

1. Institute of Industrial Sciences, The University of Tokyo

Within the framework of Earth System modelling, land sub-models usually represent water dynamics as vertical 1-dimentional processes to provide lower boundary conditions for the atmospheric model. In addition, river sub-models represent water transport along the river network to represent global hydrological cycle across atmosphere, land and oceans. Thus, terrestrial water dynamics has been represented as simplified “1D:vertical + 1D:along river” processes. While the actual terrestrial water dynamics is more complex, including horizontal dynamics such as flooding, surface flow, and sub-surface flow. They affect land-atmosphere interactions and global material cycles by changing surface water extent, moisture redistribution and vegetation type distribution, thus should be better represented in climate modelling. However, representing these detailed terrestrial water dynamics within Earth system model had been difficult because of the discrepancy of spatial scales. In very recent years, there are significant advancements in representing detailed terrestrial water dynamic such as flooding and hillslope moisture redistribution by utilizing sub-grid scale physics approaches, and also due to the development of high precision global topography datasets. Here, we review recent advances in global-scale terrestrial water dynamics modelling and discuss the potential applications in Earth system modelling.

Keywords: Earth System Modelling, Terrestrial Water Dynamics

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Breaching flood impact analysis of landslide dams in the Yarlung Tsangpo River Basin

*Danyi Shen[1,2], Zhenming Shi[1,2], Ming Peng[1,2]

1. Key Laboratory of Geotechnical & Underground Engineering of Ministry of Education, Tongji University, Shanghai 200092, China, 2. Department of Geotechnical Engineering, Tongji University, Shanghai 200092, China

Breaching floods of landslide dams occur frequently in mountainous area, and pose great threats to people and infrastructures downstream. Evidences show dam-break floods resulted in extremely catastrophic in the Yarlung Tsangpo River due to its high relief, narrow river gorges and numerous tributaries. On 9 April 2000, a large landslide occurred at the Zhamu Creek and blocked the Yigong Tsangpo River (a tributary of the Yarlung Tsangpo River). On 17 October 2018, another large landslide blocked the main course of the Yarlung Tsangpo River near Gyalha. The breaching of the Yigong and Gyalha landslide dams caused mega floods with peak discharge of 124,000 m^3/s and 32,000 m^3/s, respectively. Previous researches mainly focused on breaching floods of a single dam or cascade dams in the same river. However, the impact of breaching floods caused by simultaneous dam-break of mainstream and its tributaries on downstream are significantly different from that of a single dam-break flood.

This study presents works on flood routing caused by failures of the Yigong and Gyalha landslide dams in the Yarlung Tsangpo River and its tributaries, amplified floods by considering overlapping effects on the basis of these two landslide dams, and possible measures taken to mitigate breaching floods downstream. The erosion-based physical model is applied to predict flood hydrographs at dam site, and the one-dimensional hydrodynamic model is used to simulate the flood routing along the river and its tributaries.

Based on results of simulation, the peak discharge at dam sites and corresponding outflow rate along rivers agree well with field observations. The attenuation of peak outflow rate and flood propagation time along the river is decreased with the increase of peak discharge at dam site. The peak outflow rate is amplified when breaching floods of the mainstream and its tributaries are overlapping. Both flood peaks and inundated area downstream can be reduced by changing discharge magnitude and desynchronizing peak flow in different rivers. The work can serve as basis to predict overlapping floods of landslide dams and manage flood risks in the Yarlung Tsangpo River and its tributaries.

Keywords: Landslide dam, breaching flood, peak discharge, overlapping effects, flood attenuation

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Sediment transport analysis from the Abukuma river to the sea by typhoon No.19 in 2019

Makoto Kobayashi[1], *Daisuke Nakahara[1], Keiko Udo[1], Hiroshi Takebayashi[2]

1. International Research Institute of Disaster Science, Tohoku University, 2. Disaster Prevention Research Institute, Kyoto University

A large amount of sediment was run off in the Abukuma river because of the record-breaking heavy rainfall of Typhoon No.19 in October 2019. This kind of heavy flood occurs in the Abukuma river once every few years, and it is important from the viewpoints of the river and coastal management to clarify the influence of sediment transport on the shape of the riverbed and the amount of sediment in the downstream area. To clarify the long-term sediment transport characteristics in the Abukuma river, the purposes of this study are to calculate the long-term sediment dynamics in the lower reaches of the Abukuma river and to estimate the sediment supply to the coast for each particle size with a one-dimensional mixed-grain riverbed fluctuation analysis model.

The Abukuma River, which is the subject of this study, is a first-class river with a drainage area of 5390 km² and a trunk river channel length of 239 km. The source of the water originates in Asahidake, Fukushima Prefecture, it flows into the Kakuda Basin through alternating plains and narrow areas and joins the Shiraishi River, the largest tributary, to flow into the Pacific Ocean. The calculated section is 36.4 km from Marumori to Arahama in the lower reaches of the Abukuma Valley, and the riverbed slope of the calculated section is about 1/3700 to 1/2000. The target runoffs are 47 runoffs with flow rates exceeding 1000 m³/s, when sediment transport generally starts, from 2000 to 2019 when water level and flow data are available. The initial riverbed level was obtained from the measured riverbed level in 1999, The initial riverbed level was obtained from the measured riverbed level in 1999 provided by the Tohoku Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, and 101 riverbed levels were given for each transect of 0.2 km in the longitudinal direction. The data from the Marumori Water Level Station was used for the upstream flow rate, and the data from the Arahama Water Level Station was used for the downstream water level. The flow rate of the Shiraishi River was measured using data from the Funaoka Bridge water level station located approximately 6 km upstream from the confluence. The particle size distribution of the riverbed material is based on the measured data of 2002 provided by the Tohoku Regional Development Bureau of the Ministry of Land, Infrastructure, and Transport. The calculation results were validated using the estimated sediment discharge associated with the seven runoff events that recorded 3000 m³/s at the Iwanuma water level observation station from 1999 to 2007.

To validate the one-dimensional riverbed fluctuation model, we compared the results of the analysis and the estimated values of the sediment discharge associated with the seven runoffs from 1999 to 2007. Although there is a tendency to overestimate the amount of fine sand (0.075-0.25mm) discharge when the discharge scale is large, the analysis results for other particle sizes are generally good, and it is judged that this model can be used to study sediment discharge in the Abukuma River. The annual average sediment discharge is about 140,000 m³ of fine sand, about 30,000 m³ of medium sand (0.25-0.85 mm), and about 0.3 m³ of coarse sand (0.85-2 mm), for a total of about 180,000 m³/year. In Typhoon No. 19 in 2019, it was estimated that about 400,000 m³ of sediment was supplied to the coast from rivers, including about 240,000 m³ of fine sand, 140,000 m³ of medium sand, and 20,000 m³ of coarse sand.

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Keywords: Long-term sediment dynamics, Sediment supply, One-dimensional mixed-grain riverbed fluctuation analysis model, The Abukuma river

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Structural characteristics of airflow and blown sand flux over fine-grained gravel surfaces in wind tunnel

*Jiaqi Liu[1], Reiji Kimura[1], Jing Wu[1]

1. Arid Land Research Center, Tottori University

To reduce damage caused by wind-blown sand, it is necessary to clarify the mechanism of soil erosion under various surface conditions. In the present study, we investigated the influence of gravel coverage on aerodynamic characteristics of airflow and blown sand flux in a compact wind tunnel developing boundary layer equipped with a turbulence generator and a piezoelectric blown sand meter.

The vertical profile of wind-blown sand over a flat sand surface showed an exponential distribution at all wind speeds, whereas the profile over fine-grained gravel surfaces of 20% or greater coverage showed a non-monotonic vertical distribution. At 20% to 30% gravel coverages, a peak of wind-blown sand flux developed between 6 and 10 cm above the ground at all wind speeds because of less energy loss due to grain-bed collisions at that level. We found that the wind-blown sand flux at 4 cm height accounted for about 20% of the total flux regardless of wind speed and gravel coverage. This finding can simplify future estimations of total near-surface wind-blown sand flux based on field observations because such measurements can be taken at just one height.

The effect of fine-grained gravel coverage on drag coefficient, wind-speed gradient, and turbulent transfer coefficient was investigated to understand the structure characteristic of blown sand flux. The drag coefficient of the gravel surface reached the maximum value at 15% coverage and then tended to stabilize at gravel coverage 20% and greater. At a height of 4 cm, near-surface airflow on gravel surfaces can be divided clearly into upper and lower sublayers, defined as the inertial and roughness sublayers, respectively. The coefficient of variation of wind speed over gravel surfaces in the roughness sublayer was 8.6 times as much as that in the inertial sublayer, indicating a greater effect of gravel coverage on wind-speed fluctuations in the lower layer. At the height of 4 cm, changes in gravel coverage had the same degree of effect on wind-speed fluctuations under the observed wind speeds. In addition, an energy-exchange region, where sand particles can absorb more energy from the surrounding airflow, was found between the roughness and inertial sublayers (6-10 cm), enhancing the erosional state of wind-blown sand. This finding can be applied to evaluate the aerodynamic stability of the gravel surface and provide a theoretical basis for elucidation of the vertical distributions of wind-blown sand flux.

Keywords: wind erosion, vertical profiles, blown sand flux, piezoelectric blown sand meter, wind tunnel developing boundary layer

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Predictive simulations of redeposition and seawater transportation after a tsunami in Osaka Bay where bottom sediments were disturbed by tsunami

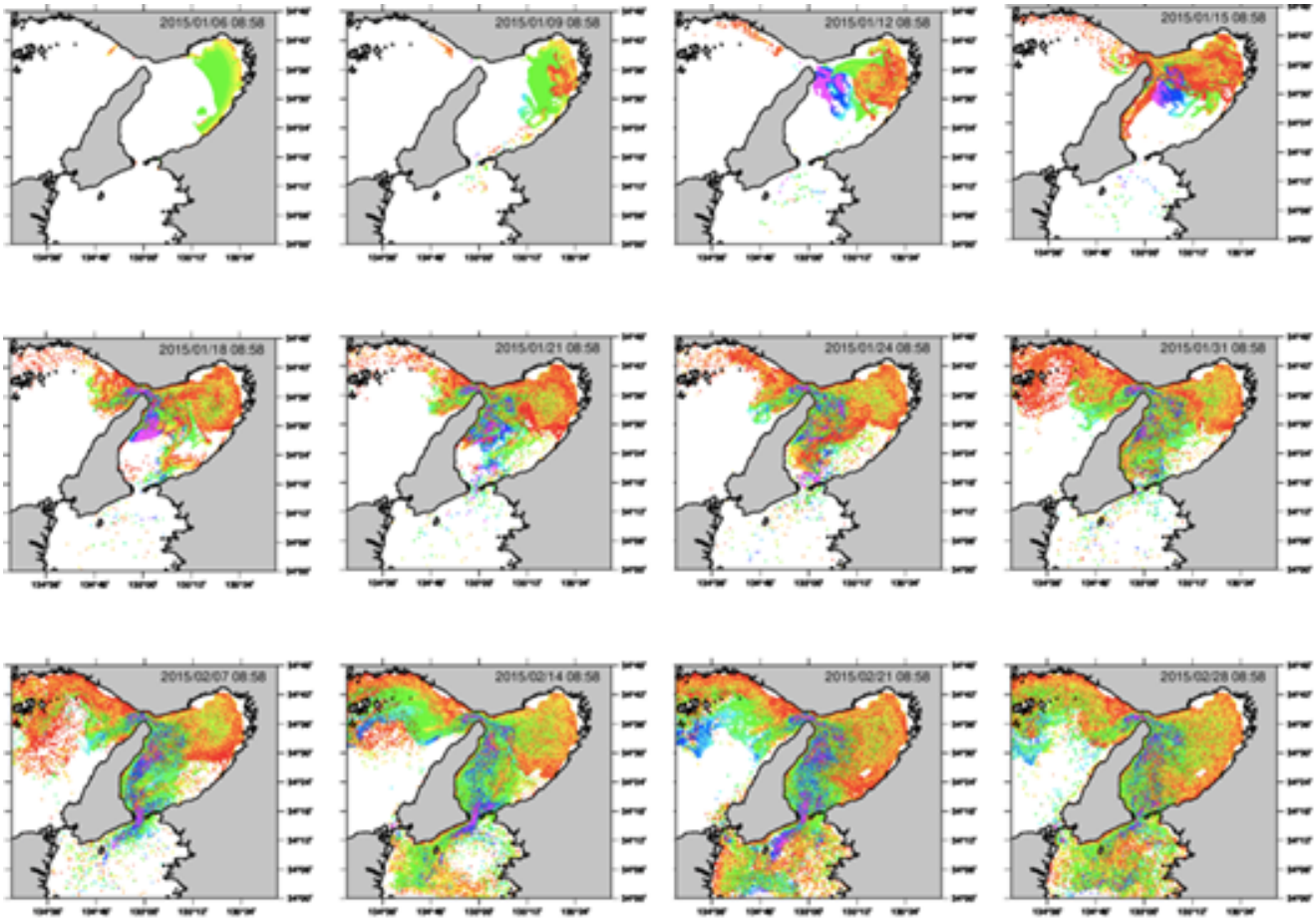
*Mitsuru Hayashi[1,2], Satoshi Nakada[4], Soichi Hirokawa[2], Shuto Fujisawa[3]

1. Research Center for Inland Seas, Kobe University, 2. Graduate School of Maritime Sciences, 3. Faculty of Maritime Sciences, 4. National Institute for Environmental Studies

Tsunami caused by Nankai Trough Earthquake will disturb marine bottom sediments in Osaka Bay. This disturbance is the first large-scale disturbance for Osaka Bay after the rapid economic growth. The sediments contain several materials such as nutrients, cysts of harmful algae, bacteria and heavy metals. It is necessary to predict the changes in the marine environment and ecosystems caused by tsunamis for the ocean SDGs. Nakada *et al.* (2018) predicted by the tsunami simulation that the sediments would be disturbed at the inner part (the eastern half) of Osaka Bay. The sediments were disturbed particularly at the mouth of the harbor and estuary, and the total flux for 10 hours after the earthquake is more than 10 kg/m^2. Transportation and redeposition of the sediments and transportation of seawater with dissolved materials in Osaka Bay after the tsunami were simulated in this study by ocean models. The transport and redeposition of the sediments were calculated by a tidal simulation. The deposition rate was given by the Stokes' low. The sediments were redeposited along the shore line and Okinose where the water depth was shallow and along the oceanic fronts by the tidal residual current as the results of the calculation for one month after the earthquake. Seawater transportations were simulated by the three-dimensional ocean model, FVCOM. Calculations were carried out for six cases for two months with different timing of earthquake occurrence every two month. The path and speed of seawater transportation inside Osaka Bay, and the timing and speed of outflow from the bay were different for each case.

Keywords: Tsunami, Osaka Bay, Marine Bottom Sediment, Simulation, Redeposition, Seawater transportation

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Application of an isopycnal-layered model to islands

*Hiroaki Sato[1], Yosuke Alexandre Yamashiki[2]

1. Kyoto University, 2. Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University

An isopycnal-layered model can effectively solve the dynamics of surface runoff, river flow, and oceanic flow seamlessly without determining specific arrangements for each component. Therefore, we presume that it is an adequate model for solving the entire island's hydrological processes using a single model. We applied an isopycnal-layered model into three islands, Yakushima, Iriomoteshima, and Ishigakishima, located southwest of Japan's main islands. To verify the simulation, we used in situ measured vertical profile of temperature and salinity. We aim to use satellite remote-sensing data to confirm the simulation in the next step.

Keywords: entire island's hydrological processes

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.07 Zoom Room 07

[A-CG43] Earth & Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy), Chairperson:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology)

In recent years, we have been required to explore various gigantic data leading earth and environmental sciences such as modern meteorology, oceanography, hydrology and so on to accomplish Society 5.0 and Sustainable Development Goals (SDGs). To examine such gigantic environmental data faithfully, it may be required to use the techniques of artificial intelligence/machine learning (AI/ML) including spatiotemporal data modeling of AI, prediction and detection by ML, techniques of automated data mining, and so forth. At the present, AI/ML is also expected to lead the data-driven science as a bridge connecting science and big data. This session calls for various studies applying the techniques of AI/ML to scientific/environmental issues and will discuss them in both natural and information sciences.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[ACG43-01] Introduction

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[ACG43-02] Deep Learning that Ensures Laws of Physics and Other Constraints and Its Applications

★Invited Papers

*Takashi Matsubara[1] (1.Osaka University)

2:10 PM - 2:30 PM JST | 5:10 AM - 5:30 AM UTC

[ACG43-03] Recent trends in earth and environmental informatics

★Invited Papers

*Daisuke Matsuoka[1,2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Science and Technology Agency)

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

[ACG43-04] Adversarial Multi-task Learning Algorithm for Solving Partial Differential Equations

*Pongpisit Thanasutives[1], Masayuki Numao[1], Ken-ichi Fukui[1] (1.Osaka University)

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

[ACG43-05] Statistical Downscaling of Meteorological Fields from the Synoptic Scale to the Mesoscale Using Deep Convolutional Neural Networks

*Thomas Sekiyama[1] (1.Meteorological Research Institute)

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

[ACG43-06] Deep learning approach for rainfall forecasting using U-Net with data augmentation

*Ryo Kaneko[1], Shiho Onomura[2], Makoto Nakayoshi[2] (1.The University of Tokyo, 2.Tokyo University of Science)

[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-CG Complex & General

[A-CG43] Earth &Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy), Chairperson:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.07 (Zoom Room 07)

In recent years, we have been required to explore various gigantic data leading earth and environmental sciences such as modern meteorology, oceanography, hydrology and so on to accomplish Society 5.0 and Sustainable Development Goals (SDGs). To examine such gigantic environmental data faithfully, it may be required to use the techniques of artificial intelligence/machine learning (AI/ML) including spatiotemporal data modeling of AI, prediction and detection by ML, techniques of automated data mining, and so forth. At the present, AI/ML is also expected to lead the data-driven science as a bridge connecting science and big data. This session calls for various studies applying the techniques of AI/ML to scientific/environmental issues and will discuss them in both natural and information sciences.

1:45 PM - 1:50 PM

[ACG43-01]Introduction

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Deep Learning that Ensures Laws of Physics and Other Constraints and Its Applications

*Takashi Matsubara[1]

1. Osaka University

Machine learning and artificial intelligence are attracting much attentions, mainly thanks to the flexibility of deep learning. When feeding big data to deep learning, it learns meaningful representations and builds a sophisticated model of decision making automatically. However, the flexibility is not the sole requirements. For example, deep learning is expected to learn physical phenomena and to accelerate the physical simulations. Then, deep learning has to reproduce the underlying geometric structure that admits laws of physics rather than the superficial dynamics. Indeed, most of deep learning methods gain outstanding performances by being associated with certain symmetries and constraints based on prior knowledge, e.g., a convolutional neural network is designed to be shift-invariant. The same can be said of probabilistic modeling and reinforcement learning. This talk introduces such deep learning based on prior knowledge.

Keywords: artificial intelligence, physics simulation, geometric structure, prior knowledge

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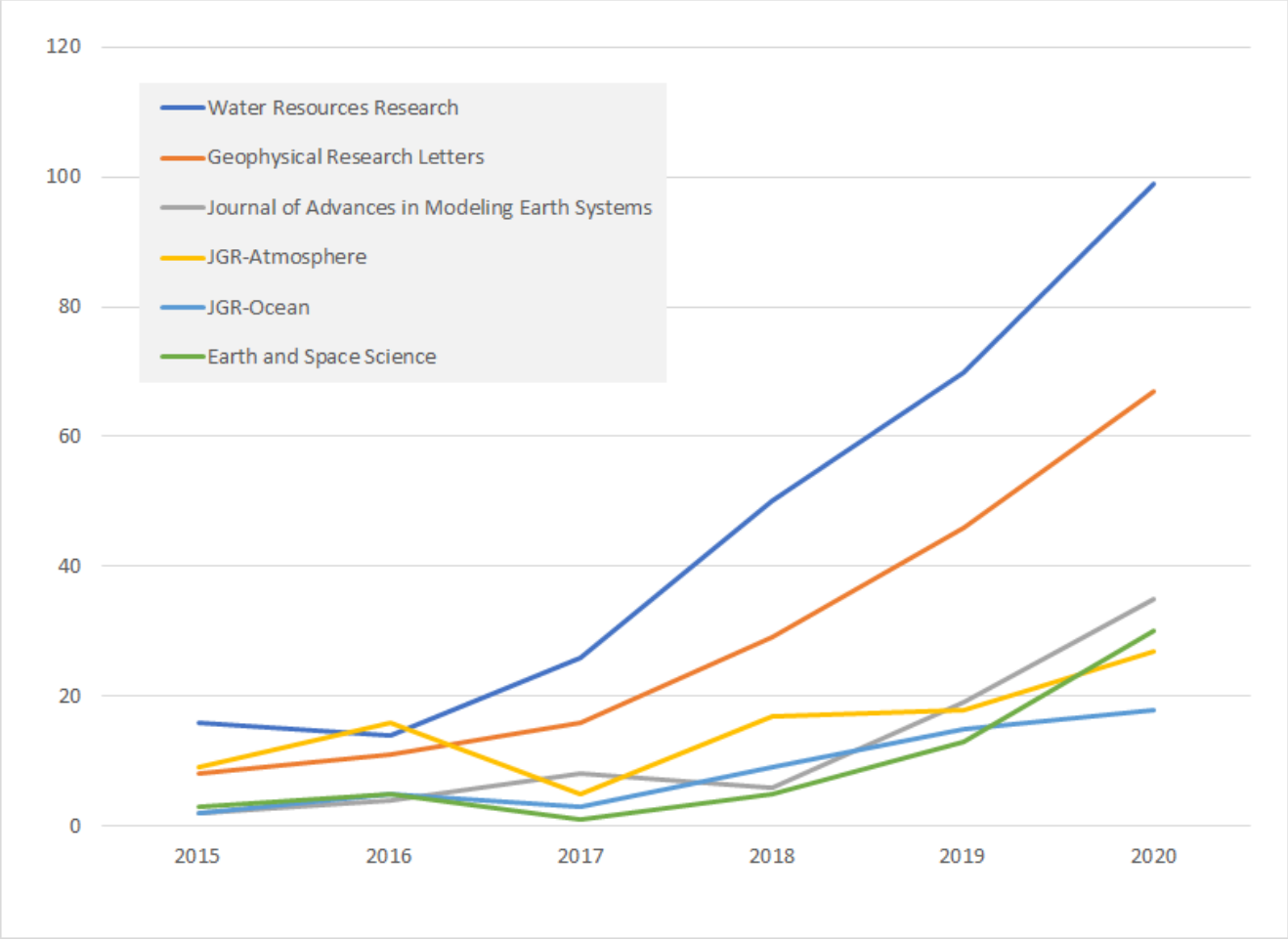
Recent trends in earth and environmental informatics

*Daisuke Matsuoka[1,2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Science and Technology Agency

In recent years, the application of machine learning techniques, such as deep learning, has been actively promoted in the earth and environmental sciences. For example, the number of relevant papers published by the American Geophysical Union (search using machine learning as keywords) has increased rapidly as shown in the figure. Comparing the number of papers published in 2015 and 2020, there is a total increase of about seven times. Especially in the atmospheric and climate sciences, many studies have been published on pattern detection, parameterization, downscaling, bias correction, and future prediction. Some studies utilizing adversarial generative networks (GANs), which artificially generate data, have also been reported. In addition, benchmark data such as WeatherBench (Rasp et al., 2020; Rasp and Thuerey, 2021) is also available to the public with the aim of accelerating data-driven weather and climate prediction research. From these kinds of background, some research organizations such as NOAA and ECMWF have published roadmaps on the use of AI and data-driven science to provide a direction for future research and development. In this presentation, we will introduce some notable studies published in recent years, and present our personal opinions on the research trends and future directions.

Keywords: Deep learning, Machine learning, AI, Big data, data-driven science



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Adversarial Multi-task Learning Algorithm for Solving Partial Differential Equations

*Pongpisit Thanasutives[1], Masayuki Numao[1], Ken-ichi Fukui[1]

1. Osaka University

Recently, researchers have utilized neural networks to accurately solve partial differential equations (PDEs), enabling the mesh-free method for scientific computation. Unfortunately, the network performance drops when encountering a high nonlinearity domain. To improve the generalizability, we introduce the novel approach of employing multi-task learning techniques, the uncertainty-weighting loss, and the gradients surgery, in the context of learning PDE solutions. The multi-task scheme exploits the benefits of learning shared representations, controlled by cross-stitch modules, between multiple related PDEs, which are obtainable by varying the PDE parameterization coefficients, to generalize better on the original PDE. Letting the network pay closer attention to the high nonlinearity domain regions that are more challenging to learn, we also propose adversarial training for generating supplementary high-loss samples, similarly distributed to the training distribution. In the experiment, our proposed methods are found to be effective and reduce the error on the unseen data points as compared to the previous approaches in various PDE examples, including high-dimensional stochastic PDEs.

Keywords: Burgers' equation, Multi-task learning, Adversarial training, Physics-informed neural networks

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Statistical Downscaling of Meteorological Fields from the Synoptic Scale to the Mesoscale Using Deep Convolutional Neural Networks

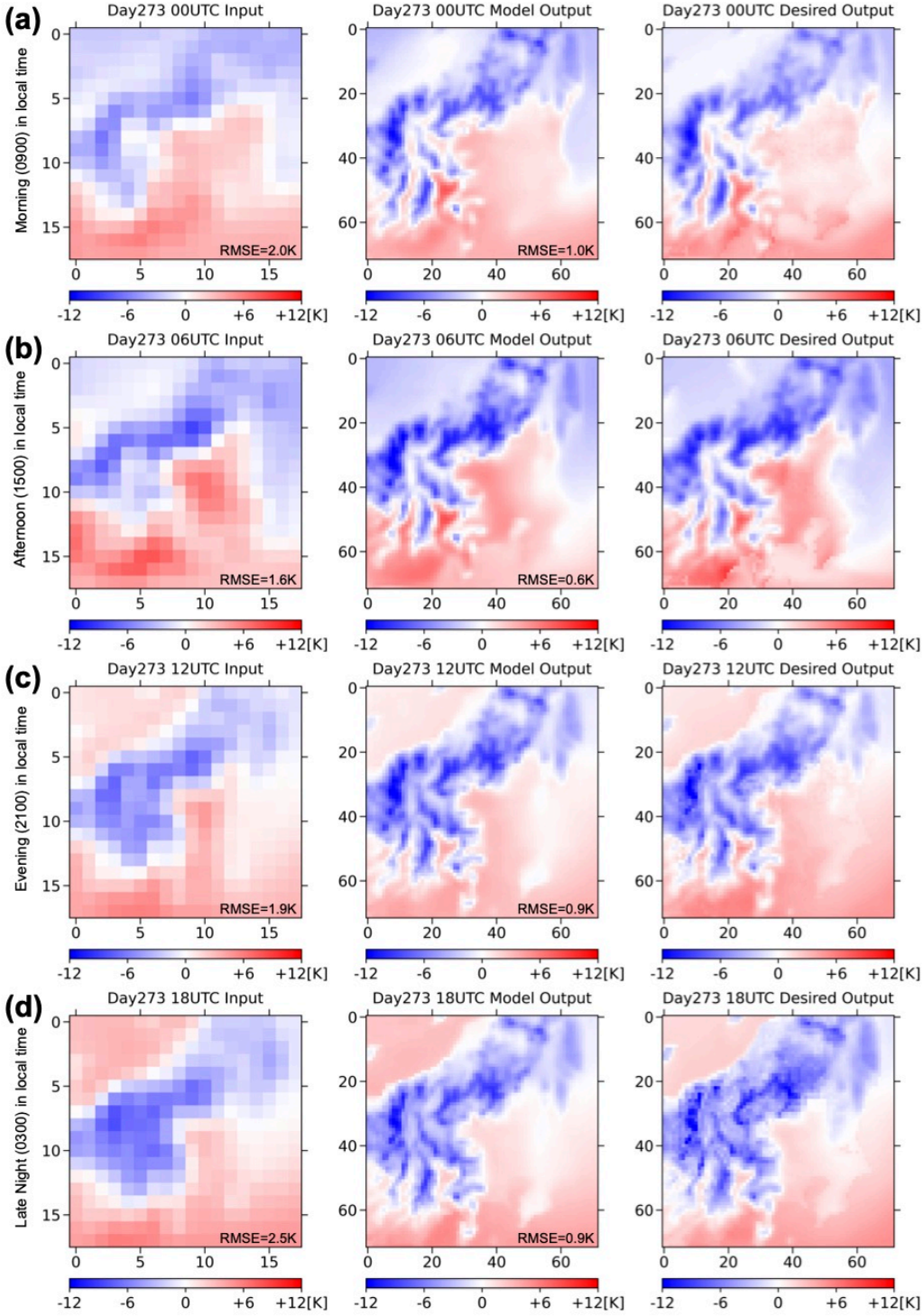
*Thomas Sekiyama[1]

1. Meteorological Research Institute

Deep learning, particularly convolutional neural networks for image recognition, has been recently used in meteorology. One of the promising applications is developing a statistical surrogate model that converts the output images of low-resolution dynamic models to high-resolution images. Our study exhibits a preliminary experiment that evaluates the performance of a model that downscales synoptic temperature fields to mesoscale temperature fields every 6 hours. The deep learning model was trained with operational 22-km gridded global analysis surface winds and temperatures as the input, operational 5-km gridded regional analysis surface temperatures as the desired output, and a target domain covering central Japan. The results confirm that our deep convolutional neural network (DCNN) is capable of estimating the locations of coastlines and mountain ridges in great detail, which are not retained in the inputs, and providing high-resolution surface temperature distributions. For instance, while the average root-mean-square error (RMSE) is 2.7 K between the global and regional analyses at altitudes greater than 1000 m, the RMSE is reduced to 1.0 K, and the correlation coefficient is improved from 0.6 to 0.9 by the surrogate model. Although this study evaluates a surrogate model only for surface temperature, it probably can be improved by augmenting the downscaling variables and vertical profiles. Surrogate models of DCNNs require only a small amount of computational power once their training is finished. Therefore, if the surrogate models are implemented at short time intervals, they will provide high-resolution weather forecast guidance or environment emergency alerts at low cost.

Keywords: numerical weather modeling, surrogate modeling, artificial intelligence, deep learning, super resolution

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Unbiased surface temperature snapshots from December 29, 2019, at (a) 00:00 UTC or 09:00 local time, (b) 06:00 UTC or 15:00 local time, (c) 12:00 UTC or 21:00 local time, and (d) 18:00 UTC or 03:00 local time. The snapshots are taken from the inputs of the test data (left), the model outputs (middle), and the desired outputs of the test data (right).

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Deep learning approach for rainfall forecasting using U-Net with data augmentation

*Ryo Kaneko[1], Shiho Onomura[2], Makoto Nakayoshi[2]

1. The University of Tokyo, 2. Tokyo University of Science

Recently, heavy rainfall disaster occurs almost every year in Japan. The Japan meteorological agency (JMA) expects the rainfall to become severer and more frequent in the future. In those situations, predicting precipitation accurately in the short term is essential to leave enough time for people to evacuate to safer places. In recent years, deep learning technology has attracted attention for its achievements in various fields such as autonomous cars and machine translation. Although deep learning is gradually being applied to precipitation predictions, there is no example of its extension to heavy rainfall prediction to the best of our knowledge. In this study, we aimed to develop a deep learning model that can predict heavy rainfall events.

We trained U-Net (Ronneberger et al., 2015), a deep learning architecture for semantic segmentation, with the nationwide Radar-AMeDAS precipitation (RAP) data produced by JMA, which spatial resolution is 1 km and temporal resolution is 30 minutes. We divided the data into 13 regions of 256 km square because the nationwide data is too large for learning. The input data is the continuous variables of rainfall intensity for 6 hours up to the current time (30-minute intervals), and the teacher data is the categorized rainfall intensity for the next 6 hours (1-hour intervals). The output category was determined referring to the JMA's precipitation categories: Cat.0 denotes no precipitation, i.e., less than 0.1 mm h^{-1}, Cat.1 0.1 - 10 mm h^{-1}, Cat.2 10 - 30 mm h^{-1}, Cat.3 30 - 50 mm h^{-1}, and Cat.4 over 50 mm h^{-1}. We divided the 13 years' precipitation data as follows: The data of 2006 - 2012 was prepared for training, 2013 - 2015 was used as validation for checking the learning progress. The data between 2016 and 2018 was for a test in which the prediction accuracy was evaluated.

Furthermore, we applied data augmentation to training data by generating pseudo data. We used affine transformations, such as rotations from -60 degrees to 60 degrees and expansions from 1x to 4x to heavy rain events. We made two calculation cases, CNT with no augmented data and AUG with augmentation. The two cases were compared in terms of prediction accuracy.

Figure1 shows the prediction of the July 2017 heavy rainfall event occurring in the northern Kyushu region from 10 a.m. to 3 p.m. on 5th July. We can find that the CNT model predicted only light rain but unable to predict the heavy rainfall. On the other hand, the AUG model could predict the two linear precipitation systems extending east-west at 6 hours ahead, though it tended to overestimate. It was also found that the accuracy of the AUG's prediction was higher with the shorter prediction time. Furthermore, we evaluated the forecast results of AUG for the entire test period (Figure2). Even for Cat.4, the critical success index (CSI) exceeded 0.3 at 1 hour ahead, but the false alarm rate (FAR) decreased rapidly with the longer forecast time, and the CSI decreased accordingly. However, the probability of detection (POD) decreased gradually with longer forecast times in all categories. Thus, the model trained with pseudo data could predict some heavy rainfall events six hours prior to the occurrence, even though it has a tendency of overestimation.

We found that data augmentation is a powerful tool for predict low-frequency events such as heavy rainfall and our method of transformation was appropriate to reproduce the real phenomena. On the

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other hand, there was a tendency of overestimation, which might be partly due to the lack of balance in the sample size during training. For example, the sample size is different among categories and also for prediction time. That leads to a bias toward a specific category during training. For preventing this problem, the method of data augmentation and data balance control has to be explored.

Keywords: Precipitation forecasting, Radar precipitation, Deep learning, Heavy rainfall, Disaster

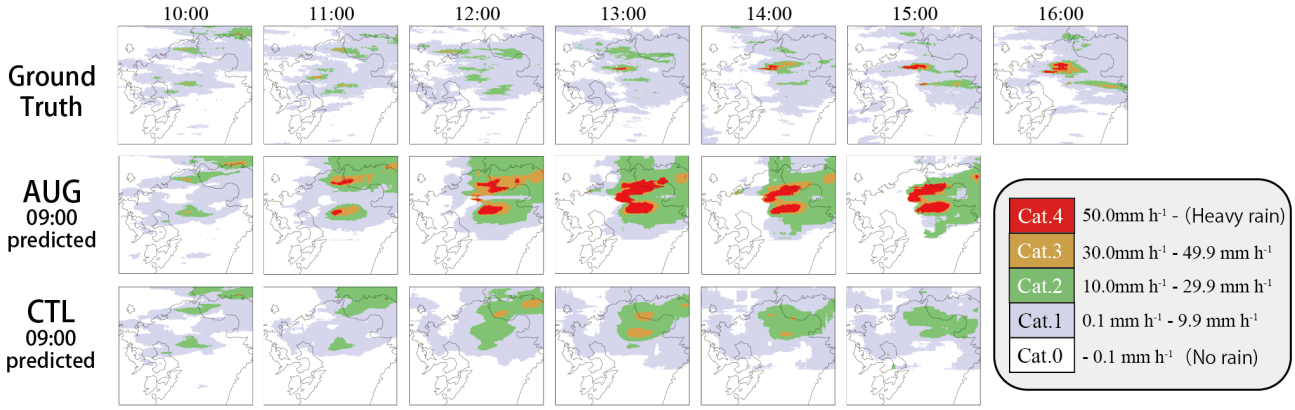


Figure1 The northern Kyushu region from 10 a.m. to 3 p.m. on 5th July 2017.

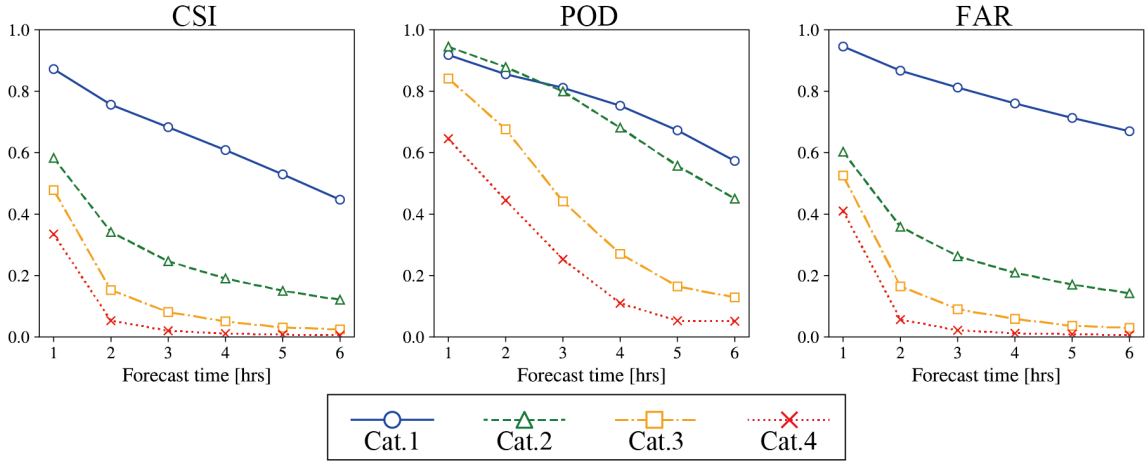


Figure2 The scores of the AUG model.

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.06 Zoom Room 06

[A-CG43] Earth & Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy), Chairperson:Shigeki Hosoda(Japan Marine-Earth Science and Technology), Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University)

In recent years, we have been required to explore various gigantic data leading earth and environmental sciences such as modern meteorology, oceanography, hydrology and so on to accomplish Society 5.0 and Sustainable Development Goals (SDGs). To examine such gigantic environmental data faithfully, it may be required to use the techniques of artificial intelligence/machine learning (AI/ML) including spatiotemporal data modeling of AI, prediction and detection by ML, techniques of automated data mining, and so forth. At the present, AI/ML is also expected to lead the data-driven science as a bridge connecting science and big data. This session calls for various studies applying the techniques of AI/ML to scientific/environmental issues and will discuss them in both natural and information sciences.

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[ACG43-07] Automated identification of tornadic vortex with Doppler radar data using deep learning approaches: Recent progress and challenges

★Invited Papers

*Kusunoki Kenichi[1], Naoki Ishitsu[2], Toru Adachi[1], Hanako Inoue[1], Osamu Suzuki[1], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd., 3.East Japan Railway Company)

3:50 PM - 4:10 PM JST | 6:50 AM - 7:10 AM UTC

[ACG43-08] **Estimation of cloud and meteorological state from satellite image by deep neural network**

★Invited Papers

*Hironobu Iwabuchi[1], Xinyue Wang[1], Hana Kato[1], Takaya Yamashita[1] (1.Graduate School of Science, Tohoku University)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[ACG43-09] Clustering global ocean profiles according to temperature-salinity structure

*Nozomi Sugiura[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[ACG43-10] **Automated Hybrid Machine Learning Approaches for Groundwater Level Forecasting in Kumamoto area, Japan**

*A T M Sakiur Rahman[1], Takahiro Hosono[4,5], John Quilty[2], Jayanta Das[3], Amiya Basak[3] (1.Postdoctoral researcher, Kumamoto University, 2.Department of Civil and Environmental Engineering , University of Waterloo, Waterloo, ON, Canada , 3.Department of Geography and Applied Geography, University of North Bengal, Darjeeling - 734013, India , 4.Faculty of Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan, 5.International Research Organization for Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[ACG43-11] **Improving Detection of Tropical Cyclones by Deep Convolutional Neural Network through a Two-step Training**

*TAKERU TSUCHIYA[1], Shunji Kotsuki[2], Ryota Kikuchi[3], Takeshi Umezawa[4], Noritaka Osawa[4] (1.Department of Information Engineering, Chiba University, Chiba, Japan, 2.Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3.Office of Society Academia Collaboration for

Innovation, Kyoto University, Japan, 4.Graduate School & Faculty of Engineering, Chiba University, Chiba, Japan)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

[ACG43-12] Discussion

Automated identification of tornadic vortex with Doppler radar data using deep learning approaches: Recent progress and challenges

*Kusunoki Kenichi[1], Naoki Ishitsu[2], Toru Adachi[1], Hanako Inoue[1], Osamu Suzuki[1], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3]

1. Meteorological Research Institute, 2. Alpha-denshi Co., Ltd., 3. East Japan Railway Company

In recent years, deep learning (DL) techniques have been applied in many fields.The Convolutional Neural Network (CNN) is one of the most widely used DL techniques mainly for image processing tasks. The collaborative study between the Meteorological Research Institute and the East Japan Railway company has developed a CNN model to extract vortex pattern from Doppler velocity field while reducing false pattern.

The accuracies of the CNN model is applicable for detection of wintertime tornadic vortices over the coast of the Sea of Japan and has been in operational use since November 2020. In this presentation, we will introduce the basic concepts of our model and further approaches to extend to other regions and/or other seasons especially tornadoes of warm- season over the Pacific coast in Japan.

This study is partly supported by Cabinet Office, Government of Japan, Public/Private R&D Investment Strategic Expansion Program (PRISM).

Keywords: tornado, Doppler radar, deep learning

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Estimation of cloud and meteorological state from satellite image by deep neural network

*Hironobu Iwabuchi[1], Xinyue Wang[1], Hana Kato[1], Takaya Yamashita[1]

1. Graduate School of Science, Tohoku University

Machine learning has been applied to satellite remote sensing of atmosphere, ocean, and land. Recent machine learning techniques show high ability to represent a relationship between satellite measurement signals and an atmosphere/surface state utilizing rich information contained in high-dimensional, spatial/temporal/spectral measurement data. This well meets both a requirement of processing big data available from recent satellite observation systems and a demand for high accuracy of estimation. Popular deep neural networks are good at analysis of satellite measurement image, effectively using spatial/temporal features contained in the image or a sequence of images. If we use time series of satellite images, information about temporal variation of meteorological state can be well obtained. This is a big difference from previous satellite data analysis because traditional satellite remote sensing uses data at an image pixel at a time step. The authors have applied deep neural networks to cloud retrieval from GCOM-C and Himawari-8 satellites. With a multispectral image as input, a deep neural network estimates a spatial distribution of cloud properties fusing multi-scale, spatial and spectroscopic features. We show two different training approaches. One makes a training dataset from physics-based (realistic) simulations, and the other takes independent observations that are assumed to be correct. Prior of cloud and radiative transfer imprinted in multispectral images should be learned by machine in the training process. High accuracy of estimation is shown for cloud properties from visible or thermal infrared channels. Infrared-only method is particularly attractive because it can be used uniformly irrespective to sunlight. We show not only cloud properties but also meteorological states such as wind and humidity can be estimated from a snapshot or time series of Himawari-8 infrared image. An advantage of deep learning is the usage of spatial and temporal features for estimation/prediction of atmospheric properties, which is a new direction for the community.

Keywords: deep learning, satellite earth observation, cloud

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Clustering global ocean profiles according to temperature-salinity structure

*Nozomi Sugiura[1]

1. Japan Agency for Marine-Earth Science and Technology

An unsupervised clustering using a Gaussian mixture model is applied to Argo profiles distributed over the entire ocean. We employ as the coordinate components in feature space the path signature, which is a central notion in rough path theory. This allows us to better identify the oceanic condition at each horizontal point with distinct clusters, than by using conventional temperature and salinity coordinate. To the best of my knowledge, it is the first attempt at clustering almost all of the existing Argo profiles with the full use of measured sequences of temperature, salinity, and pressure. We will also discuss why the path signature is relevant to representing the property of a profile.

Keywords: path signature, Argo, clustering

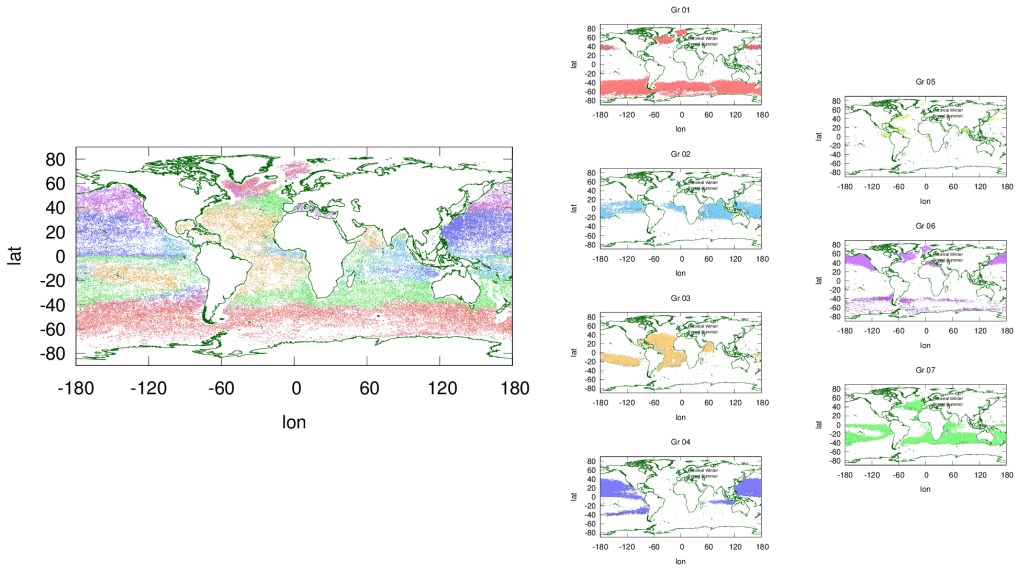


Figure: Seven clusters of Argo profiles identified by the Gaussian mixture model in terms of their path signature

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Automated Hybrid Machine Learning Approaches for Groundwater Level Forecasting in Kumamoto area, Japan

*A T M Sakiur Rahman[1], Takahiro Hosono[4,5], John Quilty[2], Jayanta Das[3], Amiya Basak[3]

1. Postdoctoral researcher, Kumamoto University, 2. Department of Civil and Environmental Engineering , University of Waterloo, Waterloo, ON, Canada , 3. Department of Geography and Applied Geography, University of North Bengal, Darjeeling - 734013, India , 4. Faculty of Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan, 5. International Research Organization for Advanced Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan

Groundwater level (GWL) forecasting is crucial task for planning and management of water resources. However, accurate GWL forecasting is challenging due to nonlinear relationships between GWL and driving hydro-meteorological (input) variables (e.g., rainfall, air temperature). One of the pre-requisites for developing accurate machine learning (ML) models is to select relevant input variables from a range of candidates and afterwards optimizing the model parameters. To address these problems, this study tested the ability of ML approaches such as Random Forests (RF) and eXtreme Gradient Boosting (XGB), which can select input variable internally during model development, for GWL forecasting. Afterwards, RF and XGB were compared with Support Vector Regression (SVR), which has a history of high performance for GWL forecasting. Further, RF, XGB, and SVR models were fed with multiscale information obtained through wavelet transforms (WT) to develop new hybrid ML approaches (WT-RF, WT-XGB, and WT-SVR) for GWL forecasting in Kumamoto, Japan. ML approaches were also coupled with Bayesian hyper-parameter optimization (BHO) to estimate the model parameters automatically. The capability of the models was tested for different monthly lead times (1, 2, and 3 months-ahead) GWL forecasting. The obtained results revealed that standalone ML approaches can successfully forecast the GWL across all lead times and revealed that XGB and SVR had very similar accuracy, while RF showed higher error in Kumamoto, Japan. Although the accuracy was similar for SVR and XGB, it is necessary to apply external algorithms for proper selection of input variables prior to develop model using the SVR. Further, the WT-based models showed improved performance (3-5%) over the standalone models. Therefore, coupling BHO, WT, and ML is a new promising framework for GWL forecasting and is recommended to be explored for short and long-term forecasting of other hydro-meteorological variables (e.g., streamflow, evaporation).

Keywords: Automated Hybrid Machine Learning, Groundwater level forecasting, Kumamoto, Japan

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Improving Detection of Tropical Cyclones by Deep Convolutional Neural Network through a Two-step Training

*TAKERU TSUCHIYA[1], Shunji Kotsuki[2], Ryota Kikuchi[3], Takeshi Umezawa[4], Noritaka Osawa[4]

1. Department of Information Engineering, Chiba University, Chiba, Japan, 2. Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3. Office of Society Academia Collaboration for Innovation, Kyoto University, Japan, 4. Graduate School & Faculty of Engineering, Chiba University, Chiba, Japan

Detecting tropical cyclones (TCs) is important to mitigate disasters induced by TCs. The Japan Meteorological Agency operationally uses the Dvorak method that manually estimates TC intensities by cloud patterns. With the recent progress of machine learning algorithms, TC detections using deep neural network have been explored. Matsuoka et al. (2018) used a deep convolutional neural network (DCNN) to detect TCs or non-TC for simulated cloud images. They found that the classifications were less accurate when images were densely or sparsely covered by clouds.

This study aims at developing an efficient approach for training DCNN for TC or non-TC classifier. We first developed a VGG16-based DCNN that has one additional layer with two features before the classifier (Machine 1). We trained Machine 1 using Matsuoka et al. (2018)’ s cloud images, and found that the classification was less accurate when the two features were close to zero. Based on this preliminary results, we developed a new machine (Machine 2) that uses three inputs for the fully-connected NN: (1) cloud cover ratio, (2) two features from pre-trained Machine 1, and (3) outputs from standard VGG16-based DCNN. This two-step training improved detection accuracy significantly with relative to the classical VGG16. Although cloud images contain cloud cover ratio and two features implicitly, using “extracted features” explicitly enables efficient training with limited training data. At the conference, we will introduce the details of our DCNN approach together with preliminary unsuccessful experiments.

Keywords: Tropical Cyclones, Deep Learning

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-CG Complex & General

[A-CG43] Earth &Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy), Chairperson:Shigeki Hosoda(Japan Marine-Earth Science and Technology), Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University)
Thu. Jun 3, 2021 3:30 PM - 5:00 PM Ch.06 (Zoom Room 06)

In recent years, we have been required to explore various gigantic data leading earth and environmental sciences such as modern meteorology, oceanography, hydrology and so on to accomplish Society 5.0 and Sustainable Development Goals (SDGs). To examine such gigantic environmental data faithfully, it may be required to use the techniques of artificial intelligence/machine learning (AI/ML) including spatiotemporal data modeling of AI, prediction and detection by ML, techniques of automated data mining, and so forth. At the present, AI/ML is also expected to lead the data-driven science as a bridge connecting science and big data. This session calls for various studies applying the techniques of AI/ML to scientific/environmental issues and will discuss them in both natural and information sciences.

4:55 PM - 5:00 PM

[ACG43-12]Discussion

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.03_4

[A-CG43] Earth & Environmental Sciences and Artificial Intelligence/Machine Learning

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Shigeki Hosoda(Japan Marine-Earth Science and Technology), Ken-ichi Fukui(Osaka University), Satoshi Ono(Kagoshima Univeristy)

In recent years, we have been required to explore various gigantic data leading earth and environmental sciences such as modern meteorology, oceanography, hydrology and so on to accomplish Society 5.0 and Sustainable Development Goals (SDGs). To examine such gigantic environmental data faithfully, it may be required to use the techniques of artificial intelligence/machine learning (AI/ML) including spatiotemporal data modeling of AI, prediction and detection by ML, techniques of automated data mining, and so forth. At the present, AI/ML is also expected to lead the data-driven science as a bridge connecting science and big data. This session calls for various studies applying the techniques of AI/ML to scientific/environmental issues and will discuss them in both natural and information sciences.

[ACG43-P01] Machine learning for remote sounding of the ionosphere in Taiwan

*ALEXEI DMITRIEV[1] (1.National Central University, Jungli City, Taiwan)

[ACG43-P02] Precipitation predictions using RNN and LSTM with simple time series observations and the comparison between them.

*He Zhang[1], Tomohiko Tomita[2], Ken-ichi Fukui[3], Satoshi Ono[4] (1.Kumamoto University, 2.Faculty of Advanced Science and Technology, 3.The Institute of Scientific and Industrial Research, Osaka University, 4.Faculty of Engineering, Kagoshima University)

[ACG43-P03] Hindcast of the July 2018 torrential rainfall event in Kagoshima City using LSTM

*Genki Shirasawa[1], Ryusei Hamasaki[1], Shinichiro Kako[2], Hirohiko Nakamura[3] (1.Kagoshima University, Faculty of Engineering, 2.Graduate School of Science and Engineering, Kagoshima University, 3.Kagoshima University, Faculty of Fisheries)

[ACG43-P04] Real-time Data Quality Control of Phased Array Weather Radar by using Semantic Segmentation

*Isoda Fusako[1], Shinsuke Satoh[1], Masashi Kimura[2], Takemasa Miyoshi[3] (1.National Institute of Information and Communications Technology, 2.Convergence Lab., 3.RIKEN)

[ACG43-P05] A Preliminary Study on Developing a Smartphone Application for Weather Classification Using AutoML

*Satoshi Ono[1], Kento Wakamatsu[1], Yusaku Hayashi[1], Tomohiko Tomita[2] (1.Kagoshima Univeristy, 2.Kumamoto University)

[ACG43-P06] Fundamental Study on Weather Judgement of Image Data using Machine Learning Classification

*Tomohiko Tomita[1], Kosuke Tanaka[2] (1.Faculty of Advanced Science and Technology, Kumamoto University, 2.Faculty of Science, Kumamoto University)

Machine learning for remote sounding of the ionosphere in Taiwan

*ALEXEI DMITRIEV[1]

1. National Central University, Jungli City, Taiwan

A. V. Dmitriev and NCU AI group

Global Navigation Satellite System (GNSS) plays crucial role for positioning and navigation. The GNSS accuracy is directly controlled by the conditions in the ionosphere. Routing monitoring of the ionospheric conditions is conducted by ground-based ionosondes, which provide experimental information about radio-echoes from ionospheric layers, so-called ionograms. The ionograms contain a lot of noise from numerous artificial transmitters such that the recovery of ionospheric signals becomes a very difficult problem. We present application of various machine learning (ML) techniques for determination of the signals from ionospheric E and F layers in very noisy environment of Taiwan, where the noise is comparable with the signal (SNR ~ 1). It is shown that deep ML techniques allow increasing of the determination accuracy up to 80% even for extremely nosy conditions.

NCU AI group: Chang Y.-C., Dmitriev A., Hsieh M.-C., Hsu H.-W., Huang G.-H., Li Y.-H., Lin C.-H., Lin Y.-C., Mendoza M., Tsai L.-C., Tsogtbaatar E.

Keywords: ionospheric sounding, machine learning

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Precipitation predictions using RNN and LSTM with simple time series observations and the comparison between them.

*He Zhang[1], Tomohiko Tomita[2], Ken-ichi Fukui[3], Satoshi Ono[4]

1. Kumamoto University, 2. Faculty of Advanced Science and Technology, 3. The Institute of Scientific and Industrial Research, Osaka University, 4. Faculty of Engineering, Kagoshima University

Precipitation prediction is one of most difficult predictions in weather and climate but strongly required for society. It is well known that there are three problems when artificial neural network (ANN) is employed to predict precipitation. The first is that the predicted local maximum in precipitation is not large enough; the second is that the time of occurrence of the maximum is lagged one interval time; the third is that the state of zero precipitation cannot be accurately represented. In this study, RNN and LSTM were employed to replace the multi-layer Perception (MLP) of ANN for the precipitation prediction, and the outputs were compared so as to explore the degree to which the above three problems could be improved.

Using simple time series observations, three different ANN models, that is, MLP, RNN, LSTM, were tested, two experiments were carried out for these three models. The data sets used in this study are observational time series data compiled by the Japan Meteorological Agency. The stations are five, i.e., Kumamoto, Kikuchi, Mashiki, Nagasaki, and Yatsushiro located in Kyushu of Japan. The used variables are six, that is, hourly precipitation, temperature, pressure, vapor pressure, wind speed, and wind direction. The evaluation functions are SS and RMSE, where SS is the ratio of observed values to predicted values larger than 10 mm/h, which varies between 0 and 1, and the large value means the better prediction performance.

When MLP was used for prediction, the predicted local maximum was less than one third of the observed value, and the occurrence of the maximum was delayed one hour. When RNN was used for prediction, this problem was obviously improved. The predicted maximum can reach about 90% of the observed one, but the maximum's occurrence was still delayed one hour. Finally, when we employed LSTM, the maximum's occurrence time was adjusted with large predicted maximum, which means the time-lag problem was certainly improved. When the ANN model is transformed from RNN to LSTM, the structure of LSTM seemed to improve the short-term dependency bottleneck of RNN, which means that the time series data can be better processed. Some unnecessary data can be forgotten and discarded, and the key data can be retained, which greatly improve the accuracy of the prediction.

When only data of Kumamoto was used for prediction, the best result of MLP was SS=0.45, RMSE=1.36, and for using 5 sites' data, it came to SS=0.54, RMSE=1.04. By adjusting the number of nodes in the two hidden layers, the results were further improved to SS=0.45, RMSE=1.04 for one site's experiment and SS=0.60, RMSE=1.04 in 5 sites' experiment. The results of RNN came to SS=0.46, RMSE=0.96 in one site's experiment and SS=0.61, RMSE=0.96 in 5 sites’ experiment. Finally, when the LSTM model was employed, our prediction reached the best so far, which was SS=0.62, RMSE=1.01 in one site's experiment and SS=0.72, RMSE=0.88 in 5 sites' experiment.

Keywords: precipitation forecast, evalution functions, RNN

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Hindcast of the July 2018 torrential rainfall event in Kagoshima City using LSTM

*Genki Shirasawa[1], Ryusei Hamasaki[1], Shinichiro Kako[2], Hirohiko Nakamura[3]

1. Kagoshima University, Faculty of Engineering, 2. Graduate School of Science and Engineering, Kagoshima University, 3. Kagoshima University, Faculty of Fisheries

In this study, we constructed a long short-term memory (LSTM) model to hindcast the torrential rainfall event that occurred in Kagoshima City in July 2018. In this model, automated meteorological data acquisition system (AMeDAS) and radar–AMeDAS rainfall data from Kyushu were used as training data. Our LSTM model could hindcast the time variation of the rainfall event; however, it tended to underestimate the rainfall event observed by AMeDAS, and in some cases the start times of the precipitation events were late. Underestimation and phase lags were probably because the LSTM model was optimized for light rainfall events that occur frequently. To further improve the prediction accuracy of our model, it was necessary to improve the reproducibility of the magnitude of the precipitation amplitude. Therefore, we selected further training data such as physical quantities over the East China Sea that contribute to the forecast/hindcast of torrential rainfall events. The use of radar–AMeDAS rainfall data as training data over the ocean in the southern part of Kagoshima significantly improved the accuracy of our LSTM model compared to that without this additional training data.

Keywords: LSTM, Torrential rain, Radar AMeDAS, AMeDAS, Hindcast/Forecast of rainfall event

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Real-time Data Quality Control of Phased Array Weather Radar by using Semantic Segmentation

*Isoda Fusako[1], Shinsuke Satoh[1], Masashi Kimura[2], Takemasa Miyoshi[3]

1. National Institute of Information and Communications Technology, 2. Convergence Lab., 3. RIKEN

The observation data of Phased Array Weather Radar (PAWR) which performs volume scan every 30 seconds is used for real-time precipitation prediction such as 3D precipitation nowcast (Otsuka, et al., 2016. doi: 10.1175 / WAF-D-15-0063.1) and the smartphone application "3D Amagumo Weather". The data quality control (QC) of PAWR is necessary to make accurate predictions, and It is important to remove non-precipitation echoes (clutters derived from buildings on the ground and mountains, fake echoes appear before and after strong echoes which is called range side-lobe echoes). In the current real-time QC, clutter discrimination is performed using thresholds of the Doppler velocity and the texture information of the reflectivity. However, if the data QC is performed in various cases with a certain threshold value, erroneous judgment may occur. Therefore, to perform appropriate QC in various cases, we apply semantic segmentation, one of the deep learning applications that detects objects from images in pixel units.

We report the results using ESPNet (Mehta, et al., 2018.arXiv: 1803.06815v3), which has high inferences speed. The data was selected from 10 cases of convective rainfall observed by PAWR installed at the Osaka University from 2015 to 2017, and a total of 666 images with elevation angles 6 to 12 (corresponding to elevation angles 4.4 ˚to 9.4 ˚) were prepared. For stratiform rainfall, another 10 cases were selected, and 644 images were prepared. By using color images of reflectivity and annotation images (0 = no data, 1 = precipitation data, 2 = non-precipitation data) as training data, two models for convection and stratiform rainfall were created. For the annotations, the QC flag created by the conventional method was used, and the flag data that was considered to be false judgments by visual inspection was removed as much as possible.

Figure 1 shows the inference results of convective (left) and stratiform rainfall (right) with an elevation angle of 6.2 ˚converted to PPI in the Cartesian coordinates. They are examples of input data (reflectivity: upper row), inference results (middle row), and the QC flag (lower row: as ground truth). In the result of inferences and the QC flag, black part is judged to be a non-precipitation echo. In the inference of convective rainfall, the range side-lobe echoes are discriminated, and the judgment is very similar to the QC flag. Looking at the inference results of stratiform rainfall, the non-precipitation echoes were hardly identified on this elevation angle, and the model inference was performed correctly.

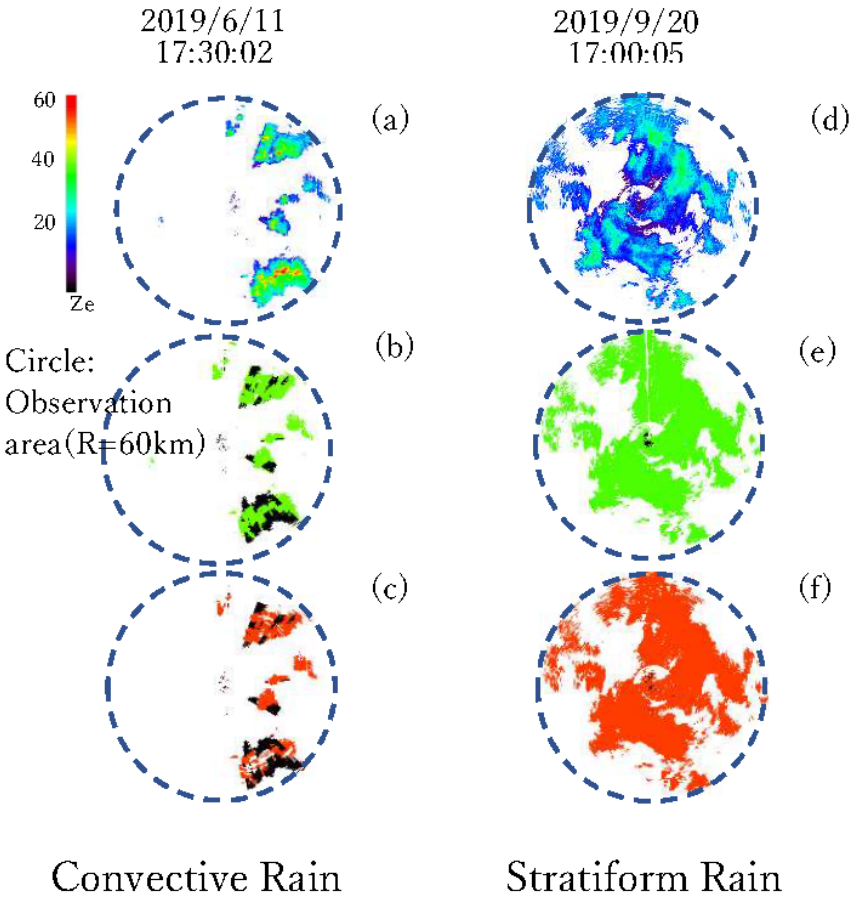
In this study, learning and inference were performed on a Linux server equipped with one GeForce RXT 2080 Ti. For convective rainfall, it took about 0.02 seconds to inference the data for one elevation angle, and for stratiform precipitation with a large precipitation area, it took about 0.04 seconds. The reading of observation data was accelerated by calling a C program using Cython (0.035 seconds / file, 1 file is about 40MB). Considering the data processing of 110 elevation angles obtained by the PAWR observation every 30 seconds, it was expected that QC processing would be performed in a few seconds.

As a future work, it is necessary to create other models for each elevation angles, because the types of non-precipitation echoes in the data near lower elevation and zenith angles are different from the above. In order to further improve the accuracy of inference, we think that it is necessary to tune the QC flag used as annotations for each case, create more correct ground truth, and increase the number of learning data. The goal is to complete a processing system that can process data reading, convection / stratiform judgment by CNN, segmentation of total elevation angles data, aggregation and output of inferences results within 10 seconds.

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This work was supported by JST AIP Grant Number JPMJCR19U2, Japan.

Keywords: Phased Array Weather Radar, Semantic Segmentation, Quality Control



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A Preliminary Study on Developing a Smartphone Application for Weather Classification Using AutoML

*Satoshi Ono[1], Kento Wakamatsu[1], Yusaku Hayashi[1], Tomohiko Tomita[2]

1. Kagoshima Univeristy, 2. Kumamoto University

In recent years, the need for local weather observation has increased for various applications. For instance, predicting local weather phenomena such as guerrilla rains and tornadoes requires detailed ground-based observation networks. In addition, recording weather conditions in an individual's environment can be used to treat physical illnesses caused by climate and weather changes, known as weather-related diseases. Therefore, this study develops a smartphone application that discriminates the weather as a tool to realize a local meteorological observation network or to record meteorological factors to patients. This study utilizes an automatic machine learning design technique (AutoML) that include neural architecture search and hyper-parameter optimization to design deep neural network architecture for weather classification and compresses the designed architecture to implement it on smartphones.

Keywords: machine learning, artificial intelligence, AutoML, neural architecture search, weather classification

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Fundamental Study on Weather Judgement of Image Data using Machine Learning Classification

*Tomohiko Tomita[1], Kosuke Tanaka[2]

1. Faculty of Advanced Science and Technology, Kumamoto University, 2. Faculty of Science, Kumamoto University

The sky and ground conditions in many image data, i.e., pictures and video images, are valuable weather information. Using the multi-class classification technique of machine learning, this study investigated the potential how well the technique judged the weather condition involved in image data. For this purpose, about 30,000 pictures were taken with a 10-minute interval (144 pictures per day) by a field monitoring camera fixed in the Kumamoto University. Corresponding weather condition was then assigned from the published data of Kumamoto weather station. At this timing, the weather conditions were summarized into three categories, i.e., sunny, cloudy, and rainy conditions. The supervised training, validation, and test data were prepared from these pictures and weather condition data. This study employed simple multilayer perceptron with two hidden layers for building a classification model, and investigated the accuracy of the three-category classification of following four cases: (1) all pictures, (2) daytime, (3) nighttime pictures and (4) pictures around sunrise and sunset times. The results showed that the accuracy rates of four cases all reached about 85%. It is interesting that our classification model could judge weather conditions even using nighttime and around sunrise and sunset pictures. However, we confirmed that the significant difference appeared the time until when the accuracy rate reached 80% in the training process. That is, the training of the nighttime pictures needed longer time than the daytime ones. It was suggested that our model might have trained using relative brightness of pictures without convolution.

Keywords: machine learning multi-class classification, judgement of weather conditions in image data

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.10 Zoom Room 10

[A-CG44] Biogeochemical linkages between the surface ocean and atmosphere

convener:Sohiko Kameyama(Hokkaido University), Yoko Iwamoto(Graduate School of Integrated Sciences for Life, Hiroshima University), Noguchi Maki Aita(Japan Agency for Marine-Earth Science and Technology), Daisuke Sasano(Japan Meteorological Agency), Chairperson:Sohiko Kameyama(Hokkaido University)

Multi-scale vertical and horizontal ocean mixing processes can strongly influence the distribution of dissolved and suspended substances including macro- and micro-nutrients, and may impact on the global carbon cycles. The changes in nutrient dynamics generally affect the abundance, composition and metabolic activity of marine organisms such as phytoplankton and bacteria during the bloom. Marine phytoplankton can produce volatile organic compounds (VOCs) and marine atmospheric aerosols, which strongly influence on atmospheric chemistry. Primary and secondary organic and inorganic components produced via marine phytoplankton activity can contribute to the Earth's radiative forcing, and in turn marine ecosystems including biogeochemical processes directly or indirectly. Therefore, the biogeochemical cycles have a tight linkage between the ocean and the atmosphere. In order to understand physical, chemical and biological processes relevant to phytoplankton bloom formation in the ocean, dynamics of VOCs and marine aerosols in the atmosphere, and the biogeochemical linkage between the ocean and the atmosphere, we welcome new interdisciplinary presentations and active discussions on physical, chemical, and biological sciences both from ocean and atmospheric fields in this session. Studies linked to the Surface Ocean-Lower Atmosphere Study (SOLAS) project are good examples, but other related studies are also invited.

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

[ACG44-01] R/V Mirai cruise for IMPACT-SEA project 2021: Preliminary results

*Fumikazu Taketani[1], Kana Nagashima[1], Minoru Kitamura[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[ACG44-02] **Seasonal and interannual variations of surface water carbonate chemistry in the Indian sector of the Southern Ocean**

*Manami Tozawa[1], Daiki Nomura[1,2,3], Shin-ichiro Nakaoka[4], Masaaki Kiuchi[1], Daisuke Hirano[5], Shigeru Aoki[5], Hiroko Sasaki[6], Hiroto Murase[7] (1.Faculty of Fisheries Sciences, Hokkaido University, 2.Field Science Center for Northern Biosphere, Hokkaido University, 3.Arctic Research Center, Hokkaido University, 4.National Institute for Environmental Studies, 5.Institute of Low Temperature Science, Hokkaido University, 6.Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 7.Tokyo University of Marine Science and Technology)

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

[ACG44-03] **Summer carbonate chemistry near the Totten Ice Shelf, Sabrina Coast, East Antarctica**

*Tetsuya Tamura[1], Daiki Nomura[1,2,3], Daisuke Hirano[3,4], Takeshi Tamura[5], Masaaki Kiuchi[1], Gen Hashida[5], Shigeru Aoki[4], Hiroko Sasaki[6], Hiroto Murase[7] (1.Faculty of Fisheries Science, Hokkaido University, 2.Field Science Center for Northern Biosphere, 3.Arctic Research Center, 4.Institute of Low Temperature Science, 5.National Institute of Polar Research, 6.Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 7.Tokyo University of Marine Science and Technology)

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

[ACG44-04] Iodomethane and Iodoethane distributions in coastal seawater of subarctic Pacific and Northern Bering sea

*Atsushi Ooki[1], Keita Minamikawa[1], Fanxing Meng[1] (1.Hokkaido University)

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

[ACG44-05] Effects of marine nitrogen fixation on the formation of atmospheric water-soluble organic nitrogen revealed by a laboratory incubation experiment

*Tsukasa Dobashi[1,2], Koji Suzuki[2], Yuzo Miyazaki[1] (1. Institute of Low Temperature Science, Hokkaido Univ., 2.Graduate School of Env. Sci., Hokkaido Univ.)

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

[ACG44-06] Characterization of Adhesivity of marine organic aerosols by atomic force microscopy

*Kohei Ono[1], Ayumi Iwata[2], Takeshi Fukuma[3], Yoko Iwamoto[4], Koji Hamasaki[5], Atsushi Matsuki[6] (1.Graduate School of Natural Science and Technology, Kanazawa University, 2.Faculty of Science and Technology, Keio University, 3.Nano Life Science Institute, Kanazawa University, 4.Graduate School of Integrated Sciences for Life, Hiroshima University, 5.Atmosphere and Ocean Research Institute, The University of Tokyo, 6.Institute of Nature and Environmental Technology, Kanazawa University)

R/V Mirai cruise for IMPACT-SEA project 2021: Preliminary results

*Fumikazu Taketani[1], Kana Nagashima[1], Minoru Kitamura[1]

1. Japan Agency for Marine-Earth Science and Technology

We carried out the cruise to investigate the influence of atmospheric species to the marine ecosystem in the subarctic/subtropical of the North Pacific Ocean from February 13 to March 24 using R/V Mirai(IMPACT-SEA projest). In this cruise, we performed several observations. In the presentation, we are planning to introduce the preliminary results.

Keywords: air-sea interaction, deposition, marine ecosystem

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Seasonal and interannual variations of surface water carbonate chemistry in the Indian sector of the Southern Ocean

*Manami Tozawa[1], Daiki Nomura[1,2,3], Shin-ichiro Nakaoka[4], Masaaki Kiuchi[1], Daisuke Hirano[5], Shigeru Aoki[5], Hiroko Sasaki[6], Hiroto Murase[7]

1. Faculty of Fisheries Sciences, Hokkaido University, 2. Field Science Center for Northern Biosphere, Hokkaido University, 3. Arctic Research Center, Hokkaido University, 4. National Institute for Environmental Studies, 5. Institute of Low Temperature Science, Hokkaido University, 6. Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 7. Tokyo University of Marine Science and Technology

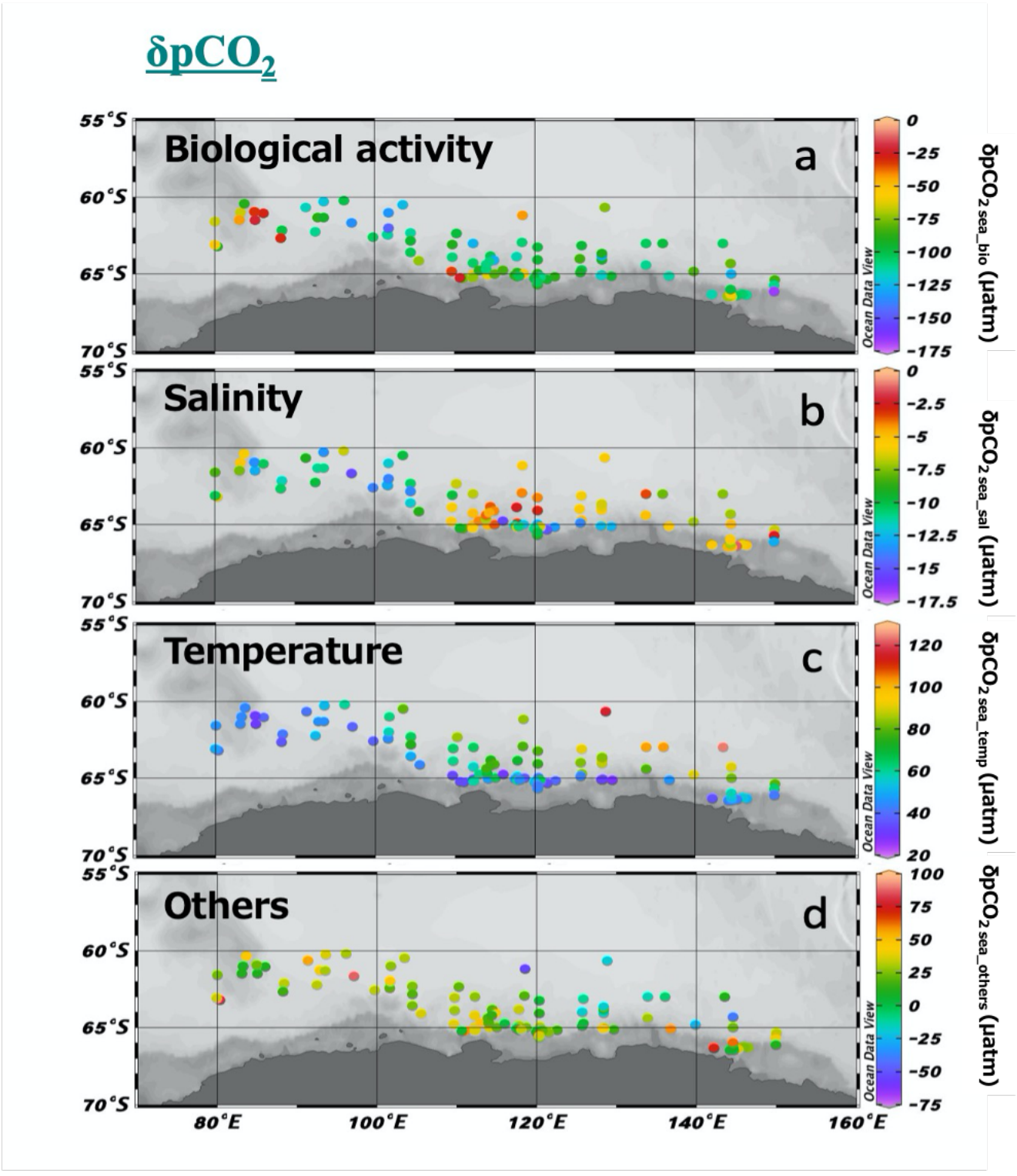
To assess carbon cycling in the Indian sector of the Southern Ocean (80˚E–150˚E, south of 60˚S) quantitatively, we measured seawater temperature, salinity, chlorophyll-*a* concentration, partial pressure of carbon dioxide (pCO_2), dissolved inorganic carbon (DIC) concentration, alkalinity (TA), and nutrient concentrations.

The air-sea CO_2 flux in this region was evaluated to be −7.6±10.9 mmol C m^{-2} day^{-1} (−75.6 −+14.1 mmol C m^{-2} day^{-1}) suggesting that the region was a weak sink. Then, we estimated the change in pCO_2 from winter to summer (pCO_2) due to changes in seawater temperature, salinity, and biological activity on the basis of the assumption that the observed values of DIC concentration and TA in the temperature minimum layer remain the same as in the winter under sea-ice with a temperature of −1.8℃ and salinity of 34.25. The spatial distribution of pCO_2 in the western area (80˚E–120˚E) observed from December to early January was influenced by biological activity, and that in the eastern area (120˚E–150˚E) observed from January to February was influenced by temperature and salinity.

We also examined the annual change in oceanic and atmospheric CO_2 concentrations (xCO_2) between 1996 and 2019. The mean values of oceanic and atmospheric xCO_2 increased by 24 ppm and 45 ppm, respectively. This suggests that the main reason of the rise in oceanic xCO_2 is that the ocean have absorbed CO_2 from atmosphere as a result of the rise in atmospheric xCO_2. However, it also indicates that the oceanic xCO_2 rise is due to the rise in sea water temperature and changes in the ocean circulation.

Keywords: Southern Ocean, carbon cycling, pressure of carbon dioxide, air-sea CO2 flux

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Summer carbonate chemistry near the Totten Ice Shelf, Sabrina Coast, East Antarctica

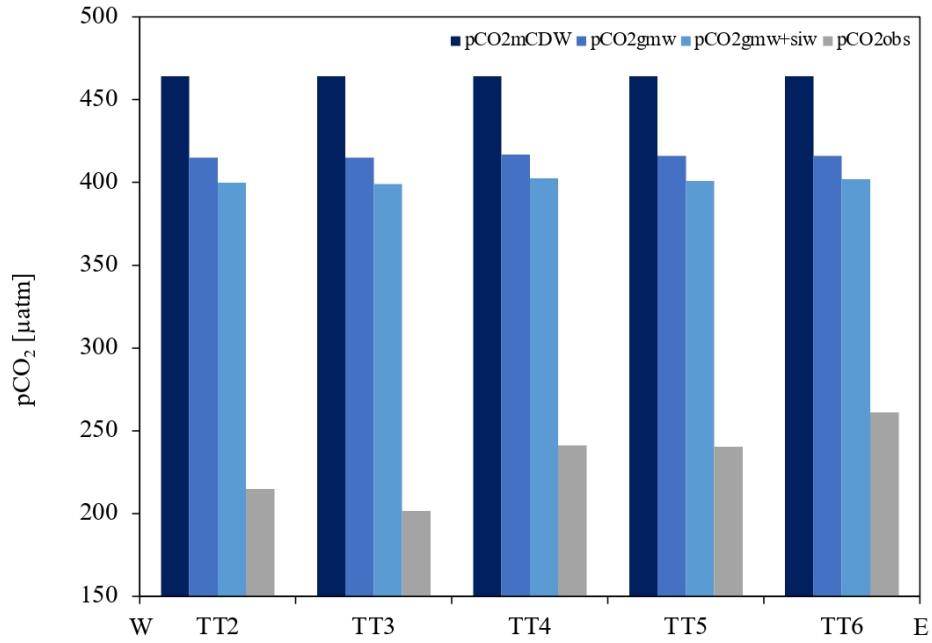
*Tetsuya Tamura[1], Daiki Nomura[1,2,3], Daisuke Hirano[3,4], Takeshi Tamura[5], Masaaki Kiuchi[1], Gen Hashida[5], Shigeru Aoki[4], Hiroko Sasaki[6], Hiroto Murase[7]

1. Faculty of Fisheries Science, Hokkaido University, 2. Field Science Center for Northern Biosphere, 3. Arctic Research Center, 4. Institute of Low Temperature Science, 5. National Institute of Polar Research, 6. Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 7. Tokyo University of Marine Science and Technology

To clarify the effect of basal melting of Antarctic ice sheet on the marine biogeochemical components in the coast of the Southern Ocean, dissolved inorganic carbon (DIC), total alkalinity (TA), nutrients (NO_3^-, PO_4^{3-}, $Si(OH)_4$), oxygen stable isotope ratio ($\delta^{18}O$), chlorophyll *a* were measured off from offshore slope (ice margin area) to Totten Ice Shelf ice front (sea ice area) during summer 2018 and 2019 conducted by *Kaiyo-maru* and *Shirase*. The distribution of DIC concentration, TA and nutrients concentration was corresponded to a following ocean current: (1) mCDW existing on the offshore slope flows beneath the Totten Ice Shelf along the trough, (2) the flow mixes with Totten Ice Shelf basal melt water and (3) the becomes low density and rises to the surface. DIC concentration and TA on the surface of the ice front were strongly influenced by the dilution effect of the ice shelf basal melt water and the inflow of mCDW. The ratio of ice shelf basal melt water with respect to the other water masses (sea ice water and mCDW) calculated using $\delta^{18}O$ was about 1.4% and the ratio of sea ice melt water was 2.9 % and the rest ratio was inflow of mCDW. Because of the dilution effect, DIC concentration decreased about 80 μmol kg^{-1}, and this decrease was corresponded to a decrease of about 64 μatm for the partial pressure of carbon dioxide (pCO_2). However, the surface of the ice front was strongly influenced by biological processes. The nDIC and nTA that normalized to salinity (34.3 pus) to remove the dilution effect of melt water were changed along nDIC:nTA = 106:16 by the photosynthesis of phytoplankton. Furthermore, the net community production (NCP) from 20 to 100 dbar was higher than that for the previous study (December 31st, 2014-January 1st, 2015, [Arroyo et al., 2019]) because the open water area was higher and availability of light for phytoplankton during this study observation was greater in our study period than those in previous study. Therefore, the decrease of more than 150 μatm for pCO_2 would be resulted by the biological productivity in this study. On the west side of the ice shelf, both the ratio of ice shelf basal melt water and NCP were higher and pCO_2 was lower than those of east side of the ice shelf. Therefore, the mCDW mixed with the ice shelf basal melt water floats on the west side of the ice shelf. This study highlighted that ice shelf basal melt water has a significant impact on marine biogeochemical components.

Keywords: Southern Ocean, ice shelf, basal melting, carbon cycling

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Iodomethane and Iodoethane distributions in coastal seawater of subarctic Pacific and Northern Bering sea

*Atsushi Ooki[1], Keita Minamikawa[1], Fanxing Meng[1]

1. Hokkaido University

Volatile organic iodine compounds (VOIs) such as iodomethane (CH_3I), iodoethane (C_2H_5I), diiodomethane (CH_2I_2) and chloroiodomethane (CH_2ClI) carry iodine from the ocean into the atmosphere (Chameides and Davis, 1980). These VOIs have the potential to deplete ozone in boundary layer air on a wide scale (e.g., Carpenter et al., 1999) via the catalytic ozone destruction of iodine atom released from VOIs. Marine organisms are the dominant producers of VOIs. Many studies have reported the productions of VOIs from marine organisms of macro algae, micro algae, photosynthetic bacteria, and heterotrophic bacteria (e.g. Schall et al. 1994; Tokarczyk and Moore 1994; Hughes et al. 2008). The vertical distributions of VOIs in water column have been measured in many ocean areas, however, VOIs in ocean sediment have not ever measured so far. In this study, we have firstly measured VOIs in coastal ocean sediment of Chukchi Sea, northern Bering Sea, and Funka bay, Japan. We found that iodoethane (C_2H_5I), which is a minor VOIs anywhere in the air and ocean water, becomes overwhelming majority of VOIs in the surface of ocean sediment on the sea floor of Arctic and subarctic coastal area. The iodoethane concentrations in the sediment drastically increased soon after the diatom spring bloom in water column above the sediment. We verified that the aggregates of dead diatom cells in a dark incubation bottle produced large amounts of iodoethane as well as small amounts of iodomethane (CH_3I) within 7 days. Live marine algae have been thought to drive sea-air cycle of iodine via. biogenic CH_3I, CH_2ClI, and CH_2I_2 productions. Dead marine algae (diatom) drive sea-sediment cycle of iodine via. biogenic C_2H_5I production. Iodoethane in the ocean sediment will give us a key to understand global iodine cycle.

Keywords: haloarbon, Volatile Organic Compounds (VOCs), Iodine

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Effects of marine nitrogen fixation on the formation of atmospheric water-soluble organic nitrogen revealed by a laboratory incubation experiment

*Tsukasa Dobashi[1,2], Koji Suzuki[2], Yuzo Miyazaki[1]

1. Institute of Low Temperature Science, Hokkaido Univ., 2. Graduate School of Env. Sci., Hokkaido Univ.

Marine atmospheric aerosols formed in the sea surface play a key role in the climate system, as they act as cloud condensation nuclei (CCN) and ice nuclei (IN) and thus can control the atmospheric radiative budget through cloud formation. Water-soluble organic nitrogen (WSON) in marine aerosols affects the physicochemical properties such as water-solubility, acidity, and light-absorbing properties of aerosol particles. A previous ship-board measurement of atmospheric and marine biological paraments in the subtropical North Pacific suggests that nitrogen-fixation in the ocean surface significantly contributed to the formation of aerosol WSON in the atmosphere. *Trichodesmium* is a genus of filamentous cyanobacteria and is one of the most representative nitrogen-fixing organisms, which is widely distributed in the tropical and subtropical oceans. It has been recognized that *Trichodesmium* contributes up to approximately 50% of marine nitrogen fixation in the global ocean. However, effects of nitrogen fixation in the ocean surface on the formation of atmospheric reactive nitrogen have not been understood. This study aims to elucidate the contribution of nitrogen-fixing organisms to the formation of atmospheric reactive nitrogen including WSON by a laboratory incubation experiment.

In the laboratory experiment, *Trichodesmium erythraeum* IMS101 (hereafter referred to as *Trichodesmium*) was cultured in artificial seawater YBC-II medium (15-L) in a polycarbonate bottle installed in an incubator, the temperature of which was set at 25°C. Atmospheric aerosol ($PM_{2.5}$) and gas samples were collected on quartz fiber filters set at three stages of a NILU impactor. Atmospheric and seawater samples were collected every 24 hours. Water-soluble total nitrogen (WSTN) and water-soluble organic carbon (WSOC) concentrations in the atmospheric sample as well as dissolved nitrogen (DN) and dissolved organic carbon (DOC) concentrations in the seawater samples were measured by a total organic carbon analyzer with a TN unit (TOC/TN). The WSON concentration was defined as the difference between the concentrations of WSTN and inorganic nitrogen (IN) which was measured by ion chromatography. To investigate the temporal variation of *Trichodesmium*, *in vivo* chlorophyll *a* (Chl *a*) fluorescence intensity was measured using a Qubit 2.0 fluorometer and chlorophyll *a* concentration was measured using an ultra-high performance liquid chromatography (UHPLC). In addition, heterotrophic bacterial concentration in the seawater was measured using a flow cytometry.

A life cycle of *Trichodesmium* was confirmed by monitoring the Chl *a* concentration in seawater during the incubation period of about one month. In the growth phase, the increase in the Chl *a* concentrations corresponded well with the increase in the DN and DOC concentrations as well as the DN/DOC ratio in the seawater. The results suggest that the growth of *Trichodesmium* released DN and DOC in the seawater, where DN was preferentially released more than DOC. The temporal variation of the Chl *a* concentration showed a significant positive correlation with the WSON concentration in the atmospheric samples. The overall results demonstrate that the growth of *Trichodesmium* in seawater contributed to the formation of atmospheric WSON, mostly through the nitrogen fixation process.

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Keywords: Organic nitrogen, Marine atmospheric aerosol, Nitrogen fixation, Trichodesmium, Biogeochemical linkage between the atmosphere and the ocean

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Characterization of Adhesivity of marine organic aerosols by atomic force microscopy

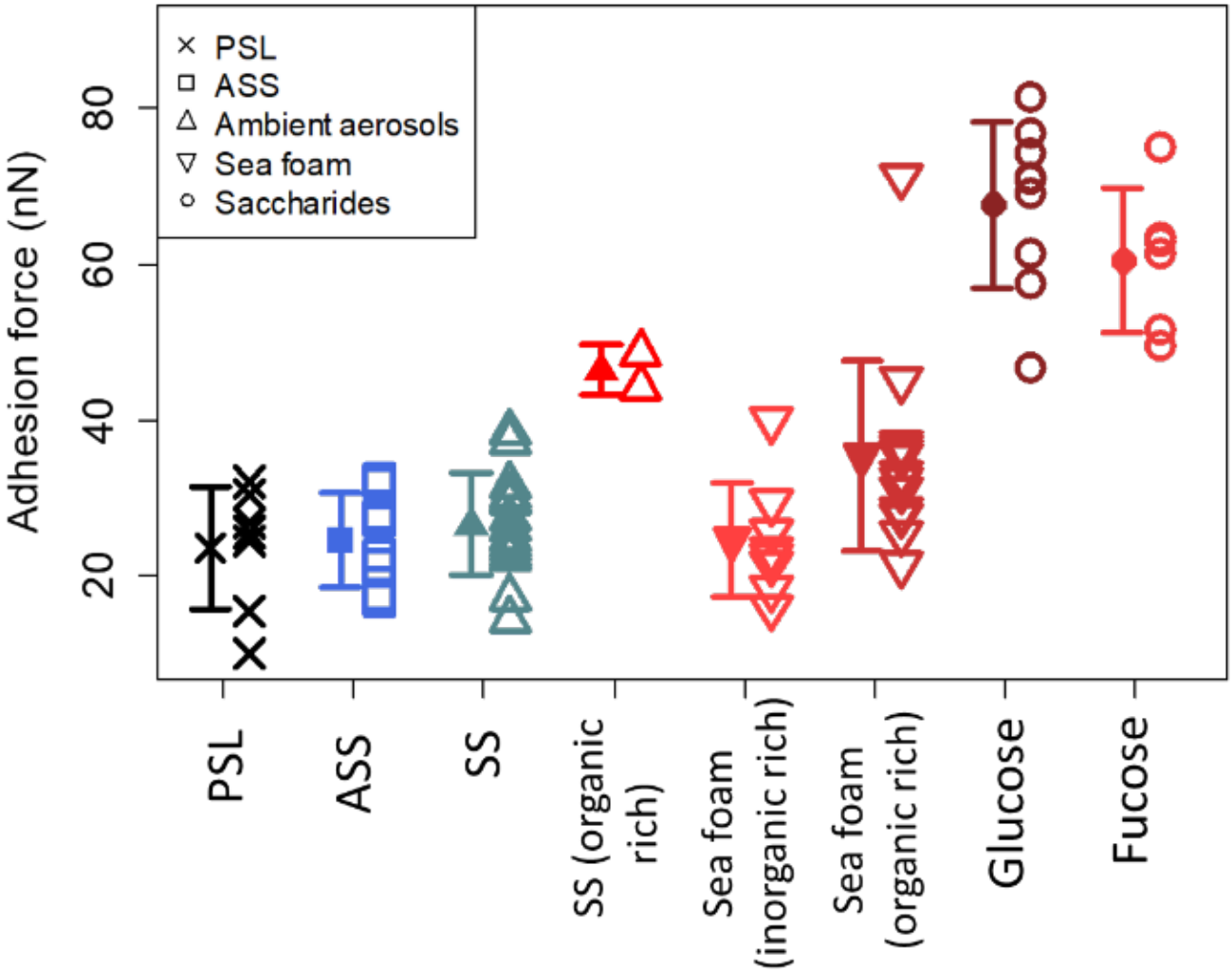
*Kohei Ono[1], Ayumi Iwata[2], Takeshi Fukuma[3], Yoko Iwamoto[4], Koji Hamasaki[5], Atsushi Matsuki[6]

1. Graduate School of Natural Science and Technology, Kanazawa University, 2. Faculty of Science and Technology, Keio University, 3. Nano Life Science Institute, Kanazawa University, 4. Graduate School of Integrated Sciences for Life, Hiroshima University, 5. Atmosphere and Ocean Research Institute, The University of Tokyo, 6. Institute of Nature and Environmental Technology, Kanazawa University

Aerosol particles can trigger various environmental issues even after their deposition at the interface with the atmosphere. For example, sea spray aerosols (SSA) can deposit on the surfaces and cause corrosion of infrastructures such as electrical power cables and tower, as well as related polymer insulators especially in coastal areas. The adhesion force is the force by which aerosol particles continue to remain in contact with the deposition surface. The adhesion behavior of ambient aerosol particles is largely controlled by this force but has not earned enough attention. The aim of this study was to evaluate the physical property of SSA by measuring adhesion forces of simulated SSA on an individual particle basis using atomic force microscopy (force-distance curve mapping method). In order to simulate an organic enriched SSA, aerosols were generated using a bulk sea foam sample collected at Noto Peninsula during the Sea Surface Microlayer-Aerosol Project (SSMAP). The adhesion force of sea foam particles was compared with that of standard monosaccharide (glucose and fucose), artificial sea salt (ASS), as well as ambient SS particles. Mono saccharide particles showed significantly larger adhesion forces than ASS and SS. In addition, it was found that a few of sea foam particles and ambient SS particles showed similar adhesion forces and morphological features as the pure mono saccharides, suggesting that organic (e.g. mono saccharides) enriched SSA can be significantly more adhesive than the inorganic salts. Therefore, in the case of evaluating adhesive property of SSA, it is necessary to consider the presence of organics such as saccharides.

Keywords: Sea Spray Aerosol, Sea Foam, Atomic Force Microscopy (AFM), Adhesion Force, Deposition

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.07_4

[A-CG44] Biogeochemical linkages between the surface ocean and atmosphere

convener:Sohiko Kameyama(Hokkaido University), Yoko Iwamoto(Graduate School of Integrated Sciences for Life, Hiroshima University), Noguchi Maki Aita(Japan Agency for Marine-Earth Science and Technology), Daisuke Sasano(Japan Meteorological Agency)

Multi-scale vertical and horizontal ocean mixing processes can strongly influence the distribution of dissolved and suspended substances including macro- and micro-nutrients, and may impact on the global carbon cycles. The changes in nutrient dynamics generally affect the abundance, composition and metabolic activity of marine organisms such as phytoplankton and bacteria during the bloom. Marine phytoplankton can produce volatile organic compounds (VOCs) and marine atmospheric aerosols, which strongly influence on atmospheric chemistry. Primary and secondary organic and inorganic components produced via marine phytoplankton activity can contribute to the Earth's radiative forcing, and in turn marine ecosystems including biogeochemical processes directly or indirectly. Therefore, the biogeochemical cycles have a tight linkage between the ocean and the atmosphere. In order to understand physical, chemical and biological processes relevant to phytoplankton bloom formation in the ocean, dynamics of VOCs and marine aerosols in the atmosphere, and the biogeochemical linkage between the ocean and the atmosphere, we welcome new interdisciplinary presentations and active discussions on physical, chemical, and biological sciences both from ocean and atmospheric fields in this session. Studies linked to the Surface Ocean-Lower Atmosphere Study (SOLAS) project are good examples, but other related studies are also invited.

[ACG44-P01] Relationship between the variability in dissolved inorganic carbon in surface seawater and the formation volume of subtropical mode water along the 137°E line

*Ono Hisashi[1], Masao Ishii[1], Yosuke Iida[2], Kazutaka Enyo[2], Daisuke Sasano[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

[ACG44-P02] Verification of the effect of aerosol deposition on surface chlorophyll in subtropical oligotrophic waters using JRAero reanalysis datasets

*Naohiro Kosugi[1], Taichu Y Tanaka[1] (1.Meteorological Research Institute)

[ACG44-P03] Seasonal Variation of Phosphate in Atmospheric Aerosols in Higashi-Hiroshima

*Yoko Iwamoto[1], Mako Hirota[2], Kazuhiko Takeda[1], Hiroshi Sakugawa[1] (1.Graduate School of Integrated Sciences for Life, Hiroshima University, 2.School of Integrated Arts and Sciences, Hiroshima University)

[ACG44-P04] Modelling regional and global scale impacts of atmospheric nitrogen inputs on marine biogeochemistry

*Maki Noguchi Aita[1], Fumikazu Taketani[1], Yoko Iwamoto[2], Tomohiro Hajima[3] (1.Earth Surface System Research Center, Japan Agency for Marine-Earth Science and Technology, 2.Hiroshima University, 3.Research Center for Environmental Modeling and Application, Japan Agency for Marine-Earth Science and Technology)

[ACG44-P05] Contribution of lightning-induced nitgen oxide to nitrogen cycle in air-sea boundary estimated by plasma discharge in laboratory

Ryo Hashimoto[1], *Sohiko Kameyama[1], Kohki Satoh[2], Hiroshi Ogawa[3] (1.Hokkaido University, 2.Muroran Institute of Technology, 3.The University of Tokyo)

Relationship between the variability in dissolved inorganic carbon in surface seawater and the formation volume of subtropical mode water along the 137˚E line

*Ono Hisashi[1], Masao Ishii[1], Yosuke Iida[2], Kazutaka Enyo[2], Daisuke Sasano[2]

1. Meteorological Research Institute, 2. Japan Meteorological Agency

1. Introduction

Based on the data of partial pressure of CO2 in seawater (pCO_2^{sea}) along the 137˚E since the beginning of the 1980s, we previously reported the growth rates of dissolved inorganic carbon (DIC) in surface seawater from subtropic to tropic zone by means of a multiple regression analysis (Ono et al., 2019). In addition, we showed that the rates varied greatly on a decadal time scale in the Kuroshio recirculation. Besides, the paper by Kobashi et al. (2020) indicated the decadal scale variability of the North Pacific subtropical mode water (STMW) and its influence on the pycnocline along the 137˚E. In this study, we investigate the relationship between the variability in DIC in surface seawater, STMW thickness and the depth of isopycnal surface at 30˚N along the 137˚E line.

2. Data & Methods

We mainly used measurement data at 30˚N along the 137˚E line in each summer acquired by Japan Meteorological Agency (JMA). Based on the measurement data of DIC since 1994, the long-term trend of DIC in surface seawater was calculated by linear regression analysis. And the time-series of DIC was detrended. Using the data acquired by CTD system, we evaluated the temporal variability of the depth of isopycnal surface and STMW thickness which was defined as a layer of potential vorticity (PV) less than 2.0×10^{-10} $m^{-1}s^{-1}$. From these data, 3-year running means and correlations of each time-series were calculated.

3. Result & Discussion

Temporal variability of salinity-normalized DIC (nDIC) in surface seawater corresponded with those of STMW thickness and depth of isopycnal surface (Figure a-c). Significant correlations between them were seen and their coefficients were 0.69 ($p<0.01$) and -0.77 ($p<0.01$), respectively. These results indicate the thicker STMW and the shallower isopycnal surfaces are, the higher DIC is. Namely, higher values of nDIC around 2015 are considered to be caused by the heaving of isopycnal surfaces and the relatively larger supply of DIC from subsurface to surface by vertical mixing in winter.

It has been reported that the STMW thickness varies corresponding to the decadal variability of the Kuroshio Extension and which are fluctuated in association with the Pacific Decadal Oscillation (PDO) (e.g., Qiu and Chen, 2005). The time lag correlation analysis between nDIC in surface seawater and PDO index showed the maximum coefficient of -0.77 ($p<0.01$) with 4-year lag applied.

These results suggest that the temporal variability of nDIC in surface seawater in the Kuroshio recirculation along the 137˚E line is directly attributed to the fluctuation of STMW formation and isopycnal surface, and originally affected by PDO whose influence is transmitted in around 4 years.

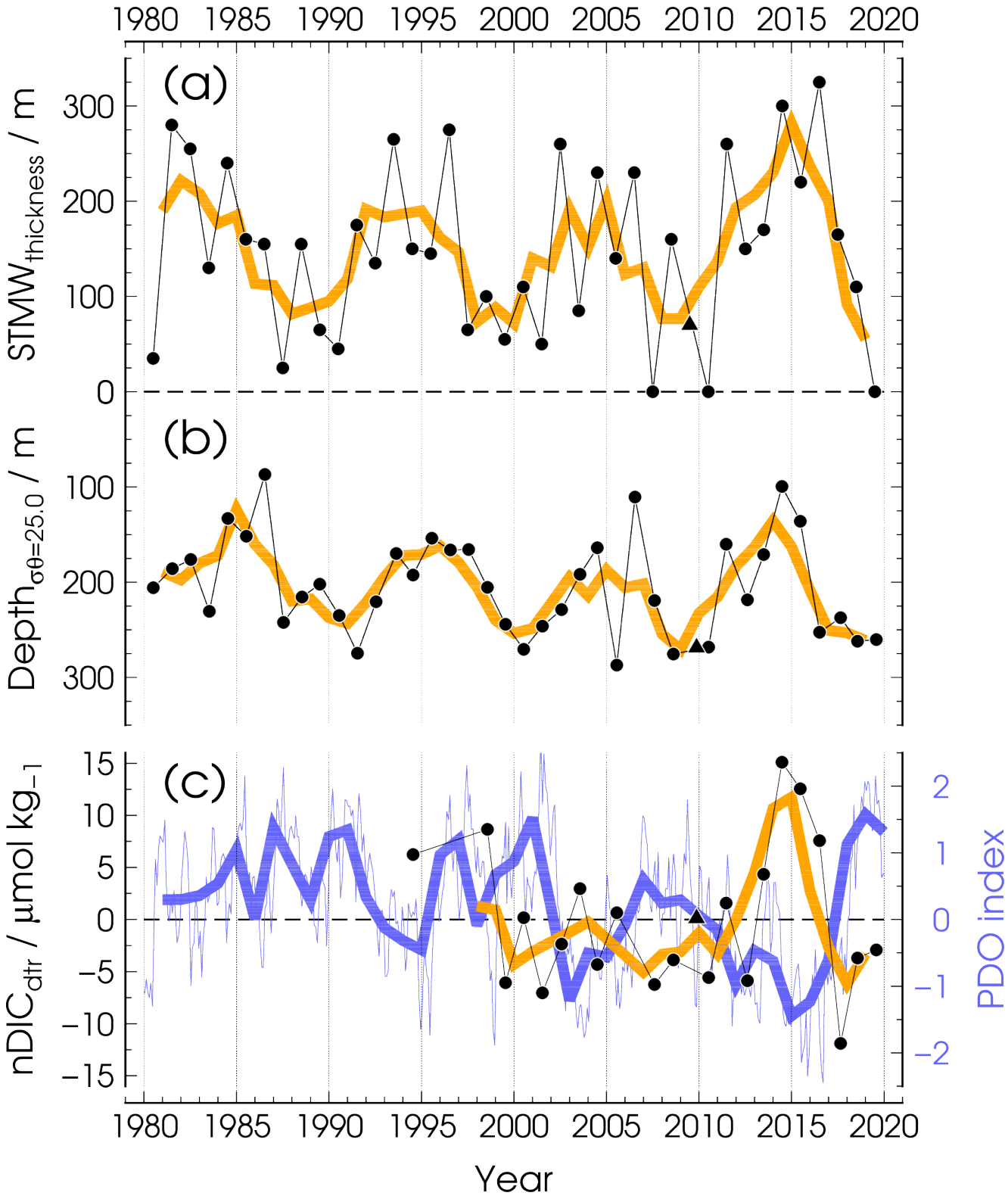
Figure caption

Time-series of (a) STMW thickness, (b) depth of isopycnal surface (σ_θ=25.0 kg/m^3), and (c) detrended nDIC in surface seawater in summer at 30˚N, 137˚E. The thick yellow lines in (a)-(c) represent 3-year running means. The thin and thick blue lines in (c) indicate monthly means and 3-year running means of

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PDO index, respectively.

Keywords: 137°E section, Dissolved inorganic carbon, Subtropical mode water, Isopycnal surface, Decadal scale variability, PDO



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Verification of the effect of aerosol deposition on surface chlorophyll in subtropical oligotrophic waters using JRAero reanalysis datasets

*Naohiro Kosugi[1], Taichu Y Tanaka[1]

1. Meteorological Research Institute

Introduction

Aerosols emitted from highly populated areas in East Asia contain inorganic nitrogen as a form of nitrate ion (NO_3^-) and ammonium ion (NH_4^+). Some of them deposit in the subtropical zone of the western North Pacific. This area is called “the desert of the ocean” due to its oligotrophy and low productivity. The aerosol deposition is supposed to be a valuable source of nutrients in this region. According to model calculations, significant increases in surface chlorophyll concentration and gross primary production are estimated in the western North Pacific due to the deposition [Taketani et al., 2018]. However, there are few examples of verifying the effect of the deposition on biochemical processes using observational data. In this study, the effects of the deposition on ocean biochemical parameters are examined by using the data obtained in research vessels and Japanese Reanalysis for Aerosol (JRAero) [Yumimoto et al., 2017].

Data

Hydrographic data obtained by research vessels “Ryofu-Maru” and “Keifu-Maru” which belong to Japan Meteorological Agency is used for our analysis. The study area and period are 20-30N, 130-165E, and winter (January, February, and March) from 2011 to 2017, respectively. Temperature, salinity, and chlorophyll data obtained from 10 m depth are used. Nitrate and ammonia are not recorded in JRAero although they supply inorganic nitrogen and stimulate biological activity in the ocean. Black carbon was used as a substitute index of nitrate and ammonia.

Results

The chlorophyll concentration in winter tended to be high as the temperature was low (see Figure). This is thought to be due to the vertical mixing and the entrainment of nitrates was promoted in cold water. On the other hand, the chlorophyll concentration was variable even at the same water temperature. This means chlorophyll concentration depended on factors other than the water temperature. In an incubation experiment onboard, chlorophyll concentration increases within 24-48 hours after the deposition [Zhang et al., 2019]. Therefore 24-hours accumulated amount of black carbon deposition was calculated. As a result, when the water temperature was about the same, the chlorophyll concentration tended to be

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higher when the amount of black carbon deposition was large.

In our study, the possibility that atmospheric deposition stimulates biological activity in the subtropical oligotrophic region is shown by actual observations. However, quantitative evaluation is difficult as the number of data is too small spatially and temporally. For more accurate verification, more detailed observations of both the atmosphere and the ocean are essential.

References

Taketani et al., Scientific Report, 2018.

Yumimoto et al., Geosci. Model Dev., 2017.

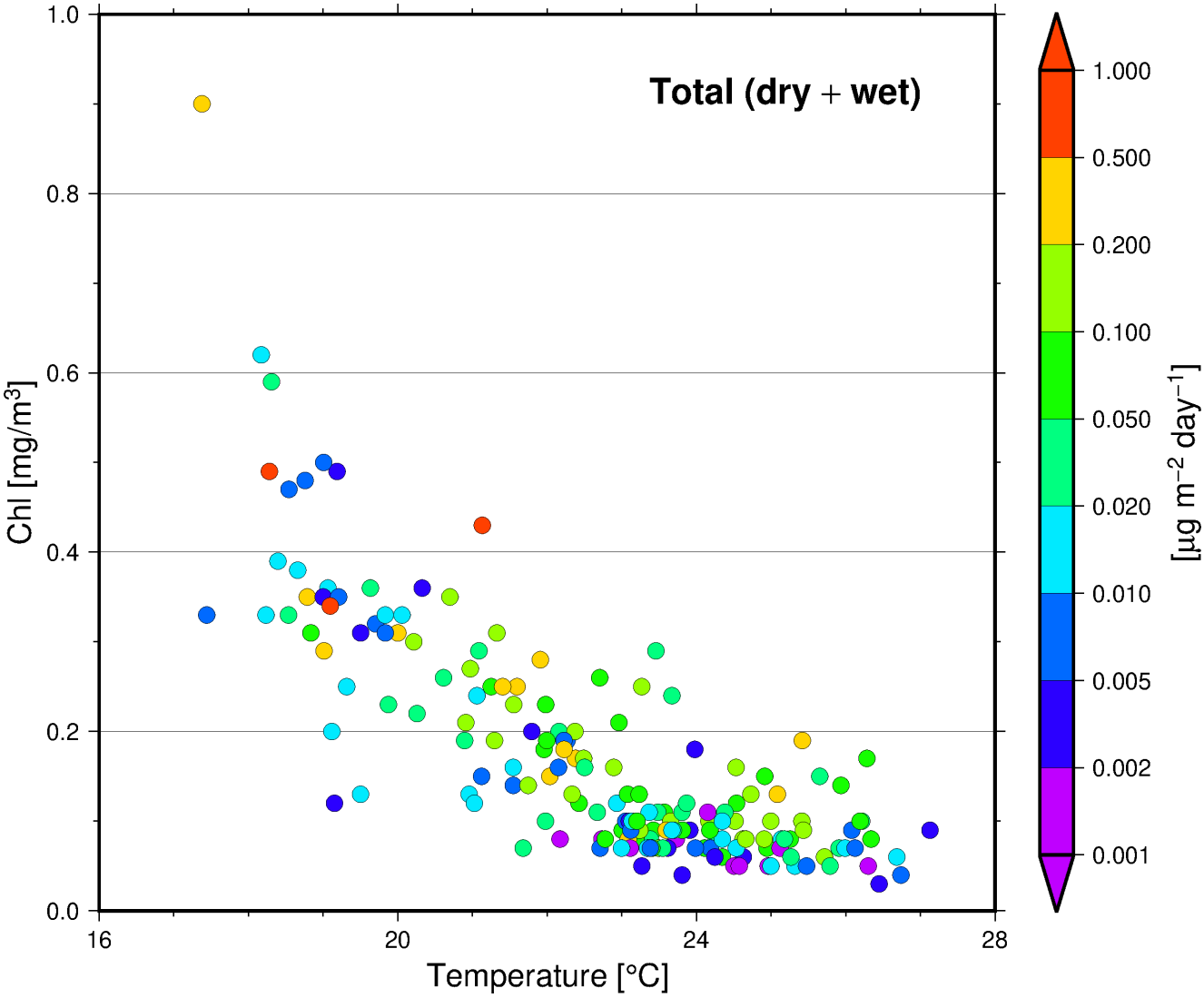
Zhang et al., Global Biogeochemical Cycles, 2019

Figure caption

Relationship between the water temperature and chlorophyll concentration at a depth of 10 m. The color shows the amount of black carbon deposition (dry + wet) in 24 hours before observation at the grid point of JRAERO closest to the observation point.

Keywords: depotision, aerosol

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Seasonal Variation of Phosphate in Atmospheric Aerosols in Higashi-Hiroshima

*Yoko Iwamoto[1], Mako Hirota[2], Kazuhiko Takeda[1], Hiroshi Sakugawa[1]

1. Graduate School of Integrated Sciences for Life, Hiroshima University, 2. School of Integrated Arts and Sciences, Hiroshima University

Phosphorus is an essential element for the life support of all living organisms, but it can be depleted in the surface layer of the ocean and may control the primary productivity. The supply of phosphorus into the oceans is primarily from rivers, with atmospheric deposition accounting for about 5% of the supply. Atmospheric deposition can be an important source of phosphorus in the Seto Inland Sea, where the amount of phosphorus flowing into rivers has decreased in recent years and the primary productivity has decreased. However, reports on the source and behavior of phosphorus in the atmosphere are limited. In this study, we focused on phosphate (PO_4^{3-}), which is most easily utilized by organisms, and investigated the concentration range, seasonal variation, and source of phosphate in atmospheric aerosols in Higashi-Hiroshima, Japan.

Atmospheric aerosol samples were collected on cellulose fiber filters using a high-volume air sampler from December 2017 to June 2020 at the campus of Hiroshima University in Higashi-Hiroshima, Japan. The molybdenum blue method was used to determine the concentration of phosphate in the samples. Water-soluble inorganic ions were also measured by ion chromatography. In order to estimate the source of phosphate, backward trajectory analysis, comparison with meteorological data, and principal component analysis were conducted.

Concentrations of phosphate in atmospheric aerosols during the observation period ranged from 1.7 to 49.0 ng m^{-3} and tended to be high in spring and low in winter. Principal component analysis showed that phosphate had the same factor as non seasalt- (nss-) Ca^{2+} and K^+. Because the concentration of phosphate is high in spring and mineral dust is a source of phosphorus in the atmosphere, the peaks of phosphate in spring was considered to originate from Kosa. However, the peak of nss-Ca^{2+}, which is an indicator of mineral dust, coincided with the Kosa periods, but slightly deviated from the peaks of phosphate. Furthermore, backward trajectory analysis showed that the air mass during the period of phosphate peaks did not pass through the arid regions of the Asian continent. On the other hand, the variation of phosphate concentration was similar to that of nss-K^+, an indicator of plant origin, suggesting that the source of phosphate is plant in addition to mineral particles. Specifically, the high concentration of phosphate in spring, a positive correlation with solar radiation, and the presence of phosphorus as a major component of pollen suggested that pollen contributed to the origin of phosphate. Although the calculated dry deposition flux of phosphate was as small as 0.21 to 0.54 mg m^{-2} $month^{-1}$, phosphate from the atmosphere is suggested to be used for phytoplankton production in the Seto Inland Sea, where phosphorus is depleted particularly in spring.

Keywords: Atmospheric aerosol, Phosphorus, Pollen, Dry deposition flux

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Modelling regional and global scale impacts of atmospheric nitrogen inputs on marine biogeochemistry

*Maki Noguchi Aita[1], Fumikazu Taketani[1], Yoko Iwamoto[2], Tomohiro Hajima[3]

1. Earth Surface System Research Center, Japan Agency for Marine-Earth Science and Technology, 2. Hiroshima University, 3. Research Center for Environmental Modeling and Application, Japan Agency for Marine-Earth Science and Technology

The spatio-temporal distribution and seasonality of oceanic primary producers may be altered by various external factors, including atmospheric deposition of anthropogenic aerosols, rising water temperature, increasing frequency of typhoons, and changing ocean mixing due to global warming (*e.g.*, IPCC AR5). Primary producers in the surface ocean are sustained by nitrogenous nutrients supplied via five main processes: nitrification, vertical mixing, nitrogen fixation, atmospheric aerosol deposition (including rainfall), and inflows from rivers. Over the last several decades, atmospheric aerosol emissions from East Asia have increased rapidly. However, the effects of "atmospheric aerosols" on primary producers have not yet been well quantified (*e.g.*, Steffen *et al.*, 2015). To investigate the impact of atmospheric nitrogen deposition on primary producers, we conducted simulations using a marine ecosystem model combined with an atmospheric chemistry transport model. Our results showed that aerosol deposition enhanced primary production in the surface ocean by a factor 1.7 in the subtropical North western Pacific (Taketani *et al.*, 2018). This is because aerosol deposition has enhanced the supply of essential nutrients such as nitrogen, phosphorus and iron, which typically limit production under natural conditions near the ocean surface. Statistical analyses of observed sea surface nutrient concentrations in the North Pacific over the past 50 years have revealed decreasing trends for phosphate and silicate concentrations, whereas no significant trend was detected for nitrate concentration (Yasunaka *et al.*, 2016). The lack of a clear trend for nitrate may reflect the net effect of increased anthropogenic nitrogen sources combined with reduced supply of nitrogen from deep waters as mixed layer depths have decreased due to global warming. We will review previous studies using marine ecosystem models and Earth System Models, focusing on the effects of atmospheric nitrogen inputs on marine biogeochemistry during short- and long-term climate change and global warming.

Keywords: atmospheric aerosol, nitrogen deposition, ocean biogeochemical cycle, primary production, marine ecosystem model

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Contribution of lightning-induced nitgen oxide to nitrogen cycle in air-sea boundary estimated by plasma discharge in laboratory

Ryo Hashimoto[1], *Sohiko Kameyama[1], Kohki Satoh[2], Hiroshi Ogawa[3]

1. Hokkaido University, 2. Muroran Institute of Technology, 3. The University of Tokyo

Lightning discharge is one of the important phenomena in atmospheric chemistry because it promotes oxidation of nitrogen in the atmosphere and is a major factor in production of nitrogen oxides derived from nature. It is known the lightning discharge occurs frequently not only in land areas but also in sea areas. In addition, tropical and subtropical sea areas, which are known as oligotrophic sea areas, are areas where the lightning discharge is particularly frequent. Recent studies have predicted an increase in the lightning discharge due to global warming and increasing in particle emissions from ships, resulting in enhancement of oceanic primary production. Consequently, the amount of nitrogen oxides deposited to the sea, which is the main nutrient supporting oceanic productivity, may increase. Therefore, in this study, we simulated the lightning discharge near sea surface by artificial plasma discharge with various environmental factors in laboratory and evaluated the generation/consumption of nitrogen oxides. As a result of laboratory experiments, we confirmed that nitrogen oxides are produced by the plasma discharge significantly. In addition, based on the results, we estimated effects of the lightning discharge in a wide area of oligotrophic waters and we suggested the lightning discharge may locally activate biological production.

Keywords: lightning discharge, nitrogen fixation, oligotrophic oceanic region

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[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.15 Zoom Room 15

[H-RE12] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Kenzo Sanematsu(Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University)

Ore deposits containing valuable elements and minerals at high concentrations in supracrustal rocks are formed by the Earth's dynamics including magmatism, hydrothermal activity, metamorphism, and weathering. The formation of ore deposits is also closely associated with global environmental changes and biological evolution in the Earth's history. Involvement of difference academic fields in earth sciences including geology, petrology, geochemistry, mineralogy, and microbiology is required to understand the genesis of ore deposits. The field of resource geology is essential not only for efficient exploration and development of ore deposits but also for better understanding and assessment of hazardous elements that may be caused by the resource development. This session widely covers various topics of field investigation and observation, laboratory experiments, theoretical calculation, development of analytical methods and others related to the supracrustal migration and concentration of elements.

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

[HRE12-01] Formation of various types of iron ore deposits in the Earth's surface environments: A review

*Tsubasa Otake[1] (1.Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University)

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

[HRE12-02] A rapid analytical method of Re-Os isotope on sulfides by MC-ICP-MS and sparging method: Its application to the Kamaishi deposit in NE Japan

*Mizuki Ogasawara[1], Junichiro Ohta[1,2], Mizuki Ishida[1], Moei Yano[2,1], Ryota Maki[1], Tatsuo Nozaki[3,1,4,2], Yutaro Takaya[5,3,2], Koichiro Fujinaga[2,1], Kazutaka Yasukawa[1,2], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC, 4.Kobe University, 5.Waseda University)

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

[HRE12-03] Geochemical Characterization of Rivers Contaminated by Acid Mine Drainage from an Abandoned Mine in Northern Japan

*Sereyroith Tum[1], Tatsuya Matsui[1], Frances Chikanda[1], Ryosuke Kikuchi[2], Yoko Ohtomo[2], Tsubasa Otake[2], Susumu Norota[3], Tsutomu Sato[2] (1.Graduate School of Engineering, Hokkaido University, 060-8628, Sapporo, Japan , 2.Faculty of Engineering, Hokkaido University, 060-8628, Sapporo, Japan, 3.Geological Survey of Hokkaido, Hokkaido Research Organization, 060-0819, Sapporo, Japan)

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

[HRE12-04] Utilizing isotopic Fe fractionations to trace the behaviour of dissolved and colloidal Fe in mine drainages

*Frances Chikanda[1], Tsubasa Otake[2], Tatsuya Matsui[1], Sereyroith Tum[1], Tsutomu Sato[2] (1.Division of Sustainable Resources Engineering, Graduate School of Engineering, Hokkaido University, 2.Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC
[HRE12-05] Discussion

Formation of various types of iron ore deposits in the Earth’s surface environments: A review

*Tsubasa Otake[1]

1. Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University

Iron is the fourth abundant element on the Earth’s surface, and it has been mined and utilized for various industrial activities. Whereas average continental crust contains ~5 wt% of Fe (as FeO), the minimum Fe grade for minable ore is 20–25 wt%. Although its concentration factor (4–5) is not as high as that for some other elements, formation of iron ore deposits requires crystallization of iron as oxides (e.g., magnetite and hematite), not either silicates or sulfides, which occurs more commonly in ordinary igneous and sedimentary rocks. There are various geological processes, including magmatic, hydrothermal, and sedimentary processes, to concentrate Fe and form Fe ore deposits. However, ore genesis may be ambiguous for some deposits, which makes exploration difficult. The objective of this study is to review various types of Fe ore deposits and geochemical factors controlling concentration of Fe in the Earth’s surface environments. Some recent geochemical techniques to indicate Fe ore genesis are also reviewed.

Based on previous literatures, Fe ore deposits can be divided into orthomagmatic (or Fe-Ti-V type), iron oxide-apatite (IOA) type (or Kiruna type), skarn, submarine volcanogenic iron oxide (SVIO), banded iron formations (BIF), and phanerozoic iron stone. Production of iron ores, particularly high-grade ores, in the world is currently dominated by those associated with BIFs, Fe-rich chemical sedimentary rocks formed in Precambrian era. Complication of ore reserves and average grade on various (~200) Fe ore deposits over the world demonstrates that a number of large and high-grade Fe deposits belong to BIF-associated deposits although some other types of Fe deposits, such as orthomagmatic, Kiruna-type, skarn, contain gigantic deposits (>1 billion ton reserve). Although other hydrothermal and sedimentary deposits contain fairly large deposits, the average ore grades are not as great as those associated with BIFs.

In magmatic processes, fractional crystallization may concentrate Fe as magnetite since it is one of the minerals that crystallize at the early stage of magma cooling. However, further enrichment of Fe to form Fe-Ti-V or IOA type deposits requires to decrease in SiO_2 activity in magma, possibly due to immiscible segregation of oxide melts from silicate melts. Although hydrothermal processes typically precipitate Fe as sulfides (e.g., pyrite), highly oxidized and Cl^--rich fluids may cause enrichment of Fe as oxides in some magmatic-hydrothermal systems. Other important parameters to form hydrothermal Fe deposits include CO_2 fugacity and temperature for skarn and SVIO Fe deposits, respectively. In sedimentary processes, redox state of sweater is the key parameter since reduced seawater is needed to dissolve and transport Fe in a large scale in the surface environments. However, primary precipitates and its mechanism to form BIF in Archean is still controversial. Recently, trace element chemistry of magnetite as well as Fe and O isotopes are developing geochemical indicators for Fe ore genesis although there will be more case studies needed to verify the indicators.

Keywords: Iron, concentration factor, magma, hydrothermal fluid, sedimentation, redox conditions

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A rapid analytical method of Re-Os isotope on sulfides by MC-ICP-MS and sparging method: Its application to the Kamaishi deposit in NE Japan

*Mizuki Ogasawara[1], Junichiro Ohta[1,2], Mizuki Ishida[1], Moei Yano[2,1], Ryota Maki[1], Tatsuo Nozaki[3,1,4,2], Yutaro Takaya[5,3,2], Koichiro Fujinaga[2,1], Kazutaka Yasukawa[1,2], Yasuhiro Kato[1,2]

1. School of Engineering, The University of Tokyo, 2. ORCeNG, Chiba Institute of Technology, 3. JAMSTEC, 4. Kobe University, 5. Waseda University

The Re-Os isotope system is a powerful tool in geological/geochemical studies, especially in radiometric dating of sulfide minerals, black shale and meteorite. Since both Re and Os are siderophile and chalcophile elements enriched in various sulfide minerals, the Re-Os isotope geochronology has been applied to the direct age determination of sulfide mineralization. However, the conventional analytical method of the Re-Os isotope dating using a N-TIMS is time-consuming and requires some reagents harmful to the human body. Also, the simpler, more rapid and safer sparging method for Os isotope analysis using a MC-ICP-MS [1,2] had not been applied to sulfide minerals.

Here, we present an improved analytical method for the Re-Os isotope and its first application to the Kamaishi skarn sulfide deposits in NE Japan. In our method, 0.4 g of powdered sulfide was digested by 1 mL of $HClO_4$ and 4 mL of inverse aqua regia in the Carius tube, which was analyzed using a MC-ICP-MS. The isotopic compositions of $^{187}Os/^{188}Os$ and $^{187}Re/^{188}Os$ obtained in the present study showed good agreements with those obtained by the conventional method digesting 0.5 g of the same powdered sample using 10 mL of inverse aqua regia and measuring with a N-TIMS. The less volume of sample solution is favorable for Re-Os isotope analysis by the sparging method using a MC-ICP-MS to accomplish low blank level, which enables us a simpler and more efficient analytical procedure for Re-Os dating on sulfide deposits.

1: Nozaki, T. et al. (2012) *Geostand. Geoanal. Res.* **36**, 131-148.

2: Kimura, J.-I. et al. (2014) *J. Anal. Atom. Spectr.* **29**, 1483-1490.

Keywords: Re-Os isotopes, MC-ICP-MS, sparging method, sulfide deposits

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Geochemical Characterization of Rivers Contaminated by Acid Mine Drainage from an Abandoned Mine in Northern Japan

*Sereyroith Tum[1], Tatsuya Matsui[1], Frances Chikanda[1], Ryosuke Kikuchi[2], Yoko Ohtomo[2], Tsubasa Otake[2], Susumu Norota[3], Tsutomu Sato[2]

1. Graduate School of Engineering, Hokkaido University, 060-8628, Sapporo, Japan , 2. Faculty of Engineering, Hokkaido University, 060-8628, Sapporo, Japan, 3. Geological Survey of Hokkaido, Hokkaido Research Organization, 060-0819, Sapporo, Japan

Acid mine drainage (AMD) of an abandoned mine in northern Japan riches of Fe, As, Pb, and Cd, has been flowing into river A and B. At the monitoring point, the contaminants of river A decreased to below the environmental standard level. In contrast, river B's contaminants remain slightly higher than the environmental standard level, even though the two rivers have the same contamination source. The natural process in river A makes the contaminants attenuated, but not in the river B. If the geochemical differences between A and B are well understood, information from the two rivers is ambiguously valuable for the geochemical passive treatment in river B. Therefore, river A and river B detail studies were investigated to determine the geochemical differences in both rivers, and define the natural attenuation mechanisms in river A.

AMD from both rivers contains a high ferric iron concentration with an average pH of 2.8. After AMD having mixed with the natural river water, river A's pH is 3.1. The formation of schwertmannite (ferric hydroxide sulfate mineral) appears on the riverbed. At the mixing point, As concentration decrease due to its adsorption on to schwertmannite surface. Yet, the concentrations of Pb and Cd were decreased by dilution of the natural water in river A. Oppositely, the pH of AMD in river B pH is 2.9 after mixing with the natural river water. No reduction of dissolved ferric, As, Pb, and Cd concentrations, neither precipitation of ferric minerals such as schwertmannite, were significantly found after the mixing in river B. Dilution of the natural river water plays an important role to make the geochemical differences in the study area. The mixing ratios of both rivers to the natural water do not only control the pH changes, but it is also responsible for the decreasing of the contaminants' concentration in the rivers. The dilution ratio of river A to the natural water is comparatively more than it is in river B. Learning from the natural attenuation process in river A, the geochemical passive treatment of river B is applicable by increasing pH to 3.2 by using a dilution method and an open limestone channel.

Keywords: Natural attenuation, Schwertmannite , Adsorption

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Utilizing isotopic Fe fractionations to trace the behaviour of dissolved and colloidal Fe in mine drainages

*Frances Chikanda[1], Tsubasa Otake[2], Tatsuya Matsui[1], Sereyroith Tum[1], Tsutomu Sato[2]

1. Division of Sustainable Resources Engineering, Graduate School of Engineering, Hokkaido University, 2. Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University

Mining-related water contamination is on the rise, thereby increasing the popularity of passive treatment in mine drainages. Fe, a commonly occurring element in mine drainages significantly affects the behaviour of other elements, therefore, understanding its behaviour would highlight the fate of the co-existing elements. This study utilizes iron isotope fractionations as important tracers of the contamination caused by mining, given that varying Fe sources and phases have varied δ^{56}Fe values.
An investigation was carried out at two mine drainages; circumneutral mine drainage that has Fe^{2+} input, that oxidizes to Fe^{3+}, resulting in the formation of ferrihydrite colloids, and acidic mine drainage that has a Fe^{3+}input, which, through hydrolysis, forms schwertmannite colloids. The isotopic fractionations were observed in three fractions; the total (0.2 μm + 200 kDa), colloidal (0.2 μm to 200 kDa) and dissolved (< 200 kDa).
In both drainages, the total fractions displayed δ^{56}Fe values representing averaged isotopic fractionation values of the different filtered sizes and that are near continental crust values (0.07 ±0.03 ‰). However, in the circumneutral system, clear fractionation was observed in the dissolved and colloidal fractions. The colloidal fraction had heavier δ^{56}Fe values compared to the dissolved fraction, which was attributed to the preferential complexation of heavier Fe by hydroxyl groups to form stronger bonds. This trend was not seen in the acidic drainage, thereby strongly showing that the oxidation process is a significant factor for the δ^{56}Fe fractionation. An overall negative fractionation is observed in both colloidal and dissolved fractions towards the downstream. These trends correspond with the Rayleigh fractionation model; however, misfits are observed, particularly in the colloidal fraction. The misfit, $\Delta^{56}Fe_{colloid\text{-}rayleigh}$ is considered to reflect the Fe colloids transported in the drainage.
Utilizing Fe isotopes, we understand that (i) filtration of samples highlights δ^{56}Fe fractionation behaviours, (ii) a certain amount of Fe in the drainage is transported in colloidal phase to rivers, transporting along the other toxic elements.

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[J] Oral | H (Human Geosciences) | H-RE Resource and Engineering Geology

[H-RE12] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Kenzo Sanematsu(Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.15 (Zoom Room 15)

Ore deposits containing valuable elements and minerals at high concentrations in supracrustal rocks are formed by the Earth's dynamics including magmatism, hydrothermal activity, metamorphism, and weathering. The formation of ore deposits is also closely associated with global environmental changes and biological evolution in the Earth's history. Involvement of difference academic fields in earth sciences including geology, petrology, geochemistry, mineralogy, and microbiology is required to understand the genesis of ore deposits. The field of resource geology is essential not only for efficient exploration and development of ore deposits but also for better understanding and assessment of hazardous elements that may be caused by the resource development. This session widely covers various topics of field investigation and observation, laboratory experiments, theoretical calculation, development of analytical methods and others related to the supracrustal migration and concentration of elements.

2:45 PM - 3:15 PM

[HRE12-05]Discussion

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[J] Poster | H (Human Geosciences)：H-RE Resource and Engineering Geology

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.08_1

[H-RE12] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Kenzo Sanematsu(Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

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[HRE12-P01] Exploration of multiple geothermal resources in southern Yuzawa area, Akita prefecture

*Hayata Sato[1], Keishi Nunohara[1], Ryoichi Yamada[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1] (1.tohoku university)

[HRE12-P02] The Gold and Silver mineralization of layered yellow ore in Furutobe mine.

*Teruhiro Suzuki[1], Yasushi Watanabe[1], Takuya Echigo[1] (1.Graduate School of International Resource Sciences, Akita University)

[HRE12-P03] The significance of geology and sulfur isotope compositions of sulfates and sulfides at the ca.3.4 Ga Big Stubby Kuroko deposit in Pilbara, Western Australia

*Tomoaki Koya[1], Akizumi Ishida[1], Takeshi Kakegawa[1] (1.Graduate school of science, Tohoku University)

Exploration of multiple geothermal resources in southern Yuzawa area, Akita prefecture

*Hayata Sato[1], Keishi Nunohara[1], Ryoichi Yamada[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1]

1. tohoku university

Multiple geothermal resource exploration was conducted in the southern part of Yuzawa city, Akita prefecture.

The Sanzugawa caldera is distributed around this area, and in this caldera, there are basement rocks of pre-tertiary granitic and metamorphic rocks from the lower part, and the Doroyu and Torageyama formations are distributed in the upper part. In particular, the Torageyama formation is composed of partially fused tuff and is widely distributed in this area. The upper part of the Torageyama formation includes the Sanzugawa formation, the Kabutoyama formation, and the Takamatsudake volcanic rocks. In this study, we carried out Thermoluminescence measurements and identification of alteration minerals.

Thermoluminescence geothermal prospecting is a method of analyzing the luminescence produced by heating quartz particles in igneous rocks, and is used to evaluate the thermal effects of the rocks.

Alteration minerals can be broadly classified into acidic, neutral, and alkaline alteration minerals. The alkaline alteration zone was observed in Yunomatazawa in the western part of this area. Pyrophyllite was also found in the middle reaches of the Minasegawa, and it can be assumed that there was strong acidic alteration in this area. Furthermore, acidic and alkaline alteration minerals are distributed locally, while neutral alteration minerals are distributed over a wide area.

As a result of TL measurement, low TL values were detected near the lower reaches of the Minasegawa, and the surrounding streams were also found to have low TL values. Furthermore, the TL values decreased as the elevation decreased from Torageyama to Minasegawa. This indicates that there is a strong thermal influence from Torageyama to Minasegawa.

We developed a thermal structure model of the subsurface in this area by coupling the decay rate equation of TL with temperature and the unsteady heat conduction model to estimate the location of the heat source. The heat source was modeled as a heat source on a uniform flat plate, with a source temperature of 700℃ and initial surface and subsurface temperatures of 15℃. The TL values at the surface were best explained when the heat sources were located at a depth of 5000 m near Toragesawa and 4000 m downstream of the Minasegawa. In the middle reaches of the Toragesawa river, the TL values are consistent with the case where the heat source is located at 4500 m below the ground surface. From the above, it can be inferred that the subsurface thermal structure in the target area is not a uniform heat source, but a shallow heat source in parts.

Keywords: geothermal resources

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The Gold and Silver mineralization of layered yellow ore in Furutobe mine.

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An important ore was discovered in the Furutobe deposit to represent the gold and silver mineralization of the kuroko type deposit. In this study, we interpret the formation of this ore and the precipitation process of gold and silver. This ore has a layered structure, and characteristic mineral assemblages are identified in each layer. These layers are classified into five types of mineral assemblages A to E, identified by microscopic and macroscopic observation.

Bornite is the main component of A zone and chalcocite, silver-bearing tetrahedrite, stromeyerite, chalcopyrite, galena, sphalerite, and barite are accessory components. This zone includes barite lens. Pyrite and bornite are main components of B zone and chalcopyrite, galena, tetrahedrite are associated. This zone have lens-shaped chalcopyrite. Pyrite, bornite and barite are main components of C zone and accessory components are galena, sphalerite, tetrahedrite, and electrum. The amount of bornite decreases away from B zone in this zone. Pyrite, chalcopyrite and barite are main components of D zone and sphalerite, galena, and tetrahedrite are accessory components. Bornite is rare in this zone. Zone E consists of barite, pyrite and chalcopyrite.

Barite and pyrite increase from A zone to E zone. Bornite and Cu-S minerals are more abundant on the A band side, and chalcopyrite, galena and sphalerite are abundant on the E band side.

Mineral paragenesis in this ore are determined as that pyrite is the earliest, followed by copper minerals, sphalerite, and galena. Although chalcopyrite and bornite occur in different layers, their paranegentic stages are similar. Chalcopyrite and bornite either fill the pyrite grain boundaries or substitute pyrite and other minerals. Electrum in A zone occurs as small droplets in silver-bearing tetrahedrite and chalcocite. Electrum in C zone occurs along the grain boundaries and in voids of chalcopyrite and pyrite.

The occurrence of ore minerals indicates that this ore formation started by a large amount of pyrite precipitation. The reason why pyrite is small in amount on the A zone side is that it is substituted by bornite and chalcopyrite. Bornite and Cu-S minerals are abundant on A zone side, and chalcopyrite is more abundant on E zone side. This indicates that A zone side ore was formed at higher temperature and higher sulfur fugacity than that of E zonee. From the above, this ore was originally void-rich, mainly composed of pyrite, and the void-rich layers in the ore becames the hydrothermal flow path. In the center of the hydrothermal path (zone A and B), a solution of relatively high temperature and high sulfidation flowed and precipitated bornite, chalcocite, and stromeyerite. In outer C zone, seawater was mixed to create a medium-temperature, high-to-medium sulfidation solution, which precipitated bornite, chalcopyrite, and tetrahedrite. Finally, due to rapid cooling and decreaseed sulfur fugacity of the solution led the precipitation of electrum to fill the grain boundaries of the previously crystallized minerals. More involvement of sea water formed barite, sphalerite and galena at the latest in the ore.

Keywords: Kuroko, Gold and silver, Hydrothermal, Sea water

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The significance of geology and sulfur isotope compositions of sulfates and sulfides at the ca.3.4 Ga Big Stubby Kuroko deposit in Pilbara, Western Australia

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1. Graduate school of science, Tohoku University

The Big Stubby deposit is located at the Pilbara district in Western Australia. The age of this deposit is ca. 3.4 Ga and considered as the oldest Kuroko deposit. On the other hand, it has been unknown if Big Stubby and Miocene Kuroko deposits were formed by the same geological conditions (problem 1). The seawater sulfate had an important role for the formation of Miocene Kuroko deposits. On the other hand, the sulfate-poor ocean model is popular for the Archean age, and it is unknown if Big Stubby deposit could have formed under “sulfate-poor” conditions, differing from the Miocene Kuroko deposits (problem 2). In order to approach above problems, comparative studies between the Big Stubby and Miocene Kuroko deposits are performed in the present study.
Paleo-geological structures of the Big Stubby deposit was reconstructed in the present study combining pre-existing geological information and detailed examination of core samples. As a result, massive and Keiko (silicified) ores developed at the interface between rhyolite dome and tuff. Distal massive or disseminated sulfates overlain altered rhyolite dome. Those geological, mineralogical and geochemical information suggest that the Big Stubby deposit was formed by the similar mechanism as the Miocene Kuroko formed (answer to problem 1).
The $\delta^{34}S$ values for sulfate and sulfide minerals in the Big Stubby deposit range from +11 to+16‰ (V-CDT) and -1 to +1‰ (V-CDT), respectively. The isotope fractionation factor between sulfate and sulfides at the Big Stubby deposit are interestingly the identical to those at the Miocene Kuroko deposits. Such commonness suggests the circulation of sulfate-rich seawater in deep footwall rocks was responsible to generate ca. 3.4 Ga black smokers, accompanied with high temperature sulfate reduction in depth (answer to problem 2). The $\Delta^{33}S$ values indicate that the sulfate and sulfide minerals in the Big Stubby deposit are surprisingly following the MDF trend. This finding is different from the MIF signature found in other Archean sulfides and sulfates. This further rises possibility that MIF of sulfur was not global but local at the middle Archean age.

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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.16 Zoom Room 16

[H-TT16] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Ki-Cheol Shin(Research Institute for Humanity and Nature), Nozomu Takeuchi(Chiba University), Chairperson:Nozomu Takeuchi(Chiba University)

Modern society uses almost all the elements present in the natural world. Although there have long been calls for the sustainable use of the resources that provide these elements and the building of human societies that are in harmony with the environment, the survival of the human race is increasingly at risk as a result of qualitative changes to the environment as a whole. Implementation by the society of methodologies for diagnosing and tracking these various elements of the natural environment and their relationships with humans are now required.
Elements cycle within and among the Earth system spheres, human society, and the human body. Information on the concentrations and stable isotopes of elements is a powerful tool for tracing this cycling and has been applied in studies of atmosphere-hydrosphere circulation, ecological systems, and the life, health, and history of humans. We propose a session to discuss the development and applications of environmental traceability methods toward the goal of establishing traceability in natural and human systems.
We encourage the presentation of research integrating isotopic information in various disciplines, such as geochemistry, hydrology, ecology, geology, mineralogy, anthropology, food science, and forensics. We call the research Environmental Isotope Study.

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

[HTT16-01] Application of environmental traceability methodology by multi-isotopes

*Ichiro Tayasu[1], Ki-Cheol Shin[1] (1.Research Institute for Humanity and Nature)

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

[HTT16-02] Daily variation in winter precipitation isotopes over Hirosaki and associate atmospheric circulation - Case study of a winter season 2019/2020 -

*Akiyo Yatagai[1], Syota Nishioka[2], Kei Yoshimura[3] (1.Graduate School of Science and Technology, Hirosaki University, 2.Faculty of Science and Technology, Hirosaki University, 3.IIS Chiba Experimental Station, The University of Tokyo)

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

[HTT16-03] Identification of snow characteristics in the basin to applied chemical composition and meteorological hydrological data

*kawagoe seiki[1], shiho yabusaki[2] (1.Faculty of Symbiotic Systems science/Fukushima university, 2.Research institute for Humanity and Nature)

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

[HTT16-04] Distribution of trace element concentrations in groundwater and spring water near coastal and inland area of Fukushima prefecture

*Shiho Yabusaki[1] (1. Research Institute for Humanity and Nature・Faculty of Symbiotic Systems Science, Fukushima University)

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

[HTT16-05] Response of forest ecosystems to reduction of atmospheric sulfur deposition

*Hiroyuki Sase[1], Tsuyoshi Ohizumi[1], Yayoi Inomata[2], Naoyuki Yamashita[3], Toko Tanikawa[4], Masamichi Takahashi[3], Tatsuyoshi Saito[5], Masayuki Morohashi[1], Hiroki Yotsuyanagi[1] (1.Asia Center for Air Pollution Research, 2.Kanazawa University, 3.Forestry and Forest Products Research Institute, 4.Nagoya University, 5.Niigata Prefectural Government)

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

[HTT16-06] Estimate the origin of nutrients supplied to coastal areas using Ulva pertusa's nitrogen and carbon stable isotope ratios.

*Tatsuhiro Ishida[1], Osamu Tominaga[1], Ryo Sugimoto[1], Naoki Kisa[1], Keisuke Koba[2], Keitaro Fukushima[2]
(1.Fukui Prefectural University, 2.Center for Ecological Research,Kyoto University)

Application of environmental traceability methodology by multi-isotopes

*Ichiro Tayasu[1], Ki-Cheol Shin[1]

1. Research Institute for Humanity and Nature

Stable isotope ratios of elements, together with the concentrations of elements, can trace a matter flow, the environmental condition of sites, ecosystem structure, and food products. Spatio-temporal variation of isotope ratios of multiple elements (multi-isoscapes) can be used to study the earth systems from local to global points of view. Using the traceability function of the multi-isotopes, we can conduct research that contributes to solving global environmental problems covering various regions and time scales. Spatio-temporal variation of multi-isotopes can be used for studying earth systems, ranging from local to global scales. The information may serve as a key decision-making factor for local people to consider water, food, and environmental security, all of which are fundamental for the sustainability of human society.

Research Institute for Humanity and Nature is conducting collaborative research named “Environmental Isotope Study” that researchers from various universities and research institutes can use facilities of mass spectrometers for multiple elements. From 2017 to 2019, we have conducted research to establish a methodology for how to use the concept of environmental traceability “Proposal and verification of the validity of isotope environmental traceability methodology in environmental studies.” In this study, we indicated that the role and perception of traceability methods in transdisciplinary processes differ among stakeholders and that the co-production of “Multi-Isoscapes” can act as an effective “bridging tool” for understanding and explaining variation in local environments. Based on the research results, we started a project, “Applied research platform based on environmental traceability,” from 2020 and established an internet website, “The world on the view of Environmental Isotope Study (https://www.environmentalisotope.jp),” to serve as a platform that shares and develops the environmental traceability methodology. The website aims to connect providers of the environmental traceability methodology with potential users.

Keywords: Stable isotopes, Multi-isoscapes, Environmental traceability

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Daily variation in winter precipitation isotopes over Hirosaki and associate atmospheric circulation - Case study of a winter season 2019/2020 -

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The precipitation stable isotope ratio is an index that allows inverse estimation of the phase change and circulation process that the water has undergone. Therefore, understanding the variability of precipitation stable isotope ratios, especially snowfall stable isotope ratios, will improve the accuracy of paleoclimate reconstructions and lead to a better understanding of present-day hydrological processes, but it is also necessary to analyze them meteorologically because they are affected by atmospheric circulation. A regional isotope circulation model Iso-RSM (Yoshimura et al., 2010), which incorporates known isotope fractionation processes into an atmospheric general circulation model and a regional meteorological model, can be able to reproduce the isotope ratio variations. In this study, we used modeled isotope ratios of precipitation and water vapor to improve our understanding of the observed isotope variations, and for the processes that did not reproduce the isotope ratio variations, the observed isotope ratio results can be used to improve the model.

In this paper, we report the results of the observed variations of winter precipitation in Hirosaki during the last winter (2019/2020). There were few days of snowfall due to a warm winter and less snowfall, but precipitation from the previous day was collected from December 24th to March 17th, including rainfall days. The oxygen and hydrogen isotope ratios of 40 samples were measured by Picarro spectroscopy at Research Institute for Humanity and Nature. δ 18O varied between -1.39‰ and -18.87‰, and δ D varied between -9.9‰ and -142.2‰. The trend of isotopic variation of precipitation in Hirosaki by Iso-RSM was qualitatively consistent from mid-January to early March, while that of d-excess was not consistent with observation except for a period in February.

Based on the observed precipitation stable isotope ratios and the water vapor transport field by ERA5 reanalysis, we found the following.

(1) when the isotope ratio is low and the d-excess is high, precipitation is brought to Hirosaki by the rapid evaporation of cold, dry air from Eurasia over the Japan Sea (no moist air from the south);

(2) when the isotope ratio is high and the d-excess is low, precipitation is brought by warm, moist air masses from the southwest;

(3) when the isotope ratio is high and the d-excess is high, the northwest monsoon passes near the Korean Peninsula and the rapid merging of evaporated water vapor in the Sea of Japan and moist air from the southwest is observed.

During the period of the study, we identified three periods that show the precipitation isotope ratio gradually increased over several days. These trends are reproduced in the Iso-RSM. Period-1: on January 10th to 14th, water vapor from (3) mixed with water vapor from (1) resulting in little change in d-excess;

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Period-2: on February 9th to 13th, water vapor from (2) mixed with water vapor from (1), resulting in an increase in isotope ratio but a decrease in d-excess; Period-3: on February 17th to 21st, air masses from (1) merged with air masses from (3), resulting in a decrease in d-excess; and on February 17th to February 21st, air masses from (1) merged with water vapor from (1), resulting in a decrease in d-excess. During the period-3, a low-pressure system moved northward (17th -19th) and a local circulation effect (20th -21st) which was strongly affected by Shirakami mountains seems to affect the precipitation isotope characteristics. In order to clarify the cause of the decrease in d-excess during the period, vertical precipitation isotope ratio in the clouds and cloud development process according to the topography should be considered.

In the winter of 2020/2021, we measured not only daily snowfall but also water vapor isotopes once or twice a day. The comparison between the two years and the snowfall process that can be understood from the water vapor isotope variation will also be reported at the meeting.

Keywords: snowfall, isotope, water vapor

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Identification of snow characteristics in the basin to applied chemical composition and meteorological hydrological data

*kawagoe seiki[1], shiho yabusaki[2]

1. Faculty of Symbiotic Systems science/Fukushima university, 2. Research institute for Humanity and Nature

Changes in the water environment due to climate change have been pointed out, and data development is being undertaken to guide the future image of the quantity and quality of the water cycle. As part of these efforts, we have analyzed the chemical composition of snowfall and snowfall in the Agano River basin, which is a heavy snowfall area. The Agano River depends on snow resources and is responsible for water resources such as power generation. In addition, multiple national parks are distributed, and ecotourism associated with the natural environment is formed. Therefore, the impact of climate change on the water environment is positioned as a large basin. Due to the changes in the chemical composition of snowfall and snowfall that have been carried out since 2014, snowfall other than that derived from the Sea of Japan was rarely observed in the Urabandai area and Tajima area located in the upstream, northeastern, and southeastern parts of the basin. It was suggested that the Tajima area was mostly covered with snow from the Pacific Ocean. On the other hand, the results suggest that the Urabandai area is covered with snow that does not originate from both the Sea of Japan and the Pacific Ocean. In order to verify the results of these chemical properties, we compared the relationship with meteorological hydrological data. As a result, there was a tendency that the weather was more related to the short-term scale than the yearly scale. We report on this characteristic.

Keywords: short time scale, stable isotope ratio analysis, regional water cycle

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Distribution of trace element concentrations in groundwater and spring water near coastal and inland area of Fukushima prefecture

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1. Research Institute for Humanity and Nature・Faculty of Symbiotic Systems Science, Fukushima University

The salination or water quality change for some parts of groundwater neat the coastal area in Fukushima prefecture was occurred which was caused by the tsunami of the 2011 off the Pacific coast of Tohoku Earthquake. As a result of investigation from April 2012, it was obviously that multiple groundwater flows were existed and it was related with the depth of groundwater or aquifer. The recharge area of groundwater and spring water were mainly divided into two groups by the oxygen and hydrogen stable isotopes and dissolved component concentration of water; one is plateau near the coastal area, the other is highland around the Abukuma mountains (Yabusaki, 2020). This result agrees with the residence time estimated by the CFCs and SF_6. Furthermore, it may be more cleared by using the multiple tracers.
The 51 trace elements of groundwater, spring water and river water in this study area sampled from April in 2014 to August in 2020 were analyzed by ICP-MS (Agilent 7500cx). As a result of analysis, concentration of B, Al, Mn, Fe, Zn, Sr and Ba was relatively high in some sites. Especially, Mn and Fe were extremely high near the coastal area (exceed 500 μg/L of Mn and exceed 10,000 μg/L of Fe), it is probably influenced by the local geological condition. Sr concentration for all sites was from 10 to 900 μg/L, it was higher near the coastal area in Minami-soma City and Shinchi Town than the inland area. In the former area was affected by the tsunami. Sr concentration of sea water is very high about 7.8 mg/L (Nozaki, 1997), so the Sr concentration near the coastal area might be high caused by the tsunami. Because in these sites water quality indicated Na-Cl and dissolved concentration was relatively high, this result suggested mentioned earlier. As a result of trace element analysis, it is considered trace element concentration reflected the difference of geology and residence time, and also influence of tsunami.
In future, we will measure the $^{87}Sr/^{86}Sr$ of groundwater and spring water in this study area, and will consider the recharge area and groundwater flow system by using the multi-tracer methods.

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Keywords: coastal area of Fukushima prefecture, groundwater flow, water quality, stable isotopes of oxygen and hydrogen, trace elements

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Response of forest ecosystems to reduction of atmospheric sulfur deposition

*Hiroyuki Sase[1], Tsuyoshi Ohizumi[1], Yayoi Inomata[2], Naoyuki Yamashita[3], Toko Tanikawa[4], Masamichi Takahashi[3], Tatsuyoshi Saito[5], Masayuki Morohashi[1], Hiroki Yotsuyanagi[1]

1. Asia Center for Air Pollution Research, 2. Kanazawa University, 3. Forestry and Forest Products Research Institute, 4. Nagoya University, 5. Niigata Prefectural Government

Sulfur oxides (SO_X) derived from anthropogenic fossil fuel combustions have been causing so-called “acid rain problem” in various regions of the world. In fact, sulfate (SO_4^{2-}) derived from atmospheric deposition is a major counter ion of proton (H^+) in terrestrial ecosystems and sulfur deposition was a primary cause of acidification. While SO_X emissions have already been enough reduced in Europe and the United States and just started declining in Asia, recovery processes from acidification are still concerned in these regions. However, dynamics of sulfur has not been investigated in terrestrial ecosystems in Asia, where recovery from acidification has just started in accordance with reduction of air pollution. To clarify the sulfur dynamics in Asia, we have been applying the isotopic analysis to rainwater, soil and soil solution, and/or stream water in forest catchments in Japan, Thailand and Malaysia. In this paper, outputs from two catchment sites in Japan will be presented mainly based on the recent publications (Sase et al. 2019, 2021) and perspectives on relevant studies may also be introduced with information on sites in Thailand and Malaysia.

Field surveys on atmospheric deposition and stream water started in Lake Ijira catchment in Gifu Prefecture (IJR) and Kajikawa catchment in Niigata Prefecture (KJK) in 1988 and 2002, respectively. For these sites, sulfur isotopic ratio ($\delta^{34}S$) has been determined for rainwater, soil solutions, and stream water since 2014 and 2012, respectively. The $BaSO_4$ precipitates obtained from water samples were analyzed using a mass spectrometer equipped with an elemental analyzer, EA-IRMS (EA2500−Delta Plus by Conflo II or EA IsoLink CN −Delta Plus Advantage by Conflo IV, Thermo Fisher Scientific, USA) according to the methods described in the previous publications (Inomata et al. 2019; Sase et al. 2019, 2021).

Atmospheric S deposition at IJR and KJK decreased over the last decade, possibly reflecting reduction of both transboundary air pollution and domestic air pollution. Accordingly, pH and/or alkalinity increased with decrease of SO_4^{2-} concentrations in stream water, suggesting recovery from acidification. At IJR, the sulfur outputs via stream water exceeded the atmospheric inputs significantly, larger than two times (Sase et al. 2019). On the other hand, at KJK, the outputs gradually increased and exceeded the inputs occasionally (Sase et al. 2021). The phenomena seemed to be similar, however, the isotopic evidence showed a clear difference between them. The $\delta^{34}S$ values in stream water at IJR were stable with negative values, which were significantly lower than the range of rainwater, while the values in stream water at KJK were stable within the range of rainwater. It was suggested that the stream water at IJR was largely influenced by sources other than atmospheric deposition, such as geological (rock) sulfur (Sase et al. 2019). In the presentation, importance of a retention - release cycle of sulfur in forest ecosystems and possibility of disturbing recovery processes by climate change will also be highlighted.

This work was supported by grants from the Asia-Pacific Network for Global Change Research (ARCP2012-18NMY-Sase; ARCP2013-13CMY- Sase) and the Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Numbers JP19H00955, JP19K12315 and JP18K11616.

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References. Inomata et al. 2019. Science of the Total Environment; Sase et al. 2019. Biogeochemistry; Sase et al. 2021. Atmospheric Environment.

Keywords: sulfur, acidification, recovery, climate change

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Estimate the origin of nutrients supplied to coastal areas using Ulva pertusa's nitrogen and carbon stable isotope ratios.

*Tatsuhiro Ishida[1], Osamu Tominaga[1], Ryo Sugimoto[1], Naoki Kisa[1], Keisuke Koba[2], Keitaro Fukushima[2]

1. Fukui Prefectural University, 2. Center for Ecological Research,Kyoto University

In recent years, attention is focused on various problems caused by nutrients flowing into coastal areas. However, there is little specific knowledge about how the influx of nutrients is incorporated into coastal ecosystems. In this study, in order estimate the contribution of nutrients of multiple origins to primary producers, we recorded fluctuations in the stable nitrogen and carbon isotope ratio through a culture experiment of *Ulva pertusa* in Obama Bay, Fukui Prefecture. We conducted *Ulva pertusa* culture experiments four times in July-August 2018, October-November, April-May 2019, and September-October in Obama Bay and the laboratory outdoor aquarium. The maximum culture period was 25 days. Finally, the stable nitrogen and carbon isotope ratio were measured, and the fluctuation of the isotope ratio was verified through the culture experiment. Fluctuations in the nitrogen and carbon stable isotope ratios of *Ulva pertusa* were confirmed through culture experiments. *Ulva pertusa* placed in nutrient environments of different origins had large fluctuations in isotope ratio from the first day of culture, and the error between cultured individuals was small. Our results suggest that *Ulva pertusa* can be used to estimate the origin of nutrients.

Keywords: δ15N, δ13C, environmental tracer

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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.16 Zoom Room 16

[H-TT16] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Ki-Cheol Shin(Research Institute for Humanity and Nature), Nozomu Takeuchi(Chiba University), Chairperson:Ichiro Tayasu(Research Institute for Humanity and Nature)

Modern society uses almost all the elements present in the natural world. Although there have long been calls for the sustainable use of the resources that provide these elements and the building of human societies that are in harmony with the environment, the survival of the human race is increasingly at risk as a result of qualitative changes to the environment as a whole. Implementation by the society of methodologies for diagnosing and tracking these various elements of the natural environment and their relationships with humans are now required.
Elements cycle within and among the Earth system spheres, human society, and the human body. Information on the concentrations and stable isotopes of elements is a powerful tool for tracing this cycling and has been applied in studies of atmosphere-hydrosphere circulation, ecological systems, and the life, health, and history of humans. We propose a session to discuss the development and applications of environmental traceability methods toward the goal of establishing traceability in natural and human systems.
We encourage the presentation of research integrating isotopic information in various disciplines, such as geochemistry, hydrology, ecology, geology, mineralogy, anthropology, food science, and forensics. We call the research Environmental Isotope Study.

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

[HTT16-07] A comparative study of diet of winged and wingless stoneflies on alpine snow in Mt. Gassan, Yamagata Prefecture, using carbon and nitrogen stable isotopes

*Nozomu Takeuchi[1], Risako Yonechi[1] (1.Chiba University)

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

[HTT16-08] The spatial variations in carbon and nitrogen stable isotopes of organic matter on the surface of Gulkana Glacier in Alaska

*Tsubasa Takahashi[1], MASATO ONO[1], Ayumi Kizawa[2], Nozomu Takeuchi[1] (1.Chiba University, 2.Chuo University)

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

[HTT16-09] Reconstructing lifetime isotope baselines of fish from eye lenses

*Yota Harada[1], Shin-ichi Ito[2], Chisato Yoshikawa[1], Nanako O. Ogawa[1], Naoto Ishikawa[1], Naohiko Ohkouchi[1] (1.Biogeochemistry Research Center, Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[HTT16-10] Tracing habitat areas and migration of marine fishes from fish bone Pb isotopes

*Keiji Horikawa[1], Hinako Nishimura[2], Ki-Cheol Shin[3] (1.Faculty of Science, University of Toyama, 2.Graduate School of Engineering and Science for Education, University of Toyama, 3.Research Institute of Humanity and Nature)

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

[HTT16-11] Dietary evaluation through zinc isotope ratios of human skeletal remains from Yoshigo shell mound of Jomon period

*Soichiro Kusaka[1], Ki-Cheol Shin[2] (1.Tokai Univ., 2.RIHN)

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

[HTT16-12] Origin of prehistoric pottery clay deciphered from Sr-Nd-Pb isotope ratios

*Eriko Ishimaru[1], Ki-Cheol Shin[2], Makoto Tomii[3], Yoshiki Nobusato[4] (1.Hiroshima Univ., 2.RIHN, 3.Kyoto Univ., 4.Kagawa Mus.)

A comparative study of diet of winged and wingless stoneflies on alpine snow in Mt. Gassan, Yamagata Prefecture, using carbon and nitrogen stable isotopes

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Wingless-stoneflies are commonly observed in spring on the snow surface in Japan. Lack of wing in adult of the stoneflies is consider to be adaptive to cold environment. On the same snow surface, we also often find winged-stoneflies, which appear to be different species and to come accidentally from the downstream area without snow. However, recent studies showed some stoneflies enable to control the presence of wing in the adult stage depending on the environmental conditions. However, there has been no comparative study of ecology and morphology between wingless and winged stoneflies on snow surface in Japan. We collected the wingless and winged stoneflies on snow surface of Mt. Gassan in Yamagata prefecture in Japan. We described their morphology, distribution, and timing of appearance, and analyzed carbon and nitrogen stable isotopes of their body to compare their diet. Results showed that the wingless and winged stoneflies have distinctive morphology and distribution. The stable isotopes were also significantly different between them. Results suggest that the wingless and winged stoneflies have distinctive ecology although both of them are active on the snow surface at the same time.

Keywords: wingless stonefly, Gassan, stable isotope

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The spatial variations in carbon and nitrogen stable isotopes of organic matter on the surface of Gulkana Glacier in Alaska

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Light absorbing impurities in snow and ice can reduce surface albedo and accelerate melting of snow and ice. In particular, photosynthetic algae growing on snow and ice are major constituents of the albedo reducing impurities on glaciers. The algae growing on the glacier ice surface have dark purple pigments in their cells and are mostly species of *Ancylonema nordenskioeldii* and *Mesotaenium berggrenii*. On the other hand, the algae growing on the snow surface have red pigments in their cells and are genus of *Sanguina*. Their distribution usually varies on a glacier, however, their controlling factors are not understood well. In this study, we investigate spatial variations in carbon and nitrogen stable isotopes of biogenic impurities on Gulkana Glacier in Alaska, where these algae dominate on glacier surface, and discuss formation process of organic matter on the glacier.

The field investigation was carried out in July of 2019 on Gulkana Glacier, which is a small mountain glacier with a total length of 4 km, locates on the Alaska Range. We collected surface ice samples and biogenic impurities at the 46 points on the glacier surface and analyzed carbon and nitrogen stable isotopes, concentrations of chlorophyll a and soluble ions, and cell volume biomass of algae.

The carbon and nitrogen stable isotopes of organic matter on the glacier ranged from -26.3 to -23.9‰ (Mean: -25.0±0.5) and from -5.7 to -2.9‰ (Mean: -3.8±0.6), respectively. They were higher in the downstream area but lower at the upstream area. This suggests that the organic matter on the glacier is not derived from a single source, but from microbial activities varied among the study sites. The chlorophyll a concentration and cell volume biomass showed that the biomass was higher and *Sanguina* spp. was dominant in the upstream areas whereas the biomass is lower and *A. nordenskioeldii*e dominated at the mid and downstream sites. The variation in the nitrogen stable isotopes is likely to reflect the sources of nitrogen used by the algae at each site. The algae in the upstream area probably assimilate the nitrogen with low nitrogen isotope ratio supplied currently from atmosphere whereas the algae in the downstream area assimilate the nitrogen with high nitrogen ratio derived from the glacier ice, which had been deposited on the glacier in the age before the Industrial Revolution.

This study revealed that the organic matter on glacier were products of various algae, which assimilate different nutrient sources depending on area of the glacier. The difference of the algal community and products may affect glacier darkening.

Keywords: carbon and nitrogen stable isotope, snow algae, glacier

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Reconstructing lifetime isotope baselines of fish from eye lenses

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Compound-specific nitrogen isotope analysis of amino acids archived in eye lens laminae was carried out to reconstruct lifetime nitrogen isotope baselines and trophic position of Chub mackerel (*Scomber japonicus*), a commercially important fish species in Japan. The bulk ^{15}N values gradually increased from the eye lens core (~ 2‰) to the outer layers (~ 10‰). The trophic position increased slightly from 2.6 (larval-juvenile stage) to 2.8 (adult stage). However, nitrogen baselines (phenylalanine) shifted substantially from -2.8‰ (larval-juvenile stage) to 2.8 (adult stage), likely associated with the typical ontogenetic migration of Chub mackerel in the western North Pacific that migrate from the subtropical ^{15}N depleted Kuroshio region to subarctic ^{15}N enriched Oyashio region. This study shows that lifetime trends in N isotope baselines can be reconstructed from eye lens laminae and are useful for studying ontogenetic migration of individual fish.

Keywords: isotope, nitrogen, fish

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Tracing habitat areas and migration of marine fishes from fish bone Pb isotopes

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Lead (Pb) isotopes will be a useful tracer that enable to discern geographic origin of marine fishes because the average residence time of Pb in the ocean is short (about 10 to 100 years) and Pb isotopes have characteristic values in each oceanic region reflecting different anthropogenic Pb sources. Pb is highly accumulated in fish bones up to several ppm, allowing us to measure Pb isotopes with a small amount of bone samples. Therefore, fine bone Pb isotope ratios have a potential as a new method to trace migration patterns and/or to determine geographic origin of even small and juvenile fishes.

In this study, we measured Pb isotopes of Mackerels and Horse mackerels inhabited in the Japan Sea, the East China Sea, the western North Pacific, and the North Atlantic (totally 163 samples). Bones were digested by ultrapure HNO_3, and Pb was separated from bulk solution using either Sr resin (Eichrom) or anion resion. Then, Pb isotopes were measured by a MC-ICP-MS (NEPTUNE, Thermo Scientific) at RIHN.

Atlantic mackerels habited (n = 23) in the North Atlantic and Blue mackerels (n = 50) habited near Japan represented distinctly different 208Pb/206Pb ratios. Likewise, Atlantic horse mackerels, Japanese scads, and Japanese jack mackerels in the Atlantic and near Japan also showed different 208Pb/206Pb ratios. These fish bone Pb isotopes of Mackerels and Horse mackerels obtained from the Northwest Pacific and the North Atlantic exhibited almost identical Pb isotopic compositions of the surface seawaters where fishes grew. This consistency between fish bone and seawater Pb isotopes suggests that fish bone Pb isotopes faithfully record seawater Pb isotopes. Cluster analysis based on fish bone Pb isotopes shows that geographic origins of Atlantic and Northwest Pacific fishes can be identified.

We also found a large scater of Pb isotope in Japanese jack mackerels (n = 19) caught in Kurobe (Toyama Bay), which can be interpreted as reflecting some fishes had migrated between the East China Sea and Japan Sea and some fishes had not migrated seasonally down to the Each China Sea. Similar scattering of Pb isotopes was also found in Blue mackerels habited in the Pacific Ocean near Japan. These scatters were strongly related to the ages of fishes; elder fishes tended to show lower 208Pb/206Pb ratios, which might reflect a migration pattern biased toward the upstream Kuroshio Current. In summary, we concluded that fine bone Pb isotope ratios can trace a north-south migration pattern and identify a geographic origin of marine fishes at least Mackerel and Horse mackerel of North Atlantic and Northwest Pacific, respectively.

Keywords: Pb isotope, fish bone, geographical origin, migration pattern

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Dietary evaluation through zinc isotope ratios of human skeletal remains from Yoshigo shell mound of Jomon period

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This study investigates zinc isotope ratios in tooth enamels of human skeletal remains of the Jomon period in Japan. Carbon and nitrogen isotope analysis on bone collagen was traditionary used to reconstruct diet and trophic levels on prehistoric human populations. The progress of isotope measurements using MC-ICP-MS enables us to analyze isotope ratios of zinc and other metals. Some researchers report that the zinc isotope ratios of animals reflect dietary sources and vary according to trophic levels. This study newly develops zinc isotope analysis on human tooth enamels. The zinc isotope analysis has great potential to reconstruct dietary information from inorganic materials of archaeological bones or fossils which do not contain organic components.
The material used in this study is 37 samples of human tooth enamels from the Yoshigo shell mound of Aichi prefecture, and faunal remains (six deer enamels, three boar enamels, six marine fish bones, 12 modern marine shellfish, and six modern plant leaves). Zinc was purified from these samples using anion exchange resin. Zinc isotope ratios were measured by MC-ICP-MS with the zinc standard solution of AA-ETH. The mass bias was corrected with Cu standard solution added to all standards and samples. The deer, marine fish and shellfish samples showed the value expected from their dietary ecology. The zinc isotope ratios of Jomon skeletal remains were higher than those of plants, but lower than deer and marine fish. The combination of the zinc isotope ratios and carbon and nitrogen isotope ratios previously reported showed wide distribution between the endmembers of C_3 plants, marine fish, and shellfish. This result indicates that the isotopic variation of zinc for humans were largely influenced by these dietary sources. The results indicate that the sources of zinc for humans were evaluated through zinc isotopes in tooth enamels of human skeletal remains.

Keywords: Jomon period, Human skeletal remains

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Origin of prehistoric pottery clay deciphered from Sr-Nd-Pb isotope ratios

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In archaeological research, it is important to know the production place of pottery and the clay source for discussing the migration, distribution of goods, and exchange in each era. Among the Jomon and Yayoi pottery in western Japan, a pottery group called "Ikoma seirokusan" has a brown color characterized by amphibole-rich pottery. It is thought that this pottery group was manufactured in villages in the western foot of Mt. Ikoma (Higashi-Osaka City, etc.) in the eastern part of the Osaka Plain and distributed in each area centered on the Kinki region. Clay sources of the pottery group have been estimated from the viewpoint of archaeological observation, texture analysis of sand grain, X-ray fluorescence analysis, etc. Until now, these methods cannot identify their origin.
We analyzed the production locality of the pottery using Sr (strontium) -Nd (neodymium) -Pb (lead) isotope analysis, which has different isotope ratios depending on the geology and the age of the formation. In this presentation, we report the radiogenic isotope analysis of Jomon and Yayoi pottery excavated from the two regions. One is the eastern part of Osaka Plain on Mt. Ikoma's west side, and the other in the northeastern part of the Kyoto Basin on the west side of Mt.Hiei. We have measured with bulk samples, separated amphiboles, and matrix clay to verify amphibole effects.
As a result of the analysis, the isotopic difference observed between the pottery from "Ikoma seirokusan" and "Hi-Ikoma seirokusan"(none Ikoma seirokusan pottery). The former's Sr-Nd isotope ratios are included in the range of the Ikoma gabbro's isotopic values. A few separated amphiboles and matrix clay from the same sample have different isotopic values from each other and their bulk isotopic values. With a new data set of lead isotope ratios, grain analysis of sand, and X-ray fluorescent analysis of the bulk samples, we will evaluate the effectiveness and the prospect of the radiogenic isotope analysis to estimate the origin of source materials.

Keywords: Jomon and Yayoi pottery, Sr-Nd-Pb isotope ratios, source of clay material

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[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.08_2

[H-TT16] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Ki-Cheol Shin(Research Institute for Humanity and Nature), Nozomu Takeuchi(Chiba University)

Modern society uses almost all the elements present in the natural world. Although there have long been calls for the sustainable use of the resources that provide these elements and the building of human societies that are in harmony with the environment, the survival of the human race is increasingly at risk as a result of qualitative changes to the environment as a whole. Implementation by the society of methodologies for diagnosing and tracking these various elements of the natural environment and their relationships with humans are now required.
Elements cycle within and among the Earth system spheres, human society, and the human body. Information on the concentrations and stable isotopes of elements is a powerful tool for tracing this cycling and has been applied in studies of atmosphere-hydrosphere circulation, ecological systems, and the life, health, and history of humans. We propose a session to discuss the development and applications of environmental traceability methods toward the goal of establishing traceability in natural and human systems.
We encourage the presentation of research integrating isotopic information in various disciplines, such as geochemistry, hydrology, ecology, geology, mineralogy, anthropology, food science, and forensics. We call the research Environmental Isotope Study.

[HTT16-P01] Oxygen and hydrogen isotopic signatures of surface and groundwater during a dry season in the Tonle Sap Lake basin

*Yumi Yoshioka[1], Takao Masumoto[2], Kumiko Tsujimoto[3], Yuji Ito[4] (1.Shimane University, 2.Akita Prefectural University, 3.Okayama Univerisity, 4.Kagoshima University)

[HTT16-P02] Identification of regional characteristics of the basin using elemental components as tracers

*Yusuke Hataya[1], Shiho Yabusaki[2], Seiki Kawagoe[3] (1.Fukushima University Faculty of Symbiotic Systems Science, 2.Research Institute for Humanity and Nature, 3.Fukushima University Faculty of Symbiotic Systems Sciences)

[HTT16-P03] Seasonal variation of $\delta^{34}S$ and $\delta^{18}O$ in sulfate in rain water and aerosols on the outskirts of Gifu City

*Masako Kagawa[1], Nagayoshi Katsuta[1], Yusuke Hashimoto[1], Yuto Yamagishi[1], Ichiro Tayasu[2], Chikage Yoshimizu[2] (1.Gifu University, Faculty of Education, 2.Research Institute for Humanity and Nature)

[HTT16-P04] Seasonal variations and trends of dissolved elements in rainwater and stream water in forest catchment area of central Japan

*Masayuki Morohashi[1], Hiroki Yotsuyanagi[1], Masaaki Takahashi[2], Tatsuyoshi Saito[2], Yayoi Inomata[3], Ki-Cheol Shin[4], Ichiro Tayasu[4], Tsuyoshi Ohizumi[1], Hiroyuki Sase[1] (1.Asia Center for Air Pollution Research, 2.Niigata Prefecture, 3.Kanazawa Univercity, 4.Research Institute for Humanity and Nature)

[HTT16-P05] Geochemical and isotopic study of river water from the Okayama and Tottori Prefectures, Japan.

*Katsuyuki Yamashita[1], Takahiro Kamei[1], Keisuke Kishimoto[1], Masahiko Mori[1], Yuga Kishimoto[2], Aya Ooi[2], Ayaka Onishi[2], Yoko Kurihara[2], Miyake Ryota[2], Ryosuke Yamano[2], Hitoshi Chiba[1], Takanori Nakano[3], Ki-Cheol Shin[4] (1.Graduate School of Natural Science and Technology, Okayama University, 2.Department of Earth Sciences, Okayama University, 3.Ono City, 4.Research Institute for Humanity and Nature)

[HTT16-P06] Stable sulfur isotope variations in lacustrine sediments in Mongolia and its paleo-environmental implication

Miku Yoichi[1], *Nagayoshi Katsuta[1], Shinya Ochiai[2], Sayuri Naito[1], Masako Kagawa[1], Yuma Masuki[1], Ichiro Tayasu[3] (1.Faculty of Education, Gifu University, 2.Institute of Nature and Environmental Technology, Kanazawa University, 3. Research Institute for Humanity and Nature)

[HTT16-P07] Variations in sedimentation rates of Tsuya River in the western Nobi Plain, central Japan over the last decades

*Takashi Tashiro[1], Ichiro Tayasu[2] (1.Nagoya University, 2.Research Institute for Huminity and Nature)

[HTT16-P08] Neutralization using recycled waste materials for acid wastewater from the Kusatsu hot spring area in Japan

*Takeshi Saito[1], Naoki Watanabe[2] (1.Graduate School of Science and Engineering, Saitama University, 2.Research Institute for Natural Hazards and Disaster Recovery, Niigata University)

[HTT16-P09] Evaluating temperature dependence of arsenic and boron adsorption onto sediments

*Keigo Kurita[1], Takeshi Saito[2] (1.Department of Civil and Environmental Engineering, Faculty of Engineering, Saitama University, 2.Graduate School of Science and Engineering, Saitama University)

[HTT16-P10] Soil food webs after more than a year since litter-removal experiment: an evaluation based on carbon and nitrogen stable isotope ratios

*Takashi F Haraguchi[1], Soshi Yoshida[2], Syuhei Fujimoto[2], Keiichiro Sato[2], Motohiro Hasegawa[2] (1.Biodiversity Research Center, RIEAF, Osaka, 2.Doshisha University Faculty of Science and Engineering, Environmental Systems Science)

[HTT16-P11] Evaluation of air pollution stress in roadside trees using stable carbon isotope ratio

*Yuko T. Hanba[1], Mayu Matsumoto[1], Takashi Kiyomizu[1], Tomomitsu Kinoshita[1], Atsushi Kume[2] (1.Kyoto Institute of Technology, 2.Kyushu University)

[HTT16-P12] **Effects of Traffic Volume on Photosynthetic Function and Water Use Efficiency of Tall Street Trees in Kyoto City**

*Takumi Matsuura[1], Yuko T. Hanba[1] (1.Kyoto Institute of Technology)

[HTT16-P13] Effect of flooding stress on photosynthesis of aquatic plants

*Yutaro Yasui[1], Yuko T. Hanba[1] (1.Kyoto Institute of Technology)

[HTT16-P14] The incubation method using ^{18}O-water and phosphate oxygen isotope for quantitative evaluation of bioavailable phosphate in soil.

*Takuya Ishida[1] (1.Hiroshima University)

[HTT16-P15] Trace element quantification in organic materials by low temperature plasma ashing

Taisuke Hino[1], Yuriko Umeda[1], Hibiki Shishime[1], Akane Ito[1], *Masaharu Tanimizu[1] (1.Kwansei Gakuin University)

[HTT16-P16] Metal element isotope analysis for Environmental Reference Materials

*Ki-Cheol Shin[1] (1.Research Institute for Humanity and Nature)

Oxygen and hydrogen isotopic signatures of surface and groundwater during a dry season in the Tonle Sap Lake basin

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Tonle Sap Lake located in Cambodia is the largest lake in South Asia. This lake has several inflow rivers and one outflow river. It is connected to the Mekong River via the outflow river and the Mekong river water inflows to the lake during wet seasons. Thus, the lake is characterized by key fluctuations of water levels and surface area. There is a need for better understanding of water supply to the lake from surface or under surface water. The contribution of groundwater is still unknown. Stable isotopes in water are often used to identify lake water balances. We therefore conducted a sampling campaign in February 2020 of a dry season. We collected water samples for four lake waters, nine river waters including inflow rivers, outflow river, and subbranch of the Mekong River, eight groundwater, and eleven commercial bottled water made in Cambodia and Thailand. Major dissolved ions, dissolved silica (DSi), and stable isotope ratios of oxygen and hydrogen ($\delta^{18}O$ and $\delta^{2}H$) were analyzed. Isotopic composition of rain obtained in earlier studies were used for data analyses. The highest ratios were observed in the lake and were ranging from 0.0 to 2.2 ‰for $\delta^{18}O$ and -18 to -9 ‰for $\delta^{2}H$. The isotopic ratios became higher in the order of subbranch of the Mekong River, the inflow rivers, and the outflow river. The isotopic composition of the groundwater varied widely: from -7.3 to -2.3 ‰for $\delta^{18}O$ and -52 to -21 ‰for $\delta^{2}H$. Average isotopic composition of groundwater was consistent with the volume-weighted average isotopic compositions of rain. Isotope signatures of groundwater did not depend on the depths of the wells. The regression line was delineated on a dual-isotope plot by samples of the lake and outflow river, and it was defined as the local evaporated line (LEL). The slope of LEL was 5.0. In addition, the slopes of regression lines for inflow river and groundwater were 4.9 and 6.2, respectively. The flatter slopes than that of the LMWL indicated that surface and groundwater were more evaporative than the source water, and isotope compositions were enriched by the kinetic isotope effect during evaporation even in river water. Small isotopic differences (ratios and slopes) between groundwater and commercial bottled water were observed. The intersect of LEL and LMWL, which is the initial composition before isotopic enrichment process, was fall near samples of groundwater and the average isotopic compositions of rain. The DSi concentration is used as a residence time indicator in groundwater. The higher concentration in the lake (less than 20 mg/L) than in inflow rivers (less than 10 mg/L) was consistent with the contribution of groundwater to the lake. Water sampling survey with monthly interval has been implemented since May 2020. Further works are monitoring of isotopic fluctuation throughout dry and rainy seasons, and tracing water source of the lake.

Keywords: Stable isotope, Groundwater, Kinetic isotope effect , Lake water balance, Mekong River, Cambodia

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Identification of regional characteristics of the basin using elemental components as tracers

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1.Introduction

1.1 background

Changes in the environmental dynamics of the basin are expected in response to "land use development due to human modification" and "extreme temperature rise and precipitation due to climate change", and research on the impact assessment of eutrophication is being developed especially in closed water areas. Has been done. Along with internal production, it is necessary to understand the inflow effect of external load on the drastic environmental changes. Predicting the future image of water quality can be evaluated more precisely based on detailed information on both internal production according to the shape scale of each basin and external load according to regional characteristics.

1.2 Research purpose

In this research, as part of the purpose of developing an external load database that can be used for land cover and current conditions, and for assessing the water environment impact of climate change, the Abukuma River basin, which is a first-class river in the Tohoku region, was set as the target area and numerical geography. Based on the information, we attempted to compare and examine the relationship between regional characteristics (vegetation, land cover, soil, geology) and sampled and analyzed chemical outflow components (chemical component content due to multiple elements) for each small basin. ,

In the basin condition analysis, the types of basin conditions of the basin were classified using cluster analysis. We decided to compare the characteristics of the global region with the values obtained from chemical analysis (content of elements).

2.Main subject

2.1. Results of multi-element analysis using ICP-MS

Inductively coupled plasma mass spectrometry (ICP-MS) was used for analysis to determine the amount of elements contained in the Abukuma River basin (Na, Mg, Al, Si, K, Ca, Mn, Fe, P).

The chemical composition (element content) of the Abukuma River main river increases from the upstream to the middle basin, with the confluence with the Ose River at its maximum and decreasing toward the downstream.

In addition, in the results of this analysis, the value of Arakawa was the largest among the main river and tributary points. Above all, the concentration of Mg was more than twice as high as that of other

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tributaries.

At each concentration, Na and Ca varied at each point, so it is considered that there are some regional characteristics.

2.2 Results of Regional Characteristics Analysis

2.2.1 Classification results by cluster analysis

For the sake of convenience, the classification by cluster analysis was integrated, and the integration numbers were shown as equivalent values in the relative positional relationship, and a total of three groups were shown. Vegetation in the Abukuma River basin was divided into 5 groups, 5 categories for land cover, 4 categories for soil, and 5 categories for geology. The classification categories of "4334 (Fujita River, Sasahara River)", "5112 (Suwon River, Yashiro River)", and "2113 (Kitasu River, Yui River)" have overlapping basin characteristics. Depending on the conditions, there is a high possibility that similar chemical component outflow will occur.

2.2.2 Comparison with multi-element analysis results

As basin conditions that are considered to contribute to the outflow of chemical components, vegetation includes deciduous and evergreen broad-leaved forests in the Yabutsubaki class area, land cover includes basins that occupy a high proportion of urban areas, and soil includes Andosols. In terms of humus and geology, the basin has a high occupation ratio related to volcanic ejecta. From the transition of the material outflow component (element content) as the material circulation route in the Abukuma River basin, it became clear that it changes depending on the basin where the outflow is artificially high due to the urban area and the regional characteristics due to the contribution of forests and volcanoes. ..

3.Conclusion

From the chemical analysis (content of elements) and the comparative study of the basin conditions, the elements of deciduous / evergreen broadleaf forest zone, urban area, humus, and volcanic ejecta were shown as basin conditions that contribute to the formation of water quality in the Abukuma River basin.

Furthermore, it is shown that classification by natural factors and social factors is necessary as a pattern of load increase due to basin conditions.

This time, the analysis was performed without considering the item of estimated population as the basin condition, so we plan to add some conditions in the future and work on the elucidation of the chemical composition and its material cycle.

Keywords: Elemental component, Tracer, Regional characteristics, Land cover

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Seasonal variation of $\delta^{34}S$ and $\delta^{18}O$ in sulfate in rain water and aerosols on the outskirts of Gifu City

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1. Introduction

Reportedly, Lake Ijira, which is located on the outskirts of Gifu City, has the highest deposition of non-sea-salt sulfate ion (nss-SO_4^{2-}) and the hydrogen ion (H^+) in Japan (Ministry of the Environment, 2004). It has also been demonstrated that its outflow of SO_4^{2-} is about twice its inflow (Ministry of the Environment, 2004). Based on these results, we sampled atmospheric aerosols and rainwater before deposition from November 2018 until the present (2021) to measure the contained sulfate ion, its sulfur isotope ratio ($\delta^{34}S$) and oxygen isotope ratio ($\delta^{18}O$) for this study. Thereafter, we examined the source of sulfur derived from the atmosphere and accumulated on the soil surface around Lake Ijira.

2. Methods for Observations and Analyses

Rainwater was sampled using a simple rainwater collector: a PET bottle equipped with polypropylene funnel. For ion analyses, atmospheric aerosols were sampled onto a 0.2-μm PTFE filter at an 8–10 L/min flow rate with a vacuum pump. For isotope analyses, atmospheric aerosols were sampled onto a quartz filter (QR-100®; Advantec) at a suction flow rate of 1000 L/min once a week using a high-volume air sampler (HV-RW; Sibata Scientific Technology Ltd.).After the samples filtered through membrane filter, they were subjected to quantitative analysis for concentrations using ion chromatography (ICS-1100; Thermo Fisher Scientific Inc.) for anions and inductively coupled plasma atomic emission spectrometry (ICP-AES) (ULTIMA2; Horiba Ltd.) for cations.For the sulfur isotope ratio and the oxygen isotope ratio were precipitate SO_4^{2-} in the sample as $BaSO_4$. It was analyzed using S-IRMS (Flash EA 2000 + ConFlo IV + delta V plus; Thermo Fisher Scientific Inc.) and OH-IRMS (TC/EA+ConFlo III+Delta plus XP; Thermo Fisher Scientific Inc.) installed in the Research Institute for Humanity and Nature.

3. Results

3-1. Changes in SO_4^{2-} and NO_3^- concentrations during the lockdown period in China

In early 2020, China adopted a lockdown policy because of the outbreak of COVID-19. Itabashi *et al.* (2020) reported that the concentrations of PM2.5, SO_4^{2-}, and NO_3^- were measured for three years of 2018–2020 at four sites (Goto Islands, Oki Islands, Maki, and Nonodake), the mean concentrations of PM2.5, SO_4^{2-}, and NO_3^- during January–March were lower than the prior year at all observation sites in the lockdown period of China during January–March. For Lake Ijira, comparison of SO_4^{2-} and NO_3^- concentrations of January–March between 2019 and 2020 indicated a remarkable decrease, suggesting a decrease in concentrations of atmospheric aerosols because of decreased economic activities resulting from lockdowns.

3-2. $\delta^{34}S$

$\delta^{34}S$ in the sulfate ions in rainwater during December 2018 –December 2020 was 4–12‰ in winter and 2–4‰ in summer, exhibiting clear seasonal changes to decrease in winter and increase in summer. $\delta^{34}S$

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in sulfate aerosols was 5–6‰ in winter and 2–6‰ in summer, reflecting seasonal changes, although there were variations.

3-3. Analysis by back-trajectory analysis
Back-trajectory analysis was applied using NOAA HYSPLIT data every day during the observation period, to be classified into eight categories (Figure 1). Figure 2 shows nss-SO_4^{2-} and NO_3^- concentrations and the $\delta^{34}S$ value of each category from December 2019 through December 2020. The most frequently classified category was CE (route that passes the eastern side of the Korean Peninsula) followed by the second-most frequent, CN (route that passes the western side of the Korean Peninsula). Air masses from the Eurasian continent accounted for 80% of air masses that arrived at the observation points. It is therefore considered that most of the atmosphere comes from the Eurasian continent.

Keywords: sulfate ion, sulfur isotope, atmospheric aerosol, rain water

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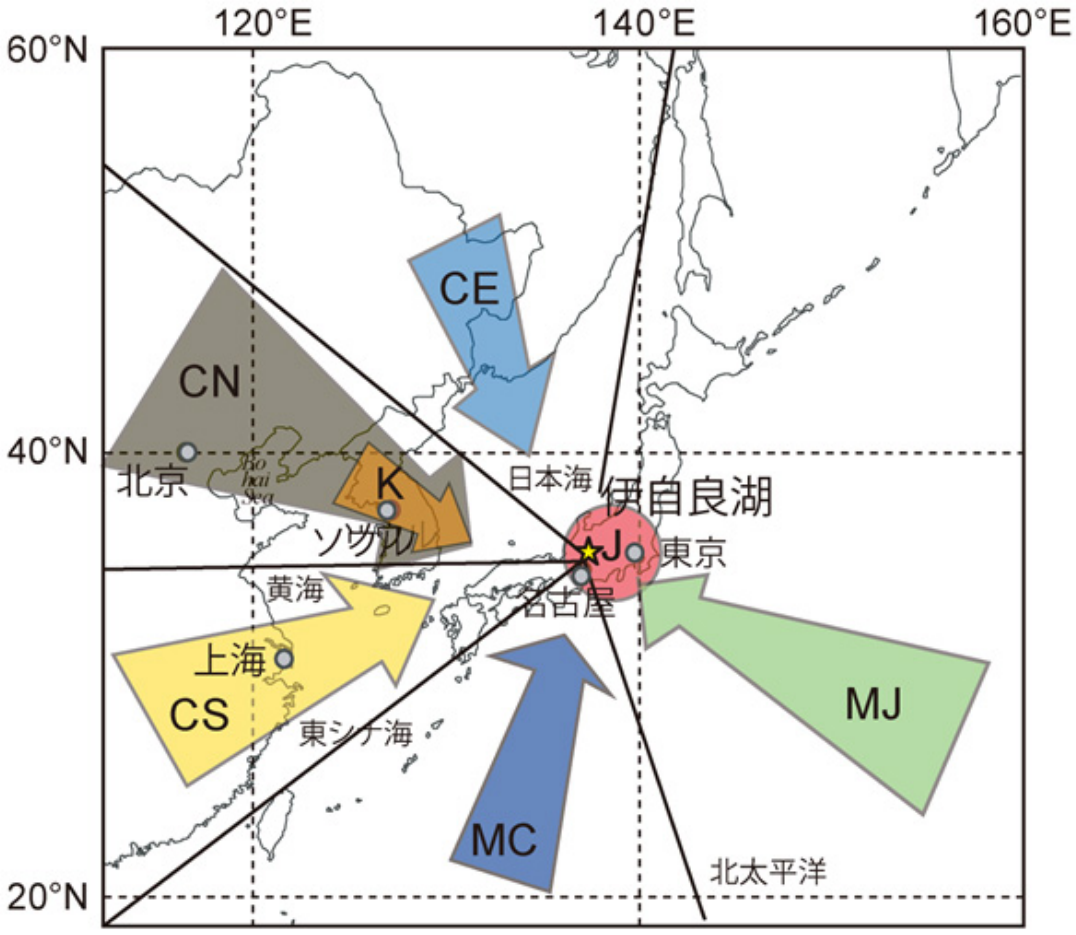


図 1. 気塊経路の後方流跡線による分類

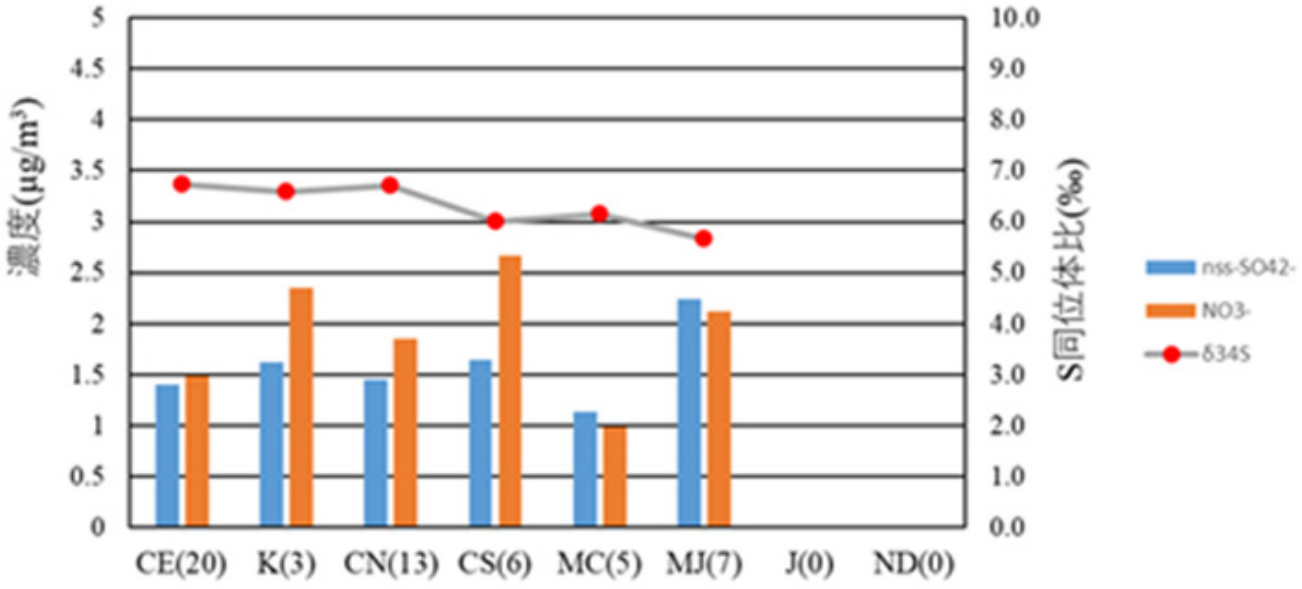


図 2. 気塊経路ごとの nss-SO_4^{2-}, NO_3^-濃度と $\delta^{34}S$ 値

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Seasonal variations and trends of dissolved elements in rainwater and stream water in forest catchment area of central Japan

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Metal elements released into the atmosphere by human activities such as fossil fuel combustions flow into forest ecosystems by wet deposition (precipitation) and dry deposition (particulate matters), and some of them flow out of the system via mountainous stream water. Some elements are essential for lives, but excessive intake is harmful. It is important to grasp the concentration level of dissolved metal elements, because they are easily taken into the living organisms.

The Kajikawa catchment site in Niigata Prefecture, which is located on the continental side of central Japan, has been suffering to a large amount of acidic substances deposited due to its geographical conditions and meteorological seasonality, and is affected by transboundary air pollution originating from the Asian continent. In this study, concentrations of trace elements dissolved in rainfall (RF) and mountain stream water (SW) were clarified in order to evaluate the effects of transboundary air pollution in forest ecosystems more comprehensively. In addition, stable isotope ratio analysis was used to analyze the dynamic mechanism in more detail.

RF were collected by using bulk samplers at the end of each month, and SW were also collected on the same day during the period from 2014 to 2018. Trace element concentrations were quantified by ICP-MS and major inorganic ion concentrations by using ion chromatography. At the same time, pH, electrical conductivity, precipitation amount and flow rate were measured. In this study, we focus on Al, V, Cr, Zn, As, Sr, and Pb as trace elements. In addition, stable isotope ratios were measured for Sr and Pb.

Concentrations of trace elements and major inorganic ions in RF tended to be high in winter and low in summer. Fluxes of many trace elements also increased in winter, reflecting the high amount of precipitation in winter. The enrichment factors (EFs) calculated based on Al (as an index of earth crust) was high in winter and low in summer. The EFs for many elements were found to be above 10, suggesting that they are derived from anthropogenic sources, such as fossil fuel combustion. The EFs of many elements showed an upward trend, while that of Pb showed a downward trend.

The isotopic ratio of Sr increased over the years, especially in the spring, possibly due to the influence of the Asian dust (yellow sand). At the time of poster presentation, we will compare and discuss the change in the isotope ratio of Pb.
This work was supported by grants from the Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Numbers JP19H00955 and JP18K11616.

Keywords: trace element, Forest catchment, Isotope ratio analysis

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Geochemical and isotopic study of river water from the Okayama and Tottori Prefectures, Japan.

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Geochemical and isotopic properties of river water are influenced by various processes such as evaporation, interaction with rocks and soils, and input from human activities. In order to understand the cause of geochemical variation observed in river water from the Okayama and Tottori Prefectures, Japan, we have collected over 700 samples from 539 locations over the past ten years. All samples were filtered with 0.2 μm acetate cellulose disposable filter prior to the analyses for major dissolved components, trace element concentration, and O-H-S-Sr isotopes. The data from these analyses were used to construct high-resolution geochemical maps of the two Prefectures. Many elements, such as Ca, Rb, Cs, V and Si show geographic variations that are consistent with the geochemistry of the rocks exposed in the area. For example, high concentration of Ca is observed in the western Okayama Prefecture where limestones are widely exposed, and high concentrations Rb, Cs, V and Si are observed around Mt. Daisen of dacitic volcanic rocks. These regional variations exceed seasonal variation and thus we attribute this to the chemical weathering of watershed rocks.

Regional variation is also seen in various isotopic signatures. New Sr isotope data show that $^{87}Sr/^{86}Sr$ is low (<0.706) in the area near Mt. Daisen and Hiruzen, where Quaternary volcanic rocks are exposed. On the other hand, $^{87}Sr/^{86}Sr$ in excess of 0.709 is seen in areas where Paleozoic sedimentary rocks distribute. Such correlation between $^{87}Sr/^{86}Sr$ and the average age of rocks exposed in the area supports the idea that Sr (and perhaps Ca) in the river water is largely derived from rocks and soils in the vicinity of the river. The sulfur isotopic signature ($\delta^{34}S$), on the other hand, is high (>12‰) in the central to western Tottori Prefecture, and low in the Okayama Prefecture (<6‰). The high $\delta^{34}S$ seen in the river water from the Tottori Prefecture may be ascribed to sulfur originating from combusted Chinese coals and sea-salt during the winter with high rainfall. The $\delta^{34}S$ of the river water from the Okayama Prefecture tends to converge to ~0 ‰as the SO_4 concentration increases. This correlation may imply that Okayama river water with low $\delta^{34}S$ is enriched in artificial sulfur of domestic origin (e.g. sulfur released from breakdown of fertilizer), whose $\delta^{34}S$ is about 0 ‰.

Keywords: River water, Okayama Prefecture, Tottori Prefecture

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Stable sulfur isotope variations in lacustrine sediments in Mongolia and its paleo-environmental implication

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In this study, we present the results of stable isotope variations since the last 300 years of lake sediment samples, southwest Mongolia, and discuss its environmental implication.

Keywords: lake sediment, stable sulfur isotope, permafrost zone

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Variations in sedimentation rates of Tsuya River in the western Nobi Plain, central Japan over the last decades

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The Nobi Plain has been formed with the fluvial processes of the Kiso Three Rivers (composed of the Kiso, Ibi and Nagara rivers), central Japan. Tsuya River, a branch of the Ibi River is flowing at the eastern foot of Yoro Mountains, Gifu prefecture, in the western margin of the plain with abundant groundwater. Because the current main channel of Tsuya River has the modern continuous levee only on its eastern side, it flows across ends of their alluvial fans with receiving a lot of spring water and sediment via its western side derived from the Yoro Mountains. This study is conduced to describe the environmental changes of Tsuya River from the viewpoints of sedimentation dynamics with natural and artificial impacts.
Sediment dynamics over the last decades in the Tsuya River are evaluated with the lead (Pb) -210 dating method. The sedimentation rates were determined by applying CIC (Constant Initial Concentration) and CRS (Constant Rate of Supply) models to the sediment cores in the pond linked to the right/western bank of main channel. The CRS model mostly agreed with the Cs-137 dating, which the CIC model was not applicable because of fluctuations in the lead 210 profiles. The average sediment rates of 0.24 - 0.44 g cm^{-2} yr^{-1} were obtained, which were larger than the reported values in most of the lakes in Japan. Furthermore, the higher sedimentation rates with the maximal values such as 0.59, 0.71 and 2.62 g cm^{-2} yr^{-1} were obtained from 1961 to 1984, which could respectively correspond to flood events and construction works in Tsuya River watershed during the same period by according to conventional literatures. Consequently, these results might clarify the river sediment dynamics also be explained with the classical lead-210 method (CRS model).

Keywords: sedimentation rate, flood history, Pb-210 dating, Tsuya River

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Neutralization using recycled waste materials for acid wastewater from the Kusatsu hot spring area in Japan

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Acid river waters from active volcanos and mines influence seriously to ecosystems in the river basins. This study is paid attention to the Yukawa River that is characterized by markedly lower pH value (less than 2.0) and higher concentration of harmful elements such as arsenic (As) and lead (Pb) and that is the acid discharged water from the Kusatsu hot spring and closed sulfur mines located in the eastern foot of Kusatsu-Shirane Volcano in central Japan. The neutralization treatment of this river water using crushed limestone has been continuously carried out by the Ministry of Land, Infrastructure, Transport and Tourism (government of Japan) for more than 50 years. We have examined the applicability of recycled waste materials as alternative liming agents to the neutralization treatment using crushed limestone through batch neutralization experiments in laboratory. The neutralization experiments for the acid wastewater were performed the mixing of water from the Kusatsu hot spring with fly ash, clinker ash, steel slug, autoclaved lightweight aerated concrete, recycled concrete, wood ash, oyster shell, and calcium carbonate as a reference liming agent. The experimental conditions are as follows. Centrifuge tubes with 50 mL volume were filled with appropriate weight of each recycled waste material and 40 mL of the acid wastewater to have the solid-liquid ratio of 1:10 to 1:4000. Water samples are separated by centrifugation after shaking for 10 minutes. Subsequently we measured pH, electric conductivity (EC), and concentrations of harmful elements (As and Pb) immediately. As the results, neutralization performance of steel slug and recycled concrete was significantly higher than that of other recycled waste materials. For removal performance of both As and Pb, steel slug, recycled concrete, and wood ash revealed clearly higher comparing with calcium carbonate as a common liming agent. The above results suggest that steel slug and recycled concrete are promising alternative liming agents to calcium carbonate.

Keywords: Kusatsu hot spring area, Acid wastewater, Neutralization treatment, Recycled waste materials

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Evaluating temperature dependence of arsenic and boron adsorption onto sediments

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Subsurface temperature increase likely due to global warming and urbanization has been observed all over the world. This phenomenon may cause changes in physical, chemical, and microbial processes in subsurface environment, resulting in groundwater quality changes. The effect of temperature increase on subsurface environment including groundwater system has not been sufficiently clarified. The objective of this study was therefore to clarify temperature dependence of arsenic and boron adsorption onto sediments based on batch adsorption experiments under 20°C and 40°C conditions. Completely different two samples of Holocene (non-marine sediment) and Miocene deposits (marine sediment) were used in this study. The adsorbed amount of arsenic at 40°C was significantly higher than that at 20°C, suggesting clear temperature dependence for arsenic. Oppositely, the adsorbed amount of boron was not clearly affected by temperature.

Keywords: Temperature dependence, Adsorption, Arsenic, Boron, Sediment

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Soil food webs after more than a year since litter-removal experiment: an evaluation based on carbon and nitrogen stable isotope ratios

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Organic layer on soil surface is vertically heterogeneous habitat and one of the important endmembers; i.e. their source of energy and nutrients, for soil fauna. The vertical heterogeneity of soil organic matter is primarily ascribed to decomposition process from plant litter to different matters so called fumus and humin. Many studies have shown that species composition of soil fauna is changed by perturbations of soil organic matter, mainly because the spatial heterogeneity is disrupted. On the other hand, effects of the disturbances to biological interactions between predator and prey; food web structures, are little described. In this study, we aimed to elucidate response of diets of soil microarthropods to ecological disturbances and compared carbon and nitrogen stable isotope ratios of them between those from litter removal plots and those from control plots.

Litter removal manipulation was conducted at a Japanese cypress forest (*Chamaecyparis obtusa*) in Kamigamo Experimental Station, Kyoto, Japan on July 12th, 2019. Litter manipulation plot was comprised of three 4 m x 4 m quadrates settled in one-line, and two 2 m x 4 m quadrates on both sides of the litter removal plot were defined as control plot. All quadrates were split into 2 m x 2 m subplots, and at least two soil cores were sampled from every subplot for the extraction of soil microarthropods by Tullgren apparatus. The extracted microarthropods in September 2019, were identified to order or suborder for the measurements of stable isotope ratios of carbon and nitrogen (δ^{13}C and δ^{15}N) for the following taxa; Oribatida (detritivore), Collembola (detritivore), Prostigmata (Predator or microbivore), and Gamasida (predator). Part of the soil cores were used for the δ^{13}C and δ^{15}N measurements of the following four collembola species; *Tetracanthella sylvatica*, *Tomocerus varius*, *Folsomia octoculata*, and *Isotoma carpenteli*. In 2020, only Gamasida and the four collembola species were chosen for measurements of the stable isotope ratios.

To test the effect of manipulation and sample type on the δ^{13}C or δ^{15}N values, ANOVA-like GLMM considering effect of plot as block factor, were conducted for each of soil organic layer, three Acari suborders with Collembola, and four Collembola species. Goodness of fit was evaluated by AIC, and in case singular fit was returned, block random factor was removed and GLM was re-selected. Post-hoc test was also conducted by model selection of GLMM for every sample type.
Based on the models, effect of litter removal was selected for δ^{13}C, δ^{15}N of Collembola species and δ^{15}N of Acari suborders and Collembola. δ^{15}N of organic layers were slightly different between manipulated plots and control plots, although the effects were not consistent between the sample types: δ^{15}N of litter layer was increased, while δ^{15}N of humus was decreased by litter removal. Collembola species living in the deeper organic layer showed in higher δ^{13}C and δ^{15}N than surface-living species, as shown in previous studies. Gamasida in the manipulated plot showed on average 1.7‰ and 0.7‰ higher δ^{15}N values in 2019 and 2020, than those from control plot. These results indicate that predators approached to prey in deeper organic layers. Collembola species sampled in manipulated plot showed up to 0.5‰ lower δ^{13}C values and up to 0.7‰ higher δ^{15}N values than controlled plot in 2019. The difference in the δ^{13}C value expanded up to 1.1 ‰in a surface-dwelling Collembola (*Tomocerus varius*). Based on the effect of litter removal on δ^{13}C of some Collembola species, phytophagous-oriented diet shift was

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suggested. On the other hand, relative abundance of *Tomocerus varius* was higher in the litter exclusion plot, while relative abundance of *Folsomia octoculata* and *Isotoma carpenteli*, species inhabiting deeper organic-layer (Upper F, lower F), decreased. These results indicate that ecological plasticity both on food and habitat is a key to survive in a perturbed system.

Keywords: soil microarthropods, food web, ecology

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Evaluation of air pollution stress in roadside trees using stable carbon isotope ratio

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In Japan, the problem of air pollutants, especially nitrogen oxides, emitted from automobiles and other vehicles became apparent as "urban- and lifestyle-type" air pollution in the 1970s. In Japan in the year of 2021, the amount of nitrogen dioxide in the air has been steadily decreasing in general, but in areas with heavy traffic, the amount of nitrogen dioxide can exceed the environmental standard concentration. Therefore, air pollution in cities is not a problem of the past in Japan. On the other hand, since the 2000s, the amount of nitrogen oxides in the atmosphere has been dramatically increasing in the Asian region along with the remarkable economic growth of China and India, causing serious air pollution problems.

Roadside trees planted in cities have many benefits, such as absorption and trapping of air pollutants in the canopy, suppression of high temperatures through canopy shade formation, and absorption of carbon dioxide through photosynthesis. Since photosynthesis is a physiological function that supports the growth and survival of roadside trees, maintaining photosynthetic activity is essential for the survival of trees in urban areas, which are harsh environments. However, photosynthetic activity is extremely sensitive to various stresses, including air pollution. In particular, the stomata, which uptake carbon dioxide for photosynthesis, close quickly when stressed, resulting in reduced photosynthesis. In order to maintain the photosynthetic function of roadside trees, it is necessary to develop technology that can evaluate the function of the stomata of planted roadside trees in the field. Carbon stable isotope fractionation (Δ13C) of photosynthetic products in leaves has been found to reflect average stomatal openness and has been widely used to determine stress in plants in the natural environment, but there are limited examples of studies applying it to plants in urban areas.

In this presentation, we report the results of a survey conducted from 2007 to 2019 to evaluate the air pollution stress of roadside trees. *Rhododendron* x *pulchrum* (*R. pulchrum*) and *Ginkgo biloba* (*G. biloba*) were selected for the study. The *R. pulchrum* is the most widely used roadside shrub tree species in Japan. Since it is evergreen and often trimmed to within about one meter in height, it is very susceptible to the effects of automobile exhausts. *G. biloba* is the most widely used tree species in Japan as a tall roadside tree. *G. biloba* is a deciduous species, with its height is often trimmed to less than 20 meters in urban areas.

The study was conducted as follows:

(1) Twenty-one locations were selected in Kyoto City where traffic volumes and concentrations of nitrogen oxides in the air were different.

(2) Branches of *R. pulchrum* and *G. biloba* were collected, and the photosynthetic function of the leaves was analyzed in detail in 2016 and 2017.

For the calculation of Δ13C, the stable carbon isotope ratio of carbon dioxide in the atmosphere was used as a correction. For the amount of nitrogen oxides, we used values from a database provided by the National Institute of the Environmental Studies.

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4) Using the data of traffic volume and 3), we mapped Δ13C of *R. pulchrum* in Kyoto City.

Photosynthesis data analysis for 2016-2017 revealed that the photosynthetic rate of *R. pulchrum* was lower at study sites with higher concentrations of air pollutants, while the rate of photosynthesis of *G. biloba* was higher at study sites with higher concentrations of air pollutants. The analysis of the annual data from 2007 to 2019 showed that the Δ13C of *R. pulchrum* was decreased with higher atmospheric nitrogen dioxide concentration. This indicates that the higher the nitrogen dioxide concentration in the air, the smaller the stomatal opening of the *R. pulchrum*, indicating that the high nitrogen dioxide concentration imposes a stress to *R. pulchrum*. On the other hand, the Δ13C of *G. biloba* was almost constant regardless of the nitrogen dioxide concentration, indicating that the effect of nitrogen dioxide on the stomatal behavior was small. Mapping of Δ13C for *R. pulchrum* showed that the stomatal opening of *R. pulchrum* was reduced mainly due to the effect of automobile exhaust at the area around Kyoto Station where the traffic volume was particularly high.

Keywords: photosynthesis, stomata, water use efficiency

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Effects of Traffic Volume on Photosynthetic Function and Water Use Efficiency of Tall Street Trees in Kyoto City

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Introduction

Urban trees play an important role in improving the urban environment by providing shade through their canopy, cooling effects through transpiration, capturing air pollutants, and absorbing carbon dioxide.

However, because street trees are planted in urban areas, they are susceptible to the air pollution caused by exhaust gases. The stress caused by air pollution is known to reduce physiological functions such as photosynthesis, which may prevent street trees from fulfilling their required role.

In this study, we focused on the environmental stress caused by air pollution and investigated the effect of different traffic levels on the photosynthetic function of tall street trees by measuring the photosynthetic function and stable carbon isotope ratios of three street tree species at four sites with different traffic levels in Kyoto City. Since traffic volume and air pollution levels are strongly related, we used traffic volume as an indicator to measure air pollution in Kyoto City.

Materials and methods

1. Tree species

Three species were used: ginkgo (*Ginkgo bioloba* L.), Japanese maple (*Acer buergerianum* Miq.), and Someiyoshino cherry (*Prunus×yedoensis* Matsum.). These are all deciduous tall trees. The top three most commonly planted tall trees in Japan and in Kyoto were selected for the study.

2.Study site

The four study sites were chosen to be near an air monitoring stations that was set up by the Kyoto city government, which constantly measures the concentration of air pollutants. he four study sites were selected to provide as much variability as possible in 12-hour vehicle traffic volumes on adjacent roads.

3.Photosynthesis measurements using the Li-6400 XT

The collected leaves were used to generate an A-Ci curve using a photosynthesis measurement system (Li-6400 XT, Li-Cor, USA). The maximum carboxylation rate (V_{cmax}) and the electron transport rate (J) of the thylakoid membrane were determined from the A-Ci curves.

Since the average CO_2 concentration in the environment where trees are actually planted is about 400 μ mol mol^{-1}, the photosynthetic rate (A) at a CO_2 concentration of 400 μmol mol^{-1} of CO_2 was calculated as A_{400}, and the stomatal conductance (g_s) at 400 μmol mol^{-1} was also determined. The water use efficiency (WUE) was calculated as A_{400}/g_s.

4.Stable carbon isotope ratio measurement of leaves

The dried leaves were powdered and sealed in tin foil at 1.0 ±0.05 mg each. The stable carbon isotope ratios (delta-^{13}C) were measured using a CN-IRMS mass spectrometer at the Research Institute for Humanity and Nature. Working standards CERKU-03 and CERKU-07 (03:Glycine, 07:STARCH-C4) were used for the correction of delta-^{13}C.

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Results

The photosynthetic rate of *G. biloba* was lower at high traffic sites and higher at low traffic sites. For *P. yedoensis*, the photosynthetic rate was lower at the site that had second highest traffic volume, compared to the other three sites. For *A. buergerianum*, stomatal conductance decreased with increasing traffic volumes, but the maximum carboxylation rate increased, and as a result, there was no difference in photosynthetic rate between sites. Water use efficiency tended to increase with traffic volume in *P. yedoensis,* but did not correlate with traffic volume in *G. biloba* and *A. buergerianum*.

Discussion

Different air pollution levels had different effects on photosynthetic function in different tree species. High air pollution levels imposed negative impact on the photosynthetic rate for *G. biloba*, and it imposed positive impact on the water use efficiency for *P. yedoensis*. The photosynthetic rate of *P. yedoensis* was higher than that of the other two tree species at all study sites, and it may have a sensitive response to stress because its water use efficiency increased with the increase in traffic volumes. These results suggest that the leaves of *P. yedoensis* effectively absorbed CO_2 as a street tree in the year 2020.

Keywords: Stable carbon isotope ratio, Environmental stress, Photosynthesis

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Effect of flooding stress on photosynthesis of aquatic plants

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Introduction

How to efficiently take in CO_2 from the air through photosynthesis is an important issue for plants to grow and survive in various environments on earth. However, in the natural environment, there are various environmental stresses such as high light stress, low temperature stress, and water stress, which cause a decline in photosynthetic function. Among the water stresses is the flooding stress caused by floods. Aquatic plants are subjected to significant changes in the degree of flooding, and the area in contact with the air fluctuates, resulting in large fluctuations in the amount of CO_2 they can take up. Therefore, photosynthetic function is also expected to change significantly due to flooding stress. However, although many ecological studies have been conducted on aquatic plants in response to flooding stress, it is not well understood how photosynthetic function is affected. Therefore, the purpose of this study was to investigate how flooding stress affects the photosynthetic function of aquatic plants.

Material & Method

Two types of grasses were used as plant material: rice(*Oryza sativa*), a crop, and reeds(*Phragmites australis*), a wild plant that grows in colonies in lakes and marshes. The height of the grass is about 60 cm for rice and about 150 cm for reeds. Plant seedlings were planted in plastic pots and flooded to fix the water level at 60 cm, and the flooding response of photosynthetic function was investigated at three stages: 5, 10, and 15 days later.

The LI-7000 infrared gas analyzer was used to measure the following three parameters of leaf photosynthetic function: the saturation photosynthetic rate (A_{400}) at a CO_2 concentration of 400 ppm, the stomatal conductance (g_s), which indicates how open the stomata were, and the mesophyll conductance (g_m), which indicates how easily the CO_2 taken up through the stomata passed through the mesophyll cells. The leaf conductance is a measure of carbon stability. Leaf conductance was measured using the carbon stable isotope method. In addition, the number of pores per 1 mm^2 of leaf area (stomatal density) was measured using the secondary replica method.

Results

In both rice and reed species, all three parameters of photosynthetic function were significantly reduced by flooding. In other words, rice and reed showed strong responses to flooding stress, such as reduced photosynthetic rate, stomatal closure, and limited CO_2 diffusion in the mesophyll cells. The rate of decrease was higher in reed than in rice for all parameters. The stomatal density of reed was 661, which was about 16 times higher than that of rice.

Discussion

The reason for the significant decrease in the three parameters of photosynthetic function in plants subjected to flooding stress is that the exposure of the plant to water caused problems in the regulation of stomatal opening and closing, which inhibited CO_2 uptake. In addition, some morphological changes in the leaves may have restricted CO_2 diffusion in the mesophyll cells. The reason why each photosynthetic parameter was significantly reduced in reed than in rice was because the stomatal density was greater than that of rice, and thus the limitation of CO_2 uptake by flooding was greater. These results indicate that

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flooding is a strong stress on aquatic plants and that the degree of response of photosynthetic functions varies among plant species.

Keywords: flooding stress, carbon stable isotope method, mesophyll conductance

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The incubation method using ^{18}O-water and phosphate oxygen isotope for quantitative evaluation of bioavailable phosphate in soil.

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Phosphorus (P) is one of the main limiting factor for primary production and has a significant impact on biogeochemical processes and food production in ecosystems. The amount of bioavailable P in soils is about 1% of total phosphorus, and most of it exists in organic form or tightly bound to clay minerals (Pierzynski et al., 2005). Bioavailable P is formed by physicochemical processes such as adsorption/desorption and precipitation/dissolution, and biological processes such as absorption/release and mineralization of organic P by organisms. To understand bioavailable P dynamics, it is necessary to clarify the fluxes to bioavailable P pool through each processe and factors affecting the processes.
Recently, phosphate oxygen isotope ratio ($\delta^{18}O_{PO4}$) has been used as a promising tool to elucidate the P cycling (Paytan and McLaughlin, 2012). Because the P–O bonds in dissolved inorganic phosphate (DIP) do not easily hydrolyze at typical earth's surface temperatures and pressures, DIP movement through physicochemical processes maintain the $\delta^{18}O_{PO4}$ values in a reactant pool. In contrast, biological processes mediated by enzymes that cleave the P–O bonds cause large isotopic fractionation. For example, inorganic pyrophosphatase (PPase) associated with absorption/release and phosphatases associated with organic P mineralization can alter the $\delta^{18}O_{PO4}$ signatures. These isotopic fractionations are controlled by water oxygen isotope ratio and temperature. Equations have been proposed to estimate the fractionation (Paytan and McLaughlin, 2012). These facts indicate it is possible to control the $\delta^{18}O_{PO4}$ value of DIP generated by each process by controlling the water oxygen isotope ratio and temperature. The purpose of this study is to propose a soil incubation experiment using incubation water with two different water oxygen isotope ratios (e.g., +30‰ and -5‰) to quantitatively evaluate the flux of each process to the available P pool. The incubation experiment can simulate a two-isotope system like $\delta^{15}N\text{-}NO_3$ and $\delta^{18}O\text{-}NO_3$, and the fluxes of each process can be quantified by Bayesian mixing model. The poster will present the detailed theoretical background, hypothesis, and preliminary results of the study.

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Keywords: Phosphorus dynamics, Soil incubation, Bayesian mixing model

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Trace element quantification in organic materials by low temperature plasma ashing

Taisuke Hino[1], Yuriko Umeda[1], Hibiki Shishime[1], Akane Ito[1], *Masaharu Tanimizu[1]

1. Kwansei Gakuin University

Inorganic chemical analysis of various environmental samples has been applied to clarify the elemental cycle on the earth's surface, and determination of elemental concentrations among biological samples and fossil fuels is sometimes necessary for the purpose. Instrumental analyses by Atomic absorption spectrometry, ICP optical emission spectrometry, and ICP mass spectrometry are frequently used for the determination, and decomposition of samples is usually required prior to the analysis. For the decomposition and removal of organic hydrocarbons, which are the main components of organic samples, pretreatment methods using the high-temperature ashing method and the microwave thermal decomposition method have been conventionally used. In the former method, the loss of volatile elements due to high temperature and contamination from the surrounding environments are concerned. In the latter case, there are potential spectral and non-spectral interferences due to a large amount of dissolved organic components remaining in the solution. In particular, a large amount of organic sample must be pretreated for the isotope analysis of trace inorganic elements, so the limitation of the decomposable sample amount is a fundamental problem in the latter method.
Our group has been working on the establishment of a low-temperature plasma ashing method using oxygen radicals as the pretreatment method to efficiently remove organic hydrocarbons in organic samples. Organic hydrocarbons are gradually oxidized in oxygen plasma generated by glow discharge under reduced pressure, and finally removing them into the gas phase. In this report, elemental recovery yields in the low-temperature ashing treatment were evaluated using a commercially available organometallic standard solution. As a result, the yield changed depending on factors such as volatility of element oxides, formation of insoluble compounds during ashing, and solubility of residual ash in various inorganic acids. This method was applied to crude oil, seaweed, and brown rice, and their elemental yields were evaluated.

Keywords: plasma ashing, isotopic analysis, organic material

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Metal element isotope analysis for Environmental Reference Materials

*Ki-Cheol Shin[1]

1. Research Institute for Humanity and Nature

In recent years, the development of analytical technics has made it possible to detect a limited variation of stable isotope ratios in metal elements. After that, many researchers had challenged and produced excellent results in this field, but the supply of primary reference materials for isotope measurement is limited.

To promote a stable isotope study related to the environmental research fields, RIHN has carried out high-precision isotope analysis using MC-ICP-MS for relatively abundant secondary environmental reference materials (ERMs).

For this research, I purchased 30 types of ERMs from NIST (National Institute of standard and technology, U.S.), JRC (European Commission's Joint Research Centre), and NMIJ(National Metrology Institute of Japan). These materials are not for isotopic analysis but certification of metal element concentration.

This presentation reports a data set of Mg-Zn-Fe stable isotope values and Sr-Pb-Nd radiogenic isotope ratios. This data set is a final version of earlier reports related to the isotopic analysis of environmental reference materials.

Keywords: Reference materials, metal element, isotope analysis

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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.15 Zoom Room 15

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Toru Takahashi(Fukada Geological Institute), Kunio Aoike(Oyo corporation)

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9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[HTT17-01] Introduction

9:05 AM - 9:25 AM JST | 12:05 AM - 12:25 AM UTC

[HTT17-02] Accumulation pattern of near-seafloor methane gas revealed by a shallow seismic survey in the northern Tokyo Bay

*Tetsuro Tsuru[1], Kazuki Takanaka[1], Koichi Fujimoto[1], Osamu Takano[2], Yukio Nakagawa[3], Naoto Kumagai[1] (1.Tokyo University of Marine Science and Technology, 2.University of Tsukuba, 3.Tobako LLC)

9:25 AM - 9:45 AM JST | 12:25 AM - 12:45 AM UTC

[HTT17-03] Imaging of near surface structure beneath a coastal plain by means of high-resolution S-wave seismic reflection survey

*Tomio INAZAKI[1], Kyoko Kagohara[2], Shinsuke Okada[3], Takayuki Nakano[4], Nobuhisa Matta[5] (1.Research Institute of Geology and Geoinformation, AIST, 2.Yamaguchi Univ., 3.Iwate Univ., 4.GSI, 5.Okayama Univ.)

9:45 AM - 10:05 AM JST | 12:45 AM - 1:05 AM UTC

[HTT17-04] Differences in P-wave velocities due to velocity logging in overlapping sections of horizontal boring surveys in sedimentary rock tunnel ground

*Kenji OKAZAKI[1], Toshiyuki KURAHASHI[1] (1.Civil Engineering Research Institute for cold region, Public Works Research Institute)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[HTT17-05] Applicability of Distributed Acoustic Sensing (DAS) technology for surface wave measurement

*Hayato Nonaka[1], Peter Hubbard[2], Koichi Hayashi[3], Yasuhiro Yokota[1], Kensuke Date[1], Kazuhiko Masumoto[1], Kenichi Soga[2] (1.Kajima corporation, 2.University of California, Berkeley, 3.OYO Corporation)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

[HTT17-06] Discussion

[J] Oral | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Toru Takahashi(Fukada Geological Institute), Kunio Aoike(Oyo corporation)

Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.15 (Zoom Room 15)

The session of shallow geophysics calls various research topics to contribute on geophysical exploration techniques for the near surface. The shallow geophysics uses many types of methods to survey various targets. This session does not restrict any survey methods and targets of your research but restrict the target depth in the zones from 5 cm to 30 m (or from 2 in to 100 ft) below the surface of the ground. The shallow part under the ground may be the closest and unknown territory for human society, and advanced societies cannot have controlled it yet to avoid disasters caused by dynamics in the near surface. Peoples require techniques to manage levee, landslide and earth constructions and knowledge to control groundwater, liquefaction and soil pollution. The near surface faces many geotechnical, environmental and hydrogeologic problems. Major survey techniques are surface wave method, electric exploration, ground-penetrating radar and microtremor survey, but any methods can be discussed if your target is located in the shallow depths. This session also welcomes to discuss laboratory tests and rock physics for unconsolidated porous media in the vadose zone. Additionally, we will welcome not only cutting-edge technologies but also usual works, if the knowledge and skills is useful for human living. 3D will be one of main subjects in this year.

9:00 AM - 9:05 AM

[HTT17-01]Introduction

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Accumulation pattern of near-seafloor methane gas revealed by a shallow seismic survey in the northern Tokyo Bay

*Tetsuro Tsuru[1], Kazuki Takanaka[1], Koichi Fujimoto[1], Osamu Takano[2], Yukio Nakagawa[3], Naoto Kumagai[1]

1. Tokyo University of Marine Science and Technology, 2. University of Tsukuba, 3. Tobako LLC

Recently, activity of seismic survey is extremely reducing in shallow waters where marine traffic is busy and fishing activity is high. Accordingly, the shallow waters are becoming brank zones in seismic survey. For example, in the northern part of the Tokyo Bay, no seismic surveys have been conducted since in the late 2000s. Therefore, we have been developing a new seismic data acquisition system using an underwater speaker (UWS) as a seismic source available even in the extremely shallow waters. The UWS shoots a non-pulsive source wave with significantly smaller sound pressure level than explosive sources such as airgun guns, mitigating environmental impacts to marine ecosystems. This mitigation effect is similar with that of a vibroseis survey on land.

In December 2017, *T/B Hiyodori* of Tokyo University of Marine Science and Technology conducted a seismic survey using the USWS off the Urayasu in the inner part of the Tokyo Bay. As a result, a low-velocity zone was detected about 7 m below the seafloor, whose stacking velocity was estimated 1100 m/s from velocity analysis, suggesting the existence of gas. The subsequent investigations revealed that the gas was composed mainly of methane and the gas layer was widely distributed in the northern part of the Tokyo Bay.

In addition to the widely distributed near-seafloor methane gas, a possible local gas pool was found about 17-20 m below the seafloor, from its low-velocity and reverse reflection polarity. The local gas pool is laterally bounded by a fault. Interestingly, no low-velocity anomalies can be detected in the other side of the fault. The gas appears to be sealed laterally by the fault, like a so-called fault trap. If the fault is activated by an earthquake in future, the gas will be released from the seafloor into the water. Total volume of the gases is unknown at this moment. However, considering the high flammability of methane, potential risks from the methane gases might be assumed from a viewpoint of disasters on marine traffic and offshore structures. Further seismic surveys would unveil potential risks as well as potential resources in the shallow waters.

Keywords: shallow seismic survey, underwater speaker, environment-friendly, Tokyo bay, gas

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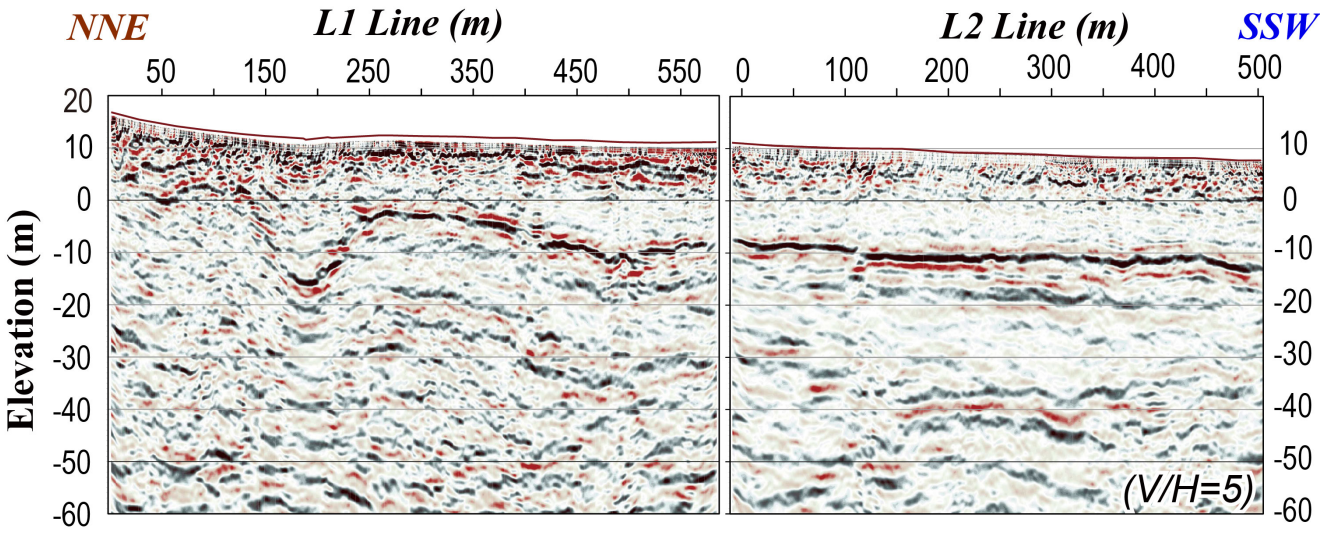
Imaging of near surface structure beneath a coastal plain by means of high-resolution S-wave seismic reflection survey

*Tomio INAZAKI[1], Kyoko Kagohara[2], Shinsuke Okada[3], Takayuki Nakano[4], Nobuhisa Matta[5]

1. Research Institute of Geology and Geoinformation, AIST, 2. Yamaguchi Univ., 3. Iwate Univ., 4. GSI, 5. Okayama Univ.

We conducted a high-resolution S-wave seismic reflection survey to delineate the near surface structure beneath a beach ridge plain facing Ensyu-nada, Ohbuchi District, Kakegawa City, Sizuoka Prefecture. The field survey was carried out in August to September 2020 along a total of 1.1 km long survey lines set on a road extending from the foot of Ogasa-yama Hills to the shoreline. We adopted an S-wave type Landstreamer, consisted of a total of 96 channel, 14 Hz horizontal geophone units at 50 cm intervals mounted on stainless wires, as the survey tool. Horizontal hitting of wooden plank was employed to generate a polarized SH-wave impulsive signal. Total shotpoints and recorded files amounted to 1,084 and 3780 respectively. All the shot records were visually inspected to eliminate miss-triggered records and dead traces, and to estimate shot statics before applying diversity stack. Migrated time sections were reconstructed through the ordinary processing flow with iterative velocity analyses and statics. Finally, we obtained migrated depth sections along the survey lines based on the NMO RMS velocity and on time to depth conversion curves estimated from an empirical relationship between S-wave velocities and geotechnical data.
A clear event was delineated at about -10 m in altitude, or 20 m in depth. The reflector showed flat structure beneath the coastal side line, and gradually ascended towards the hill side. In addition, it formed a small buried valley near the foot of the hills. Reflectors having similar trends were also traced at depths but not so clear. Boring and VSP are being planned to obtain core sample and direct S-wave velocity profile of the near surfaces.

Keywords: S-waves, seismic reflection survey, Land Streamer, beach ridge plain, Kakegawa City



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Differences in P-wave velocities due to velocity logging in overlapping sections of horizontal boring surveys in sedimentary rock tunnel ground

*Kenji OKAZAKI[1], Toshiyuki KURAHASHI[1]

1. Civil Engineering Research Institute for cold region, Public Works Research Institute

P-wave velocity is one of the evaluation indexes in the ground classification of tunnels. At the time of design, it is measured from the ground surface of the tunnel, and at the time of construction, it is measured at the core, inside the borehole, and rock fragments by the horizontal boring survey from the tunnel face. In addition, the P-wave velocity at the time of construction is used for reviewing the ground classification as the value closest to the excavation site. In one horizontal boring survey, about 100 m is excavated, but the next horizontal boring survey may be carried out before the tunnel excavation reaches the deepest part excavated in the horizontal boring survey. Therefore, in the first horizontal boring survey and the next horizontal boring survey, there may be an overlapping section of about 30 m. The P-wave velocity by the velocity logging of the first horizontal boring survey is the P-wave velocity about 100 m ahead of the tunnel face and in the state where the ground before tunnel excavation is not loosened. On the other hand, the P-wave velocity by the velocity logging of the next horizontal boring survey is the P-wave velocity in the state where loosening occurs due to tunnel excavation at the tunnel face. It is important information for reviewing the ground classification and deciding the selection of auxiliary construction method by knowing the change of P wave velocity in advance.

Therefore, in this survey, we collected P-wave velocities by velocity logging in the overlapping section (8 boreholes total length 197 m) at the time of the horizontal boring survey (104 boreholes in total) for 5 tunnels (total length 11,104 m) with sedimentary rock tunnel ground. Then, the difference between the P-wave velocity by the velocity logging of the first horizontal boring survey and the velocity logging of the next horizontal boring survey was investigated.

As a result of the survey, the overlapping section was 25 m on average. The P-wave velocity by velocity logging in the first horizontal boring survey was 2.5-3.2 Km/s (average 2.7 Km/s). On the other hand, the P-wave velocity by velocity logging in the next horizontal boring survey was 1.0 to 2.8 Km/s (average 2.2 Km/s). From this results, it was clarified that the P wave velocity in the overlapping section decreased by about 17% due to the excavation of the tunnel.

Keywords: tunnel, velocity logging , P-wave velocity

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Applicability of Distributed Acoustic Sensing (DAS) technology for surface wave measurement

*Hayato Nonaka[1], Peter Hubbard[2], Koichi Hayashi[3], Yasuhiro Yokota[1], Kensuke Date[1], Kazuhiko Masumoto[1], Kenichi Soga[2]

1. Kajima corporation, 2. University of California, Berkeley, 3. OYO Corporation

Recently, the distributed acoustic sensing (DAS), which is one of the distributed fiber optic sensing technologies using fiber optics, is receiving increased attention. DAS is promising as an innovative vibration monitoring tool in various fields including geophysics because it utilizes an optical fiber itself as a sensor and it can acquire data over long length at spatially high density. In civil engineering, preliminary investigation of underground conditions with boring survey and/or geophysical survey techniques are often required for the safe and rational construction of underground structures. This study aimed at investigating the applicability of DAS for geophysical exploration using elastic wave and Multi-channel Analysis of Surface Waves (MASW) survey was performed to understand the basic performance of DAS.

A trench with a length of about 100 m was excavated in a research field located in Richmond, California, USA, and fiber optic sensor cables were directly buried in the trench. Surface waves induced by an active source using a sledgehammer were measured at 1 m intervals along with a fiber optic sensor. The result with a tightly coupled sensing cable (i.e. high-sensitivity cable) showed that the clear surface waves propagating to the other end. On the other hand, the wave propagation could not be clearly detected due to background noise in the latter part of the loosely coupled telecommunication-cable (i.e. low-sensitivity cable). These results indicated that the cable structure affects the response sensitivity for the seismic wave. However, stacking of the waveforms in low-sensitivity cables allowed the signal-to-noise ratio to improve and showed almost the same results as high-sensitivity cables. In addition, surface waves were measured using a three-component geophone to compare with DAS measurement results. It could be found that similar waveform recordings and the phase velocity dispersion curve as DAS were obtained from the geophone with the measurement results of the horizontal component in the same direction as the fiber optic cable.

In the frequency band necessary for the analysis of geophysical exploration, surface wave measurement of the active source can be performed with almost the same performance as existing survey method with geophones. DAS, which can simultaneously acquire data at intervals of several meters over several tens of kilometers, will enable an application to a wider range of subjects.

Keywords: Distributed Acoustic Sensing (DAS), Surface wave,, Multi-channel Analysis of Surface Waves (MASW), Phase velocity dispersion curve

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[J] Oral | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Toru Takahashi(Fukada Geological Institute), Kunio Aoike(Oyo corporation)

Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.15 (Zoom Room 15)

The session of shallow geophysics calls various research topics to contribute on geophysical exploration techniques for the near surface. The shallow geophysics uses many types of methods to survey various targets. This session does not restrict any survey methods and targets of your research but restrict the target depth in the zones from 5 cm to 30 m (or from 2 in to 100 ft) below the surface of the ground. The shallow part under the ground may be the closest and unknown territory for human society, and advanced societies cannot have controlled it yet to avoid disasters caused by dynamics in the near surface. Peoples require techniques to manage levee, landslide and earth constructions and knowledge to control groundwater, liquefaction and soil pollution. The near surface faces many geotechnical, environmental and hydrogeologic problems. Major survey techniques are surface wave method, electric exploration, ground-penetrating radar and microtremor survey, but any methods can be discussed if your target is located in the shallow depths. This session also welcomes to discuss laboratory tests and rock physics for unconsolidated porous media in the vadose zone. Additionally, we will welcome not only cutting-edge technologies but also usual works, if the knowledge and skills is useful for human living. 3D will be one of main subjects in this year.

10:25 AM - 10:30 AM

[HTT17-06]Discussion

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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.15 Zoom Room 15

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Kyosuke Onishi(Public Works Research Institute), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology)

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10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

[HTT17-07] Introduction

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

[HTT17-08] CCR survey using plate electrodes

*Chisato Konishi[1], Hiroshi Kisanuki[1], Dennis Wilkison (1.OYO Corporation)

11:10 AM - 11:30 AM JST | 2:10 AM - 2:30 AM UTC

[HTT17-09] Differential tomography of continuously repeated measurement data using electrical exploration method - Application to monitor changes in soil moisture content due to rainfall

*Ryota Watatani[1], Koichi Suzuki[2] (1.Cooperative Program for Resources Engineering, Graduate School of Engineering, Hokkaido University, 2.Research Group of Geoenvironmental Engineering, Division of Sustainable Resource Engineering, Faculty of Engineering, Hokkaido University)

11:30 AM - 11:50 AM JST | 2:30 AM - 2:50 AM UTC

[HTT17-10] Subsurface exploration by multifrequency electromagnetic portable senser GEM-2 at the Goshogake geothermal area

*Shin'ya Sakanaka[1], Keigo Tsuboe[1], Yuya Tada[1], Inoue Yusuke[2], Shura Taomote[3], Ritsu Sakiyama[1] (1.Graduate school of International Resource Sciences, Akita University, 2.OYO corporation, 3.Faculty of International Resource Sciences, Akita University)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[HTT17-11] Bayesian estimation method of near-surface density under irregular distribution of gravity network

*Yuanyuan Niu[1], Jiancang Zhuang[1] (1.Institute of Statistical Mathematics)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[HTT17-12] Discussion

[J] Oral | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Kyosuke Onishi(Public Works Research Institute), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.15 (Zoom Room 15)

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10:45 AM - 10:50 AM

[HTT17-07]Introduction

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CCR survey using plate electrodes

*Chisato Konishi[1], Hiroshi Kisanuki[1], Dennis Wilkison

1. OYO Corporation

The CCR (Capacitively coupled resistivity) survey system using dipole-cable has an issue of low sensitivity for estimating resistivity profile of shallow subsurface less than 2m in depth due to a limitation of dipole-cable length. A new system using cylinder electrode was developed (Konishi et al., 2018) to solve the problem. Because the length of the cylinder electrode is one eighth of the shortest dipole-cable length, it enables the separation between the transmitter and the receiver small; however, the signal was interfered by EM coupling between the receiver and the transmitter when the separation was too small. To resolve the new issue, which was probably associated with EM wave in the air, plate electrodes were developed and tested. The plate electrode is the same as long as the cylinder electrode and is placed only towards the ground. In the field experiment, we found that the EM coupling was significantly reduced by using the plate electrodes. Additionally, the measured apparent resistivity was comparable with the one measured by ordinary resistivity measurement with dipole-dipole array configuration using iron stakes placed at the center positions of the plate electrodes. Therefore, it is possible to obtain a resistivity profile from the surface to 10 m in depth effectively by the CCR survey using both the plate electrodes and the dipole-cables.

Keywords: CCR survey, resistivity, plate electrode

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Differential tomography of continuously repeated measurement data using electrical exploration method - Application to monitor changes in soil moisture content due to rainfall

*Ryota Watatani[1], Koichi Suzuki[2]

1. Cooperative Program for Resources Engineering, Graduate School of Engineering, Hokkaido University, 2. Research Group of Geoenvironmental Engineering, Division of Sustainable Resource Engineering, Faculty of Engineering, Hokkaido University

Slopes at risk of large-scale landslides should be evaluated across the entire slope for the behavior toward groundwater infiltration from heavy rainfall. It is imperative to establish monitoring techniques to visualize rainwater infiltration across the entire slope for the long-term risk management of landslides. However, it is difficult to quantitatively evaluate the saturation rate change caused by rainwater infiltration using only the electrical exploration data. Suzuki et al. (2018) estimated the porosity and saturation rate sections by combining the S-wave velocity and resistivity based on an unconsolidated sand model (Avseth, 2005). In this study, differential tomography by Sugimoto (1995) was performed on the electrical exploration data measured repeatedly on the slope formed on the Joso Plateau, and the cross section of the resistivity change rate was obtained. In addition, by combining the S-wave velocity structures obtained by surface wave exploration conducted on the same survey line, the cross-section of the rate of change in saturation due to precipitation infiltration was estimated according to the analysis flow shown by Suzuki et al. (2018). Hence, the differential tomography result had a smaller RMS residual than the conventional method and was consistent with the geological structure. In the cross-section of the rate of change in saturation, saturation increased from the ground surface and a region where the saturation decreased appeared below it; a minor change in saturation was observed in the region below the clayey layer.

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Keywords: electrical exploration, differential tomography, RMS residual

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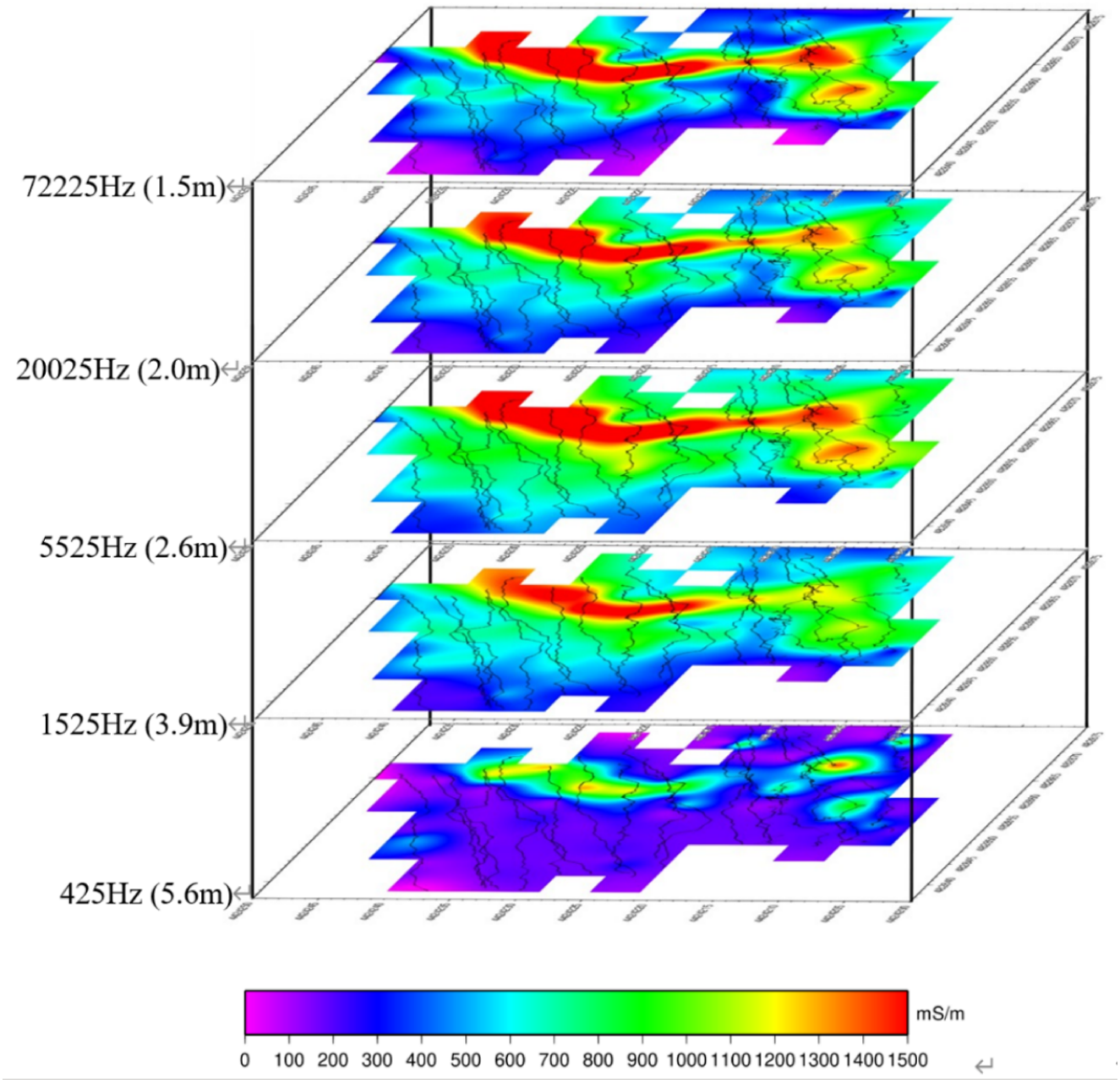
Subsurface exploration by multifrequency electromagnetic portable senser GEM-2 at the Goshogake geothermal area

*Shin'ya Sakanaka[1], Keigo Tsuboe[1], Yuya Tada[1], Inoue Yusuke[2], Shura Taomote[3], Ritsu Sakiyama[1]

1. Graduate school of International Resource Sciences, Akita University, 2. OYO corporation, 3. Faculty of International Resource Sciences, Akita University

Since 2016 the high temperature watery mud has eroded the promenade called Goshogake Onsen Nature Trail at the Goshogake geothermal area, Kazuno city, Akita prefecture, northeast of Japan. For the purpose of delineate subsurface hydrothermal activity, geophysical explorations were carried out. Various methods were utilized like as GPR (Ground Penetrating Radar), ERT (Electrical Resistivity Tomography), SP (Self Potential) and electromagnetic induction method by the instrument called GEM-2. Especially GEM-2 can clearly delineate subsurface structure. The GEM-2 is an instrument that can observe changes of conductivity in the depth direction by using multiple frequencies simultaneously. In this study, five frequencies were used: 425 Hz, 1525 Hz, 5525 Hz, 20025 Hz, and 72225 Hz. The two types of exploration, VDM (vertical direction mode) on August 21, 2020 and HDM (horizontal direction mode) on October 21, 2020, were conducted over two days.
In advance of HDM measurement, free air calibration was performed at 4 m height above the ground using a pipe made by vinyl chloride but at the VDM measurement free air calibration couldn’t be done. Free air calibration is the process of a calibration setting the zero-level of the GEM-2 instrument free from the influence of the ground.
Within the active mud pots area, measurement range was set as 28 m in the direction of the survey line and 34m perpendicular to the survey line for GEM-2 measurement. Location of two mud pods in the measurement range were surveyed by GNSS. Electrical conductivity contour diagram was created based on the GEM-2 measurement data with median processing in the range of 3 m. Attached figure shows the conductivity maps arranged at equal intervals in the depth direction. The depths in the figure were derived based on the average values of the electrical conductivity at each frequency and calculated by the square root of skin depth by Huang (2005). In addition, topographical map was drawn by using GNSS data in the function of GEM-2 instrument and Geographical Survey Institute’s DEM data.
As a result, high electrical conductivity at lower elevations can be seen. The cause of the high electrical conductivity can be clay. The areas of high electrical conductivity in the deeper layers are the possibly the pathways of the clay and hot liquid.

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Bayesian estimation method of near-surface density under irregular distribution of gravity network

*Yuanyuan Niu[1], Jiancang Zhuang[1]

1. Institute of Statistical Mathematics

Bouguer gravity anomaly is an important data to reveal underground structure and construction. It is calculated by terrain correction and Bouguer correction of Free-air gravity data. Near-surface density is an important parameter to be determined in these two corrections. We proposed an Bayesian estimation method to simultaneously estimate Bouguer gravity anomaly and near-surface density. Firstly, the inversion objective function is constructed from the observed Free-air gravity data, near-surface density model and Bouguer gravity anomaly model. At the same time, considering the irregular distribution of 2D gravity network, we use Delaunay triangulation and quadratic polynomial fitting to constrain the faltness and smoothness of Bouguer gravity anomaly model. Then, trade-off parameters are automatically determined by Akaike's Bayesian Information Criteria (ABIC). Finally, the optimal estimated results are obtained by maximizing the posterior estimation of model parameters. Estimated near-surface density can be used to indicate shallow geologic structure and estimated Bouguer gravity anomaly can provide more reliable data onto the study of regional deep structure and tectonics.

Keywords: ABIC, Delaunay triangulation, Second-order smoothness, Quadratic polynomial fitting, Near-surface density

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[J] Oral | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute), Chairperson:Kyosuke Onishi(Public Works Research Institute), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.15 (Zoom Room 15)

The session of shallow geophysics calls various research topics to contribute on geophysical exploration techniques for the near surface. The shallow geophysics uses many types of methods to survey various targets. This session does not restrict any survey methods and targets of your research but restrict the target depth in the zones from 5 cm to 30 m (or from 2 in to 100 ft) below the surface of the ground. The shallow part under the ground may be the closest and unknown territory for human society, and advanced societies cannot have controlled it yet to avoid disasters caused by dynamics in the near surface. Peoples require techniques to manage levee, landslide and earth constructions and knowledge to control groundwater, liquefaction and soil pollution. The near surface faces many geotechnical, environmental and hydrogeologic problems. Major survey techniques are surface wave method, electric exploration, ground-penetrating radar and microtremor survey, but any methods can be discussed if your target is located in the shallow depths. This session also welcomes to discuss laboratory tests and rock physics for unconsolidated porous media in the vadose zone. Additionally, we will welcome not only cutting-edge technologies but also usual works, if the knowledge and skills is useful for human living. 3D will be one of main subjects in this year.

12:10 PM - 12:15 PM

[HTT17-12]Discussion

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[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.08_3

[H-TT17] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Toru Takahashi(Fukada Geological Institute)

The session of shallow geophysics calls various research topics to contribute on geophysical exploration techniques for the near surface. The shallow geophysics uses many types of methods to survey various targets. This session does not restrict any survey methods and targets of your research but restrict the target depth in the zones from 5 cm to 30 m (or from 2 in to 100 ft) below the surface of the ground. The shallow part under the ground may be the closest and unknown territory for human society, and advanced societies cannot have controlled it yet to avoid disasters caused by dynamics in the near surface. Peoples require techniques to manage levee, landslide and earth constructions and knowledge to control groundwater, liquefaction and soil pollution. The near surface faces many geotechnical, environmental and hydrogeologic problems. Major survey techniques are surface wave method, electric exploration, ground-penetrating radar and microtremor survey, but any methods can be discussed if your target is located in the shallow depths. This session also welcomes to discuss laboratory tests and rock physics for unconsolidated porous media in the vadose zone. Additionally, we will welcome not only cutting-edge technologies but also usual works, if the knowledge and skills is useful for human living. 3D will be one of main subjects in this year.

[HTT17-P01] **An Atempt to Estimate the Water Level Change of Non-confined Groundwater by Earthing Resistance (III) - Characteristics of the Anniversary Changes -**

*Kunihiro Ryoki[1] (1.Polytechnic University)

[HTT17-P02] Estimation of underground structure beneath the debris control dams constructed during the Edo era based on the microtremor measurements

*Atsushi Mukai[1] (1.Faculty of Urban Management, Fukuyama City University)

[HTT17-P03] Measuring the distribution of surface thickness of pavement using ground-penetrating radar

*Kyosuke Onishi[1], Kobayashi Takayuki[1] (1.Public Works Research Institute)

An Atempt to Estimate the Water Level Change of Non-confined Groundwater by Earthing Resistance (III) - Characteristics of the Anniversary Changes -

*Kunihiro Ryoki[1]

1. Polytechnic University

1. Introduction

In order to investigate the relationship between the water level of unconfined groundwater and the earthing resistance of the grounding electrode attached to electrical equipment, measurements of both have been conducted since April 2019. As a result, the relationship was confirmed on both. In addition to the variation of the groundwater level, it is considered that the variation of the ground resistance may be affected by the annual change of the distribution of the ground temperature (Ryoki, 2020). The results, which are measured up to now, are reported and the future measurement plan is described In this paper.

2. Measurement

The earthing resistance is expected to change considering the relationship between the thickness of the first layer and the equivalent earthing resistance in a horizontal two-layer structure (Ryoki, 2019b). Therefore, in order to investigate the relationship between the water level of unconfined groundwater and the earthding resistance, an observation well, WPTU, was installed in the area where the Kanto loam layer is widely distributed. The Specifications of WPTU and measuring instruments are shown in Table 1. At the same time, groundwater temperature and electrical conductivity are measured at 10-minute intervals in WPTU. In the vicinity of the observation wells, the earthing resistance of the grounding electrodes for the safety of electrical equipment was measured repeatedly.

3. Result

Fig. 1 shows groundwater level, water temperature, and electrical conductivity in WPTU from April 23, 2019 to January 25, 2021. It shows that the conductivity increases when the water level rises rapidly. And decreases when the water level decreases relatively slowly, except for the unstable period immediately after the excavation of the observation pit.

Fig. 2 shows the earthing resistance which connected to Class A earthing electrode under a concrete building near the WPTU. It shows the water level observed at the same time, and the air temperature directly above the WPTU, too.

Fig. 2 shows that as the water level rises, the earthing resistance decreases, and as the water level decreases, the ground resistance increases. The relationship with the water level and the earthing resistance is harmonious. On the other hand, when the annual change in the 10-day moving average curve of temperature is compared with the change in water level, the relationship is harmonious, but the phases are not coincident. In general, when the temperature rises, the ground resistance decreases, and when the temperature decreases, the ground resistance increases. The phase lag of the earthing resistance to the air temperature is about two months if we focus on these extreme values.

In areas where marine clay strata are outcropping, it has been reported that when spontaneous potential is formed by the sulphide minerals in marine clay strata, the annual change in spontaneous potential lags behind the temperature (Ryoki, 1990). In response to this, Ryoki (2020) suggested that since the ground resistance is also affected by the underground temperature, the annual variation of the earthing resistance would show a lagging phenomenon with respect to the surface temperature. The measurement

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results shown in Fig. 2 are in harmony with this suggestion.

References

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Ryoki, K. (2019a): An Attempt to Estimate the Level of Non-confind Groundwater by Earthing Resistance (I) -Outline of Theory-, *Proc. Jap. Geosci. U. 2019*, HTT22-03.
Ryoki, K. (2019b): A Theory of Water Level Estimation to Focus on the Change of Earthing Resistance for the Prediction of Flood Occurrence, *Jour. of Polytech. Sci.*, **35**, 30-35.
Ryoki, K. (2020): A Study on the Relationship between Earthing Resistance and Groundwater Level, *Pro. of Kansai Geo-Sym.*, **8**, 18-21.

Keywords: electrical equipment, Musashino district, loam layer, perchied water, flood damage, equivalent earthing resistance

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表 1　観測井および測定機器の諸元

Table1 Shows the specifications of observation wells and measuring equipment

観測井	位置	35° 44' 19.2" N 139° 29' 41" E
	孔口標高	81.92m
	孔長	30.17m
	内径	50.0mm
水位計	応用地質社製	S&DL miniEC 10m計
接地抵抗計	横河製作所製	3235型

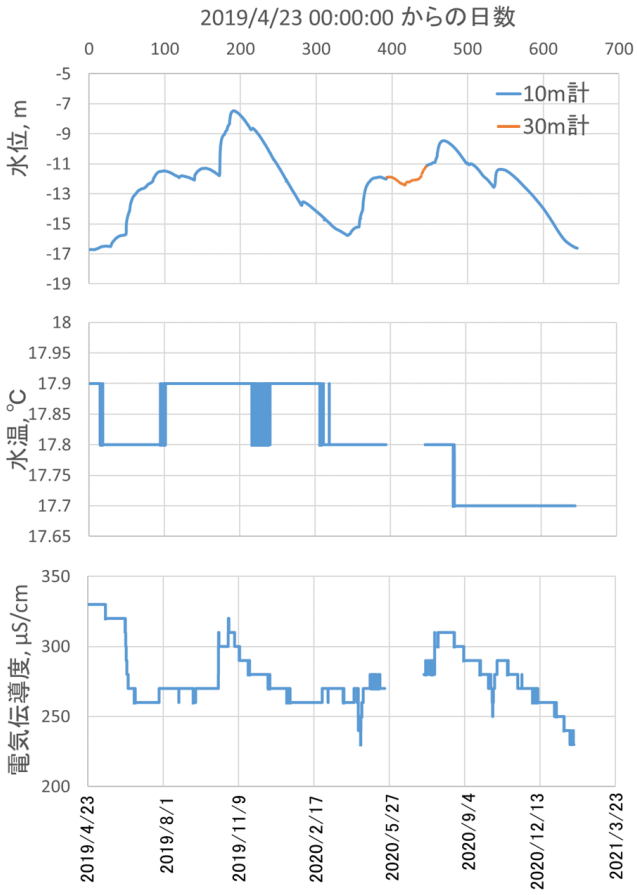


図1　観測井WPTUでの地下水の水位，水温及び電気伝導度の変化

Fig.1Observations of groundwater level, water temperature and al conductivity at WPTU.

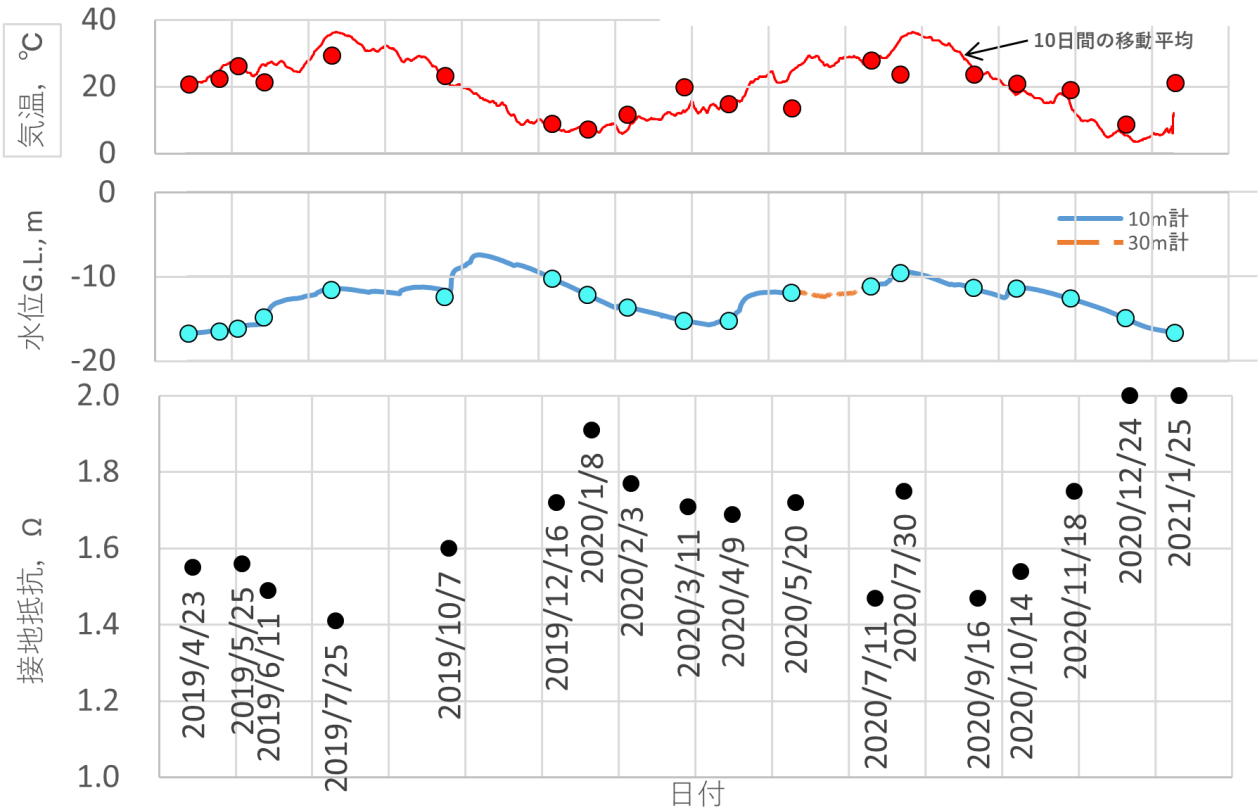


図 2　観測井WPTUでの地下水位と近傍における気温及び接地抵抗の変化

Fig. 2 Variation in groundwater level, temperature on the surface of the earth and earthing resistance, at the observation well WPTU

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Estimation of underground structure beneath the debris control dams constructed during the Edo era based on the microtremor measurements

*Atsushi Mukai[1]

1. Faculty of Urban Management, Fukuyama City University

In Fukuyama city, Hiroshima, many debris control dams "Sunadome" had been constructed during the Edo era and have been left. The largest one in such dams is “Dodo-gawa Rokuban Sunadome”. I performed the microtremor measurements at Dodo park constructed on the sedimentation of Sunadome, and estimated the underground structure beneath the park by using the H/V spectral ratio. The soft surface layer was estimated to be thicker around the Dodo river flowing in the middle of the park and be thinner nearby the mountain slope. In this study, I estimated the underground structures in other debris control dams along the river by using the microtremor measurements in order to reproduce the topography before the constructions of Sunadome.

Major geology in Hiroshima prefecture is granite, which can be easily turned to the decomposed granite soil due to weathering. Therefore, the surface layer in this area tends to collapse into landslide disaster. Fukuyama city has suffered the serious landslide disasters repeatedly. In May, 1673, the large-scale debris flow occurred along the Dodo river due to the local heavy rainfall and swept away the Kokubunji, houses and farms. That was the reason that the Fukuyama domain started the construction of Sunadome and had installed many debris control dams in this city. “Dodo-gawa Rokuban Sunadome” with dam height of 8.8m started to be constructed in 18th century.

I have performed the microtremor measurements at Dodo park since 2017. This park is about 70m x 250m in size along the Dodo river. I recorded 5 minute microtremors measured by the three-component seismometer at 70 sites which were set up at intervals of about 15m. I applied FFT to the measurements to obtain the H/V spectral ratios, and estimated the dominant frequency at each site.

Two dominant frequencies could be found at every sites in this park. One is a low frequency 0.1-1 Hz, and the other is a high frequency of 1-10 Hz. The H/V spectral ratio is larger at the latter one and can be definitely extracted from the noise. I assumed two lateral layer as the underground structure and estimated P wave velocity and thickness of the surface layer by using the higher dominant frequency and its H/V spectral ratio. The other parameters such as density and S-wave velocity were assumed to be constant.
As a result of the estimation of underground structure, the surface layer was found to be thicker around the Dodo River flowing through the middle of the park, and be thinner near the mountain slopes on both sides of the river. In addition, I could see the surface layer tended to be thinner from the downstream to the upstream of the river. It might be indicated that the subsurface structure estimated in this study shows the topography of the valley before the construction of Sunadome. These results suggest that we can estimate a complicated underground structure in the lateral scale of 10m, even if a simple horizontally stratified structure is assumed for estimation of the underground structure. In this study, we have performed the microtremor measurements at other Sunadome along the river and tried to reproduce the past topography of the valley before the construction of Sunadome.

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Keywords: microtremor measurement, debris control dam

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Measuring the distribution of surface thickness of pavement using ground-penetrating radar

*Kyosuke Onishi[1], Kobayashi Takayuki[1]

1. Public Works Research Institute

Information of the structure of pavement is sometimes required to manage conditions of paved roads. In this report, we introduce to measure the thickness distribution of the surface layer constructing pavement with the accuracy about a centimeter using ground-penetrating radar. Structure Scan of the GSSI and Mini Pod of the Earth Radar were mainly used in this measuring test. The central frequencies are about 2.7 GHz and 800 MHz, respectively. The Structure Scan is developed to detect reinforcing steels in concrete structures and can survey the undulation of interfaces in pavements with high accuracy for its high vertical resolution. Meanwhile, the Mini Pod, which is a multi-channel radar system with 12 antennas, can measure wide area in short time.

The test data were acquired on a test pavement in our research institute. The propagation velocity of electromagnetic wave was decided to fit depths verified by collected cores for improving the accuracy of depths measured from reflection responses in a shallow zone. A series of processing including zero offset processing was applied to records based on the value of propagation velocity. The velocity of asphalt concrete mixture is decided to 0.135 m/ns. Acquired velocity distribution fits to the thickness of surface layer of the pavement. The reference thickness is estimated from measuring cores which was not used for deciding propagation velocity.

The asphalt concrete mixture has two layers of the surface and the basic layer. The depth distribution of interfaces between the surface and the basic layer was measured in the radar records. The upper surface of subgrade which is constructed with heavy machineries has a certain level of roughness. On the other hand, the upper surface of basic layer in the asphalt concrete mixture has fine flatness. Therefore, the thickness of the basic layer has large variations in locations. When the ground-penetrating radar can easily measure the distribution of thickness of the basic layer, it provides important information to analyze durability and health of pavement.

Keywords: ground-penetrating radar, pavement, asphalt concrete mixture

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[E] Poster | H (Human Geosciences)：H-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.09_1

[H-CG20] International comparison of landscape appreciation

convener:yoji aoki(Open University of Japan)

Landscape assessments are being developed in a variety of areas, including geography, landscape architecture, nature conservation, and other areas. Landscape appreciation is a complex and sophisticated psychological phenomenon. Among researchers, what is the phenomenon of "landscape", how people experience it physiologically and mentally, why human attributes influence its perception, why it is. There is no consensus on how to recognize it. The concept of landscape appreciation has not yet been clearly defined, and there is a lack of consensus on evaluation methods, factors that determine landscape preferences, steps of appreciation, and so on. In this session, we will discuss the research results of landscape evaluation in various fields such as geography, topography, landscape planning, architecture, engineering, social science, environmental psychology, meteorology, and phenology.

[HCG20-P01] Appreciation of Japanese landscapes by western diplomat (1859-1861)

*yoji aoki[1], fumihoro konta[2] (1.Open University of Japan, 2.National Science Museum)

[HCG20-P02] Functional Assessment of the Outdoor Recreational Space in Matsudo Campus, Chiba University

*Zhao Yuqing[1], Lu Tingyu[1], Wang Huixin[1], Nakamura Marina[1], Luo Shixian[1], Cheng Yu[1], Liu Zhendong[1], Katsunori Furuya[1] (1.Chiba University)

[HCG20-P03] Impact of Campus lockdown on Student Spatial Behavior During COVID-19 Pandemic

*Huixin Wang[1], Tingyu Lu[1], Dan Li[1], Rosyi Damayanti T Manningtyas[1], Dibyanti Danniswari[1], Azuki Kiriyama[1], Junpei Watanabe[1], Mizuki Sakamoto[1], Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

Appreciation of Japanese landscapes by western diplomat (1859-1861)

*yoji aoki[1], fumihoro konta[2]

1. Open University of Japan, 2. National Science Museum

By the popularity of landscape painting in Europe, some visitors appreciated the beauty of Japanese landscape. After the residence of diplomat of European countries (Table 1), they investigated the local areas of Japan and found beauty of Japanese landscape.

(1)Hodgson, C.P.

He described the beauty around Hakodate. He praised Mt. Komagatake, Onuma lake, Funkawan Bay, village of Kikonai, and Mt. Esan. He called the area of Mt. Esan to be Switzerland in Japan. He described many plants, and praised oaks and Camphor tree, flowers of cherry, peaches, plums and peony, and daisies, orchids, dwarf roses, and lilies for herbs. He described the Japanese religion as resembling a forest-loving Druid. He also noted that he was a doctor a great nature lover.

(2)Alcock, R.

His description often observed the scenery and praised the beautiful scenery in Nagasaki, the suburbs of Edo, Hakodate, Hakone, Atami, Kanzaki, Kakegawa, Kasagi, etc. But he wrote that he didn't feel like admiring the Seto Inland Sea. This is a landscape evaluation that is different from many tourists. Since he is looking at Norway and Switzerland, it seems that he did not feel the topographical impression there. He noted and praised the variety of plants in the suburbs of Edo.

(3)Lindau, R.

He appreciated the scenery of Nagasaki, Edo, Kanazawa-hakkei, and Kamakura in his way. Especially in the Osumi Strait, he praised the scenery of Mt. Kaimondake. However, at Kanazawa Hakkei, he never touched on the contents of Hakkei. He describes the transparency of Japanese air by looking at the starry sky. It reminds us that the air of Swiss was polluted at that time.

(4)Eulenburg, A.G.F.

They seem to have aimed at academic research on Japan, and have excellent information gathering ability and insight. The landscape is described in Edo, Kanagawa, Kagoshima, Nagasaki, and Mogi, and the plant species are detailed. They discovered what are not in their country, such as travel guide books, flower calendars, and situations of snow accumulation. Japanese are travel lovers, horticultural enthusiasts, and Japan has abundant flowers, fist-like snow accretion, and etc., which clearly show the differences in the natural conditions of Japan to Europe.

(5)Spiess, G.

He evaluated the scenery of Yokohama, Edo, and Nagasaki. He was amazed at the camellia flowers, green leaves and bamboo. It was not clear that the beauty of the moonlit night was special in Japan.

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(6)Werner, R.

He appreciated the scenery in Nagasaki and Edo, Yokohama hill, and Mt. Kompira. He described that temples and shrines occupy a good place and good nature is set up it. He wrote that beautiful forests should reminiscent of parks in Germany. He wrote that the festival in Nagasaki is beautiful. He noted that the Chinese aesthetics did not fit. He speculated why people believes polytheism.

(7)Brant, M.

He is familiar with plants and described the natural beauty of Japan, such as the condition of the primeval forest in Hokkaido and the rows of trees on the highway. He was also pleased with the incomprehensible combination of north and south vegetation, camellia with snow, conifers with ferns. On the other hand, he points out that the Seto Inland Sea is a landscape that extends lengthy to the Rhine. He liked Hokkaido and wanted to explore the island detailed.

(8)Fortune, R.

He left descriptions of the landscape with so many plants. He praised *Aucuba japonica*, Asunaro, Sawara, Hinoki, Japanese cedar and others. He praised azaleas, cherry blossoms, Japanese primrose, wisteria, peonies, Tessen, irises, spirea, Senno, and lilies in flowers. He pointed out that Japanese people like plants. And since the lower classes also have knowledge of plants, he evaluated that Japanese culture is high. But he could not understand what was Kanazawa-hakkei.

(9)Black, J.R.

He described the beauty of the trees and views of the Tokaido, the view from Mt. Fuji, the beauty of the Fuji River from the Nanbu to Minobu, and the beauty of the mountains of Nakasendo.

Keywords: landscape appreciation, diplomat inspection, End of Edo era

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Table 2 List of focal objects

Name of visitor	Period	Fo
Hodgson, C. P.	1859–1860	ca ca pla flo
Alcock, R.	1859–1865	Na au wo
Lindau, R.	1859–1869	Na str Ka
Hepburn, J.C.	1859–1892	Na
Eulenburg, F.A.G.	1860–1861	wo hil Fu Ka ro
Spiess, G.	1860–1861	Ec vil
Werner, R.	1860–1862	au Fu
Brant, M.	1860–1875	Ha ca flo
Fortune, R.	1860–1861	wo bla isl Ec su m pe pe
Black, J.R.	1861–1880	wo Fu Mt

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Functional Assessment of the Outdoor Recreational Space in Matsudo Campus, Chiba University

*Zhao Yuqing[1], Lu Tingyu[1], Wang Huixin[1], Nakamura Marina[1], Luo Shixian[1], Cheng Yu[1], Liu Zhendong[1], Katsunori Furuya[1]

1. Chiba University

Campus landscape is always one of the key points when people introduce a university. Humans have a nature to be intimate with nature environment, and nature environment helps people get relief from stress and pressure which makes people love to take a rest in nature. For a student, the landscape environment of university campus plays an important role in study and casual time.
The indoor space contains most of the functions of a campus, technically teachers and students can keep staying indoor to finish their study. However, a campus is more like a multi-functional place to enrich their school life. In outdoor, or leisure space in a campus, it always carries more responsibilities than resting area. Teachers and students celebrate school festival and every year, bands give their live performance, baseball players practice throwing and catching ball, sometimes commencement is held on the lawn.
In outdoor, or leisure space in a campus, it always carries more responsibilities than resting area. Teachers and students celebrate school festival and every year, bands give their live performance, baseball players practice throwing and catching ball, sometimes commencement is held on the lawn.
In this study, our target is Matsudo Campus of Chiba University. The group will do site study on the current situation of how outdoor space is used for different functions in Matsudo Campus. The assessment will be based on data collected from students.

Keywords: Campus landscape, leisure space, Functional Assessment

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Impact of Campus lockdown on Student Spatial Behavior During COVID-19 Pandemic

*Huixin Wang[1], Tingyu Lu[1], Dan Li[1], Rosyi Damayanti T Manningtyas[1], Dibyanti Danniswari[1], Azuki Kiriyama[1], Junpei Watanabe[1], Mizuki Sakamoto[1], Katsunori Furuya[1]

1. Graduate School of Horticulture, Chiba University

The lockdown of campuses during the COVID-19 pandemic has changed students' campus life. This study used the method of online questionnaire survey and invited college students from Japan and China to fill in the questionnaire to explore the impact of the campus lockdown on their spatial behavior. The questionnaire is divided into three parts, respectively investigating demographic information, students' campus space behavior before and after the lockdown, and students' demand for public green space on campus in the future.
Our survey results show that most of the interviewees are aged between 20 and 24. Nearly 50% of the interviewees are graduate students, and about half of the interviewees are majors in landscape architecture. The survey results in the second part of the questionnaire show that before the campus closure, the indoor campus space most frequently used by students was the research room, and the most frequently used outdoor space was the traffic space. During the lockdown of the campus, the outdoor campus space that students most want to use is the outdoor rest space, while the indoor is still the research room. The lockdown of the campus has changed the reasons for students to go to school. The time spent on campus has been reduced, and the frequency of activities on campus has also decreased. The survey results in the third part of the questionnaire show that regardless of gender and age, students prefer larger campus green spaces in the post-pandemic era, and dislike outdoor rest spaces that can accommodate most people. Our research shows that campus lockdown affect students’ motivation to go to school, the time spent on campus, and the frequency of school activities. And, due to the COVID-19 pandemic, students' hopes for outdoor campus space in the future are greater and wider, because such a space can reduce the risk of virus infection.

Keywords: COVID-19, Campus lockdown, Spatial behavior, Campus green space

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[E] Oral | H (Human Geosciences)：H-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.14 Zoom Room 14

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull), Chairperson:Robert Michael Dorrell(University of Hull), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology)

We invite research based on all kinds of approaches to understand morphodynamics of sediment gravity flows including turbidity currents and debris flows. Multidisciplinary studies such as field observation, physical and numerical experiments, mathematical analysis, and studies from rock records are welcomed. Recent progress in research methodologies has greatly changed our understanding of dynamics of turbidity currents and relevant flows, submarine geomorphology and stratigraphy. The integration of such new knowledge on turbidity currents is important not only for scientific interests but also for practical application such as risk assessment of natural hazards, and exploration of resources. We anticipate interdisciplinary discussions about various aspects of turbidity currents, debris flows and other types of sediment gravity flows.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[HCG21-01] An analysis of sedimentation processes in pyroclastic density currents based on a two-layer depth-averaged model

★Invited Papers

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[2], Yujiro J. Suzuki[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Earthquake Research Institute, The University of Tokyo)

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

[HCG21-02] A new empirical model of vertical profile of velocity and suspended sediment concentration of steady-state turbidity currents

*Sojiro Fukuda[1], Elena Bastianon[1], Bill McCaffrey[2], Hajime Naruse[3], Robert Michael Dorrell[1] (1.University of Hull, 2.University of Leeds, 3.Kyoto University)

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

[HCG21-03] Modeling sand-rich submarine debris flow: Sand deposition, turbidity current generation and separation

*Yuichi Sakai[1], Hajime Naruse[1] (1.Graduate School of Science, Kyoto University)

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

[HCG21-04] Velocity and deposition profile of experimentally produced quasi-steady turbidity current

*Nomura Shun[1], Mikito Furuichi[1], Giovanni De Cesare[2], Yasushi Takeda[3], Hide Sakaguchi[1] (1.JAMSTEC, 2.École Polytechnique Fédérale de Lausanne, 3.ETH Zürich)

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

[HCG21-05] Dynamics of turbidity currents influenced by tidal flows in submarine canyons

*Justine Louise Marie Poppeschi[1], Hajime Naruse[1], Robert Michael Dorrell[2] (1.Department of Geology an Mineralogy, Graduate School of Science, Kyoto University, 2.University of Hull)

An analysis of sedimentation processes in pyroclastic density currents based on a two-layer depth-averaged model

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[2], Yujiro J. Suzuki[2]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Earthquake Research Institute, The University of Tokyo

During volcanic eruptions, a mixture of volcanic particles and gas is ejected from the volcanic vent and can flow along the ground surface as a pyroclastic density current (PDC). PDCs are characterized by a vertical stratification of particle concentrations in the currents; they are composed of a voluminous dilute turbulent suspension part with low particle volume fractions (<~10^{-3}) and a thin basal part with high particle volume fractions (~10^{-2}-10^{-1}). The basal part plays a major role in the sedimentation processes in PDCs. The characteristics of the basal part strongly depend on geological factors such as the particle concentration at the source; the basal part flows as a dense fluidized granular flow with very high particle volume fractions (~0.4; referred to as the “dense underflow”), or as a flow of saltating/rolling particles with relatively small particle volume fractions (~10^{-2}; referred to as the “bedload”). To understand the sedimentation processes in PDCs, it is important to elucidate the mechanisms that lead to the diversity of the basal part.

Previously the sedimentation processes of the basal part are investigated mainly from the viewpoint of the vertical particle transport. When the particle supply rate from the upper dilute part is larger than the deposition rate at the bottom of the basal part, the mass of the basal part increases and vice versa. The vertical particle transport is affected by various physical processes such as the particle cluster, the basal air lubrication, and the basal saltating/rolling particles. These processes explain some of the diverse sedimentary structures observed in PDC deposits. However, to understand the lateral variations of PDC deposits (e.g., the distributions of various sedimentary facies), additional considerations of horizontal particle transport are necessary.

This study aims to understand the flow and sedimentation processes of the basal part using a two-layer depth-averaged model of stratified PDCs (Shimizu et al., 2019, J. Volcanol. Geotherm. Res., 381, 168-184). This model allows us to discuss the diverse characteristics of the basal part (i.e., the dense underflow and the bedload) by considering both the vertical and horizontal particle transports. In this model, the stratification in PDCs is modeled as dilute and basal currents; the two currents are coupled through mass and momentum exchanges as suspended particles in the dilute current settle into the basal current. The two-layer model can generate various types of basal current from dense underflow to bedload depending on the source conditions. The simulation results quantitatively reproduce the fluid dynamical features and sedimentation processes observed in laboratory experiments (e.g., Shimizu et al., 2020, JpGU-AGU Joint Meeting, SVC42-P05).

To evaluate the effect of the horizontal particle transport, we derive an analytical solution of the steady-state horizontal mass flux of solid particles in the basal current as a function of horizontal distance (x) by integrating the mass conservation equations; we assume that a two-layer PDC is generated by a steady supply at the source point (x=0) and it flows into a one-dimensional run-out section (x>0). The analytical solution clearly expresses how the evolution of the basal current depends on (1) the horizontal supply of the basal current at the source (x=0), (2) the deposition at the bottom of the basal current at x >0, and (3) the vertical particle supply from the upper dilute current at x>0. The results of a parametric

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study based on the analytical solution suggest that the characteristics of the basal current generated at the source (x=0) govern the flow and sedimentation processes of the basal current at x>0. The run-out distance of the basal current depends also on the balance between the vertical particle supply and the basal deposition at x>0. The variation in the run-out distance explains the lateral variations of PDC deposits.

Keywords: Pyroclastic density current, Two-layer model, Sedimentation process, Deposit distribution, Dense underflow, Bedload

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A new empirical model of vertical profile of velocity and suspended sediment concentration of steady-state turbidity currents

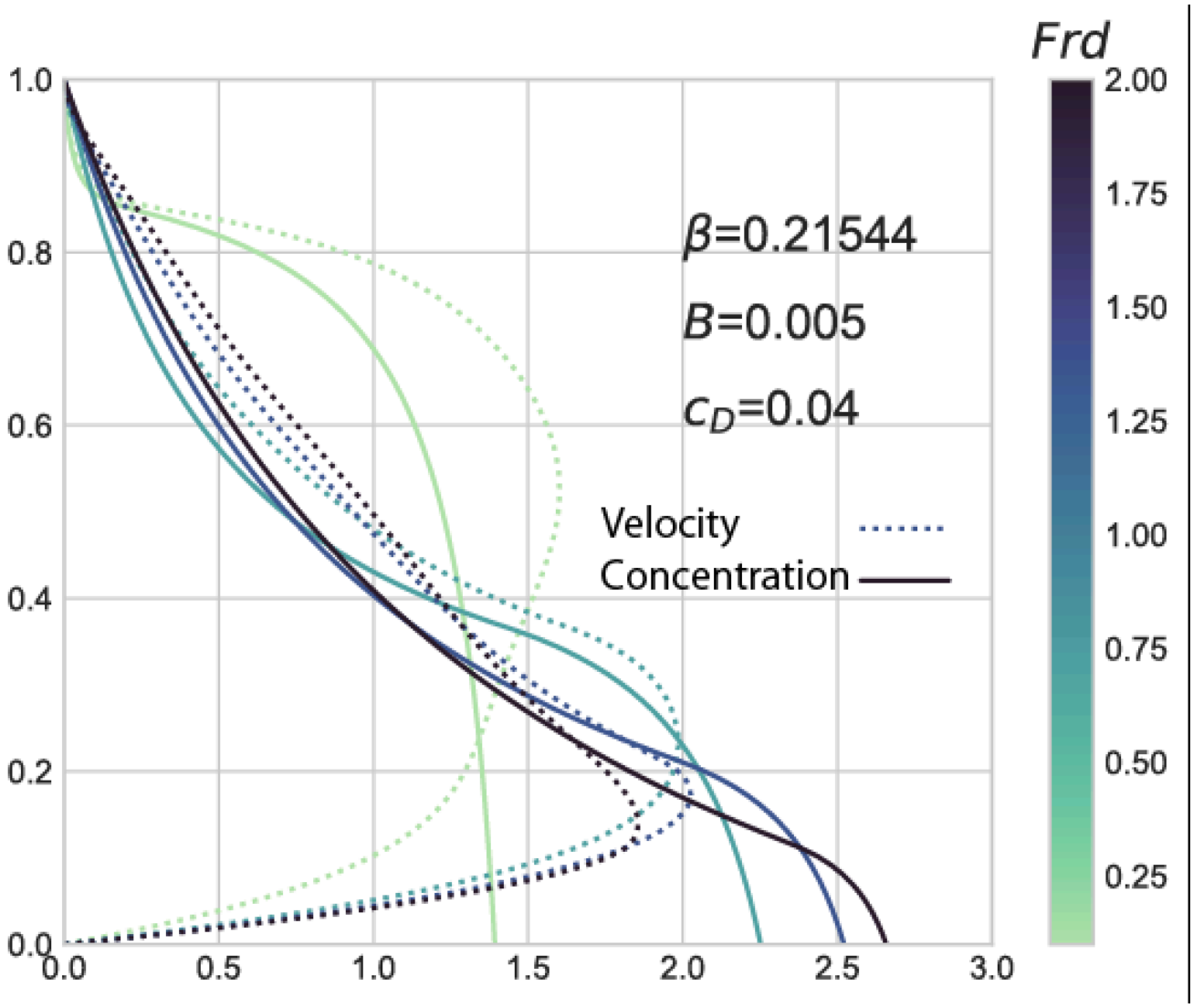
*Sojiro Fukuda[1], Elena Bastianon[1], Bill McCaffrey[2], Hajime Naruse[3], Robert Michael Dorrell[1]

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The importance of a turbidity current is characterized by its role as a dominant sediment transport mechanism from shallow to deep ocean at continental margins. Turbidity currents create one of the biggest sediment architectures on our planet, called submarine fans. During their flow processes, they running down more than 100s to 1000s km along the sinuous submarine channel, destroying and recreating the deep marine systems. The understanding of a whole flow event of a turbidity current from initiation to the deposition and the evolution of resultant deposits provides us a various kind of scientific information such as the historical records of huge earthquakes, the better risk management of submarine infrastructures, and the better understanding of potential contamination of deep marine due to the human activities (e.g. microplastics). Despite those high demands of understanding flow mechanics of turbidity currents, we actually do not understand how a turbidity current can run out such an ultra-long distance without dissipation. Although we have high-resolution numerical models to predict the flow behavior in high precision, the computational cost is too expensive to simulate the natural scale flow event. A shallow water scheme that assumes the vertically uniform flow is often used as an alternative model but is too simple to predict a turbidity current’ s flow dynamics. To tackle this dilemma of computational cost and model performance, recent studies are focusing on introducing appropriate stratification effects into shallow water models considering the vertical flow stratification of equilibrium turbidity currents assuming the Rouse profile of suspended sediment concentration. One of the problems of traditional Rouse profile and other Rouse-based vertical stratification models is that they cannot capture the flow stratification due to the strong shear between ambient fluid. Those models, therefore, cannot predict the wide variety of density and concentration profile that has been observed and predicted by both past flume experiments and direct measurements. Here, we compiled past flume experiments of steady-state turbidity currents to establish the new vertical flow profile model which is able to predict a wide variety of flow stratification. Firstly, we found a relationship between vertical velocity and concentration profiles; the ratio between normalized velocity and concentration at each height is almost constant regardless of other flow parameters. Secondly, instead of the traditional Rouse-type equations, we introduced the generalized Schlick’ s bias and gain function to describe the vertical concentration profile. Then from the results of curve fitting, we conducted model selection to describe the parameters in Schlick’ s function by characteristic flow parameters, using K-fold cross-validation method. From the obtained model of vertical concentration profile and the constant relationships between velocity and concentration profile, we readily obtained the new model of vertical flow velocity profile as well. In short, the obtained model implies that the flow stratification of turbidity currents can be well approximated by the flow concentration, densimetric Froude number, Rouse number, and drag coefficient. Within the dataset we gathered, the developed model shows quite good agreement and it depicts the basic trends of flow stratification which have been reported previously (e.g. high stratification with high Froude number). The flexibility of the developed model was highlighted by that they can demonstrate the various types of flow stratification which has been reported from both experiments and direct measurements such as traditional Rouse profile and highly-contrasted two-layer type profile which is often observed in saline flows or low Rouse number flow. As a future study, it is expected to introduce this model into shallow water model to validate the developed model’ s applicability.

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Keywords: turbidity currents, sediment transport, vertical stratification, cross validation, flume experiment



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Modeling sand-rich submarine debris flow: Sand deposition, turbidity current generation and separation

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The flow characteristics of submarine debris flows differs by their sediment composition, i.e., clay to sand ratio. Clay-rich debris flows exhibit matrix-supported, coherent flow structure, generally described by viscoplastic rheology. In contrast, sand-rich debris flows with moderate clay content have been reported to show complex flow dynamics in both longitudinal and vertical directions. In the previous experimental works of sand-rich debris flows, sand particles gradually deposited from dense sand-rich flow body with partial fluidization during its flow path. At the same time, the pore fluid with clay migrated upward, generating dilute turbidity cloud over the sand-rich flow. A turbidity current developed from this cloud may be separated from a dense sand-rich flow after its deposition. Modeling of these complicated behaviors of high-concentration flows still remains a challenge.

In this work, a numerical model of sand-rich debris flows incorporating sand deposition, turbidity current generation and separation is proposed based on two-layer shallow water equations: the lower layer represents fluidized sand-rich flow and the upper one corresponds to turbidity cloud. In this model, the simulation initialized with a fluidized sand-rich flow, and a turbidity cloud is generated depending on the upward flux of the pore fluid with clay from the sand-rich flow. To close the model, the upward flux of the pore fluid is coupled with the sand deposition rate, assumed that the sand deposition induces contractive motion of sand particles and this squeezes the pore fluid to the upper layer.

We conducted preliminary simulations of the model over a uniform slope with a given rate of sand deposition. The results reproduced important qualitative features of sand-rich debris flows reported in the literature, though further comparison with the experiment is needed in the future study to constrain the relationship between sand deposition and pore fluid migration assumed in this model.

Keywords: Sediment gravity flow, Submarine debris flow, Turbidity current, Numerical model

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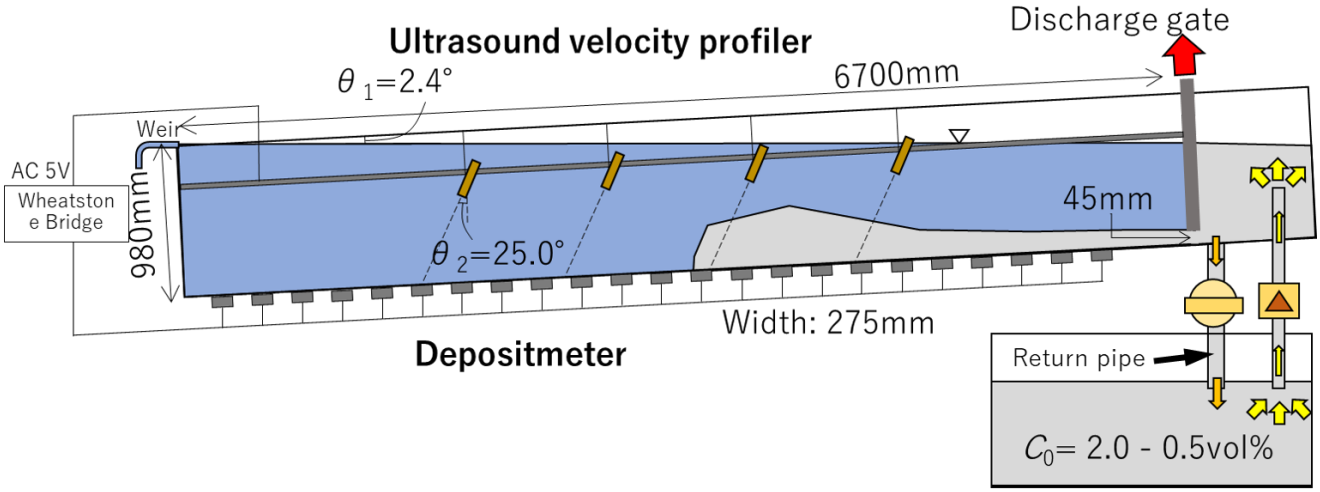
Velocity and deposition profile of experimentally produced quasi-steady turbidity current

*Nomura Shun[1], Mikito Furuichi[1], Giovanni De Cesare[2], Yasushi Takeda[3], Hide Sakaguchi[1]

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A turbidity current is a turbulent, particle-laden gravity current driven by density differences due to suspended sediment particles. It travels downslope with a large amount of sediment during its migration for over a great distance and forms the fluvial or submarine topologies.
For better understanding of the sediment transport by the turbidity currents, the spatio-temporal velocity distribution and deposition profile are important. In this study, the velocity profile and deposition process of experimentally produced turbidity currents in an inclined flume was investigated through the ultrasound velocity profiler and electrical resistance based dipositmeter.
The results of velocity distribution indicate that the turbidity current progressed in a quasi-stationary state. In addition, we found that the deposition amount along the flume bottom constantly increases with time in a specific rate and exponentially decreases along the downstream direction.
Based on the observed result, we will discuss why the turbidity current flows such a long-distance with large amount of sediment.

Keywords: Turbidity current, Velocity profile, Deposition process



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Dynamics of turbidity currents influenced by tidal flows in submarine canyons

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Turbidity currents are gravity driven currents, with a higher density than the ambient fluid due to suspended sediment. These flows represent the most efficient sedimentary transport process from continent to deep sea environments and can occur everywhere, mainly on the continental slope where the sediment is the most unstable. At these depths, turbidity currents should not be influenced by surface currents as tides. However, it has been found sedimentary features at depth not reach by surface currents but which could be associated to tides, as ripples, hummocky cross-stratification or cross lamination. The hypothesis to explain the presence of tidal sedimentary features at great depths is that tidal flows could influence turbidity currents via internal tides. The objectives of this study are to investigate the impact of the tidal flow on turbidity currents, especially in submarine canyons where both turbidity currents and internal tides are active. To examine the influence and exchanges between these flows, a model of multiple-layer shallow water equations is used. The data obtained will be tested by flume experiments and compare with in-situ measurements. If this hypothesis is verified, that could bring the light on the large disparity of the turbidity current presence in submarine canyon. Rhythmite structure in turbidites could also be explained by this fluid interactions.

Keywords: Turbidity currents, Tidal flows, Submarine canyon, Sediment transport processes, Numerical model, Flume experiments

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[E] Oral | H (Human Geosciences)：H-CG Complex & General

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.14 Zoom Room 14

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull), Chairperson:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Robert Michael Dorrell(University of Hull), Miwa Yokokawa(Osaka Institute of Technology)

We invite research based on all kinds of approaches to understand morphodynamics of sediment gravity flows including turbidity currents and debris flows. Multidisciplinary studies such as field observation, physical and numerical experiments, mathematical analysis, and studies from rock records are welcomed. Recent progress in research methodologies has greatly changed our understanding of dynamics of turbidity currents and relevant flows, submarine geomorphology and stratigraphy. The integration of such new knowledge on turbidity currents is important not only for scientific interests but also for practical application such as risk assessment of natural hazards, and exploration of resources. We anticipate interdisciplinary discussions about various aspects of turbidity currents, debris flows and other types of sediment gravity flows.

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

[HCG21-06] Sedimentological and organic geochemical characteristics of the turbiditic sequences in the Miocene Abetsu Formation, Hokkaido, Japan

*Hiroyasu Asahi[1], Ken Sawada[2] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Facility of Science, Hokkaido University)

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

[HCG21-07] X-ray fluorescence core scanning, magnetic signatures, and organic geochemistry analyses of turbidites of Ryukyu Trench floor

*KanHsi Hsiung[1], Toshiya Kanamatsu[1], Ken Ikehara[2], Kazuko Usami[3], Chorng-Shern Horng[4], Naohiko Ohkouchi[1], Nanako O. Ogawa[1], Saneatsu Saito[1], Masafumi MURAYAMA[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Japan NUS Co., Ltd., 4.Institute of Earth Sciences, Academia Sinica, 5.Faculty of Agriculture and Marine Science, Kochi University)

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

[HCG21-08] Variations in depositional environments reconstructed by biomarkers analysis of turbidite sediments from the Miocene Kawabata Formation, Hokkaido, Japan

*Muhammad Adam Ismail[1], Ken Sawada[1,2], Satoshi Furota[2,3] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

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

[HCG21-09] Sedimentary structures caused by submarine landslide southern Satsuma Peninsula

*Hiroto Yamaguchi[1], Mamoru Sano[2], Satoshi Shimizu[2], Hikaru Iwamaru[2], Nobukazu Seama[1,2], Yuzuru Yamamoto[1,2], Hironori Otsuka[1,2], Tetsuo Matsuno[1,2], Yoshiyuki Tatsumi[1,2] (1.Kobe university, 2.Kobe Ocean-bottom Exploration Center)

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

[HCG21-10] Formation process of submarine massive sandstones: Study based on grain fabric analysis using deep-learning image segmentation

*Sayo Ishii[1], Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

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

[HCG21-11] Discussion

Sedimentological and organic geochemical characteristics of the turbiditic sequences in the Miocene Abetsu Formation, Hokkaido, Japan

*Hiroyasu Asahi[1], Ken Sawada[2]

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In the middle Miocene of central Hokkaido, island-arc collision resulted in the formation of narrow foreland basins, Ishikari and Hidaka basins, extending about 400 km north-south and several tens of kilometers wide. Previous studies (Kawakami, 2013) have shown that a number of turbidite beds, Kawabata Formation, containing large amounts of terrestrial organic matter derived from higher plants have been identified. This suggested that a sedimentary system in which terrestrial organic matter was directly transported from the land to the deepseafloor was prevalent in the Ishikari Basin. In the present study, we conducted sedimentological and organic geochemical analyses on turbidites of the Abetsu Formation deposited in the Hidaka Basin to reconstruct sedimentary processes that occurred in the Hidaka Basin in the middle Miocene.

In the Hobetsu area of Mukawa-city, south-central Hokkaido, sand and mud alternations deposited in the Hidaka Basin during the middle to late Miocene are widely distributed. The upper part of the Abetsu Formation (coarse-grained sandstone alternation) and the Nibutani Formation (fine-grained sandstone alternation) are exposed at the Horokanbe-sawa River.

We analyzed two thin, fine-grained turbiditic sequences collected from the upper part of the Abetsu Formation. These are mainly composed of three units from the lower part: massive sandstone part, organic lamination part, and mudstone part. For organic geochemical analysis, the turbiditic sequences were divided into units about 1 cm thick, focusing on the changes in sedimentary structure. Biomarker composition of these units were analyzed using GC/MS. Thin sections of the turbidite sequences were observed and performed grain size measurement under transmitted light microscope.

The massive sandstone and the lamination parts are composed of fine/very fine-grained sands, and show a gradational structure from the upper part of the massive sandstone to the lamination part. The uppermost mud layer consists mainly of silt. Organic particles like plant fragment are observed throughout the sequences, but they are scattered in the massive sandstone part. Interestingly, the organic particles are extremely concentrated in the lamination section, where they are the main particles forming the lamination.

Diterpenoids (gymnosperm components), triterpenoids (angiosperm components), and *des-A* terpenoids (angiosperm components generated by microbial degradation under anoxic conditions) were detected as major biomarkers in the turbidites from the Abetsu Formation. The concentrations of diterpenoids and *des-A* terpenoids nearly constant throughout the sequences, whereas the triterpenoids significantly vary, and especially, concentrated in the from the top of the massive sandstone to the lamination part.These results suggests that the turbulent flow-forming turbidites in the Abetsu Formation contained large amounts of components originated from angiosperms. In the Kawabata Formation, the *des-A* terpenoids were remarkably abundant rather than triterpenoids and diterpenoids in the turbidites (Furota et al.,

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2014).These differences indicate that the terrigenous matter in the turbidites of the Abetsu Formation was transported from different type land area and/or different source vegetation to the deep sea.

The terrestrial/marine organic matter ratio using steroid (sterane) composition was evaluated in the turbidite sequence. The sterane index shows a high proportion of terrestrial organic matter over the massive sandstone and lamination part, with a rapid shift to marine organic matter in the mudstone part. This trend is observed in the both Abetsu turbidites, but some sequences having a higher contribution of marine organic matter throughout the sequence. Such trends were also confirmed by the pristane/phytan index (Pr/Ph), which indicates the redox condition and contribution of terrestrial organic matter.

Keywords: turbidite, Hokkaido, Organic geochemistry

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X-ray fluorescence core scanning, magnetic signatures, and organic geochemistry analyses of turbidites of Ryukyu Trench floor

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The southwestern Ryukyu Trench represents the ultimate sink of sediments shed from Taiwan into the Philippine Sea, which is mainly transported to the trench by turbidity currents via submarine canyons. This study presented very thin-bedded turbidites intercalated with hemipelagites in core KR1518PL04/PC04, obtained at 6,147m water depth on the Ryukyu Trench floor. We also analyze the Ryukyu Trench cores of YK1501PC14 and YK16116K handy cores east of KR1518PC04. These trench cores are mainly composed of homogeneous gray mud layers intercalated with coarser layers of silty sand. The coarse-grained layers are olive-black in color and mostly < 2 cm thick. Based on deep-sea turbidite classification criteria and deep-water sediment facies, the silty sand beds are interpreted as turbidites and the mud layers as hemipelagites. We performed X-ray fluorescence core scans (ITRAX profiles), magnetic measurements, and organic geochemistry analyses to discriminate turbidites from hemipelagites. Generally, Ca/Fe and Zr/Rb ratios in the ITRAX profiles mark distal turbidites (about 1 to 3 cm thick), and Zr/Rb peaks mainly reflect grain size changes. Detailed grain size analyses of a relatively thick turbidite showed a good correlation between elemental ratios (Ca/Fe and Zr/Rb) and the upward-coarsening and upward-fining units that delimit the bottom and top of turbidites, respectively. Detailed analyses of a representative turbidite show a good correlation between Ca/Fe and Zr/Rb peaks with upward-coarsening and upward-fining trends that delimit the turbidite. In PC04, three of these turbidites also presented MS peaks and magnetic signatures of pyrrhotite, which we interpret as evidence of long-range sediment transport from Taiwan to the Ryukyu Trench floor by long-runout turbidity currents. We performed organic geochemistry analyses (δ 13C, TOC, and TN) to compare turbidites and hemipelagites in core PC04, as identified based on the Ca/Fe and Zr/Rb proxies. The results concluded that hemipelagites are characterized by low Ca intensities, high TOC and TN contents, and heavy δ 13C values, whereas turbidites show high Ca intensities and peak Ca/Fe values. The multi-proxy approach employing high-resolution XRF core scans to differentiate turbidites from hemipelagites contributes to establishing a comprehensive view of modern Ryukyu Trench sedimentation.

Keywords: distal turbidite, Pyrrhotite, ITRAX, Ryukyu Trench, Taiwan

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Variations in depositional environments reconstructed by biomarkers analysis of turbidite sediments from the Miocene Kawabata Formation, Hokkaido, Japan

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The Miocene Kawabata Formation, exposed in Yubari, central Hokkaido, Japan, is described as basin filled and slope-apron turbiditic systems mainly dominated by siliclastic sediments (Kawakami *et al.*,2002). A previous study done by Furota *et al.*(2014), discovered plant fragment (PF) concentrated sandstones known as hyperpycnites, which are land-derived flood deposits abundant in terrigenous organic matter (Zavala and Arcuri, 2016). The objectives of this study are (1) to reconstruct the paleoenvironment and depositional system of a key outcrop of the Kawabata Formation, and; (2) to reconstruct variations in biomarker data in the Kawabata Formation during ca. 15-12 Ma.

The Kawabata Formation consists of siliclastic sediments with PF concentrated sandstones and are partially exposed by the Soumokumai-zawa River along a 1200m transect in central Hokkaido, Japan. The Chidorigataki outcrop is a key outcrop for evaluating the paleodepositional environment and depositional system by using sedimentological data along with biomarker analysis. Data of older parts, in the Soumokumai-zawa section were added in from previous data made available by Okano and Sawada (2007) and Furota (2017).

The 145cm thick Chidorigataki outcrop turbiditic sequence is interpreted to have been deposited by three flooding events, generally producing fining up sequences having an erosive, sandy (PF concentrated sandstone) base overlain by mud or sandy mud. The redox indicator - pristane/phytane (Pr/Ph) ratio - shows higher (more oxic) values in PF concentrated sandstones and lower (less oxic/more anoxic) values in mudstones. The $C_{27}/(C_{27}+C_{29})$ sterane ratios, used to determine the source of organic matter, shows lower values (high terrigenous organic matter input) in PF concentrated sandstones. Other terrigenous organic matter such as the oleanane and lupane triterpenoids, and their degraded aromatic counterparts were also present throughout the succession, suggesting that the sediments were derived from the terrestrial realm. TOC% averaged at 0.47% for mudstones and 3.22% for PF concentrated sandstones. Highly branched isoprenoid (HBI) alkanes were also found throughout the succession, suggesting the presence of diatom-derived organic matter. In terms of sedimentology, a dispersed type PF concentrated sandstone was discovered underlaying laminar type PF concentrated sandstones, suggesting that sediments were transported in high density flow conditions overlain by lower density flow conditions.

In the mudstone samples from the Soumokumai-zawa River, there was a gentle increase in Pr/Ph . This result suggests that they were deposited in more oxic conditions. As for $C_{27}/(C_{27}+C_{29})$ ratio, there was a gentle decrease, suggesting a higher input of terrestrial organic matter. Interestingly, higher $C_{27}/(C_{27}+C_{29}$) values were seen in rocks containing the diatom-derived HBI molecule. This could be due to an increase in diatom productivity in the region (Barron, 1998; Yamamoto et al., 1999) during the transitional global climate period of the Miocene.

This study suggests that both the Chidorigataki outcrop and the Soumokumai-zawa section of the

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Kawabata Formation were deposited by terrestrial derived sedimentary systems to the deep sea, as seen by the highly oxic character (due to freshwater input) and high amounts of terrestrial organic matter with minor marine input.

Keywords: turbidite, biomarker, sedimentology, organic geochemistry, Kawabata Formation, density flows

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Sedimentary structures caused by submarine landslide southern Satsuma Peninsula

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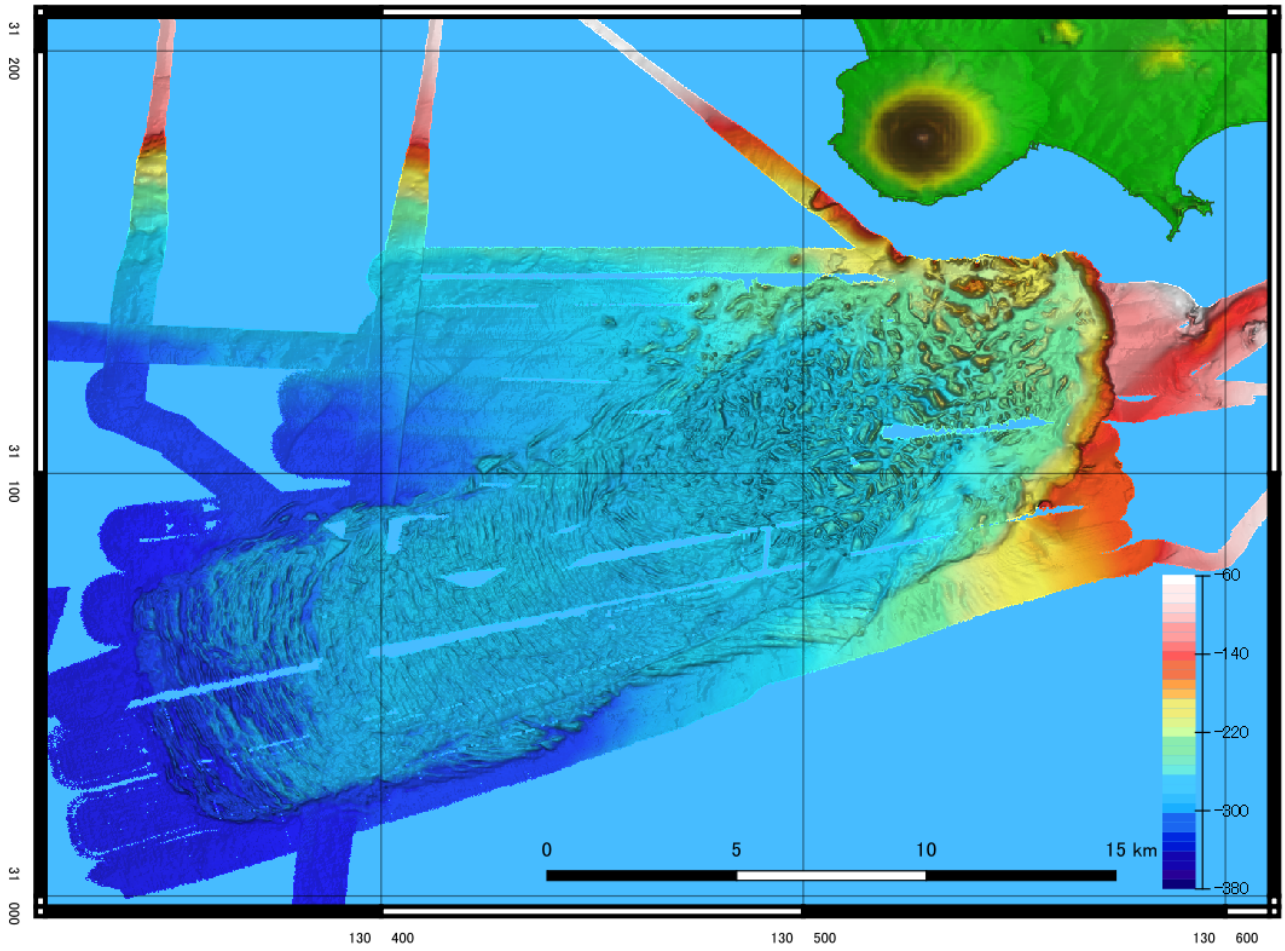
1. Kobe university, 2. Kobe Ocean-bottom Exploration Center

Most of submarine landslides occur on the slopes of ocean basins and continental margins, and have been the subject of detailed studies. However, these landslides have a complex structure due to the complex seafloor topography such as submarine valleys and multiple landslides, and their deep-water depths have prevented us from obtaining high-resolution topography. In addition, the interrelationship between the internal structure of landslides and seafloor topography has not been discussed much. In this study, the water depth is 200-300m. Precise seafloor topography data was got were obtained by multi-narrow beam echo sounder using high frequencies. The horizontal resolution is about 10m. Seismic data was got by Multi-channel seismic reflection survey(MCS) data were also obtained. The vertical resolution is 5-10m, and horizontal resolution is around 50m. Our surveys were conducted 3 times from 2017 to 2019 by the T/S “Fukae Maru”, Kobe University. The MCS surveys carried out on the 6 lines and acquired data successfully. The obtained reflection data was processed by general denoising analysis, after that, stacked with 12.5m common midpoint bins. The tomography was processed to enhance the microtopography after denoising analysis. In addition, the topography before the landslide was obtained by interpolating the landslide area using the area not affected by the landslide.
The landslide has a maximum width of about 8km and length of about 26km, and the total area including the area affected by the landslide reaches 174km². At the eastern side, there is a headwall scarp with a maximum specific height of 140m known as the “Kaimon submarine cliff”. Block-like features and ridge-like rises that are higher than the surrounding terrain are collectively called "ridge" and classified into six areas according to the regularity and scale of the ridge. Furthermore,we compared pre-landslide topography with the current topography (post-landslide) to estimate the volume and distance of moved masses. As a result, we observed irregular ridges with different strikes in the relatively subsider area and regular ridges with aligned strikes in the uplift area, and estimated that the moved mass have 1.7 km³ area with a maximum travel distance of 3 km.
In seismic sections, the changes in seismic facies generally correspond to changes in topographical features. Regions of transparent facies are identified only in the regions irregular ridges are developed, while area with prominent faults correspond to the region with regular ridges. The whole picture was observed that the acted as fluid near the source and the plastic deformation was predominant toward the end. By making these associations in more detail and analyzing the fine reflection section structure, the physical states such as the stress state at the time of formation were examined. In addition, stratified structures were widely observed outside the submarine landslide area, and the topography was almost uneven. It was found that the reflective layer found from the center to the end of the landslide area was the same as the stratified sediment found outside the area. The stratified sediments are also widespread on the slopes south of the headwall scarp and north of the landslide, and are deposited on the slopes in the form of onlap with the lower sediments. This suggests that the stratified structure was widely observed in the landslide area before the landslide, and that the stratified sediments caused the landslide.
In summary, the originally stratified sediments began to collapse from the eastern slope. Near the source, there was no sediment structure left at all, and it was crushed and mixed. In the vicinity of the source, gravels, sands and so on originating from the landslide were deposited over 10 m, and it is estimated that they were violently crushed and mixed at high speed. In the central part of the site, where the topography

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changes from lower to higher due to the landslide, the uppermost harder sediments are seen in the shallow part of the transparent reflection, suggesting that the degree of crushing and mixing is decreasing while continuing. Towards the end, the stratigraphy is clearer, and it is widely compressed from faulting and deformation. It is presumable that this is an area where past-sea sediments were moved and deformed by landslides flowing from the source. It was revealed that the landslide occurred with severe fracturing and mixing, and progressed with gradual loss of energy, and that the rapid movement of sediments over a wide area, forming the current landslide topography.

Keywords: submarine landslide, MCS, Mass Transport Complexes



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Formation process of submarine massive sandstones: Study based on grain fabric analysis using deep-learning image segmentation

*Sayo Ishii[1], Hajime Naruse[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

This study examined the dominant process of sediment transport and their variation depending on the sedimentary environments in submarine fans by analyzing grain fabric of massive sandstones. The massive deposits of sediment gravity flows are common in channel-filling or proximal lobe deposits in submarine fans, and recent studies suggested that their formation processes can be distinguished from characteristics of grain fabrics. This study sampled the massive sandstone beds from the submarine channel-fill, crevasse splay, and frontal splay deposits in the Upper Cretaceous Himenoura Group distributed in the Kamiamakusa City, Kumamoto Prefecture, southwest Japan. Images of the polished cross sections of the massive sandstones were taken by a flat bed scanner, and were analyzed by the machine-learning model using the convolutional neural network to investigate directional distributions of major axes of sand particles. As a result, three types of grain fabric were recognized in massive sandstone beds, which are characterised by upward-increasing trend of imbrication angle (Fabric Type 1), homogeneously low imbrication angle (Fabric Type 2), and imbrication angle oscillating vertically (Fabric Type 3). On the basis of comparison with results of existing flume experimental studies, Fabric Type 1 is interpreted as product of deposition from debris flows. Fabric Type 2 exhibits a typical feature of the grain fabric of low concentration turbidites. Fabric Type 3 can be interpreted as structures formed by multiple surges of debris flows or hybrid flows of debris flows and turbidity currents. The occurrence of these fabric types strongly depended on the depositional environments. Massive sandstones exhibiting Fabric Type 3 were dominated in submarine channel-fill deposits, while sandstones of Fabric Type 2 preferentially occurred in the crevasse splay deposits. Sandstones showing Fabric Type 1 was mainly observed in the frontal splay deposits which were formed in the regions downstream of the channels and crevasse splays. These results indicate that the debris flows and/or the gravity flows with two-layered structure of debris flow and turbidity current were dominated in the submarine channel environments although the spill-over flows from the submarine channel were mainly composed of turbidity currents. In contrast, it is considered that the debris flows were deposited as the massive sandstones in the frontal splay which located in the downstream end of the channel. Thus, it is implied that not only turbidity currents but also high-concentration gravity flows such as debris flows and two-layer hybrid flows should be fully taken into account in modeling the formation of submarine fans. In the future, it will be necessary to analyze submarine fan deposits in other regions and ages, accumulate data, and examine the effects of two-layer hybrid flows and/or debris flow on the formation of submarine fan by laboratory experiments and numerical simulations.

Keywords: Massive Sandstones, Submarine Fan, Grain Fabric

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[E] Oral | H (Human Geosciences) | H-CG Complex & General

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull), Chairperson:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Robert Michael Dorrell(University of Hull), Miwa Yokokawa(Osaka Institute of Technology)
Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.14 (Zoom Room 14)

We invite research based on all kinds of approaches to understand morphodynamics of sediment gravity flows including turbidity currents and debris flows. Multidisciplinary studies such as field observation, physical and numerical experiments, mathematical analysis, and studies from rock records are welcomed. Recent progress in research methodologies has greatly changed our understanding of dynamics of turbidity currents and relevant flows, submarine geomorphology and stratigraphy. The integration of such new knowledge on turbidity currents is important not only for scientific interests but also for practical application such as risk assessment of natural hazards, and exploration of resources. We anticipate interdisciplinary discussions about various aspects of turbidity currents, debris flows and other types of sediment gravity flows.

12:00 PM - 12:15 PM

[HCG21-11]Discussion

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[E] Poster | H (Human Geosciences)：H-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.09_2

[H-CG21] Sediment gravity flows: generation, morphodynamics and deposits

convener:Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Miwa Yokokawa(Osaka Institute of Technology), Michael Robert Dorrell(University of Hull)

We invite research based on all kinds of approaches to understand morphodynamics of sediment gravity flows including turbidity currents and debris flows. Multidisciplinary studies such as field observation, physical and numerical experiments, mathematical analysis, and studies from rock records are welcomed. Recent progress in research methodologies has greatly changed our understanding of dynamics of turbidity currents and relevant flows, submarine geomorphology and stratigraphy. The integration of such new knowledge on turbidity currents is important not only for scientific interests but also for practical application such as risk assessment of natural hazards, and exploration of resources. We anticipate interdisciplinary discussions about various aspects of turbidity currents, debris flows and other types of sediment gravity flows.

[HCG21-P01] Grain size segregation on cyclic steps formed by turbidity currents

*Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

Grain size segregation on cyclic steps formed by turbidity currents

*Hajime Naruse[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

Cyclic steps are long-wavelength bedform formed by Fr-supercritical flows and are characterized by the sustained occurrence of hydraulic jumps at the boundary between the downstream (lee side) and upstream (stoss side) slopes. Cyclic steps are frequently observed in deep-sea submarine fans and have recently been regarded as typical bedform formed by turbidity currents. Since submarine fan deposits often comprise large-scale hydrocarbon reservoir rocks, it is expected that the properties of reservoir rocks formed by cyclic steps will be understood in detail.

However, the cyclic step is a recently discovered bedform, and its properties especially on grain-size segregation process is still poorly understood. In this study, we developed a two-dimensional shallow-water equation model of turbidity currents that takes into account the mixed grain size, and conducted numerical experiments to clarify the grain-size segregation behavior of sediment composed of cyclic steps formed by turbidity currents. In the numerical model, the conservation law of kinetic energy is considered in addition to the conservation law of momentum and mass, and the active layer (sediment exchange layer) is set at the bottom to calculate the transport of sediment of mixed grain size.

Numerical experiments exhibited that coarse-grained sediment selectively accumulate on the upstream slope in cyclic steps caused by turbidity currents. In particular, the rapid accumulation of coarse-grained particles occurs at the points of hydraulic jumps, which correspond to the troughs of the bedform, and poorly sorted sediment is accumulated there as a result. This is consistent with the results of flume experiments in previous studies. In addition, the wavelength of the bedform changed with the grain size distribution of the turbidity currents. The flows transporting finer sediment tended to form steps of longer wavelength, and the shape of steps was also affected by the grain-size distribution of the suspended sediment. In the future, these characteristics will be compared with those of deposits of modern cyclic steps to validate the numerical model. We also aim to predict the characteristics of cyclic step deposits in the strata by numerical calculation.

Keywords: sediment gravity flow, bedform, grain size segregation, turbidity current, submarine fan

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.14 Zoom Room 14

[H-CG28] Earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Masayuki Ikeda(University of Tokyo), 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(Geological Survey of Japan, AIST), Masayuki Ikeda(University of Tokyo), 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.

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

[HCG28-01] Sedimentary environment and earthquake history off Cape Muroto, SW Japan

*Juichiro Ashi[1], Toshiya Kanamatsu[2], Masafumi MURAYAMA[3] (1.The University of Tokyo, 2.JAMSTEC, 3.Kochi University)

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

[HCG28-02] Detrital Zircon and Provenance Analysis of Sedimentary Rock in the Nemuro and Urahoro Groups, Eastern Hokkaido, Northern Japan

*Harisma Harisma[1], Hisashi Asanuma[2], Takafumi Hirata[2], Hajime Naruse[1] (1.Kyoto University, 2.University of Tokyo)

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

[HCG28-03] Numerical study on formation mechanism of *shoal* and *cauldron* topographies on the seafloor in the eastern Seto Inland Sea

*Motoki Ubara[1], Yusuke Uchiyama[1], Taichi Kosako[2] (1.Graduate School of Engineering, Kobe University, 2.Coastal and Estuarine Environment Department, Port and Airport Research Institute)

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

[HCG28-04] Long-term perspectives on coastal changes of the Mekong delta, Vietnam

*Toru Tamura[1] (1.Institute of Geology and Geoinformation Geological Survey of Japan, AIST)

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

[HCG28-05] Ichnodiversity in the Upper Cretaceous submarine channel-levee deposits: examples from the northern and southwest Japan

*Kazuki Kikuchi[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University)

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

[HCG28-06] Behavior of plucking of bedrock with fully developed joints and its sensitivity to surface roughness

*Masahiro Ishizuka[1], Noritaka Endo[1] (1.Kanazawa University)

Sedimentary environment and earthquake history off Cape Muroto, SW Japan

*Juichiro Ashi[1], Toshiya Kanamatsu[2], Masafumi MURAYAMA[3]

1. The University of Tokyo, 2. JAMSTEC, 3. Kochi University

Submarine landslide morphology is developed off the east cost of the Cape Muroto. Baba et al. (2017, JpGU abstract) estimated that this landslide caused tsunami disaster at the Shishikui village during the 1512 Eisho earthquake by numerical investigation. Hakuho-maru KH-16-5 and KH-17-2 cruises conducted subbottom profile survey (SBP) using ROV "NSS" and surface sediment core sampling at the largest landslide of this region. However, these studies did not show any evidence for recent landslide sedimentation and deformation. On the other hand, Baba et al. (2019, Tectonophysics) discovered a recent landslide west of our survey site by high resolution swath bathymetric survey, and suggests possibility of tsunami generation by the submarine landslide. The old landslide studied by core sampling and SBP survey at a water depth of 1050 m shows characteristic morphology and sedimentary structures associated with coutour current. Sedimentary structure of core samples also indicates contourite deposition. Moreover, turbidite deposits are obtained at the base of this slope. Recurrence interval of deep-sea turbdites is similar to that at the adjacent confined basin (Iwai et al., 2004, Mem.Geol.Soc.Japan). Limitation of direct sediment supply through river to our study site suggests earthquake-triggered mobilization of the surface slope sediments.

Keywords: contourite, turbidite, landslide

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Detrital Zircon and Provenance Analysis of Sedimentary Rock in the Nemuro and Urahoro Groups, Eastern Hokkaido, Northern Japan

*Harisma Harisma[1], Hisashi Asanuma[2], Takafumi Hirata[2], Hajime Naruse[1]

1. Kyoto University, 2. University of Tokyo

This study aims to examine the development processes of the Cretaceous to Paleogene sedimentary basins in the collisional zone between North East Japan and Kuril Arc systems on the basis of the U-Pb age distribution of detrital zircon grains in sandstones. The study area is located in the eastern part of Hokkaido Island, a part of the Nemuro Belt, which has been interpreted as a complex of deposits of forearc and foreland basins. Recently, the paleomagnetic analysis suggested that the Nemuro Belt complex records collisional process associated with block rotation that was driven by tectonic activity. This tectonic event is likely to cause uplifting of colliding arc crusts, and thus sediment provenance analysis in the depositional sequences of the Nemuro Belt will provide information about the exact timing and mode of the collision of two arc systems. For this purpose, this study investigated the Nemuro and Urahoro Groups that are well exposed in the Nemuro Belt complex area.

We report the first record of the U-Pb age distributions of detrital zircon grains in the Nemuro Belt. Fifty-five samples of sandstones were collected from outcrops. Detrital zircons were separated using standard mineral separation techniques at the Kyoto University. Approximately 200 grains were mounted for each sample, and their U-Pb age was measured by LA-ICP-MS (*Laser Ablation Inductively Coupled Plasma Mass Spectrometry*) to estimate the temporal variation of sediment provenances. In total, we evaluated 1053 LA-ICP-MS U-Pb detrital zircon ages, and these U-Pb sandstones analyses resulted four stratigraphic intervals with age peaks: (1) Early Jurassic (200-175 Ma), (2) Late Cretaceous (100-69 Ma), (3) Paleocene (66-56 Ma), and (4) Eocene (55 and 41 Ma). Dating results also define two detrital zircon U-Pb type signatures based on a similarity pattern of age populations. Type 1 signatures are found in the sandstones of the Shiomi, Beppo, Harutori, Tenneru, Yuubetsu, and Shitakara Formations and are characterized by peaks in the Paleogene (66-41 Ma), and type 2 signatures are found in the Hamanaka and Akkeshi Formations and are distinguished by the persistence of Mesozoic grains in the Early Jurassic (200-175 Ma). This result implies that the significant transition of the sediment provenance areas occurred at the uppermost horizon of the Nemuro Group (~60 Ma), which can be associated with the progression of the collision event between two island arcs.

Keywords: Nemuro Group, Sandstone, Urahoro Group, U-Pb dating, Zircon

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Numerical study on formation mechanism of *shoal* and *cauldron* topographies on the seafloor in the eastern Seto Inland Sea

*Motoki Ubara[1], Yusuke Uchiyama[1], Taichi Kosako[2]

1. Graduate School of Engineering, Kobe University, 2. Coastal and Estuarine Environment Department, Port and Airport Research Institute

The topography of the seafloor has an elemental importance to determining physical phenomena such as ocean currents, favorable habitats for marine organisms, optimal vessel navigation, exploration of undersea resources, etc. Prevailing currents and waves, as well as associated shear stresses acting on the ocean floor, are responsible for formation of typical topographic features including sea caldrons and sandbanks through erosion of bedrocks and sediments and their deposition processes. In the Seto Inland Sea (SIS), the most extensive semi-enclosed estuary in Japan, tidal currents are well known to serve pronouncedly for the formation of seafloor topographic features. However, due to the spatiotemporal complexity in 3-D flow field and resultant sediment transport, the formation processes of bathymetry and their underlying mechanisms have not been fully studied yet, in particular from a hydrodynamic viewpoint. This study aims at understanding bathymetric formation under predominance of tidal currents in a semi-enclosed estuary, where the SIS is chosen for the study area. The simulation results from a 3-D high-resolution Seto Inland Sea circulation model using the Regional Ocean Modeling System (ROMS) in a double nested configuration embedded in an assimilative JCOPE2 oceanic reanalysis product were utilized to examine detailed hydrodynamic processes for the topography formations in the SIS. First, the bottom shear stress and residual flow were evaluated from the modeled flow field to assess the potential for erosion of the seafloor topography. A strong correlation between the bottom shear stress and the scour depth of the erosive areas is observed, suggesting that seafloor is most likely eroded by the erosion effect of the near-bed tidal currents. Second, a simple sediment budget model was developed based on sediment erosion fluxes for each particle size typical of the bottom sediments of the SIS, i.e., gravel, sand, silt and clay, using the modeled bottom shear stresses primarily due to tidal currents. This budget model presumes depth-independent sediment concentration in each water column determined by the erosion and deposition fluxes and considers horizontal suspended sediment transport to investigate where and how erosion and deposition occur. Horizontal divergence of the residual flows indicates consistency between divergence (convergence) and erosion (deposition); the divergent outflow occurs on the eroded terrains, while the convergent inflow is prevailed on the deposited terrains frequently appeared in the vicinity of the eroded terrains. The sediment budget model also exhibits that sediments are generally transported from deep to shallow areas in the eroded terrains to form the deposited terrains fringing the eroded terrains, whereas sedimentation tendency differs largely from location to location.

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Long-term perspectives on coastal changes of the Mekong delta, Vietnam

*Toru Tamura[1]

1. Institute of Geology and Geoinformation Geological Survey of Japan, AIST

The Mekong delta, southern Vietnam, has suffered serious coastal erosion, following catchment disturbances, such as hydropower dams and river sand mining, over the last decades. Indeed, the delta area has shrunk since 2005 in contrast to the overwhelming expansion during Holocene. Here, long-term perspectives on coastal changes of the Mekong delta are presented by taking into account temporal and spatial variability based on sedimentological, geomorphological, and chronological characterization. The Mekong delta represents a typical mixed-energy delta, in which relative contributions of fluvial, wave, and tidal processes are spatially variable; tide-modulated wave processes dominate the open coast, whereas distributary channels are characterized by an upstream to downstream transition from fluvial to tide-dominated estuarine processes. All regions are influenced by strong contrasts between the winter and summer monsoons, which define an annual sedimentary cycle; the weaker southwesterly summer monsoon causes river flooding and sediment supply, whereas the northeasterly winter monsoon is dry and stronger, associated with limited fluvial sediment supply and asymmetric longshore sediment drift toward the southwest. The shrinkage of the Mekong delta has not happened evenly over the coast, but reflected a decline in accretion rate in the sandy river mouth area and significant erosion of the downdrift muddy coast. Behaviors of the sandy coast are characterized by 200–600 year cycles in which an emergence of river mouth bar causes a jump of elongate barrier shoreline several kilometers offshore, followed by a filling of back barrier with mud. This sporadic nature introduces uncertainties in estimate of sediment budget from short-term coastal mapping just over several decades. The serious erosion of the downdrift coast has continued for > 100 years and thus is not attributable to river dams and sand mining in the last decades. It may have reflected land-use changes in the catchment, construction of canal networks on the delta plain, climate changes, and possibly autoretreat. These spatially- and temporally-variable behaviors of the Mekong delta coast questions a view to simply link human disturbances with the delta shrinkage and motivates further sedimentological and geomorphological investigations.

Keywords: Human activity, coast, Southeast Aisa

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Ichnodiversity in the Upper Cretaceous submarine channel-levee deposits: examples from the northern and southwest Japan

*Kazuki Kikuchi[1], Hajime Naruse[1]

1. Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University

This study aimed to describe spatio-temporal variation of ichnoassemblages in the Upper Cretaceous deep-marine deposits in the northwestern Pacific area. It has been known that composition and number of ichnotaxa vary depending on depositional environments. Therefore, they are important and useful parameters to estimate depositional environments on the seafloor. Generally, ichnoassemblages in the submarine channel or proximal part of frontal splays are dominated in dwelling traces produced by crustacean. In contrast, small-sized, diverse patterned feeding or dwelling structures (graphoglyptids) are dominant in levees or distal parts of frontal splays. However, it is possible that the deep-marine ichnofacies was significantly different between those in Cretaceous and Cenozoic. Indeed, it is considered that some representative ichnotaxa in the Cenozoic deep-marine setting immigrated from the shallow-marine to deep-marine setting during Cretaceous. This study investigated the Upper Cretaceous submarine channel-levee deposits of the Nemuro, Himenoura, and Izumi groups to describe the ichnoassemblages and compare their characteristics with the Cenozoic ichnofacies model.

As a result, the ichnoassemblages in study areas showed low ichnodiversity and were different in composition from the previous ichnofacies models based on Cenozoic ichnoassemblages. In the Nemuro Group, 12 ichnogenera occurred from the levee deposits and no trace fossil was found in the channel-fill deposits. The ichnotaxa in the levee facies of the Nemuro Group consisted of the component ichnospecies of *Paleodictyon* ichnosubfacies while the number of ichnotaxa was smaller than that known in the Cenozoic models. In the Himenoura Group, 9 ichnogenera occurred from the channel-fill deposits and 7 ichnogenera were found in the levee deposits. The ichnoassemblages of the both of the channel-fill and levee deposits in the Himenoura Group were dominated in the grazing or dwelling traces produced by crustaceans and echinoids, and scarce in the patterned structures that consist of the *Paleodictyon* ichnosubfacies. In the Izumi Group, 11 ichnogenera occurred from the channel-fill deposits and 9 ichnogenera were found from the levee deposits. The ichnoassemblage in the Izumi Group was mainly composed of grazing or sessile feeding traces. In the Himenoura and Izumi groups, it was also characterized by high bioturbation intensity in the mudstone beds by the dwelling or grazing traces.

The difference among ichnoassemblages occurred in the groups can be explained by variation of preservation potential for each ichnotaxon caused by interactions of the benthic activity. The graphoglyptids, which is a representative group of the deep-marine trace fossils, are generally observable as convex hyporeliefs on the sole of turbidite sandstones. It is considered that they were primarily burrows or tunnels formed in fine-grained deposits near to the seafloor, and cast by subsequent deposition of sand. The high bioturbation intensity in the mudstone beds of the Himenoura and Izumi groups suggest high frequency of the dwelling or grazing behavior by large-sized benthic animals such as echinoids during inter-event[n1] periods of turbidity currents. This intense bioturbation could destroy the primary burrows or tunnels by the graphoglyptid producers and prevent to preserve the graphoglyptids.
The results of this study imply that the ichnoassembalges in the Upper Cretaceous deep-marine deposits may be characterized by high bioturbation intensity and low ichnodiversity. It is possible that decrease of bioturbation intensity in the near-surface deposits and consequent increase of preservation potential of the graphoglyptids may be a cause of the difference between the Cretaceous and Cenozoic

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ichnoassemblages. In future works, further observation focused on the bioturbation in the mudstone beds and benthic interactions will be needed.

Keywords: Trace fossil, Bioturbation intensity, Nemuro Group, Himenoura Group, Izumi Group

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Behavior of plucking of bedrock with fully developed joints and its sensitivity to surface roughness

*Masahiro Ishizuka[1], Noritaka Endo[1]

1. Kanazawa University

In bedrock rivers, the dominated mechanisms of riverbed erosion are abrasion and plucking; in the former, bedrocks are abraded by transported detrital particles, while in the latter, rock masses are detached at weakly bonded joints. While much experimental researches on abrasion have been performed from decades ago, only few experimental researches on plucking have been conducted, and the effect of roughness of rock riverbeds is unknown. In this study, we observed the influence of roughness on plucking, using a physical model in a circulating flume of 12 m long, 0.4 m wide, and 0.4 m deep. The modeled riverbed was examined while increasing the average flow velocity by gradually lowering the downstream weir, with a flow rate and channel gradient constant at 30 L/s and 0.1 %, respectively. A gypsum (specific density 1.32 to 1.44 g/cm^3) block was used as the analog material for the bedrock. Five conditions were tested: the blocks were arranged by differentiating the wavelength and height with regard to roughness of the bed surface. Results showed that plucking is more likely to occur for bedrocks with sufficiently developed joints if there is roughness. Plucking is more likely to occur in a block with a larger height of unevenness. This result simply means that the larger convex part receives a larger lift. In addition, however (somewhat opposite to intuition), as the wavelength of roughness decreases, the faster flow velocity is needed to make plucking occur. This result suggests that the flow modulated by the presence of the downstream concave portion reduces the lift from the flow applied to the block of the upstream convex portion on the other hand, our observation showed that plucking in a bedrock with roughness does not occur like a chain-reaction, i.e., following plucking after plucking is difficult to happen, because the detached blocks are likely to deposit in a concave potion and suppress the next plucking. Therefore, in the field, large fluctuations in hydraulic conditions and weather in a short period of time are necessary to promote plucking by breaking a temporarily stable arrangement of detached blocks, and these fluctuations are considered to control the long-term erosion rate in nature. Thus, it is likely that not only the time average value of hydraulic conditions but also the range and frequency (namely, pattern) of the fluctuation are also important.

Keywords: plucking, flume experiment, riverbed roughness, bedrock river, bedrock erosion

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.09_3

[H-CG28] Earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Masayuki Ikeda(University of Tokyo), 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.

[HCG28-P01] Preliminary study on the relationships between landform of coastal to alluvial plain and sediments supply from watershed

*Taku Komatsubara[1] (1.Institute of Geology and Geoinformation, Advanced Industrial Science and Technology)

[HCG28-P02] Relationship between magnetic anisotropy and hydraulic conditions in modern flood deposits

*Ryo Tateishi[1], Ichiro Kimura[1], Naoto Ishikawa[1] (1.University of Toyama)

[HCG28-P03] Flume experiment on crevasse-splay deposits formed by the 2019 flooding of the Chikuma River

*Taichi Kato[1], Masaki Yamada[1], Hajime Naruse[2], Sakai Yuichi[2] (1.Department of Geology, Faculty of Science, Shinshu University, 2.Graduate school of Science, Kyoto University)

[HCG28-P04] Sedimentary environments and fluctuations in lake levels as recorded in the latest Pleistocene and Holocene core from the Suwa Basin, central Japan

*Nozomi Hatano[1], Ritsuho Kawano[2], Kohki Yoshida[2] (1.Natural Environment Division, Nagano Environmental Conservation Research Institute, 2.Department of Geology, Faculty of Science, Shinshu University)

[HCG28-P05] Microcodization in a Kasimovian section of the Omi Limestone (Niigata Prefecture, central Japan), the Upper Carboniferous

*Yoshihiro Kakizaki[1], Yasuhiro Ota[2], Kenji Kashiwagi[3], Akihiro Kano[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Kitakyushu Museum of Natural History & Human History, 3. Graduate School of Science and Engineering for Research, University of Toyama)

[HCG28-P06] Coastal transport process of pebble along the Seisho Coast, Kanagawa Prefecture, estimated from changes in lithological composition and form of pebble particles

*Masaaki Shirai[1], Tomomi Akiyama[1], Kiyokazu Kawajiri[2], Takako UTSUGAWA[3], Takayuki Takahashi[4] (1.Tokyo Metropolitan University, 2.Sagamihara Cuty Museum, 3.Rissho University, 4.Tohoku University)

[HCG28-P07] A consideration of the age of the higher terraces in the southeastern part of the Kashiwazaki plain, Niigata Prefecture, central Japan.

*Satoshi Kaneko[1], Toshimichi Kaneto[1], Akiko Miyawaki[2], Akira Fukuchi[2], Mitsugu Momose[2] (1.Tokyo Electric Power Company Holdings, Inc., 2.Hanshin Consultants Co., Ltd.)

[HCG28-P08] Linear stability analysis of plane beds with active suspended load

Koji Ohata[1], *Hajime Naruse[1], Norihiro Izumi[2] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2.Graduate School of Engineering)

Preliminary study on the relationships between landform of coastal to alluvial plain and sediments supply from watershed

*Taku Komatsubara[1]

1. Institute of Geology and Geoinformation, Advanced Industrial Science and Technology

1. Introduction
Sedimentation data in water reservoirs became to be accumulated and annually published (e.g. Water Management and Land Conservation Bureau, MLIT, 2012), we are able to concretely discuss on the relationships between sediment production in upper course of watershed and sedimentation in the lower course of it. The presenter tried to make roughly clear some relationships among volume of the Holocene alluvium deposits, estimated duration of its sedimentation (temporary fill-up duration: estimated from sediment supply and volume of the Holocene alluvium) and geomorphological features especially river-channel landform, taking the case of seven coastal to alluvial plain which have different rate of sediment supply and geomorphological shape of sedimentary basin of the Holocene deposits.
2. Subject
ATST have continued a research project named “Investigation on Geology and Active Faults in the Coastal Zone of Japan” since 2007, its purpose is to make clear continuity of sedimentary bodies and geological structures. Subjects of this study are 7 areas (Table 1) of this AIST project except for Noto area (which do not accompany with alluvial plain).
3. Data
The author used deposition rates measured in water reservoir after Hasegawa et al. (2005) as basic data and Water Management and Land Conservation Bureau MLIT (2012) as supplementary data for estimating denudation rates in the upper course of the watershed (D), and roughly estimated sediment supply rates (S) by multiplying the area of watershed except for depositional area (Aw) and denudation rate (D). Volume of the Holocene alluvium and coastal deposits (Aa) is roughly estimated by multiplying mean thickness of the Holocene deposits (Ta) and total area of the Holocene alluvial and coastal plain (Aa). However, denudation rate (D) is short periods’ one (during only several ten years) when artificial action has done, so it may be larger than natural and long-term rate. And volume of the Holocene deposits (Aa) includes large errors (The author did not use GIS calculation).
4. Results
Va, S, temporary fill-up duration (F = Va / S), distance between recent river mouth and outer edge of the continental shelf (breadth of continental shelf), and so on in each district are shown in Table 1. This table indicates as follows. 1) The meandering channel and branching channel zones do not develop and only braided channel zone is dominant in the Sagami and Shizuoka Plains which F is less than several thousand years and less than several kilo-meters in breadth of continental shelf. 2) The braided, meandering and branching channel zones develop in the Niigata, Nobi and Tokusima Plains where F is several thousand years, breadth of continental shelf is several tens kilo meters. 3) The braided and meandering channel zone do not develop in the Yufutsu and Fukuoka Plains where F is larger than ten thousand years.
5. Discussion
F values of the Sagami and Shizuoka Plains are significantly shorter than actual duration of the Holocene deposits (several thousand to ten thousand years) and both plains directly face to deep sea. Much of sediments supplied to these plains should removed to deep sea bottom in short period. The other hand, F values of the Yufutsu and Fukuoka Plains are longer than ten thousand years, and these plains’ deposits include large amount of organic materials and they accompanies beach ridges. This investigation is no

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doubtfully loose one, however the author think it also have some values for discussion on sediment linkage from mountain, plain and sea.

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Keywords: Geomorphology, Denudation, Sedimentation, Watershd, On-going earth processes

地域	主要河川名・山地流域面積 Aw(㎢)	山地流域の削剥速度 D（㎜/年）	土砂流入速度 S（㎢/年） S=Aw×D	沖積平野の面積 Aa（㎢）	沖積層の平均厚さ Ta（m）	沖積層の体積 Va（㎢） Va=Aa×Ta	計算上満砂時間 F（年） F=Va／S	河道形態・平野地形*	盆地形態・海底地形**	陸棚幅*** （km）
勇払平野	安平川 400	±0.1	±4×10-5	80	±10	±0.8	±2×104	A+S	外洋・陸棚	21
新潟平野（新潟市以南）	*信濃川* 10000	±0.5	±5×10-3	800	±40	±30	±6×103	B+M+A+S	内湾・陸棚	33
相模平野	相模川 1500	±2	±3×10-3	80	±30	±2	±7×102	B+(M)+(S)	狭い入り江・深海	2
静岡平野	安倍川 500	±2	±1×10-3	40	±20	±0.8	±8×102	B	狭い入り江・深海	4
濃尾平野	木曽三川 8000	±1	±8×10-3	1100	±30	±30	±4×103	B+M+D	内湾	85
徳島平野	吉野川 3000	±0.5	±2×10-3	200	±20	±4	±2×103	B+M+D	内湾・陸棚	48
福岡平野	那珂川など 300	±0.1	±3×10-5	60	±5	±0.3	±1×104	D+(S)	多島海・内湾	210

斜字：中流に構造盆地をもつ河川

＊：河道形態・平野地形　B：網状河川(扇状地)　M：蛇行河川(蛇行原)　D：分岐河道(三角州)　A：アナストモージング河道(湿地帯)　S：浜堤列

＊＊：沖積層の受け皿の形態を特徴的に示す地形

＊＊＊：現河口から最も近い陸棚外縁までの距離

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Relationship between magnetic anisotropy and hydraulic conditions in modern flood deposits

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Introduction: The magnetic susceptibility measurement is widely used in paleocurrent reconstruction because of its high efficiency, but the relationship between the magnetic anisotropy and hydraulic conditions has not been well studied. In this paper, we discuss the relationship between magnetic anisoropy and paleocurrent / hydraulic conditions, based on the comparison of these analysis; observation of the modern flood sediments, the magnetic susceptibility measurement of each unit, and the particle orientation analyze using X-ray CT images.

Subject / Method: The location of the outcrop was at the east end of Toyama O-hashi on the right bank of the Jinzu River, Toyama Prefecture. The outcrop of mound-like deposits found here is 1.6 m high and 6.3 m wide, and distributed along a slope that dips 15˚ west toward the river channel. A 7cc plastic cube was used to collect samples in a fixed position, and magnetic susceptibility measurements, X-ray CT imaging, and particle analysis were performed to compare the results. ImageJ and R were used to analyze the particle orientation.

Results of field observation: The beds can be divided into three main units. The lowest unit, Unit A, consists of a 20cm thick, alternating layer of well-sorted very fine sand and fine sand, including plant fragments. The sand layer forms a foreset lamination along the slope. The upper unit, Unit B, consists of 22cm thick, well-sorted fine sand that eroding the Unit A. The sand layer has planar-cross lamination that is parallel to the channel associated with current ripple movement. The uppermost unit, Unit C, consists of 18cm thick, well-sorted fine sand with foreset lamination along the slope as in Unit A. Unit C contains no plant fragments.
Results of X-ray CT image analysis: The maximum axis of unit A is mainly towerd to the left bank or upstream direction with low angle (about 15˚), showing a radial distribution with large dispersion. The maximum axis of unit B is dominated by the upstream to downstream direction with low angle (about 15˚), and the dispersion is the largest. The maximum axis of unit C is towerd to the left bank with low angle (about 15˚), and the dispersion is the narrowest.
Results of magnetic susceptibility measurement: The shape of the anisotropy was all closer to oblate. The direction of the minimum axis of the anisotropy showed good concentration in each unit. In Unit A, the minimum axis is almost vertical, and the maximum axis has little variation and points to a very low angle (less than 10˚) on the left or right bank. In Unit B, the minimum axis is inclined by 30˚to 44˚ in the direction between the upstream and the left bank, and the maximum axis is highly variable and refers to the lower angle (less than 26˚) than the left bank. In Unit C, the minimum axis is almost vertical, the maximum axis is highly variable, and refers to the upstream, downstream right bank, and the very low angle (less than 8˚) of the right bank.

Discussion: Since the components of the particles do not change significantly with each unit and are not intercalated by temporal gaps such as mud drapes or organic thickening layers, this formation is considered to have been deposited in a single flood. The direction of deposition is basically lateral accretion along the slope. Considering the sedimentary structure and the upward coarsening of the units, the hydraulic conditions can be regarded as a lower flow regime for Units A / B and an upper flow regime

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for Unit C. X-ray CT image analysis of the particle orientation is consistent with this interpretation. When Unit A was deposited, the maximum axis was oriented toward the left bank due to down-slope gravity, and when Unit B was deposited, the downstream flow at the water level lowering was dominant, and the maximum axis was oriented in the upstream-downstream direction. When Unit C was deposited, the down-slope flow was more dominant than the downstream flow, and the maximum axis was concentrated in the left bank direction. The results of the magnetic susceptibility measurement indicate that it is difficult to completely reconstruct the paleocurrent direction and particle orientation from magnetic anisotropy alone, and that at least a detailed description and analysis of the facies is necessary. On the other hand, the increase in the dispersion of the maximum axis from unit A to unit C may reflect the increase in the traction force from the lower flow regime to the upper flow regime, suggesting that the magnetic anisotropy and hydraulic conditions correspond to some extent.

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Keywords: magnetic anisotropy, modern deposits, X-ray CT analysis

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Flume experiment on crevasse-splay deposits formed by the 2019 flooding of the Chikuma River

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On October 13, 2019, flooding of the Chikuma River was caused by heavy rain in central Japan. The 30 m wide levee revetment of the left bank of the river was breached over a length of 70 m in Hoyasu, Nagano City. As a result, gravelly and sandy piles were formed at upstream and downstream sides of the crevasse channel perpendicular to the river. This study aims to obtain a better understanding of the processes involved in transport and deposition during the flooding by flume experiments to reproduce the distribution and sedimentary characteristics of the surveyed crevasse-splay deposits.

In the flume experiments, we first mixed two types of sand grains with water, and flow it into the acrylic experimental flume which was a simplified scale model of the Chikuma River (about 2 m long and 8 cm wide). We used green-colored sand (150–250 μm in diameter) and red-colored sand (40–100 μm in diameter) as analogs of gravels and sand grains in field scale respectively. The flow depth in the main channel was controlled by narrowing the flume width at the downstream end with the board. After the flow reached the steady condition, we removed 2 cm high boards piled to compose the sluice gate (35 cm) at the middle part of the water way, causing levee breach on the floodplain (100×150 cm) adjacent to the water way. We conducted ten runs of the experiment with different conditions. Sediment sampling and analysis were conducted on Run 10 because of its highest reproducibility of the actual levee breach.

On Run 10, we first removed the top of four small boards to cause overspilling of the flow at the time of 59 s after the start of experiment. At the time of 28 s after overspilling, we removed two boards to cause the successive levee breaching while the last board was left until the time of 132 s after levee breach. Based on the video observation, a crevasse channel was formed the side sluice gate with deposition of piles composed of red sands on both sides of the channel during overflow stage. The direction of the crevasse channel was inclined downstream by 24° measured from the direction perpendicular to the main channel. Immediately after levee breach, the flooding flow swept away the sediment initially deposited on the bottom, and a pile of sediment was deposited instantly in the upstream region of the crevasse channel. As a result, the channel shifted its direction toward downstream (32° at 30 s after levee breach) because the sediment pile interrupted the flow. At the time of 90 s after the onset of levee breach, the depositional area in the upstream region of the channel expanded, and the channel consequently shifted to downstream direction furthermore (38°).

The measurement of the flooding flow indicated that the flow velocity immediately after levee breach was the highest during the experimental period. The flow in the overbank area was about 41 cm/s before levee breach and was about 83 cm/s at the timing when levee breach occurred. Then, it became about 53 cm/s at 60 s after levee breach. The pile deposited in the upstream side of the crevasse channel was formed from the bedload of the flooding flow in the initial stage of levee breach, and thus it presumably exhibited high bed shear stress. Subsequently, the pile was isolated at the upstream side by the shift of the crevasse channel to downstream region with waning of the flow velocity.
The feature of the coarse-grained pile in the upstream side of the crevasse channel quite resemble that of the gravel pile formed in the 2019 Chikuma River flooding. Thus, it can be interpreted that the crevasse splay deposits at the study site were formed in the similar process in which the shift of crevasse channel

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occurred with waning the flow. Further experimental and field surveys are needed to reveal whether the feature of the coarse-grained sediment pile examined in this study is a general characteristics of the crevasse splay deposits or it can be only formed at a specific hydraulic condition.

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Sedimentary environments and fluctuations in lake levels as recorded in the latest Pleistocene and Holocene core from the Suwa Basin, central Japan

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Introduction: The Suwa Basin is an inland basin located at a high altitude in central Japan. The sedimentation processes and sediment production in such a basin are regulated by a balance between the paleoclimate and tectonics (e.g., Shanley and McCabe, 1994; Miall, 1996). Furthermore, this basin, which has long daylight hours, can be expected to have archived paleoclimatic conditions. In this study, the sedimentary facies analysis, paleosol description, major elemental analysis, and CN elemental analysis were conducted for the late Pleistocene and Holocene boring core obtained at a site on the southern coast of Lake Suwa, to clarify the sedimentary processes occurring there and fluctuations in the lake water level.

Sedimentary facies and paleosols: The succession in the core can be divided into three sedimentological units based on the sedimentary facies, paleosols, TOC, TN, and C/N ratios. In ascending order, they are as follows: meandering fluvial, lacustrine, and delta units. The meandering fluvial unit is composed of inversely graded sand beds (crevasse splay deposits), alternating beds between sand and carbonaceous mud (fluvial and back-swamp deposits), and normally graded gravel–sand beds (channel deposits). The C/N ratios of this unit are relatively higher (10.25 on average) than those of the other units. Some paleosols are developed in this unit. These paleosols can be recognized by fine rootlet fossils, fecal pellets, illuviated clay, and brownish-reddish soil colors. Some of these paleosols underwent groundwater and surface-water gleizations. The lacustrine unit is composed of carbonaceous mud beds (pond deposits) and silt-clay beds (lake deposits) and has a low C/N ratios (8.19 on average). In this unit, some paleosols can be recognized by fine rootlet fossils and illuviated clay. The paleosol and lacustrine mud bed which has a high content of SiO_2 crowded with diatoms alternated between the depths of 14.5 and 18.0 m. The delta unit is dominated by gravel–sand and exhibits upward-coarsening successions.

Discussion: The accumulation curve constructed based on the calendar dates calculated from the ^{14}C ages provides the period of environmental changes in the Suwa Basin. Meandering fluvial depositions were laid from the last glacial maximum to ca. 15,000 cal years BP. The lacustrine (pond and marsh) environment expanded onto the study site from ca. 15,000 cal years BP. The primary productivity in the lake is considered to have been higher during the period ca. 12,000–6,000 cal years BP, based on the lower and static C/N ratios and higher TN. Delta progradation occurred at ca. 4,000–3,000 cal years BP. The repetition of paleosols and diatom-rich mud beds in the lacustrine unit suggests short-term fluctuations in the lake-level during the period between 12,000–7,000 cal years BP. The lake-level underwent declines in the period ca. 12,000–11,000 cal years BP and ca. 9,000–8,200 cal years BP. The high lake-level developing during the period ca. 7,000–4,000 cal years BP coincides with the middle Holocene climatic optimum (e.g., Wanner et al., 2008). These fluctuations of the sedimentary environments and the lake-level could have been caused by climate change and/or basement subsidence.

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This study was carried out under an ordinary research project (Research on the medium to long term management and maintenance of lakes, ponds, and their catchment areas in Nagano Prefecture) at the Nagano Environmental Conservation Research Institute.

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Keywords: late Pleistocene to Holocene, sedimentary facies, paleosol, lake-level, lacustrine deposits, Lake Suwa

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Microcodization in a Kasimovian section of the Omi Limestone (Niigata Prefecture, central Japan), the Upper Carboniferous

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INTRODUCTION

Microcodium is structure consisting of carbonate minerals, which are biologically induced via decomposition of organic matter (plant roots, fungi, corroded organic matter) by microorganisms in Ca-rich soil (Kabanov et al., 2008). Therefore, occurrence of *microcodium* from marine limestone is a powerful indicator of subaerial exposure.

Here, we report the occurrence of *microcodium* from the Gongen section of the Omi Limestone, a Caeboniferous–Permian seamount-type limestone in Niigata Prefecture, central Japan. In Japan, *microcodium* had been known as "*blackish brown sparry calcite*" (Machiyama, 1994). Hasegawa and Goto (1990) reported *blackish brown sparry calcite* is laterally and continuously occurred from the lower part of the *Triticites* zone (Kasimovian, the Upper Carboniferous) in the Omi Limestone. Takeuchi and Nakazawa (2010) also reported the occurrence of *microcodium* from the Upper Carboniferous in the Gongen section. However, they did not show the mode of occurrence and horizon.

AGE OF GONGEN SECTION

Schwagerinids (Fusuliniod foraminifer) are occurred from the middle (11 m horizon) and the uppermost part (28 m horizon) of the Gongen section, which exposes about 30 m–thick shallow marine limestone. They are identified as *Montiparus* sp., based on the following characters: 1) Small (about 2 to 3 mm diameter) and oval test with massive chomata and the relative primitive forms in the genus *Triticites* (s. l.) in the axial section, 2) Coiling tight in the early stage and gradually coiled with growth, and the dark colored secondary deposits near the septa and at the bottom of the chambers in the sagittal section. Hence, the middle to the uppermost horizons of the Gongen section can be correlated to the middle Kasimovian, the Upper Carboniferous (Davydov, 1990).

OCCURRENCE & CHARACTERISTICS OF MICROCODIUM

Microcodium is occurred in the upper horizon (~ 27 m horizon) of the Gongen section. The host rock of the microcodium is the Bioclastic Pack–wackestone, which is rich in fragments of crinoids and peloids. On the surface of the outcrop, the microcodium agglutination shows amorphous to gathering clouds–shape, and the gathering clouds–shaped agglutination partly extends to the direction of the bedding plane. In the microscopic views, *microcodium* shows a “corn-cob texture” with a diameter of ~2 mm, and is frequently occurred with solution voids filled with blocky cement.

ISOTOPIC RATIO OF MICROCODIUM

The bulk carbon isotope ratios (the $\delta^{13}C$ values) of Bioclastic Pack–wackestone, the host rock of microcodium, range from +0.8 to +3.5 ‰(Ave. +1.94 ‰), and the bulk oxygen isotope ratios (the $\delta^{18}O$ values) range from -6.9 to -5.5 ‰(Ave. -6.05). Meanwhile, the $\delta^{13}C$ values of microcodium range from +0.9 to +2.5 ‰(Ave. +1.68 ‰), and the $\delta^{18}O$ values range from -6.6 to -2.6 ‰(Ave. -4.40 ‰). On average, the microcodium has a lower $\delta^{13}C$ value (-0.26 ‰lower) and a higher $\delta^{18}O$ value (+1.65 ‰higher). The $\delta^{13}C$ values of *microcodium* are lower than those of host rock, probably because more ^{12}C were fixed in *microcodium* via microbial corrosion and decomposition process (Kabanov, 2008).

MICROCODIUM FROM OTHER SEAMOUNT-TYPE LIMESTONE IN JAPAN

From the above, it is interpreted that the Gongen section was subaerially exposed just after the middle

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Kasimovian, and then pedogenesis and microcodization were progressed on the surface of the limestone. *Microcodium* is also occurred from the Moscovian to the Kasimovian sections of the Akiyoshidai Limestone (Hasegawa, 1988; Machiyama, 1994; Sano et al., 2004). In particular, Sano et al. (2004) suggested that the Akiyoshidai Limestone was subaerially exposed during the late Kasimovian, based on the lack of the upper Kasimovian fusuline biozone. The *microcodium* has also been reported from seamount-type limestone in the Ashio Belt, which is thought to be the Kasimovian (Uchiyama et al., 2010). As the future works, it will be necessary to discuss about synchronism of the subaerial exposure and the microcodization of seamount-type limestone, including sea-level changes and the paleogeographic position of seamounts, comprehensively.

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Keywords: Microcodium, Carboniferous, Kasimovian, Omi Limestone, subaerial exposure, sea-level change

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Coastal transport process of pebble along the Seisho Coast, Kanagawa Prefecture, estimated from changes in lithological composition and form of pebble particles

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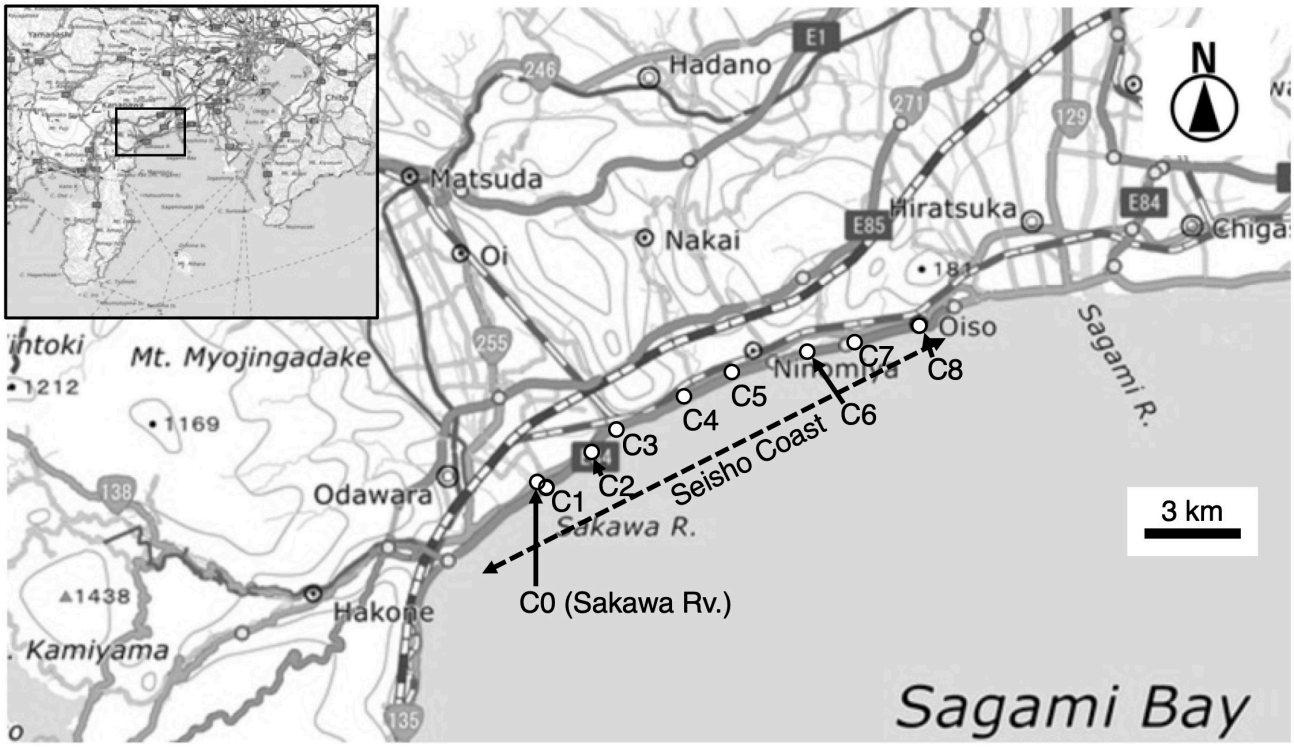
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Coastal erosion along the Seisho Coast, Kanagawa Prefecture has been one of the severe social problems on infrastructure. As a countermeasure to the coastal erosion of the Seisho Coast, artificial beach nourishment has been carried out since 1995. We estimate alongshore transport rate of pebble along the Seisho Coast using classical evaluation method of lithologic composition and flatness of pebble particles. Gravel beach of the Seisho coast is maintained by sediment supply from the Sakawa River which is rich in tuff and diorite gravels derived from the Tanzawa Mountains (e.g., Aramaki and Suzuki, 1962). Based on a temporal change of coast line on old topographic maps, spatial change of lithological composition and flatness of pebble particles along the coast, coastal transport of pebble along the Seisho Coast is estimated as below.
(1) Temporal seaward shift of shoreline occurred during 1916 to 1933. It might have been caused by increase in sediment supply due to the Taisho Kanto Earthquake slope failures at the Tanzawa mountains on 1923.
(2) An abundance of flat tuff gravels at site C5 ca. 7 km east from the Sakawa river-mouth imply that pebbles may have been transported along the Seisho Coast from the river mouth since 1923–1933. Therefore, eastward average transport rate of 16-32 mm size pebbles is estimated as 70–80 m/y.
(3) Tuff gravels with low average flatness at site C6 may be brought directly from the lower reaches of the Sakawa River by artificial beach nourishment since 1995. Site C6 locating 0.6 km east from the beach nourishment site is near enough to the site. Whereas, tuff gravels having been brought the beach nourishment site do not reach site C7 2.0 km east from the site yet.

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Keywords: pebble, transport process, flatness, beach nourishment, Seisho Coast

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A consideration of the age of the higher terraces in the southeastern part of the Kashiwazaki plain, Niigata Prefecture, central Japan.

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1. Tokyo Electric Power Company Holdings, Inc., 2. Hanshin Consultants Co., Ltd.

1.Introduction
The Kashiwazaki plain (15 km in length and 4 –7 km in width) locating in the middle part of Niigata Prefecture, central Japan is surrounded by Chuo Hills and Mt. Yoneyama.
The upper Pleistocene in this plain is described by Kashiwazaki plain Quaternary Formation Research Group (“KRG” , here in after) (1965) and Kishi et al. (1996), whereas the middle Pleistocene in this area has not been well studied, so far.
Our study implemented boring survey drilled to basement rock in order to grasp stratigraphy of the higher and middle terraces in the southeastern part of the Kashiwazaki plain.

2.Location of drilling
Kishi et al. (1996) classified terraces in the Kashiwazaki plain into the lower, middle and higher ones. The middle terrace is subdivided to M_{II} surface, M_I surface and M_I^+ surface from the lower, however several levels of higher terraces are lumped together as H surface. M_I and M_I^+ surface and H surface are correlated to Yasuda surface and Oumigawa surface that are defined by KRG (1965), respectively.
The middle and higher terraces are present in study area. The higher terrace in this area is higher than M_I surface by a level. Each three boring cores were drilled on M_I and H surfaces.

3.Stratigraphy in the southeastern part of the Kashiwazaki plain
Boring survey results showed that sediments in study area can be divided into three layers based on fining-upward cycle. These three layers are M_I terrace deposit, H terrace deposit and layer overlain by H terrace deposit, from the upper.
M_I terrace deposit under M_I surface is correlated to Yasuda Formation defined by KRG (1965), and this formation is subdivided into the lower and upper parts. Base of this formation shows coarse clastics consisting of gravels and coarse-grained sands, and silt or clay overlays them. Visible volcanic ash layer is absent in this formation.
H terrace deposit under H surface shows coarse clastics consisting of gravels at the base, and silt or clay overlying them. White-colored gravel layer consisting of well-rounded white-colored gravels is present in the lower part of this deposit. The combination of this white-colored gravel layer and overlying humic layer continues under Yasuda Formation. White fine vitric ash is present in the base of this layer.
Layer overlain by H terrace deposit is distributed only in the middle part of study area. Base of this layer shows coarse clastics consisting of gravels, and silt or clay overlays them. Visible volcanic ash layer is absent in this layer.

4.Analysis of tephra
White fine vitric ash in the base of H terrace deposit is correlated to Ata-Toihama tephra based on major chemical composition of glass shards. Presence or absence of volcanic ash in Yasuda Formation and loam overlying H terrace deposit is examined by particle composition analysis. This analysis revealed that cummingtonite is accumulated in the lower part of Yasuda Formation and in the base of loam. Cummingtonites are correlated to Iiduna Kamitaru c tephra based on their major chemical composition.

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5.Summary

Our study results are summarized as follows.

・M_I terrace deposit (Yasuda Formation) under M_I surface is correlated to MIS5e based on Iiduna Kamitaru c tephra.

・H terrace deposit under H surface is correlated to MIS7 based on Ata-Toihama tephra. It continues under M_I terrace deposit based on combination of characteristic facies.

・H terrace deposit under H terrace and layer overlain by H terrace deposits are present under M_I deposits (Yasuda Formation) and both are called “paleo-Yasuda Formation”, herein.

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Keywords: middle Pleistocene, upper Pleistocene, tephra, Niigata Prefecture

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Linear stability analysis of plane beds with active suspended load

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1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2. Graduate School of Engineering

Plane beds develop under riverine and marine environments and can be recorded as parallel lamination in sandstone beds, such as those found in turbidites. However, whereas turbidites typically exhibit parallel lamination, they rarely feature dunescale cross lamination. Although the reason for the scarcity of dune-scale crosslamination in turbidites is still debated, the formation of dunes may be dampened by suspended load. Here, I perform linear stability analysis to show that flows with suspended load facilitate the formation of plane beds. For a fine-grained bed, suspended load can promote the formation of plane beds anddampen the formation of dunes. These results of theoretical analysiswere verified with observational data of plane beds under open-channel flows. In the case of coarse-grained beds, the stability diagrams do not coincide with the experimental data of plane beds under sheet flows. Further analytical studies of bedforms should consider sheet flows, one of the transport modes associated with open-channel flows and sediment-laden gravity currents.

Keywords: bedform, turbidite, plane bed, dune, stability analysis

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.22 Zoom Room 22

[S-SS05] Crustal Deformation

convener:Masayuki Kano(Graduate school of science, Tohoku University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yoshiyuki Tanaka(Earth and Planetary Science, The University of Tokyo), Keisuke Yano(The Institute of Statistical Mathematics)

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

[SSS05-01] Formation simulation of imbrication and décollement under uniform compression based on the elasto-plastic soil mechanics

*Tomohiro Toyoda[1], Toshihiro Noda[1], Kazuya Onishi[2], Akira Asaoka[3] (1.Nagoya University, Disaster Mitigation Research Center, 2.Nagoya University, School of Engineering, 3.Association for the Development of Earthquake Prediction)

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

[SSS05-02] **Estimate of Strain Rate Field in Japan from GNSS Data: Comparison between Shen's Method and Basis Function Expansion**

*Tomohisa Okazaki[1], Yukitoshi Fukahata[2], Takuya NISHIMURA[2] (1.RIKEN Center for Advanced Intelligence Project, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SSS05-03] A Bayesian approach to estimating the crustal strain-rate fields from GNSS data and application to data from Mainland China

*ZIYAO XIONG[1], Jiancang Zhuang[1] (1.Institute of Statistical Mathematics)

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

[SSS05-04] Effects of curvature and lateral heterogeneities in elasticity constants on coseismic deformation

*Yoshiyuki Tanaka[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

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

[SSS05-05] Applicability of the Hamiltonian Monte Carlo method for single rectangular fault estimation

*Taisuke Yamada[1], Yusaku Ohta[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

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

[SSS05-06] Automatic detection of short-term slow slip events using GNSS data: An l1-trend filtering approach

*Keisuke Yano[1], Masayuki Kano[2] (1.The Institute of Statistical Mathematics, 2.Tohoku University)

Formation simulation of imbrication and décollement under uniform compression based on the elasto-plastic soil mechanics

*Tomohiro Toyoda[1], Toshihiro Noda[1], Kazuya Onishi[2], Akira Asaoka[3]

1. Nagoya University, Disaster Mitigation Research Center, 2. Nagoya University, School of Engineering, 3. Association for the Development of Earthquake Prediction

A wide variety of topography is known to be formed in the ground subjected to lateral compression, depending on the constituent materials and boundary conditions. In terms of a single displacement discontinuity, there exist "reverse faults" over 45 degree, “thrust faults” under 45 degree, and horizontal "décollements". A partitioned ground by the faults exhibits a “pop-up” structure with conjugate slip surfaces or “imbrication” with parallel slip surfaces. To simulate their irreversible and multi-step formation process, (1) the elasto-plastic constitutive model for describing material nonlinearity and (2) finite deformation scheme for tracing changes in shape and state of the ground are necessary. In this abstract, we introduce the results of the formation analysis of these structures based on our analysis code *GEOASIA* [1] that can consider (1), (2), the presence of pore water, and dynamics.

First, an elasto-plastic deformation analysis was performed with three plane-strain finite element meshes with different boundary conditions shown in Fig. 1 (a)-(c). Here, we conducted a single-phase elasto-plastic analysis considering the self-weight of the model. SYS Cam-clay model [2] was incorporated as an elasto-plastic constitutive model. The overconsolidated parameters in Noda et al. [3] exhibiting remarkable softening behavior after the peak strength (Fig. 2) were used. The shear strain distributions in Fig. 3 indicate that the analysis without fixation of the bottom displacement in (a) exhibited pop-up, whereas the analysis with the prescription of the linear bottom displacement distribution (uniform compression) in (b) obtained imbrication. Furthermore, the separation of the imbrication and the thrust sequence, i.e., piggyback in (b) and overstep in (c), were affected by the presence of the end friction. We successfully simulated characteristic structures with the irreversible and multi-step strain localization in the compressed ground based on the elasto-plastic finite deformation analysis and confirmed the effect of boundary condition.

Next, the soil-water coupled elasto-plastic analysis for the saturated ground was conducted. Material constants of semi-consolidated ground were adopted conforming to Yamada et al. [4] and the identical mesh of Fig. 1(c) was used. The lateral compressive behavior obtained by analysis of one-element width is indicated in Fig. 4. Figure 5 shows the transition of the shear strain distribution. At the beginning of the analysis, the appearance of the imbrication was confirmed in (a). However, in (b), the occurrence of dé collement with horizontal slip was solved at the central depth of the model. Then, a second slip occurred on the lower side of the first décollement and the region II accreted to the bottom of the region I in (c)-(d). The occurrence of the positive excess pore water pressure (Fig. 6) and the generation of a seismic wave due to brittle deformation (Fig. 7) were also solved.

(Acknowledgement) We received Grant-in-Aid for Scientific Research (Grant-in-Aid for Scientific Research (A): No. 17H01289).

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Keywords: Compression, Thrust fault, Imbrication, Décollement, Elasto-plasticity, Finite element analysis

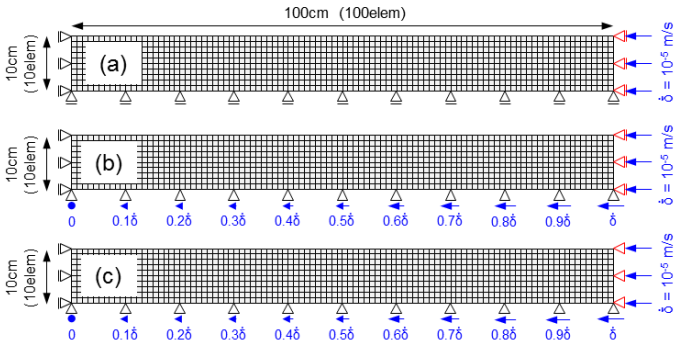


Figure 1. Finite element mesh

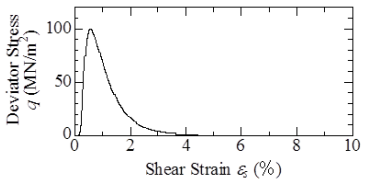


Figure 2. Drained triaxial compression behavior (p_0' = 82.8kPa)

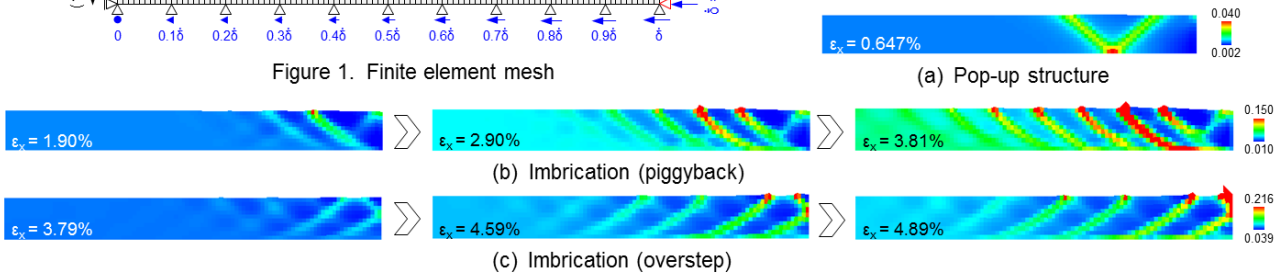


Figure 3. Shear strain distribution (single-phase analysis) (ε_x : horizontal strain of the model)

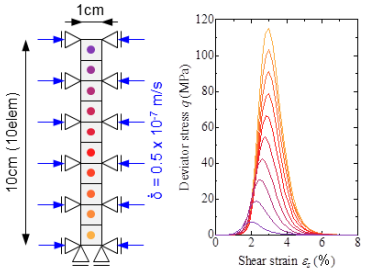


Figure 4. Lateral compressive behavior of one-element width analysis (plane-strain condition)

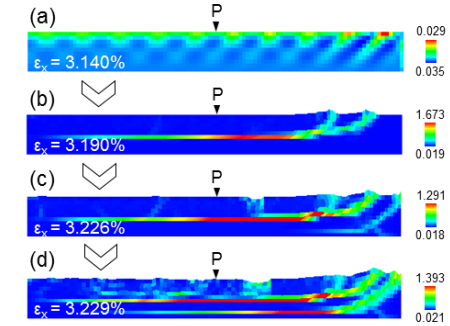


Figure 5. Shear strain distribution (two-phase analysis)

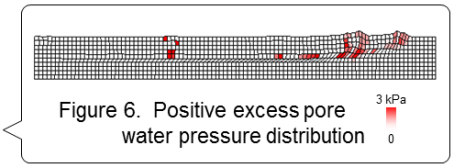


Figure 6. Positive excess pore water pressure distribution

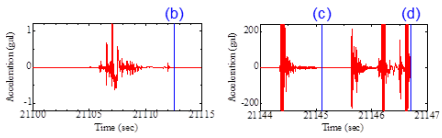


Figure 7. Vertical acceleration at point P in Fig. 5

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Estimate of Strain Rate Field in Japan from GNSS Data: Comparison between Shen's Method and Basis Function Expansion

*Tomohisa Okazaki[1], Yukitoshi Fukahata[2], Takuya NISHIMURA[2]

1. RIKEN Center for Advanced Intelligence Project, 2. Disaster Prevention Research Institute, Kyoto University

The method of Shen et al. (1996) (Shen's method) has been widely used to estimate strain rate fields from GNSS velocity data in various regions; for example, Sagiya et al. (2000) found a high strain-rate region named the Niigata-Kobe tectonic zone in central Japan. However, we point out three theoretical disadvantages of the method: inconsistency between estimated velocity and strain rate fields, inability to objectively determine the optimal value of the hyperparameter that controls the degree of smoothing, and inaccurate estimation of uncertainty. As an alternative, we propose a method of basis function expansion (Fukahata et al. 1996) with Akaike's Bayesian information criterion (ABIC) to estimate a velocity field; the above mentioned difficulties are overcome in the ABIC method, because the strain rate field is obtained by analytically differentiating the velocity field and the optimal values of hyperparameters are objectively determined with ABIC.

We applied both methods to GNSS data in Japan. The results of Shen's method significantly depend on a value of the hyperparameter, and show instability and inconsistency in peripheral regions of the observation network. On the other hand, the ABIC method does not suffer from these problems. The advantage of the ABIC method is also clear in terms of the trade-off between resolution and robustness. The strain rate field in Japan estimated form the ABIC method exhibits local deformation at active volcanos as well as regional deformation related to plate motions. The ABIC method is thus effective for analyzing crustal deformation using GNSS velocity data.

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A Bayesian approach to estimating the crustal strain-rate fields from GNSS data and application to data from Mainland China

*ZIYAO XIONG[1], Jiancang Zhuang[1]

1. Institute of Statistical Mathematics

We proposed a new Bayesian approach to estimate continuous crustal strain-rate fields from spatially discrete displacement-rate data, based on Global Navigation Satellite System (GNSS) observations, under the prior constraint on spatial flatness of the strain-rate fields. The optimal values of the hyperparameters in the model of strain-rate fields are determined by using Akaike's Bayesian Information Criterion. A methodological merit of this approach is that, by introducing a two-layer Delaunay tessellation technique, the time-consuming computation of strain rates can be omitted through the model estimation process. We applied the Bayesian approach to GNSS displacement-rate data in Mainland China and examined the correlation between the estimated strain-rate fields and seismic activity by using Molchan’ s Error Diagram. The results show that the increase rate of maximum shear strain is positively correlated with the occurrence of earthquakes, indicating the strain rate can be used to augment probability earthquake models for background seismicity forecasting.

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Effects of curvature and lateral heterogeneities in elasticity constants on coseismic deformation

*Yoshiyuki Tanaka[1]

1. Department of Earth and Planetary Science, The University of Tokyo

Recently, new geodetic observation data such as seafloor crustal deformation data and satellite gravity data have been used to study wide-area crustal movements and variations in the gravity field, associated with great earthquakes. These data are compared with a theoretical model to infer a space-time distribution of the fault slip and the locked region and mantle rheology that explain the data.

The essential component to construct a theoretical model is a Green’s function (GF) prescribing the elastic response to an internal dislocation. Many existing GFs assume a flat Earth and treat the effects of self-gravitation only approximately. Such GFs cause modeling errors when dealing with wide-area deformations obtained by the above observations. A spherical Earth model can be used to calculate the global deformation including the change in the gravity field naturally. However, most models considering lateral heterogeneities, based on an ordinary finite-element method (FEM), do not solve the deformation over the entire sphere and the effects of self-gravitation are also approximated.

In this presentation, we first compare a flat-Earth model with the PREM in the coseismic elastic deformation due to a great earthquake and show that a spherical model is necessary to deal with near-field (i.e., seafloor deformation) and far-field (i.e., GNSS) observation data consistently. Next, we introduce a spectral FEM, which combines a 1-D finite element and a spherical harmonic representation, to calculate global coseismic deformation effectively. We modify this method to include lateral heterogeneities in the elasticity constants and apply it to a deep earthquake. The effects of lateral heterogeneities in Lame’s constants are evaluated by comparing a surface displacement obtained for a laterally heterogeneous model with that obtained for a spherically symmetric case (PREM). A preliminary result indicates that the effect of lateral heterogeneity in the shear modulus is larger than in the bulk modulus and that a local heterogeneity including the source region can affect the coseismic deformation as strongly as a regional-scale heterogeneity outside the source region.

Keywords: crustal deformation, lateral heterogeneity, finite element method, gravity, satellite geodesy, seafloor crustal deformation

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Applicability of the Hamiltonian Monte Carlo method for single rectangular fault estimation

*Taisuke Yamada[1], Yusaku Ohta[1]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

The rapid estimation of the coseismic fault model and its uncertainty are extremely important to predict the possible hazard such as tsunami. Based on such motivation, Ohno et al. (in revision) developed the estimation method of single rectangular fault model deduced from Markov Chain Monte Carlo (MCMC) method in real-time. They adopted conventional Metropolis-Hasting (M-H) method to sample the probability density function. The M-H method, however, require long Markov chain because of the ideal acceptance ration is around 20-30%. Therefore, the large dimensional problem requires the very long mixing time.

To overcome such problem, we investigate the new estimation approach for single rectangular fault model based on the Hamiltonian Monte Carlo (HMC) method. HMC is a MCMC method that uses the derivatives of the density function being sampled to generate efficient transitions spanning the posterior. It uses an approximate Hamiltonian dynamics simulation based on numerical integration which is then corrected by performing a Metropolis acceptance step. To calculate the numerical integration, we adopted the leapfrog integrator, which is a numerical integration algorithm. During the leapfrog integrator, we need to assume the discretization time (e) and number of steps (L). To estimate the appropriate number of leapfrog (L), we adopted the no-U-turn sampler (NUTS). We also assumed the discretization time (e) as 10^{-4} which was determined by try-and-error. The model parameter vector that contains fault parameters of a single rectangular fault model (Okada 1992). To optimize amount of each step size for unknown parameters, we installed logit transformation for all unknown parameters except for latitude and longitude.

We applied the developed approach to numerical experience which was under the optimum site coverage. Obtained results clearly shows the rapid convergence (~1000 steps) which clearly shorter step number compared with M-H method. We will show the more detail of our developed method and results for more realistic site coverage.

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Automatic detection of short-term slow slip events using GNSS data: An l1-trend filtering approach

*Keisuke Yano[1], Masayuki Kano[2]

1. The Institute of Statistical Mathematics, 2. Tohoku University

Short-term slow slip events (SSEs) are fault slip events that occur at a slower rate than regular earthquakes and are observed by geodetic instruments such as the Global Navigation Satellite System (GNSS) and tiltmeters. The durations of short-term SSEs generally ranges from a few days to a few weeks (Obara and Kato, 2016), and SSEs occur beneath subduction zones (e.g., Sekine et al., 2010, Nishimura et al., 2013). Since SSEs have close connections to the other seismic activities such as megathrust earthquakes and low-frequency earthquakes (Kano et al., 2019), detection of SSEs is important. Nishimura et al. (2013) proposed a short-term SSE detection method based on model comparison in a moving window using the Akaike information criterion (AIC) and detected short-term SSEs in southwest Japan. This method has high detection accuracy when hyperparameters such as the length of a moving window are given properly, yet it is difficult to determine these parameters properly.

In this presentation, we propose a detection method from multiple GNSS stations based on l1 trend filtering. We apply the proposed method to GNSS data in western Shikoku, and present the results of inversion analysis using Markov Chain Monte Carlo (MCMC) method for estimating the fault models of the detected events. The proposed method considers short-term SSEs as the change points in GNSS displacement data, and quantifies the uncertainty of the change points using multiple observation points. The hyperparameters in the proposed method can be appropriately determined by using Mallows' Cp.

The proposed method conducts (a) trend filtering, (b) testing using neighboring observation stations, and (c) integrating the test results in a stepwise manner. We first fit a piecewise linear function to the observed time series by l1 trend filtering (Kim et al., 2009). The length of the interval before and after the node is automatically determined by using the nodes of the l1 trend filtering. We finally integrate the p-values of the tests for detection uncertainty at multiple observation stations. l1 trend filtering is a sparse estimation method, also called higher order total variation regularization, that accurately estimates piecewise polynomial function hidden in the input. In the subsequent tests, we use the segmentation points obtained by l1 trend filtering.

To validate the accuracy of the proposed method, we use GNSS data for western Shikoku during April 1, 2004 to March 31, 2009, and synthetic data generated from this data; GNSS common mode errors are removed by subtracting the average time series of three stations in the Goto Islands (Kano et al, 2019), and the two-dimensional displacement data are projected in the direction of subduction of the Philippine Sea Plate relative to the Amur Sea Plate (N45W). The comparison using synthetic data shows that the missed event rate and noise false positive rate of the spatial average of AIC vary with the window width, while the proposed method performs as well as the spatial average of AIC with an appropriate window width. We report the results of using the proposed method on real data and the fault model estimation using MCMC.

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.22 Zoom Room 22

[S-SS05] Crustal Deformation

convener:Masayuki Kano(Graduate school of science, Tohoku University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Yusuke Yokota(Institute of Industrial Science, The University of Tokyo)

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.

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

[SSS05-07] New stable slip on the plate in a wide area after 2015 detected by postseismic deformation model of 2011 Tohoku-Oki Earthquake

*Satoshi Fujiwara[1], Mikio Tobita[1], Shinzaburo Ozawa[1] (1.Geospatial Information Authority of Japan)

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

[SSS05-08] Preliminary results of sea-floor crustal deformation measured by GNSS-Acoustic technique in Nemuro-Oki, southwestern part of Kuril Trench

*Yusaku Ohta[1], Motoyuki Kido[2], Chie Honsho[1], Yukiho Kimura[1], Makiko Sato[1], Syuichi Suzuki[1], Ryosuke Azuma[1], Mako Ohzono[3,5], Hiroki Aota[3], Hiroaki Takahashi[3], Fumiaki Tomita[4], Takeshi Iinuma[4], Masanao Shinohara[5], Ryota Hino[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. Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 4.Japan Agency for Marine-Earth Science and Technology, 5.Earthquake Research Institute,The University of Tokyo)

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

[SSS05-09] Monitoring of the inter-plate coupling using GNSS-A seafloor geodesy along the Nankai trough

*Tadashi Ishikawa[1], Shun-ichi Watanabe[1], Yuto Nakamura[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

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

[SSS05-10] Relationship between observation ability of GNSS-A and its detection ability for coupling condition and SSE

*Yusuke Yokota[1], Tadashi Ishikawa[2], Shun-ichi Watanabe[2], Yuto Nakamura[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic Department, Japan Coast Guard)

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

[SSS05-11] **Estimation of Average Displacement Rate Vector Using GNSS Data in Yaeyama Islands**

*Aoi Ikeichi[1], Masayuki Kano[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Kazuki Komano[2], Takuya NISHIMURA[3], SHINICHI MIYAZAKI[2] (1.Graduate School of Science, Tohoku University, 2.Graduate School of Science, Kyoto University, 3.Disaster Prevention Research Institute, Kyoto University)

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

[SSS05-12] **Possible overlap of coseismic slip and afterslip investigated by InSAR analysis**

*Kanami Sakamoto[1], Yo Fukushima[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

New stable slip on the plate in a wide area after 2015 detected by postseismic deformation model of 2011 Tohoku-Oki Earthquake

*Satoshi Fujiwara[1], Mikio Tobita[1], Shinzaburo Ozawa[1]

1. Geospatial Information Authority of Japan

Outline

The time series of the postseismic deformation of the 2011 off the Pacific coast of Tohoku earthquake (Tohoku-Oki earthquake) is fitted by a function to predict the future changes over a wide area. In this presentation, we validate the model of the postseismic deformation using data up to December 2020, and find that a new stable slip on the plate has occurred since 2015 in the residuals between the observed data and the model.

Method

It has been shown by Tobita (2016) that a mixed model of two logarithmic and one exponential functions, represented by the following equation, can be used to predict with high accuracy the spatial distribution of postseismic deformation:

$$D(t) = a \ln(1+ t/b) + c + d \ln(1+ t/e) - f \exp(- t/g) + Vt$$

where $D(t)$ is each component of the postseismic deformation, t is days after the earthquake, ln is the natural logarithm, b, e, and g are the relaxation time constants of logarithmic or exponential functions common to all stations, and V is the steady-state velocity at each station. The time constants were determined for stations, Miyako, Yamoto, Minase, and Choshi, which show representative variations, as used in Tobita (2016); for the other stations, the determined time constants were given in common, and the amplitude coefficients were determined for each station and component by the least-squares method.

Results

Fig. 1 shows the observed values of the east-west component at two GEONET stations, the predicted values based on the 3.9-year fitting (until February 2015), and their residuals. The predicted values agreed with the observed values to within 1 cm until February 2015, but then showed a different trend after earthquakes in Sanriku-Oki (M6.9) in February 2015 and Miyagi-Oki (M6.8) in May 2015. This is not only shown in the residuals, but also the time constant g of the exponent in the above prediction model becomes computationally saturated if we include 2015 and beyond in the fitting period, indicating that another event occurred in 2015 different from the postseismic deformation of the Tohoku-Oki earthquake.

Obtaining a slip model from residuals

The systematic changes in residual from the prediction model after 2015 occurred simultaneously over a wide area from Hokkaido to the Chubu region, and each continued at an almost constant rate. In order to investigate the cause of this phenomenon, a slip velocity model on the plate surface was calculated as shown in Fig. 2, which shows a few centimeters of slip per year.

The location of this slip can be roughly divided into two areas: Sanriku-Miyagi-Oki and Urakawa-Oki. The Sanriku-Miyagi-Oki area is almost coincident with the afterslip region that began immediately after the Tohoku-Oki earthquake. In contrast, no significant slip was observed in the Urakawa offshore area before 2015, and it was newly added after 2015.

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The location and timing of the systematic residuals coincide with those of the Sanriku-Oki earthquake (M6.9) in February 2015 and the Miyagi-Oki earthquake (M6.8) in May 2015. This suggests that the onset of the slip and the occurrence of these medium-sized earthquakes are somehow related.

Conclusion

The prediction model by Tobita (2016) is able to predict the postseismic deformation of the Tohoku-Oki earthquake with an accuracy of a few centimeters even after 9 years. The residuals obtained from the prediction model are very effective in detecting the occurrence of other events that are not the postseismic deformation (e.g. Ozawa *et al.* 2016), and are expected to be used in various fields.

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Tobita M (2016) Earth Planets Space. https://doi.org/10.1186/s40623-016-0422-4.

Keywords: the 2011 off the Pacific coast of Tohoku Earthquake, crustal deformation, postseismic deformation, stable slip, GNSS time series, predicting model

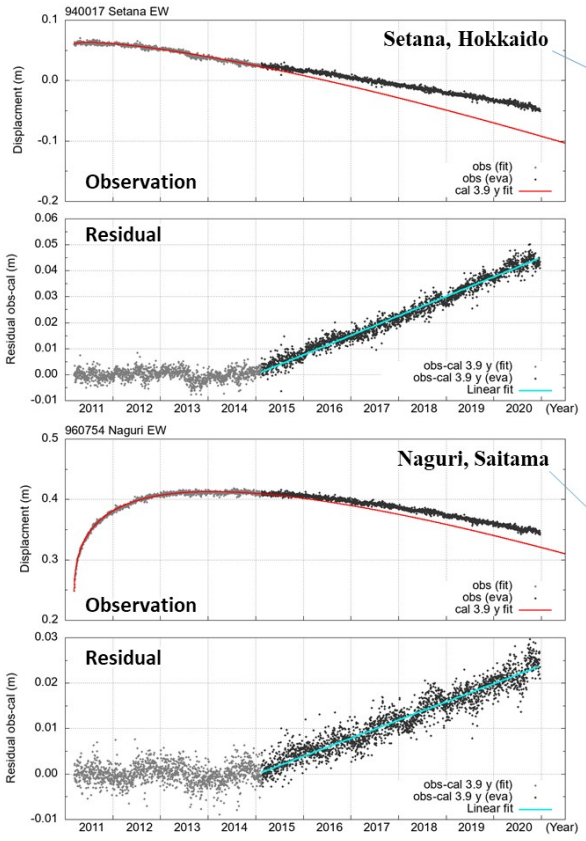


Fig 1.
above : EW displacement (dot) and forecasting model (red line) at Setana and Naguri stations.
below: Residual (dot, obs – model cal) and linear fit after 2015 (light blue line).

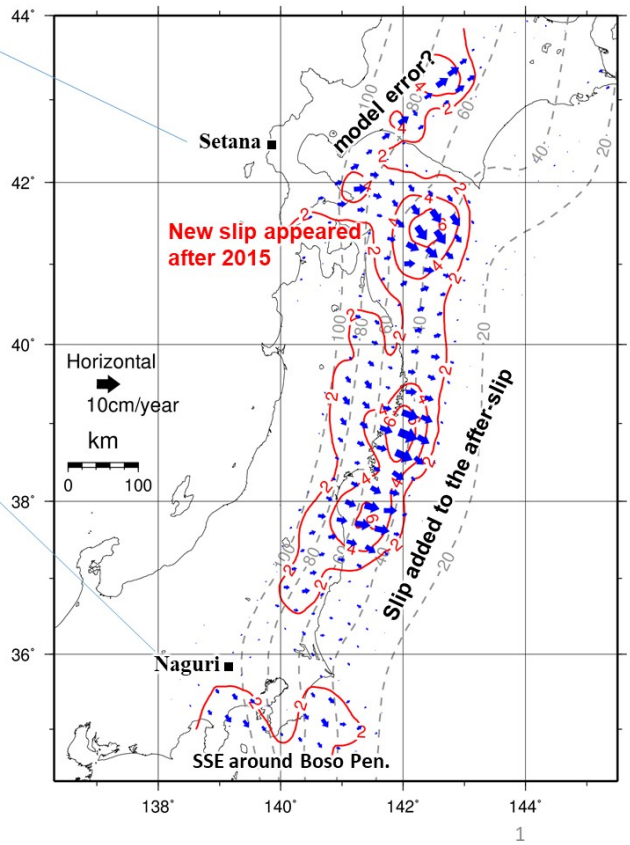


Fig 2. Slip rate model on the plate after 2015.

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Preliminary results of sea-floor crustal deformation measured by GNSS-Acoustic technique in Nemuro-Oki, southwestern part of Kuril Trench

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The sea-floor geodetic technique including GNSS-Acoustic measurement played an important role to understand the coseismic slip behavior in the 2011 Tohoku-Oki earthquake and revealed that more than 50m coseismic slip occurred at the shallow part of the plate boundary. In order to understand the diversity of earthquakes, it is essential to clarify the factors that determine the large slip at the shallow part of the plate boundary from comparative studies with past huge earthquakes in other regions.
In the Nemuro-Oki of the southwestern part of Kuril Trench, M8 class earthquakes have repeatedly occurred in the Tokachi-Oki and Nemuro-Oki segments. On the other hand, based on the survey of the distribution of tsunami deposits, it has been pointed out that a large slip may have occurred in the shallow part of the plat boundary in the 17th century, rupturing both of the Tokachi-Oki and Nemuro-Oki segments, and that the slip characteristic is similar with the 2011 Tohoku-Oki earthquake (Ioki and Tanioka, 2016). In contrast, Nemuro-Oki is no sea-floor geodetic network.
Based on these backgrounds, Tohoku University and Hokkaido University have jointly developed a sea-floor geodetic network to estimate the interplate locking at the shallower portion of the subducting plate interface, and installed three GNSS-A stations (G21, G22, and G23) in Nemuro-Oki. The G21 and G22 were installed on the landward slope, and the G23 installed on the incoming Pacific plate. The first observation was carried out in July 2019, and the second in October 2020. Although the obtained results are still tentative because of the only two times observations, the estimated horizontal velocity shows the more than 9cm/year to the northwest direction relative to the Okhotsk plate in both of G21 and G22. This result is expected to suggest that the interplate locking at the shallow part of the subducting plate interface. The modeling of these results will be discussed in detail in the presentation.

Keywords: Sea-floor geodesy, GNSS-A, Nemuro-Oki

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Monitoring of the inter-plate coupling using GNSS-A seafloor geodesy along the Nankai trough

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Recurring inter-plate megathrust earthquakes have occurred along the Nankai Trough subduction zone and the next earthquake in this region is predicted to occur in the near future. Because megathrust earthquakes are driven by accumulated inter-plate slip deficit, it is necessary to monitor the inter-plate coupling state. Crustal deformation data obtained from geodetic observations is an important tool for monitoring the coupling state. However, as the focal region of the Nankai trough earthquake is located beneath the seafloor, estimations based on terrestrial observations provide limited accuracy. Therefore, seafloor geodetic observations are particularly important for monitoring the coupling state. The Hydrographic and Oceanographic Department of the Japan Coast Guard has been developing a seafloor geodetic observation system based on the combined GNSS-Acoustic ranging (GNSS-A) technique and collecting data to monitor the coupling state.

Yokota et al. (2016) estimated inter-plate slip deficit rate of the Nankai trough subduction zone using the GNSS-A seafloor geodetic data. However, temporal variation of the coupling state could not be investigated due to the inadequacy of temporal resolution of the GNSS-A data. On the other hands, slow earthquake phenomena such as slow slip events (SSE) frequently occur along the Nankai trough. Therefore, it is essential to understand the temporal variations of the coupling state.

To clarify the difference between the SSE regions and the strong coupling regions, we evaluate the average coupling state estimated from the long-term GNSS-A data updated from Yokota et al. (2016). Because the long-term data include the SSE occurrence periods, the crustal velocity becomes relatively slow in the SSE regions. Therefore, the difference from the strong coupling regions where the crustal velocity is relatively fast becomes clear. Attritionary, we investigate temporal variations of the coupling state represented as deviation from the average state.

Keywords: GNSS-A, Seafloor geodesy, Nankai trough earthquake

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Relationship between observation ability of GNSS-A and its detection ability for coupling condition and SSE

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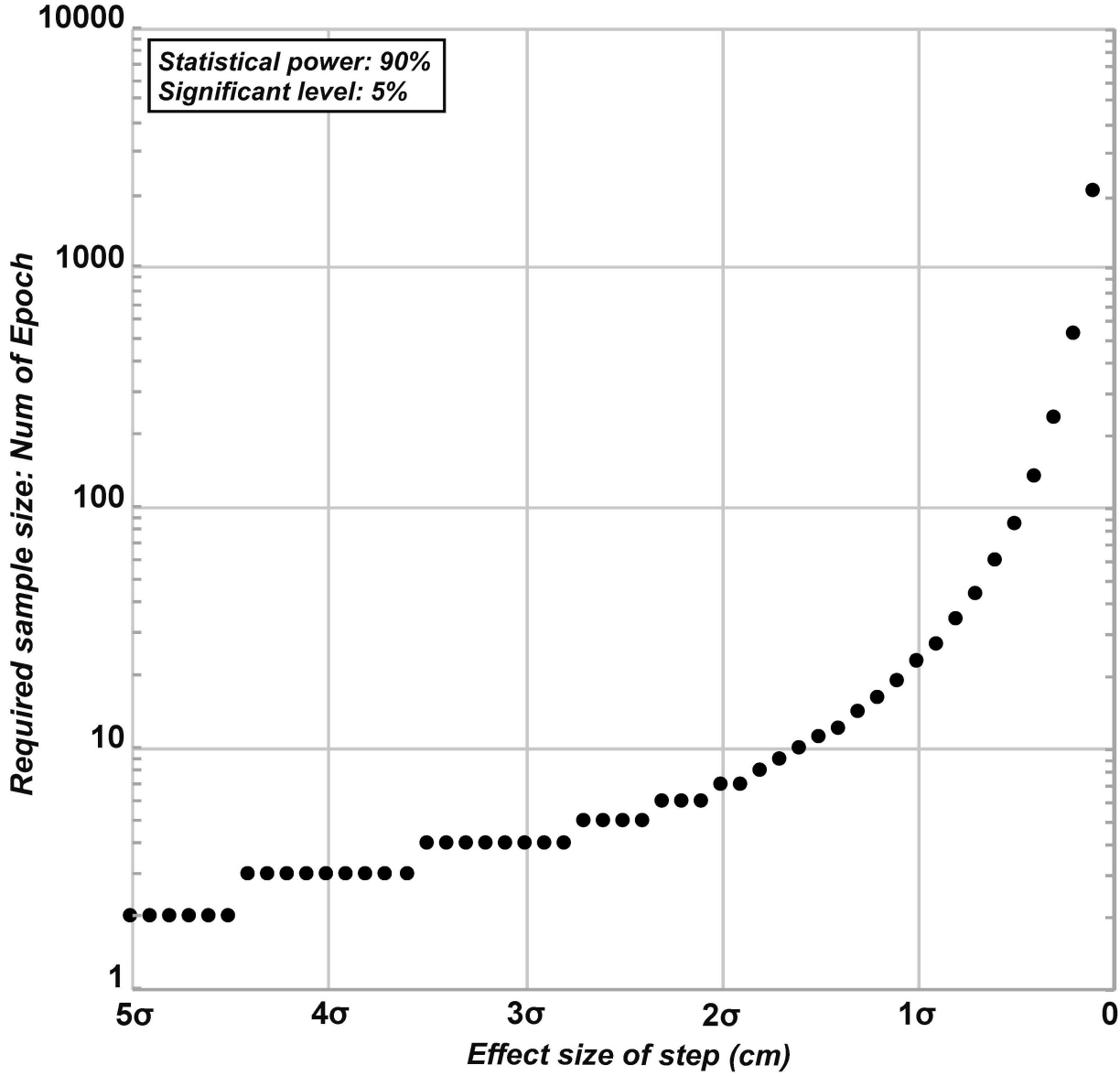
The observation frequency and observation accuracy of GNSS-A seafloor geodetic observations carried out by the Japan Coast Guard are currently 4 times/year and 2 cm (1-σ) due to technological development in about 20 years [Ishikawa et al., 2020]. By accumulating long-term observation data, it has become possible to measure interplate coupling condition and shallow slow slip events along the Nankai Trough in recent years [Yokota et al., 2016; Yokota and Ishikawa, 2020], and it has become possible to interpret the time change of postseismic deformation following the 2011 Tohoku-oki earthquake [Watanabe et al., 2014]. However, the physical process of the plate boundary can be understood by understanding the more detailed time change of a coupling condition and the postseismic processes and improving the SSE detection accuracy. This consideration will also be useful for understanding the observation results of new observation points. In this presentation, we will understand how a steady state and an event can be detected by improving GNSS-A observation ability in the future, and set development goals for that purpose.

In order to understand the detection ability of the steady state, it is sufficient to generate pseudo data with frequency and accuracy and compare the accuracy of linear regression. On the other hand, in order to understand the ability to detect events, comparison is made using detection power. Attached figure compares effect size of event step (here, the magnitude of crustal deformation due to an event) and required sample size (here, annual observation frequency). σ means the accuracy of GNSS-A obseravtion. It shows how much an event can be detected regarding to the GNSS-A observing ability. From this figure, it can be seen that when the scale of crustal movement caused by the event approaches the same level as the error, it is difficult to detect it at the current observation frequency (several times per year).

The observation ability about time constant cannot be determined by this numerical test. In this presentation, we also discuss the accuracy of event time constant and magnitude detections through some numerical experiments.

Keywords: GNSS-A, SSE, interplate coupling

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Estimation of Average Displacement Rate Vector Using GNSS Data in Yaeyama Islands

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1. Graduate School of Science, Tohoku University, 2. Graduate School of Science, Kyoto University, 3. Disaster Prevention Research Institute, Kyoto University

The Southern Ryukyu region including Yaeyama Islands is located in the southwestern part of the Ryukyu Trench, where the Philippine Sea Plate is subducting beneath the Eurasian Plate. It is well known that this region has been recurrently damaged by tsunami, e.g. the 1771 Yaeyama earthquake. Nakamura (2009) estimated the source region of the 1771 earthquake at the shallow part of plate boundary. On the other hand, on the deeper part of the plate interface at depths of 30 –60 km, SSEs with Mw ~6.6 recur with intervals of ~6 months (Heki and Kataoka, 2008; Nishimura, 2014; Tu and Heki, 2017). To understand crustal deformation in this region, GNSS observations have been conducted since 2010 by Kyoto University in addition to the permanent GEONET stations. Although these GNSS data have revealed the detail source processof the SSEs (e.g. Kano et al, 2018), few studies discussed interplate locking along the plate boundery. Therefore, we estimate average displacement rate in Yaeyama Islands based on GNSS data and discuss the interplate locking along the southern Ryukyu Trench.

We used daily coordinate data in the IGS14 coordinate system from 2010 to 2018 in a 18 GNSS stations consisting of 10 GEONET and 8 GNSS stations by Kyoto University. The average displacement rate was estimated by removing deformation due to SSEs, steps by earthquakes and antenna replacement from timeseries. Following Tu and Heki (2017), the time constant for each SSE was determined by grid search using the N20W components at 0751 (Hateruma Island), the nearest station to the trench. This direction is almost parallel to that of the plate convergence. We used the onset of each event determined by Tu and Heki (2017) or Kano et al. (2018) for the SSEs before the 2016 and visually defined for those after 2017. We considered the steps of earthquakes larger than M6.0. Then, the average displacement rate, steps of earthquakes and antenna replacements, amplitudes of SSEs were estimated using the least squares method.

As a result, Yaeyama Islands are entirely moving in a southeast direction at a rate of 5 to 8 cm/yr with respect to the IGS14 coordinate system. This steady motion is thought to be the sum of the rigid block motion, consisting of translation and rotation component, and the effect of the plate subduction. The translation component of rigid block motion was removed by subtracting the rate of reference site (0498, Miyako Island). The rotation component of the southern Ryukyu block relative to the Amurian plate was calculated from the Euler-pole and angular rate estimated in Nishimura et al. (2004).

We estimated coupling area based on the back-slip model. A fault model was approximated by a single rectangle assuming a semi-infinite homogeneous elastic body (Okada, 1992). For the fault locations, we assumed two areas: one in the shallow part near the 1771 Yaeyama earthquake and the other in the deep SSE area. We referred to Nakamura (2009) for the fault parameters such as fault length and fault width to the values for the shallow part and to Heki and Kataoka (2008) for those of the deeper part. The fault width, rake angle, and back-slip were adjusted by trial and error to reduce the difference between the observed and calculated rates. We successfully reproduced the observations at most of the stations although there were some negligible misfits at stations in Yonaguni and Ishigaki Island. The back-slip rate

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are 9 cm/yr at the shallow part and 12 cm/yr at the deeper part. By comparing the plate subduction rate of ~9 cm/yr, our results suggest the existence of the interplate locking on the shallow part of the southern Ryukyu subduction zone.

Keywords: Average displacement rate, interplate locking, Ryukyu Trench, GNSS, back-slip, Yaeyama earthquake

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Possible overlap of coseismic slip and afterslip investigated by InSAR analysis

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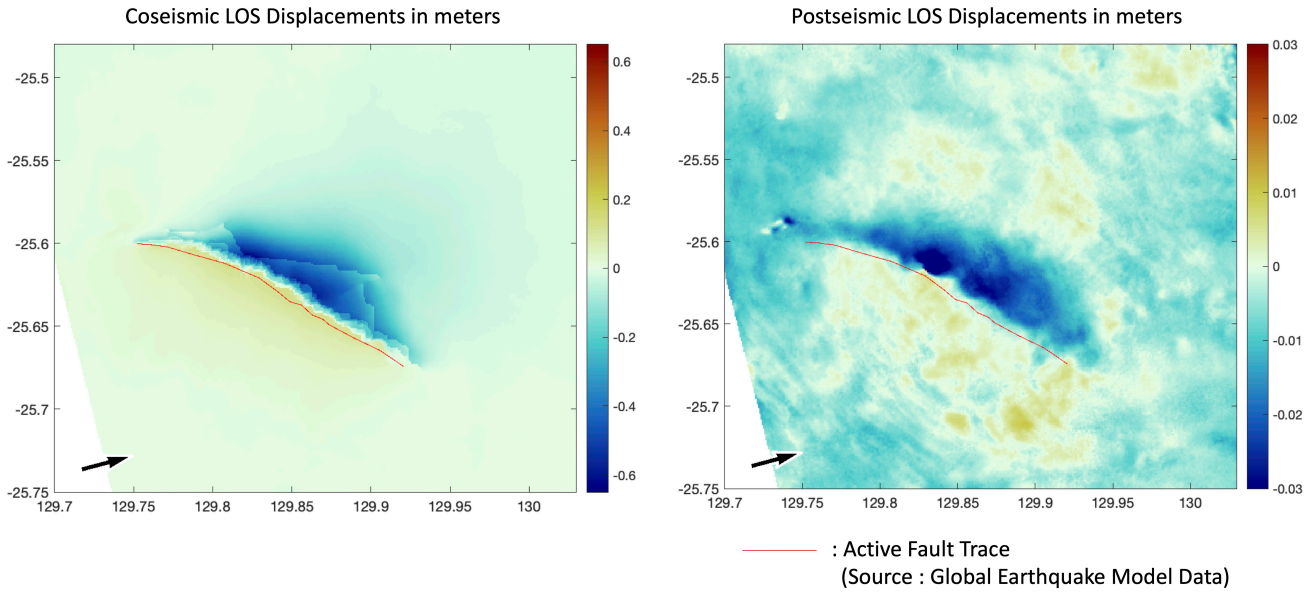
According to previous studies using seismic waves and crustal deformation data, the afterslip area on a fault is often estimated around the coseismic slip area, which is theoretically understood in such a way that the stress concentration caused by the unstable coseismic slip induces the surrounding stable slip area to slip (e.g., Marone et al., 1991, Boatwright & Cocco, 1996 etc.). In this study, we report the results of the 20 May 2016 earthquake in central Australia, where the coseismic slip and the afterslip areas may largely overlap.

We used ALOS-2 ascending data of path 124, frame 6670. For the extraction of the coseismic deformation, the pair of 15 December 2015 and 14 June 2016 were used. For the extraction of the postseismic deformation, the pairs of 14 June 2016 and 13 December 2016 (about six months after the earthquake), and 14 June 2016 and 28 November 2017 (about a year and a half after the earthquake) were used. In both InSAR analyses, spatial patterns of deformation, dominantly LOS shortening consistent with the reverse faulting, were confirmed along the known active fault trace (figure). In these results, the deformed area is localized around the fault, suggesting that the mechanism of the postseismic deformation is dominantly afterslip. The maximum coseismic LOS shortening was about 60cm, and that of the postseismic period was about 3cm. The two interferograms of the postseismic deformation periods showed no temporal increase of the deformation. Preliminary inversion analysis using the coseismic and postseismic interferograms indicated that the slip occurred on similar areas on the fault. Here we assumed that the deformation in the postseismic interferograms was due to afterslip.

The coseismic interferogram was created using the SAR image taken 25 days after the main shock, so it may contain a considerable amount of postseismic deformation. Assuming that the actual coseismic slip is significantly larger than the afterslip, however, we can consider that the “coseismic” interferogram is dominated by actual coseismic deformation. If so, an identical spatial pattern in “coseismic” and postseismic interferograms indicates an identical slip area. Based on the above results and consideration, we infer that the coseismic slip and afterslip areas largely overlapped for the case of the 2016 Australia earthquake.

Keywords: InSAR, ALOS-2, Afterslip

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[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.10_1

[S-SS05] Crustal Deformation

convener:Masayuki Kano(Graduate school of science, Tohoku University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology)

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.

[SSS05-P01] Estimation of Afterslip Distribution and Viscoelastic Deformation by MCMC Method

*Ryoji Kawabata[1], Hiroshi Munekane[1] (1.GSI of Japan)

[SSS05-P02] Application of a slow slip objective detection method to GNSS 6-hour coordinates

*Akio Kobayashi[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[SSS05-P03] Long-term SSE along the Nankai trough detected by Geonet

*Shinzaburo Ozawa[1], Ryoji Kawabata[1], Hiroshi Munekane[1] (1.Geographical Survey Institute of Japan)

[SSS05-P04] Estimation of strain-rate field in the Japanese Islands using optimized distance-decaying constants

*Issei Kosugi[1], Yuta Mitsui[2] (1.Graduate School Of Science and Technology, Shizuoka University , 2.Faculty of Science, Shizuoka University)

[SSS05-P05] **Evaluation of inland seismic potential in southwest Japan using GNSS data and seismic catalog**

*Hiroki Sato[1], Takeo Ito[1] (1.Graduate School of Environmental Studies, Nagoya University)

[SSS05-P06] Re-evaluation of earthquake swarm activity in the offshore region to the northeast of Izu Peninsula focusing on crustal deformation for several months (1990-2011)

Keisuke Takeshita[1], *Kazuhiro Kimura[1], Takeshi Kimura[2] (1.Meteorological College, 2.National Research Institute for Earth Science and Disaster Resilience)

[SSS05-P07] Evaluation earthquake potential using a kinematic block motion model in Indonesia based on GNSS Observation

*Rio Raharja[1], Takeo Ito[1], Hiroshi Kimura[1], Irwan Meilano[2] (1.Graduate School of Environmental Studies, Nagoya University, Japan, 2.Faculty of Earth Sciences and Technology, Bandung Institute of Technology, Indonesia)

[SSS05-P08] **A recent example of active intraplate deformation in the Central Anatolia: Obruk-Bor (Nigde) earthquakes, Turkey**

*Dogan Kalafat[1] (1.Bogazici University Kandilli Observatory and Earthquake Research Institute Cengelkoy, Istanbul Turkey)

[SSS05-P09] Modification of computer program GOTIC2 for calculation of the ocean tidal loading effect
- Application of Green's function to calculate theoretical strain at depth of borehole observation near coasts -

Osamu Kamigaichi[1,2], *Norio Matsumoto[2], Fuyuki Hirose[3] (1.Japan Meteorological Business Support Center, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3.Seismology and Tsunami Research Department, Meteorological Research Institute)

[SSS05-P10] Crustal deformation observed with Tenryu-Funagira laser strainmeter

*Takahiro Tsuyuki[1] (1.Meteorological Research Institute)

[SSS05-P11] Crustal movements due to the seismic motions observed in Kobe

*Atsushi Mukai[1] (1.Faculty of Urban Management, Fukuyama City University)

Estimation of Afterslip Distribution and Viscoelastic Deformation by MCMC Method

*Ryoji Kawabata[1], Hiroshi Munekane[1]

1. GSI of Japan

Summary

Postseismic deformation of the 2011 off the Pacific coast of Tohoku Earthquake is still observed about ten years after the main rupture. Afterslip and viscoelastic deformation triggered by the main rupture are considered to be the mechanisms of the postseismic deformation. In this study, following Tomita et al. (2020), we estimate contributions of the afterslip and viscoelastic deformation including viscosity value simultaneously from the spatial pattern of the postseismic deformation obtained by the geodetic observation.

Calculation method

The displacements by afterslip and Viscoelastic are given by:

$d_0 = G_e\, s_0$
$d_1 = G_{v,10}\, s_0 + G_e\, s_1$

where d_0 and d_1 are coseismic (t=0) and postseismic ($t=t_1$) displacements, s_0 and s_1 are the coseismic slip and afterslip at $t=t_1$, and G_e, $G_{e,10}$ are the elastic Green's functions and viscoelastic Green's functions at $t=t_1$ by cosesimic slip. In this study, we use only two timesteps (t=0, t_1), and do not consider the viscoelastic deformation induced by the afterslip.

We calculate elastic and viscoelastic Green's functions of 600 fault patches, which are aligned with the Pacific Plate interface, using the code of Fukahata and Matsu'ura (2005). We assume a half-space consisting of an elastic surface layer with thickness of 50 km and a Maxwell viscoelastic substratum.

Inland postseismic displacements are derived from the F3 solutions of the 448 GEONET sites, by removing linear velocities and annual/semi-annual signals estimated from preseismic data. We also use seafloor observation data of Japan Coast Guard by removing the linear velocities estimated from preseismic data and fitting the timeseries by logarithm functions (Yokota et al. 2018). In addition, coseismic deformation data of three seafloor observation points of the Tohoku University are also used (Sato et al. 2011, Kido et al. 2011, Ito et al. 2011).

We use Markov Chain Monte Carlo (MCMC) method to estimate the fault slip parameters as well as hyperparameters for the smoothness of the slip distributions (Fukuda and Johnson 2008).

Results

Fig. 1 shows estimated slip distribution five years after the main rupture. The contribution of the afterslip dominates that of the viscoelastic deformation in the coastal region near the rupture area, where the sites show eastward and upward deformation. Far from the rupture area, the contribution of viscoelastic deformation becomes relatively larger. On the other hand, on the seafloor near the rupture area, the afterslip and viscoelastic deformation contribute in opposite sense, making moderate deformation on the seafloor observation points.

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The effect of the viscoelastic deformation can be canceled by the afterslip for a wide range of viscosity in the coastal region near the rupture area. However, it is difficult to explain the deformation on the seafloor and far inland area for too large or small viscosity. As the result, the optimal viscosity, which makes smallest residuals between observed and calculated displacements, is estimated to be around 10^{19} Pa s (Fig. 2).

Note that our estimated slip distributions would not include the effect of plate interface coupling, since the preseismic velocities are subtracted from the data. This could be the reason why our estimated slip shows slightly larger seaward compared with the result of Tomita et al. (2020), in which they used the velocities relative to the continental plate. Nevertheless, the optimal viscosity in our result is very close to that of Tomita et al. (2020).
In our presentation, we will also show the results using different observation periods.

<Fig. 1> Estimated slip distribution five years after the 2011 off the Pacific coast of Tohoku Earthquake. Upper left and lower left figure respectively shows the horizontal and vertical displacements of observation (black) and calculation (white). Upper right and lower right figure respectively shows the contribution of the afterslip (magenta) and viscoelastic deformation (green) to the calculated displacements. In this calculation, the viscosity of 10^{19} Pa s is used. The estimated slip distribution of the main rupture (black contour), epicenter (star), and CMT solutions of the main shock and large aftershocks by JMA are also plotted.
<Fig. 2> Mean values of the residuals with respect to the viscosity.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, Postseismic deformation, Markov Chain Monte Carlo method

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Figure 1

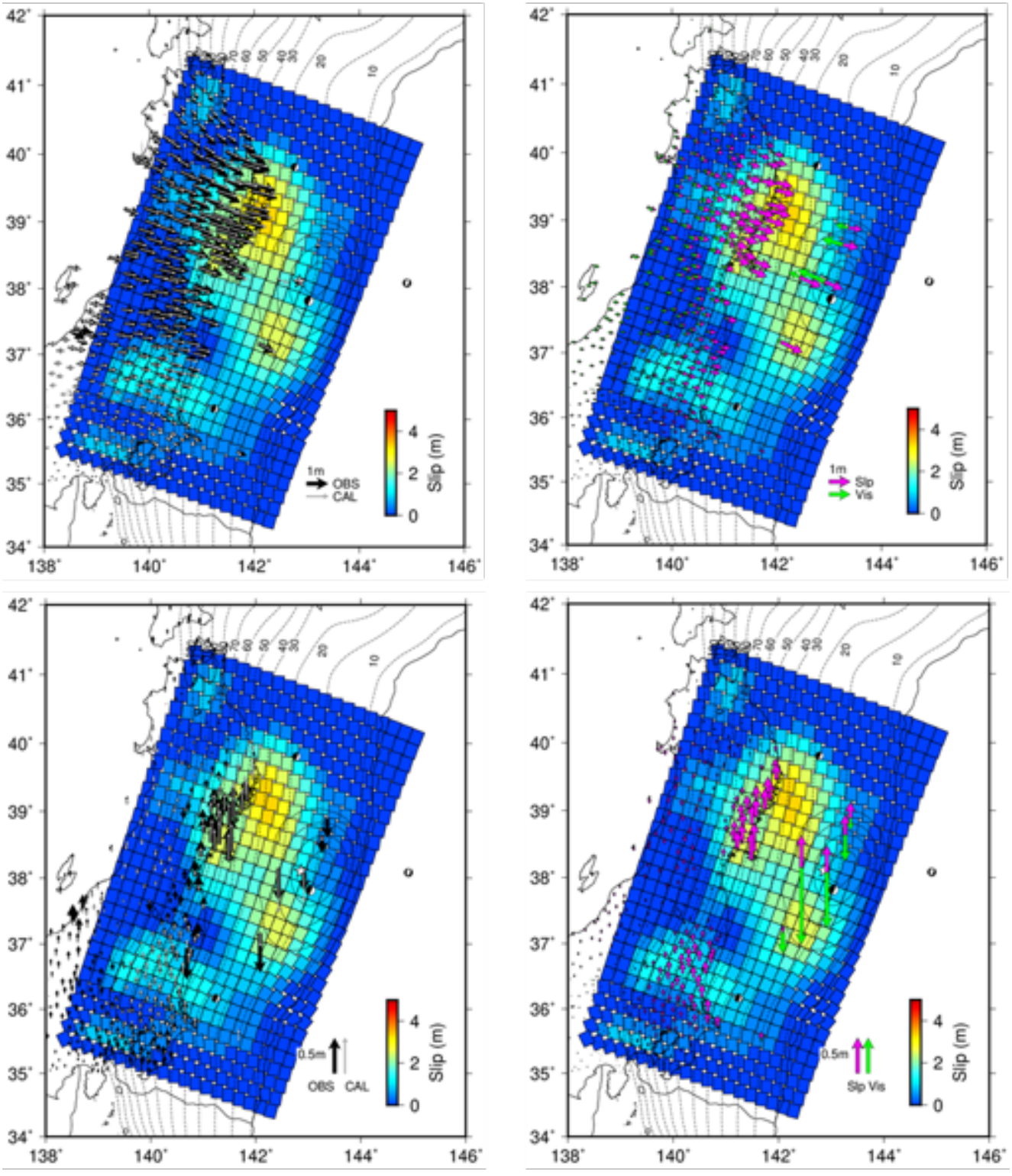
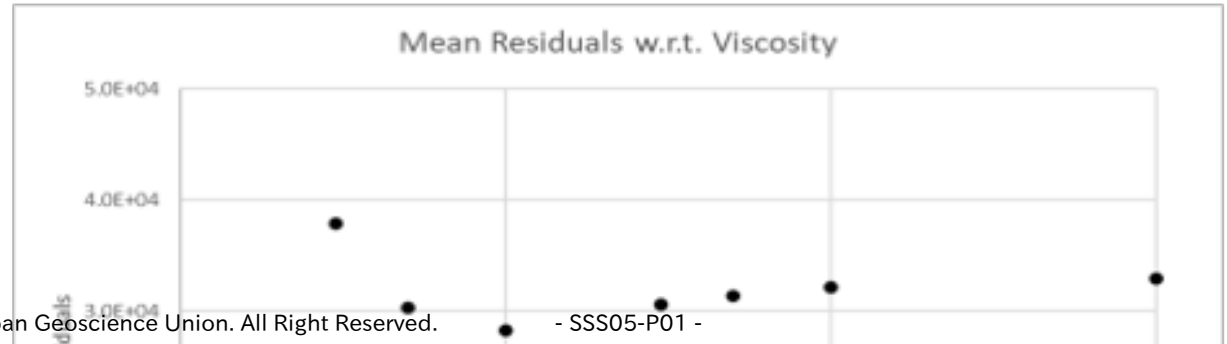


Figure 2



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Application of a slow slip objective detection method to GNSS 6-hour coordinates

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1. Meteorological Research Institute, Japan Meteorological Agency

In the Nankai Trough, slow earthquakes such as short-term slow slip events (SSEs) and long-term SSEs have been observed. Kobayashi (2017) developed a method for objective detection of long-term SSEs and revealed their spatiotemporal distribution. Kobayashi (2021) applied the method to short-term SSEs and extracted the crustal deformations associated with short-term SSEs. Here we tried the same detection method using 6-hour GNSS coordinates.

From November 15 to December 5, 2017, deep low-frequency earthquakes and strain changes were observed from Nara Prefecture to near the Aichi-Nagano border. The short-term SSE objective detection method using GNSS daily coordinates showed a high correlation associated with this phenomenon. The correlation values with the ramp function with a 7-day slope at November 25 were 0.74 for the daily coordinates, 0.44 for the 6-hour coordinates, and 0.72 for the median of the past 24 hours for the 6-hour coordinates. The 6-hour coordinates had a low correlation value, probably due to its high variability, but the change in the median value over the past 24 hours was similar to the daily coordinates, and the correlation value was also similar to the daily coordinates. Monitoring by 6-hour coordinates may detect the phenomenon earlier than daily coordinates.

Keywords: slow slip event, Nankai Trough, GNSS

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Long-term SSE along the Nankai trough detected by Geonet

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GNSS network has revealed transitional crustal movements in the Kyushu, Shikoku, Kii Channel, and Shima Peninsula areas since 2018. The interplate slip in the Nankai Trough area was estimated from the observed transient. As a result, from June 2018 to August 2019, SSE has occurred in the northern part of Hyuga Nada and Bungo Channel, and from early 2019 to late 2020, SSE has occurred in central Shikoku. It was estimated that SSE occurred in Kii Channel from around April 2019 to late 2020, and SSE occurred in the Shima Peninsula from around early 2019 to around April 2020. Northern and southern Hyuga-nada SSE occurred from mid 2020.

Introduction

In Bungo Channel, long-term SSE has repeatedly occurred in a cycle of 5 to 6 years. In central Shikoku, long-term SSE is estimated in 1977-1980, 1998, 2004, 2010, 2012, and 2015. The long-term SSE of Kii Channel occurred in 1996, 2000 and 2016. The Shima Peninsula SSE occurred during 2017-2018. Transitional crustal movements have occurred in northern Kyushu from around June 2018, and from around October 2018, in the Bungo Channel. Transient have been observed around Kii Channel since April 2019, and in the Shima Peninsula area since early 2019. In this study, we estimated the spatiotemporal variation of interplate slip in the Shikoku, Kyushu, Kii Channel, and Shima Peninsula from the data of crustal deformation detected by GNSS.

Analytical Procedure

From the position time series, the annual and semi-annual components for 2013-2019 were estimated and removed from the original position time series. The 2017-2018 trend is subtracted from the analysis for the Kyushu, Shikoku and the Kii channel areas, and the primary trend from March 2016 to March 2017 is subtracted from the Shima Peninsula analysis. Time-dependent inversion analysis was performed using the east-west, north-south, and top-bottom coordinate time-series data at 250 observation points. The shape of the Philippine Sea plate compiled by Hirose et al. (2008) is represented by triangular elements and used for analysis. The grid interval is about 20-40km. The slip direction on the plate boundary was constrained to be the plate converging direction.

Results and discussion

From around June 2018 to around August 2019, SSE occurred in Bungo Channel and in northern Hinata Nada. SSE occurred in central Shikoku from early 2019 to late 2020. The SSE of Kii-channel occurred around April 2019 and ended in late 2020. The Shima Peninsula SSE occurred from early 2019 and ended around April 2020. It was estimated that Bungo channel SSE was Mw 6.9, central Shikoku SSE was Mw 6.1, Kii channel SSE was Mw 6.1, and Shima Peninsula SSE was Mw 6.2. The Bungo channel SSE is

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roughly in harmony with the 5-6 year cycle. The repeating intervals of central Shikoku SSE do not seem to be periodic. The Kii Channel SSE does not appear to have a periodic interval. It is not clear whether Shima peninsula SSE is a series of SSEs or separate SSEs, which started from 2017. Northern Hyuga-nada SSE started from 2018 and subsided in early 2020 and started from the middle of 2020, whose rupture history seems to be different from those of the past events.

Keywords: long-term SSE, Nankai trough, GNSS

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Estimation of strain-rate field in the Japanese Islands using optimized distance-decaying constants

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Estimation of strain-rate field based on Global Navigation Satellite System (GNSS) data has been performed to extract local crustal deformation (e.g., Meneses-Gutierreza and Sagiya, 2016; Nishimura et al., 2018). The method of Shen et al. (1996) has been frequently used to estimate the strain rate. In this method, a distance-decaying constant is assumed and used for Gaussian weighting of the observation point data. The accuracy of the strain rates at grid points should depend on the coarseness of the observation points. Therefore, Shen et al. (2015) proposed a method to optimize the distance-decaying constant for each grid point using the sum of the Gaussian weightings as a constraint.

In this study, we use horizontal displacement components from the F3 solution (Nakagawa et al., 2009) of GEONET, the GNSS array by the Geospatial Information Authority of Japan (GSI), with removing offsets due to major earthquakes and antenna replacement from February 1997 to February 2020. The optimal distance-decaying constant and strain-rate fields are estimated for each grid point divided by 0.3 degrees of latitude and longitude respectively, before and after the 2011 Tohoku megathrust earthquake. The constraint is set so that the estimation errors at the observation points are the smallest.

With respect to the estimation results before the 2011 Tohoku earthquake, the maximum shear strain rate and the dilatation rate are negatively correlated as a whole (correlation coefficient is about -0.5). The areas with high shear strain rate and high compressive rate (negative dilatation rate) are located around Shikoku, Shizuoka, Tokyo, and Niigata, which may indicate the plate coupling associated with the subduction of the Philippine Sea Plate and the existence of the Niigata-Kobe tectonic zone. By contrast, the above correlation collapses in the estimated results after the 2011 Tohoku earthquake. In particular, both the shear strain rate and the expansion rate (positive dilatation rate) are higher on the Japan Sea side from Akita to Aomori in the northern Tohoku region. This relationship is not observed in the southern Tohoku region. In addition, rotational components estimated simultaneously with the strain rates show opposite directions in the northern and southern parts of the Pacific coast of the Tohoku region. Our results suggest that there was a notable north-south difference in the postseismic deformation of the 2011 Tohoku earthquake.

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Evaluation of inland seismic potential in southwest Japan using GNSS data and seismic catalog

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Major earthquakes have repeatedly caused massive damage in Japan. The Headquarters for Earthquake Research Promotion (HERP) evaluates the seismic potential for major earthquakes. Although the HERP had only assessed damaging earthquakes at major active faults, several major earthquakes occurred along non-target faults recently. Against this background, some previous research estimated inland seismic potential regionally based on strain rates estimated from GNSS observation and Japan Metrological Agency (JMA) seismic catalog. However, they ignore the effects of interplate coupling and postseismic deformations on strain rates (Takahashi & Shinohara, 2015), and use a relatively shorter period of seismic catalog for calculating the seismic moment's release rate (Kimura *et al.*, 2018). We evaluated inland seismic potential at each crustal block of southwest Japan using internal strain rates at each crustal block and a relatively longer seismic catalog.

Inland earthquakes release accumulated internal strain in the crustal block. Based on this relation, we focused on accumulation and release rates of the seismic moment at each crustal block, and evaluated inland seismic potential using the balance between both rates. To evaluate the seismic potential, we used the crustal block model and internal strain rates at each crustal block (Kimura *et al.*, 2018), and seismic catalogs by JMA and Utsu (1982, 1985). The seismic moment's accumulation rate is equivalent to the average seismic moment rate due to plate motion and interaction between crustal blocks It is calculated from internal strain rates, thickness of seismogenic layer (D90 in this research), and the equation proposed by Savage & Simpson (1997). On the other hand, the seismic moment's release rate corresponds to the released average seismic moment rate due to earthquakes. It is obtained from seismic moment integration assuming that inland earthquakes occur according to cumulative GR-law. Then, we regarded the difference of accumulation and release rates as the energy released by future earthquakes. The evaluated inland seismic potential in 30 years assumed the occurrence of M_w7.0 earthquakes using the Poisson process.

We evaluated inland seismic potential at six crustal blocks. In Kinki and Setouchi blocks, the estimated seismic potentials from combined geodetic data are 2.16±0.01% and 9.07±0.25%, respectively. We compared the results with the seismicity at each crustal block. As a result, the seismic potentials estimated from the seismicity are 0.08±0.001% and 3.25±0.02%, respectively, and are close to the seismic potentials from combined geodetic data. Therefore, the estimated seismic potentials are consistent with the seismicity. In the Forearc block, while the estimated seismic potential from combined geodetic data is 62.06±0.16%, the seismic potential from the seismicity is 3.69±0.02%. It is significantly smaller than the estimated seismic potential from combined geodetic data. However, since internal strain rates at the Forearc block are relatively larger than other crustal blocks, this discrepancy reflects the relatively higher risk for major earthquakes. In the Okinawa block, the estimated seismic potential from combined geodetic data is 99.87±0.002%. The crustal block has a significantly wide area covering from Kagoshima to Taiwan and significantly large internal strain rates due to a single crustal block, including the interaction between crustal blocks. Therefore, the significantly high seismic potential may reflect both effects. In the Chubu block and Izu microplate, the seismic potentials from combined geodetic data cannot be evaluated because the release rates are larger than the accumulation rates. In both crustal

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blocks, the release rates may be overestimated due to the various effects of active volcanoes. In the future, we need to improve our methods, such as removing the earthquakes near active volcanoes and the boundaries of crustal blocks.

Keywords: seismic potential, GNSS observation, seismic catalog, seismic moment

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Re-evaluation of earthquake swarm activity in the offshore region to the northeast of Izu Peninsula focusing on crustal deformation for several months (1990-2011)

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1. Meteorological College, 2. National Research Institute for Earth Science and Disaster Resilience

From 1978 to 2011, earthquake swarm activity had occured frequently in the offshore region to the northeast of Izu Peninsula. Previous studies had shown that volcanic activity is the cause of this earthquake swarm activity, and that crustal deformation can be explained by dike intrusion. This earthquake swarm activity caused by dike intrusion coutinuesd for a week.

We have found five different crustal deformation phenomenon that coutinuesd for several months since 1990. Four of them are sources of variation at almost the same location as the sill expansion in the inland area of the Izu Peninsula, estimated by Nishimura and Murakami (2007) after the 1930 earthquake swarm activity. In addition, our result show that the volume change of this sill is about 30% compared to the dyke intrusion at the same time, and the dike intrusion did not occur during the expansion period of the sill inland area of the Izu Peninsula.

Keywords: crustal deformation , tiltmeter, strainmeter, GNSS, volume change

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Evaluation earthquake potential using a kinematic block motion model in Indonesia based on GNSS Observation

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Indonesia is located in a tectonically complex region and lies in the interaction of four major plates. This interaction resulted in seismic activity in Indonesia and is one of the highest in the world. With this condition, research on evaluating the earthquake potential in Indonesia becomes urgent. Previous geology and geodesy studies have been done to describe the crustal block boundaries and also crustal block motion in Indonesia (e.g. Bird, 2003; Koulali et al., 2016; Koulali et al., 2017). However, some inland faults are still not well described, and used few GNSS data in previous studies. This research would provide an improved crustal block motion model for Indonesia to evaluate the interaction among these blocks and estimate the earthquake potential in research area and also to identify which regions are more vulnerable to the earthquake.

In this research, we use GNSS data derived from Indonesia CORS Network (InaCORS), Sumatran GPS Array (SuGAR), and International GNSS Service (IGS). The total number of GNSS sites is 205 during 2008 to 2018. To get the velocity field, we utilize Bernese 5.2 software package (Dach et al., 2015) and VISCO1D (Pollitz et al, 1997) for analyzing the GNSS data and removing the deformation due to earthquakes that occurred before 2008, respectively. We employ the MCMC (Markov Chain Monte Carlo) method to generate many kinematic block motion models and choose the optimum model based on AIC (Akaike’ s Information Criterion).

By using the optimum model, MODEL12, our results of coupling show that the strong coupling is estimated mostly at the depth of 0-30km and mostly weak coupling for more than lower than 30km depth. Our results also show a possible recovery from the 2006 Java earthquake. For the earthquake potential, our results show 4 areas with high coupling which possible to generate big earthquakes. Area 1 has enough seismic moment deficit to produce a Mw8.3 earthquake every 119±15 years. Area 2, Area 3, and Area 4 have enough seismic moment deficit to produce a Mw8.6 earthquake every 182±24 years, 186± 27 years, and 169±24 years, respectively. A Mw8.9 earthquake can be produced every 261±35 years if Area 2 and Area 3 rupture together at the same time.

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A recent example of active intraplate deformation in the Central Anatolia: Obruk-Bor (Nigde) earthquakes, Turkey

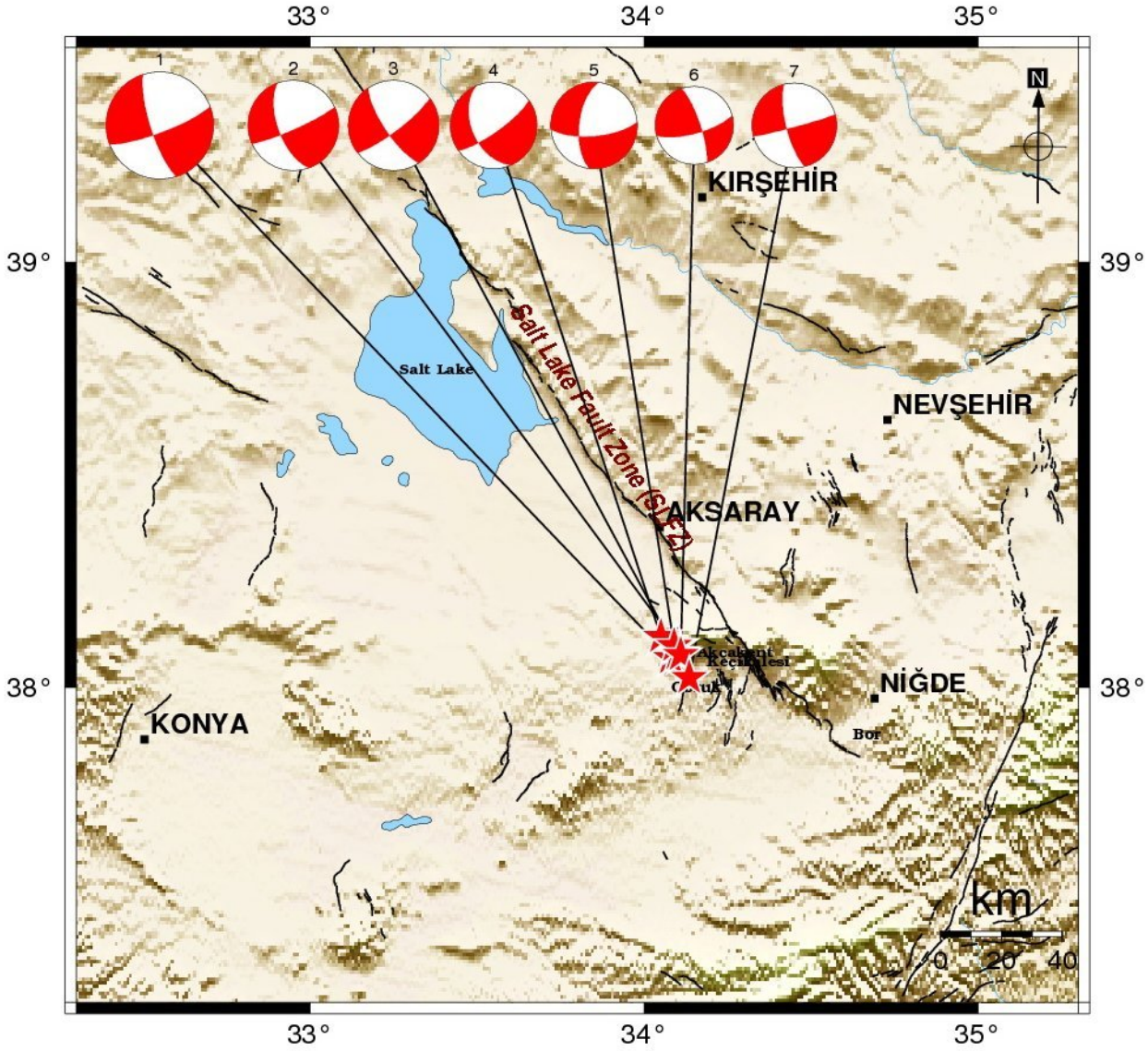
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Salt Lake (Tuz Golu) basin is evident morphological trace in the Central Anatolia which is one of the biggest tectonic lakes in Turkey. Salt Lake Basin is NW-SE trending sediment basin and generally restricted by NW-SE trending strike-slip faults which is called the Salt Lake Fault zone (SLFZ). SLFZ is the biggest faulting zone with 200 km length in the Central Anatolia. Also, SLFZ is a kind of intraplate zone of active deformation characterized by oblique right lateral strike-slip faulting. SLFZ did not produce strong earthquakes last a couple of hundred years. Salt Lake is surrounded by Aksaray Fault and Hasandagi volcanic rise. Seismicity in Salt Lake and surrounding region is quite low, because of intraplate deformation of Anatolian microplate. However recent years several moderate earthquakes (M>5) and aftershocks in the region showed that the rim of the northwest of the SLFZ and especially secondary faults in Bala-Kulu were active parts of the SLFZ. Due to these activities along the SLFZ it is decided to monitor micro-seismic activity (M<2.5) by establishing low-magnitude threshold seismic network. For this purpose, six broadband seismic stations have been established since 2010 to control the entire region.
On Sunday 20 September 2020 moderate sized (Mw=5.1) earthquake occurred at the locality approximately 4 km NE of Obruk Village (Bor-Nigde), Central Turkey. 143 masonry-adobe houses were damaged in village of Obruk of Bor district. In this study, focal mechanisms of earthquakes (M>4) are calculated using moment tensor inversion from broadband stations. Moment tensor solutions show that mainshock and important aftershocks obviously revealed that the SLFZ is being dominated by NW-SE trending dextral strike-slip faulting. Aftershock locations are correlated with fault plane orientations. Recent earthquakes have revealed the presence and activity of small fault segments parallel to the main fault segment in the SLFZ in the region. The results of the stress tensor analysis conducted within the scope of the study show that the main stress T_{max} axis is in the NW-SE direction and the maximum stress P_{max} axes are in the NE-SW direction.
This work is supported by Bogazici University BAP/SRP Project No: 16403. On this occasion, we would like to thank the Bogazici University Research Fund Commission and its valuable members. Also I would like to gratefully thanks to Prof. Dr. Nafi Toksoz from MIT/USA.

Keywords: Central Anatolia, Obruk-Bor , Intraplate deformation , Salt Lake Fault Zone , Moment tensor inversion , Dextral strike-slip faulting

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Moment tensor solutions of important earthquakes which occurred in 2020 in the Obruk-Bor (Nigde), Central Turkey region

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Modification of computer program GOTIC2 for calculation of the ocean tidal loading effect
- Application of Green's function to calculate theoretical strain at depth of borehole observation near coasts -

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We modified computer software GOTIC2 (Matsumoto et al., 2001) for estimating the crustal deformation caused by ocean tidal loading to enable calculation of the loading effect not only at the surface but also in subsurface observations using the PREM Earth model. To modify the software, we (i) revised the eigenfunctions using the PREM Earth model and (ii) calculated Green's functions of displacements and strains caused by a surface load in surface and subsurface observations by applying the eigenfunction. Green's functions of displacements and strains at depth became different from those at the surface for a range of angular distance less than 0.01 –0.1°. These Green's functions closely agree with the corresponding Boussinesq approximations for tidal loading at angular distances of less than about 0.01 –0.001°, which supports the adequacy of these Green's functions. We examined the difference between the ocean tidal loading effect estimated by Green's functions at the surface and the effect for subsurface observations based on very simple and realistic conditions, and found a non-negligible difference when the ratio of deployment depth to distance between the coast and observatory is larger than 0.05. We compared amplitudes and phase shifts of areal and shear strains in M_2 and O_1 tidal constituents observed by borehole strainmeters at 11 observatories with the theoretical strains using the Green's functions at the deployment depth and those at the surface. The theoretical strains using Green's function at the deployment depth are much closer to the observed strains than theoretical strains at the surface at four observatories where the ratios of deployment depth to distance from the coast to the observatories are large. These results suggest that Green's functions at the deployment depth are needed to estimate theoretical strains precisely near the coast. The computer program modified GOTIC2 with the Green's functions of gravity, displacement, tilt, and strain at depth was published in GSJ Open-File Report (https://www.gsj.jp/publications/pub/openfile/openfile0705.html).

Keywords: GOTIC2, oceanic tidal loading, Green's function, strain, subsurface observation

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Crustal deformation observed with Tenryu-Funagira laser strainmeter

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Meteorological Research Institute installed a long-baseline laser strainmeter (north-south direction, baseline length 400 m) at the Tenryu-Funagira station (34 ˚53.2'N, 137 ˚49.1' E) in Hamamatsu, Shizuoka Prefecture to detect wideband crustal movements including slow slips in the Tokai region (Katsumata et al., 2010). From March, 2017, the stabilized laser was replaced with the YAG laser (Araya et al., 2002).

It has been shown that the laser strainmeter has higher resolution than GNSS observation and has lower noise level with respect to the long-period deformation than borehole type strainmeter. It is expected as a measuring instrument that can detect not only short-term SSEs but also long-term SSEs. There have been no long-term SSEs that occurred during the period when the laser strainmeter was in operation, but some short-term SSE records have been detected.

This research examined the records of such slow slip after 2020. There was change that was thought to be due to short-term SSE near Aichi Prefecture occurred around January 2020. Change is almost consistent with the calculated from a fault model obtained by the Japan Meteorological Agency. Katsumata et al. (2020) detected a slow slip with a duration of 1 hour from the correlation analysis between the laser strainmeter recording and the borehole type strainmeter recording. No such slow slip could be detected from January 2020 record.

A slow slip with a duration of 1 hour (Katsumata et al., 2020) was detected during the SSE in January, 2019. I examined the effects of tidal changes during the event on faults modeled by JMA using the program used in Hirose et al. (2019). However, no siginificant correlation was found.

Keywords: Laser strainmeter, Slow slip

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Crustal movements due to the seismic motions observed in Kobe

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Strain changes due to the source processes of the 2011 off the Pacific coast of Tohoku earthquake (M9.0) and the 2018 northern Osaka earthquake (M6.1) were observed by using the Ishii-type three-component strainmeter at Rokko-Takao station of Kyoto University in Kobe (Mukai et al., 2020). This station is equipped with the extensometers as well as the strainmeter, and one extensometer is installed at the nearby Rokko-Futatabi station. Strain changes observed by those extensometers significantly contained the changes due to the source processes as well. We can get some information about a source process by investigating the observational data of strainmeters and extensometers installed in an underground tunnel away from the focal region.

Rokko-Takao station passes through the fracture zone of Manpukuji fault. In this station, the continuous observation of crustal movements have been performed by using the Ishii-type three-component strainmeter, the extensometers, the water-tube tiltmeters, the pore pressure meters and so on. The maximum principal strain of extension in the east-northeast direction increased at nearly constant rate for about 30 seconds just after the arrival of the seismic waves of the 2011 earthquake. In addition, just after the arrival of the seismic waves of the 2018 earthquake, the maximum principal strain in the east-northeast direction increased for about one second and kept constant for the following two seconds. These principal strain changes agreed with the calculated ones based on the source processes reported by the Meteorological Agency and Disaster Prevention Research Institute, Kyoto University (Mukai et al., 2020). It is considered that we could detect the strain changes due to the time development of co-seismic fault slips, that is, the source process by using the strainmeter.

Three extensometers in the direction of N69^{o}E are installed in Rokko-Takao station. Rokko-Futtabi station about 0.5km south of Rokko-Takao station is equipped with one extensometer in the direction of N9^{o}W. These extensometers observed the increase of the strain changes at nearly constant rate just after the arrival of the seismic waves of the above earthquakes as the case of the strainmeter, and the observed strain changes agreed with the calculated ones based on the source processes. This shows that we can confirm a source process by using the crustal movements observed by strainmeters and extensometers installed in the underground tunnel.
Rokko-Takao station and Rokko-Futatabi station are equipped with some water-tube tiltmeters as well. Although these tiltmeters respond slowly to the inclined ground, the tilt changes at nearly constant rate could be observed with the water-tube tiltmeters for several 10 seconds just after the 2011 earthquake as a result of the long source process. In this study, I investigated the crustal movements due to the source processes observed by the water-tube tiltmeters as well as the strainmeter and the extensometers.

Keywords: crustal movements, source process

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.20 Zoom Room 20

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency), Chairperson:Youichi Asano(National Research Institute for Earth Science and Disaster Prevention), Yohei Yukutake(Earthquake Research Institute, University of Tokyo)

This session aims to improve our understanding on seismicity. Any contribution on behavior of earthquakes as a cluster, such as regional seismicity and aftershocks, are welcomed. We also welcome contribution on temporal and spatial interactions that control seismicity, and tectonic processes, and geological and thermal structures that regulate seismicity.

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

[SSS06-01] Aseismic process driving the earthquake swarm, revealed by the dense seismic observation

*Yohei Yukutake[1], Keisuke Yoshida[2], Ryou Honda[1] (1.Hot Springs Research Institute of Kanagawa Prefecture, 2.Tohoku University)

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

[SSS06-02] Statistical analysis and its characteristics of the earthquake activity near the border of Nagano, Gifu and Fukui prefectures

*Takao Kumazawa[1], Yosihiko Ogata[2] (1.Earthquake Research Institute, The University of Tokyo, 2.The Institute of Statistical Mathematics)

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

[SSS06-03] Seismic activity around Kamikochi, Nagano Prefecture after the M5.5 earthquake on April 23, 2020

*Takayuki Kawabe[1] (1.Ex. Faculty of Education, Arts and Sciences, Yamagata University)

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

[SSS06-04] A simple way to distinguish rather shallow PAC-intraplate events from interplate ones around Japan

*Ritsuko S. Matsu'ura[1], Takeo Ishibe[1], Koji Iwasa[1] (1.Earthquake Research Center, Association for the Development of Earthquake Prediction)

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

[SSS06-05] Hypocenter determination assuming a 1-D velocity model with station corrections and its result for the Tohoku region

*Youichi Asano[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS06-06] Seismicity distribution in the Tonankai and Nankai seismogenic zones and its spatial relationship with interplate coupling and slow earthquakes

*Yojiro Yamamoto[1], Shuichiro Yada[1], Keisuke Ariyoshi[1], Takane Hori[1], Narumi Takahashi[2] (1.JAMSTEC, 2.NIED)

Aseismic process driving the earthquake swarm, revealed by the dense seismic observation

*Yohei Yukutake[1], Keisuke Yoshida[2], Ryou Honda[1]

1. Hot Springs Research Institute of Kanagawa Prefecture, 2. Tohoku University

The models for earthquake swarms are proposed as a migration of highly pressurized fluid (e.g., Parotidis et al., 2005) or an aseismic slip on a fault plane (e.g., Lohman and McGuire, 2007). However, the detailed process of fluid migration and aseismic deformation for the occurrence of earthquake swarms has not been fully understood. In Hakone volcano, central Japan, shallow intense swarm activities have been observed. Based on the dense seismic observation data, a previous study found a diffusion-like migration of swarm hypocenters that follows a diffusion equation and gives hydraulic diffusivity between 0.5 and 1.0 m^2/s (Yukutake et al., 2011). The observation implies that the occurrence of the earthquake swarms is related to the fluid migration. On the other hand, during the swarm activity from May 11 to 19, 2019, beneath Lake-Ashi, the western part of Hakone caldera, we observed a precursive seismic activity, repeating earthquakes, and tilt change. These observations may indicate the involvement of the aseismic process in addition to highly pressurized fluid in the occurrence of swarms.
We used 34 seismic stations in and around the caldera of Hakone volcano to determine the hypocenter locations and focal mechanisms. The double-difference method (Waldhauser and Ellsworth, 2000) was applied, using the differential arrival time data obtained by the manually picking and waveform cross-correlation process. The focal mechanisms of earthquakes were determined by using the P-wave polarities and P/SH wave amplitudes. To detect the events with smaller magnitude, we applied the Matched Filter method, using the template events based on the HSRI earthquake catalog. For the detection of repeating earthquakes, we applied a criterion with a correlation coefficient of >= 0.95 at more than four stations for the waveform records of 1 sec before and 5 sec after the theoretical P-wave arrival time. The borehole tiltmeters installed in Hakone volcano were also used as crustal deformation data, after removing the trend and tidal response.
The hypocenter distribution represents a plane-like distribution oriented to the azimuth of the E-W direction and nearly vertical dipping angle. One of two nodal planes of the focal mechanism is generally consistent with the orientation of planar hypocenter distribution. The detailed temporal-spatial distribution of seismicity estimated by the Matched filter method shows that the precursive seismic activity started from May 11 on the plane-like distribution, following the remarkable earthquake swarms from 05:18 (JST), May 18. We observe a downward migration of precursive seismicity to the starting point of the remarkable earthquake swarms at the speed of 70m/day, and the remarkable earthquake swarms show a diffusion-like migration of hypocenter that gives a hydraulic diffusivity of 3.0 m^2/sec. Fifty-six groups of repeating earthquakes were identified during the seismic activity. Averaged aseismic slip histories inferred from the repeating earthquakes indicate that a subtle aseismic slip of 0.3 mm occurred during the precursive seismic activity, while the aseismic slip accelerated from May 18 up to the cumulative slip of 3 mm. The tilt changes at the borehole stations can be explained most appropriately by assuming the tensile-shear on the planar hypocenter zone. The shear slip dislocation in this model is estimated as 3mm that is consistent with the result of repeating earthquakes. These observations may imply that the aseismic process due to the intrusion of highly pressurized fluid into the fault plane was also related to the triggering the earthquake swarms.

Keywords: Earthquake swarm, Fluid, Aseismic slip

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Statistical analysis and its characteristics of the earthquake activity near the border of Nagano, Gifu and Fukui prefectures

*Takao Kumazawa[1], Yosihiko Ogata[2]

1. Earthquake Research Institute, The University of Tokyo, 2. The Institute of Statistical Mathematics

An earthquake swarm activity has occurred in April 2020 near the border between Nagano and Gifu prefectures. In the same region another event had started in August 1998. These two events have comparable sizes, similar period of activities and similar transitions in time. We analyzed these events with statistical models, ETAS model and its variations to capture the characteristics of the earthquakes in the focal region.

These earthquake swarms have many strike-slip fault types with the northwest-southeast direction as the compression axis, reflecting the stress field. Since it occurred near the volcanic area, it may be related to the movement of hot water and magma fluid and the diffusion of pore pressure.

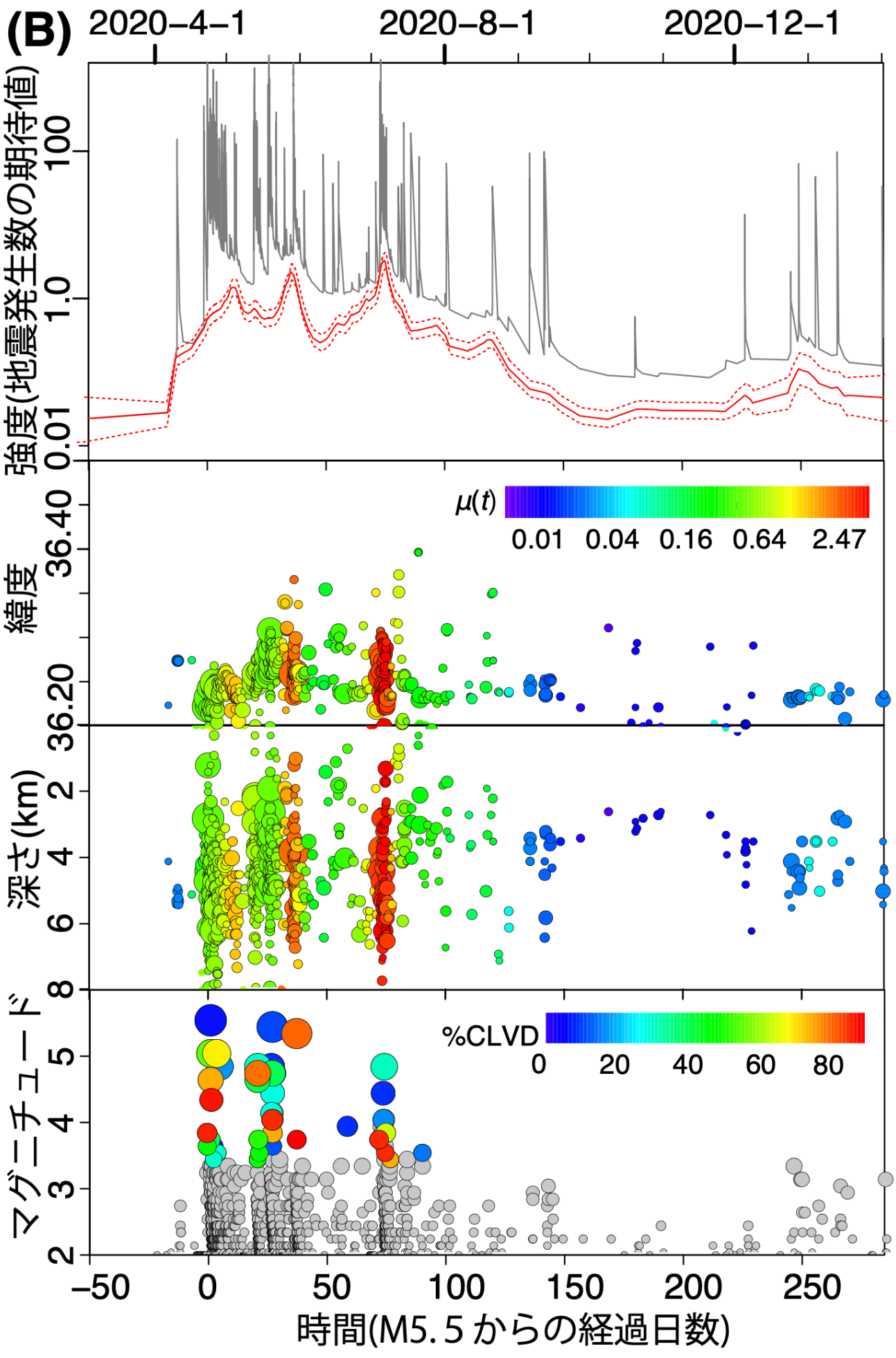
The proportion of non-double couple components (% CLVD) in the CMT solution in the focal region shows a relatively high value. Comparing to the surrounding area, other high values appear only near Mt. Ontake; many are low in the Itoigawa-Shizuoka Tectonic Line and other major active fault areas.

For the spatiotemporal patterns, there earthquake swarms both started in the southernmost region the moved northward. Earthquakes with high % CLVD occur in relatively deep locations.

The background seismic activity in 1998, which is estimated by the non-stationary ETAS model, reached dozens to hundreds of times larger than the normal level in 50 days from the beginning. This active area is concentrated in the southernmost region. In 2020, three similar peaks with similar sizes are estimated. There was another increased activity from the end of 2020, but it is settling down; the background seismic activity is dropping down to the normal level. High % CLVD values are connected with these high values in the background.

Keywords: Earthquake swarm, background seismicity, nonstationary modeling

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Seismic activity around Kamikochi, Nagano Prefecture after the M5.5 earthquake on April 23, 2020

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Introduction
The southern part of the Hida Mountains is one of the areas where shallow earthquakes occur most frequently in Honshu. Among these activities since 1922, the series of seismic activities that started at 13:44 on April 23, 2020, around Kamikochi, Matsumoto City, Nagano Prefecture, triggered by the Mj5.5 earthquake, have been carried out so far. It can be said that this is the largest activity in the seismic record.

Seismic activity around Kamikochi
Seismic activity around Kamikochi has been active in a narrow range of 25km north-south and 15km east-west, including medium-seismic earthquakes reaching a depth of about 50km for at least the past 100 years. It has been. The three-dimensional shape of the distribution area is exactly the shape of a funnel.
Looking at the seismic activity around Kamikochi up to the present, there is a cycle in which Mj5 to 5.5 class earthquakes are active in a cycle of several years to about 10 years, and among the aftershocks caused by water reduction. In addition, there is an activity cycle around Mj4 with a cycle of about one week, and an activity cycle with a cycle of half a day to one day is also observed.
More characteristically, earthquakes up to a depth of several tens of kilometers occur within hours after an earthquake of Mj5 or higher that occurs in a shallow layer with a depth of several kilometers. During this time, the depth at which earthquakes occur gradually increases. Earthquakes up to a depth of several tens of kilometers do not occur in all cycles, and the continuity between shallow and deep earthquakes may not be clear.

Mechanism of seismic activity around Kamikochi
It is possible to consider the involvement of thermofluids in such a phenomenon that shallow earthquakes and deep earthquakes occur intermittently in a narrow range (Omi, 2001; 2020, Kawabe, 2017). If thermofluids are involved, the general pattern is that a deep earthquake occurs first, and then the active area gradually shifts to shallow areas. However, in the case of an earthquake around Kamikochi, on the contrary, it is always a transition from a shallow earthquake to a deep earthquake, which is the opposite of the direct involvement of thermofluids.
according to the actual condition of the lower bottom surface of the shallow earthquake and the rise of the quaternary granite body in the southern part of the Hida Mountains, the upper crust is more brittle due to the bending deformation of the crust caused by the magma derived from the upper mantle. A model is conceivable in which rupture occurs from the ground, and the rupture progresses further downward, and eventually the rupture propagates to the lower crust and upper mantle in the plastic region under the original stress field.

Keywords: earthquake swarm activity, northern Hida Mountains, up-warping deformation

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A simple way to distinguish rather shallow PAC-intraplate events from interplate ones around Japan

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1. Earthquake Research Center, Association for the Development of Earthquake Prediction

On Feb. 13, 2021, a shallow* M_{JMA}7.3 (M_{rapid} was 7.1) event occurred off Fukushima prefecture. The hypocenter depth (rapid 60km-> 55km) was very close to the assumed PAC plate surface. Since S-net has been used for hypocenter determinations by JMA, its aftershock distribution within an hour after helped us to assume that the event was intra-slab event.

However, there is the much easier and faster way to judge the source type of such a shallow event in the east off Tohoku district by the intensity distributions in Japanese islands available within a few minutes. In Fig. 1, the expected intensity distributions by the useful GMPE (Matsu’ura et al, 2020) are shown of the same epicenter and M (37.7°N, 141.8°E, Mw7.1) events with three source types (crustal, interplate, and intraplate), respectively. Their GMPE is classified by the source type, and robust for the estimation errors of M and depth.

In Fig. 2, differences between expected intensities for some PAC-intraplate, PAC-interplate, and very shallow crustal earthquakes are compared on epicentral distance. In Fig. 3, the observed intensities of the 2021 Feb. 13 event observed at K-NET and KiK-net stations are shown with some expected intensities on hypocentral distances.

Solid marks show the adjusted intensities to exclude differences between sites on the abnormal intensity effect of PAC slab, and on the amplification factors by the surface soil. We can obtain a hypocenter, M and intensities within a few minutes after an event occur. Then the GMPE can expect intensities for various source types, and we can compare them with observed intensities. The source type can be judged, without F-net mechanism solution nor the aftershock distribution.

Acknowledgements
We used K-NET, KiK-net data by National Research Institute for Earth Science and Disaster Resilience. This study was done with funding from the Ministry of Education, Culture, Sports, Science and Technology, Japan for the Headquarters of Earthquake Research Promotion of the Japanese government.

Reference: Matsu’ura, R. S., H. Tanaka, M. Furumura, T. Takahama, andA. Noda (2020). A New Ground-Motion Prediction Equation of Japanese Instrumental Seismic Intensities Reflecting Source Type Characteristics in Japan, Bull. Seismol. Soc. Am. 110, 2661–2692, doi: 10.1785/0120180337

* In the depth classification by Utsu (1979), "very shallow" is a crustal event, "intermediate" is an intermediate intra-slab event deeper than 60km, and shallow indicates 60km or shallower interplate or intraplate in the eastern off-shore areas of Japan. He knew that it is hard to distinguish "Intra" from "Inter" for old earthquakes.

Keywords: judge source type with the intensity distribution, difference between interplate and intraplate events, the useful GMPE of intensities in Japan, Off Fukushima earthquake on Feb. 13, 2021, Ground Motion Prediction Equation

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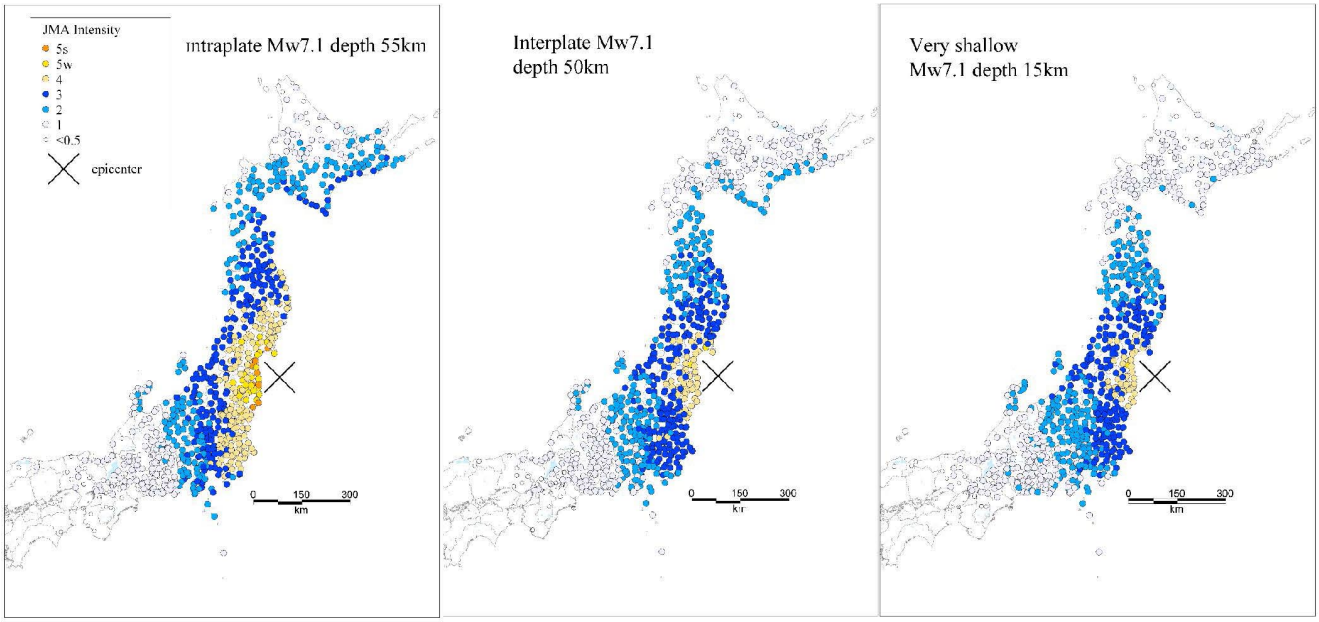


Fig. 1. Expected intensity distribution of K-NET and KiK-net stations for various source types of Mw7.1 at the same epicenter.

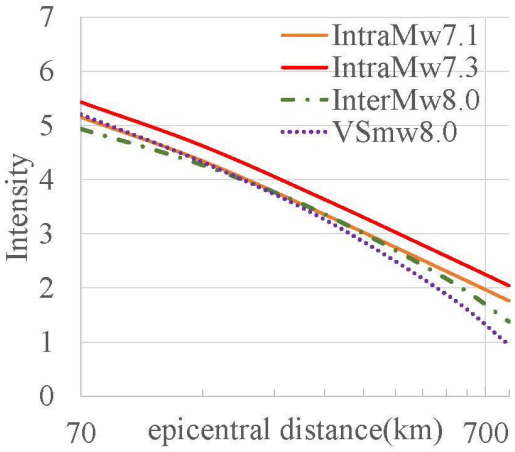


Fig. 2. Expected intensities v.s. epicentral distance for various cases.

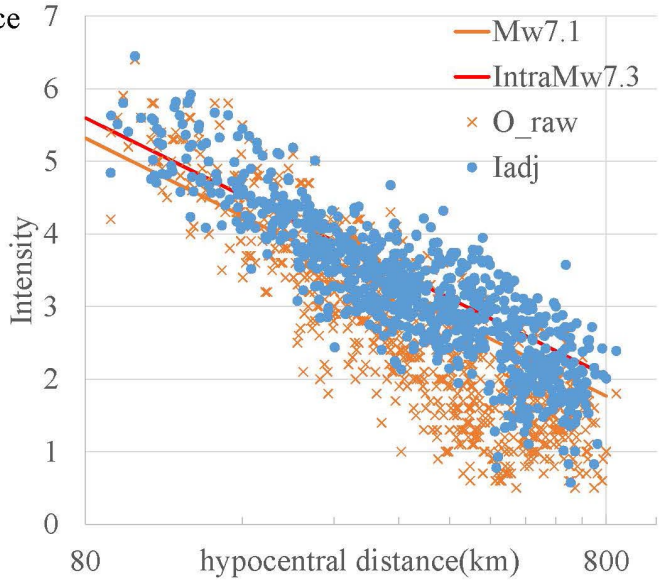


Fig. 3. Expected intensities and observed and adjusted (as PAC depth 80km and Vs30=300m/s) intensities of M_{JMA}7.3 off Fukushima event on 2021 Feb. 13.

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Hypocenter determination assuming a 1-D velocity model with station corrections and its result for the Tohoku region

*Youichi Asano[1]

1. National Research Institute for Earth Science and Disaster Resilience

We have evaluated station corrections for our routinely hypocenter determination assuming a 1-D velocity model. At first, we estimated centroid moment tensors (CMTs) for 653 earthquakes in the period of 2016-2020 from the waveform data of the F-net broadband seismometers and Hi-net tiltmeters. Next, we estimated hypocenters of these earthquakes from picked P- and S-wave arrival times at the S-net, Hi-net, and other stations operated by the JMA, ADEP, Hokkaido University, Hirosaki University, Tohoku University or University of Tokyo. Station corrections were evaluated from the residuals of this hypocenter determination under a constraint of hypocentral depths fixed to centroid depths of CMTs. Considering epicentral distance dependency of the residuals for shallow earthquakes, we used the residuals for deeper earthquakes than 20 km and longer epicentral distance than 75 km. We applied these station corrections to our hypocenter determination and relocated earthquakes used for evaluating these station corrections. The estimated depths of the earthquakes mainly located within 10 km from their centroid depths showed effectiveness of our station corrections. Finally, we analyzed 3019 earthquakes which occurred off Fukushima and Miyagi in the period from June, 2016 to February 14, 2021. In the obtained results, we can see an ENE dipping earthquake cluster probably just along the boundary between the subducting Pacific Plate and the overriding plate. Some earthquakes probably along the plate boundary are also distributed in focal area of the 2011 Tohoku earthquake. Furthermore, the 2021 off Fukushima earthquake with M_{JMA} 7.3 and its aftershocks are distributed below the dipping earthquake cluster. Therefore, these earthquakes are considered to be intraplate events in the subducting Pacific Plate.

Keywords: hypocenter determination, station correction, Tohoku earthquake, interplate earthquake, intraplate earthquake

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Seismicity distribution in the Tonankai and Nankai seismogenic zones and its spatial relationship with interplate coupling and slow earthquakes

*Yojiro Yamamoto[1], Shuichiro Yada[1], Keisuke Ariyoshi[1], Takane Hori[1], Narumi Takahashi[2]

1. JAMSTEC, 2. NIED

The Nankai Trough subduction zone is well known for repeated M8 class mega-earthquakes, which have occurred at intervals of 100–150 years (Ando, 1975). The area off the Kii Peninsula is key to understanding the seismic behavior of these large earthquakes because it includes the boundary between two of the largest seismogenic segments in the subduction zone, the Tonankai and Nankai segments. The most recent mega-earthquakes in this region, the 1944 Tonankai (Mw8.1) and 1946 Nankaido (Mw8.3) earthquakes, occurred about 75 years ago. For this reason, various seismological and geodetic studies have been carried out in the Nankai Trough. These are revealing the existence of subsurface structural heterogeneities that can control rupture propagation (e.g., Kodaira et al., 2002, 2006), slow seismic phenomena and their distribution (e.g., Nakano et al., 2018; Takemura et al., 2019), and current slip-deficit distribution (e.g., Yokota et al., 2016; Nishimura et al., 2018). However, not much research has been done on regular earthquake activity because of their low activity level and the difficulty in determining the hypocenter location with high accuracy due to offshore condition. Monitoring the spatio-temporal distribution of not only slow earthquakes but also regular earthquakes at the plate boundary is important for studying the occurrence process of large earthquakes.

In this study, we attempted to determine the hypocenter location detected by DONET (Kawaguchi et al., 2011; Kaneda et al., 2015) since 2012 with high accuracy to clarify the seismically active region on the plate boundary of the Nankai Trough. To improve the accuracy of the estimated hypocenter location, we performed seismic tomography by adding DONET data to the previous 3D tomographic study (Yamamoto et al., 2017), and updated the velocity structure and hypocenter location simultaneously.

The spatial characteristics of the updated velocity model are not so different from the previous model (Yamamoto et al., 2017), but the recovery of the checkerboard resolution test is greatly improved. From the obtained hypocenter catalog, we extract earthquakes near the plate boundary based on the plate boundary model (Nakanishi et al., 2018) and found that these earthquakes were localized in several clusters. Most of them are located outside the large slip deficit area suggested by the geodetic data (Nishimura et al., 2018). They also seem not to overlap with the active area of VLFE (Takemura et al., 2019). These spatial relationships indicate the monitoring of regular earthquakes may provide useful information about the interplate coupling status.

Keywords: Nankai Trough, Ocean bottom seismographic observation, DONET, Seismicity

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.20 Zoom Room 20

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency), Chairperson:Kohei Nagata(Meteorological Research Institute), Masatoshi Miyazawa(Disaster Prevention Research Institute, Kyoto University)

This session aims to improve our understanding on seismicity. Any contribution on behavior of earthquakes as a cluster, such as regional seismicity and aftershocks, are welcomed. We also welcome contribution on temporal and spatial interactions that control seismicity, and tectonic processes, and geological and thermal structures that regulate seismicity.

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

[SSS06-07] Toward the construction of an integrated assessment method of crustal activity - characterization of “normal” seismicity in Japan-

*Kohei Nagata[1], Koji Tamaribuchi[1], Fuyuki Hirose[1], Akemi Noda[1] (1.Meteorological Research Institute)

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

[SSS06-08] A hierarchical model of earthquake asperity

*Yoshio Fukao[1] (1.Center for Earthquake and Tsunami / Japan Agency for Marine-Earth Science & Technology)

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

[SSS06-09] Radiation-corrected empirical Green's function in slip inversion

*Ritsuya Shibata[1], Genki Oikawa[1], Naofumi Aso[1], Junichi Nakajima[1], Satoshi Ide[2] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo)

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

[SSS06-10] Modeling dynamic rupture and statistical properties of earthquakes with cellular automaton models.

*Kota Fukuda[1], Takahiro Hatano[2], Kimihiro Mochizuki[1] (1.Earthquake Research Institute The University of Tokyo, 2.Department of Earth and Space Science Osaka University)

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

[SSS06-11] Dynamic earthquake triggering in Southern California in high resolution

*Masatoshi Miyazawa[1], Emily E Brodsky[2], Huiyun Guo[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.University of California, Santa Cruz)

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

[SSS06-12] Discussion

Toward the construction of an integrated assessment method of crustal activity -characterization of “normal” seismicity in Japan-

*Kohei Nagata[1], Koji Tamaribuchi[1], Fuyuki Hirose[1], Akemi Noda[1]

1. Meteorological Research Institute

Meteorological Research Institute is progressing research to develop the method to assess the crustal activity such as seismicity and crustal deformation by integrating the various parameters that characterize the activities. The ultimate goal is to assess the potential of the integrated method to express the current anomaly of crustal activity. For that purpose, it is necessary to quantify the “normal” crustal activity from a more integrated perspective not only from the conventional viewpoint based on the results of individual parameters. In the presentation, we will report the result of the analysis of the joint distribution of the parameters characterizing the size distribution, tidal correlation, and activation/quiescence of seismicty estimated from hypocenter data for the past 20 years in Japan conducted as an attempt to develop the integrated assessment method.

In the analysis, we used the JMA unified seismic catalog from 2000 to August 2021. We extracted two types of dataset consist of shallow-inland earthquakes ($M \geqq 2.0$, depth ≦30 km) and earthquakes including subduction-zone earthquakes ($M \geqq 3.5$, depth≦100 km) from the catalog. For each dataset, the parameter values are estimated for the same N consecutive earthquakes in dl degree square spatial grids. The results are smoothed by shifting the analysis window by half, that is, $N/2$ in the temporal direction and $dl/2$ in the spatial direction. The results give us a joint distribution in addition to the individual distributions of each parameter. When comparing the distribution with parameter values observed in specific time or space, it is possible to apply a conventional statistical test such as the goodness-of-fit test by extracting the results of grids that do not overlap each other.

As a parameter characterizing the size distribution of seismicity, the GR law’s b value was estimated. The earthquakes that clearly deviate from the GR law, such as aftershocks just after a large earthquake, were excluded by the R value (Wiemer and Wyss 2000, 2002). As a parameter characterizing the tidal correlation of seismicity, based on Schuster's test (Schuster 1897), we used the D value ($D^2=(\Sigma_{i=1}^{N} \cos\theta_i)^2+(\Sigma_{i=1}^{N} \sin\theta_i)^2$, where θ_i is the tidal phase angle of i'th earthquake) to estimate the correlation between seismicity and phase angle of tidal response of volumetric strain. To eliminate the apparent correlation caused by swarming earthquakes, instead of using declustered data, which makes difficult to estimate joint distribution, we excluded the case where $N/4$ or more events occurred within half of the tidal cycle. For characterizing activation/quiescence of seismicity, the expected number of earthquakes in the analysis window by the ETAS model (E value, hereafter), whose parameters were estimated in each spatial grid, is used. Some of the ETAS parameters used here can also be used as indicators of seismicity’s regionality.

The probability density distributions of the three parameters (b, D, E) are close to, but different from those expected from theory and model. Though the difference should include the spatiotemporal fluctuations that should be investigated in detail, it makes sense to quantify them as an average characteristic of "normal" seismic activity by excluding the known "abnormal" cases such as the very early stage of aftershocks where the frequency distribution clearly deviates from the GR law or where earthquakes occur too frequently to estimate tidal correlation. With the joint distributions of these parameters, for example, when anomalies in the size distribution and tidal correlation of seismicity occur simultaneously, it will be

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possible to quantify how abnormal the observed phenomena are. It is also important to know whether a distribution of the parameter values different from "normal" may be obtained before the occurrence of a significant earthquake or in response to crustal deformations. In the presentation, we would like to introduce some examples from this perspective.

Keywords: seismicity, tidal correlation, ETAS, starain rate

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A hierarchical model of earthquake asperity

*Yoshio Fukao[1]

1. Center for Earthquake and Tsunami / Japan Agency for Marine-Earth Science & Technology

Introduction

Asperity models (Lay and Kanamori, 1981) have contributed greatly to understanding of such phenomena as regional characteristics of great earthquakes (Lay et al., 1982) and repeating earthquakes on plate boundaries (Matsuzawa et al., 2002). Hierarchical rupture models, on one hand, have been developed by remarking the self-similar characteristics of seismic rupture growth (Smalley et al., 1985; Fukao and Furumoto, 1985). The self-similarity implies unpredictability of the eventual size of rupture growth by observing seismic radiation. Recent careful analyses of seismic waves seem to support this implication (Maier et al., 2016; Okuda and Ide, 2018; Ide, 2019). The self-similar behavior is a phenomenon expected at a critical state of the stress system (Allégre et al., 1982; Turcotte, 1997). The power law of the event-size distribution known as the Gutenberg-Richter relation (Gutenberg and Richter, 1954) is regarded as an expression of this critical state (Narteau, 2007). Here, we explore a hierarchical asperity model in which asperity patches are distributed to allow their progressive unlocking from smaller to larger scales at a critical state.

Basic idea of the model

The elastic upper plate and the rigid lower plate are in frictional contact. The lower plate is kept at rest. The elasticity of the upper plate is modeled by an array of springs connecting the rigid surface at the top and a fractal set of asperities at the bottom (Fig.1). Uniform shear traction across the top surface is transmitted to the asperities through the equally deflected springs. Fig.1 shows our one-dimensional asperity model (Cantor set) and two-dimensional asperity model (Sierpinski carpet). The basic slip-system consists of the central major asperity and the surrounding minor asperities mutually isolated by already slipped patches. The major and minor asperities have the same frictional strength but their sizes are different, so stresses concentrate more on the minor asperities (Stage A). All the minor asperities are eventually unlocked and the imposed force is now supported only by the major asperity (Stage B). This state is understood as the rebirth of Stage A at the next larger scale (Stage C). The subsequent process is then the rebirth of Stage-B at this larger scale (Stage D). Rupture develops self-similarly from the smallest to larger scales, if the process A→B is appropriately renormalized to the process C→D.

Renormalization of the system

The process A→B involves the stress-release from the surrounding minor asperities and the consequent stress-accumulation on the central major asperity. Such stress transfer is guaranteed in our model by imposing the scale-independent condition that the probability for all the surrounding minor asperities to be unlocked equals the probability for the central asperity to be unlocked. These two probabilities can be calculated as functions of $p_o(\sigma / \sigma_o)$, where $p_o(\sigma / \sigma_o)$ describes the probability for an asperity to be unlocked by relative applied stress σ / σ_o (Turcotte, 1997). For the one-dimensional asperity model, the equality of the two probabilities occurs at $p_o = 0.42565$ or $\sigma / \sigma_o = 0.74466$. For the two-dimensional asperity model, the equality occurs at $p_o = 0.55831$ or $\sigma / \sigma_o = 0.90396$. If the system is tuned to this critical state, the basic system at any scale grows self-similarly into one at the next larger scale with probability p_o.

Characteristics of the two-dimensional hierarchical asperity model

(1)The asperity distribution in Sierpinski carpet →Fault plane with a fractal dimension D of 1.8928. (2)Non-asperity patches = Already unlocked asperities →GR law with a b-value of 1 (b ≠D/2). (3)Stresses on minor asperities 9 times higher than one applied on the top surface →Frictional strength of asperity

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much higher than the overall stress drop. (4)Successively upscaled radiations from surrounding minor asperities and from the central major asperity →Unpredictbility of final earthquake size by observing seismic radiation.

Keywords: earthquake, fault, asperity, hierarchy, self-similarity

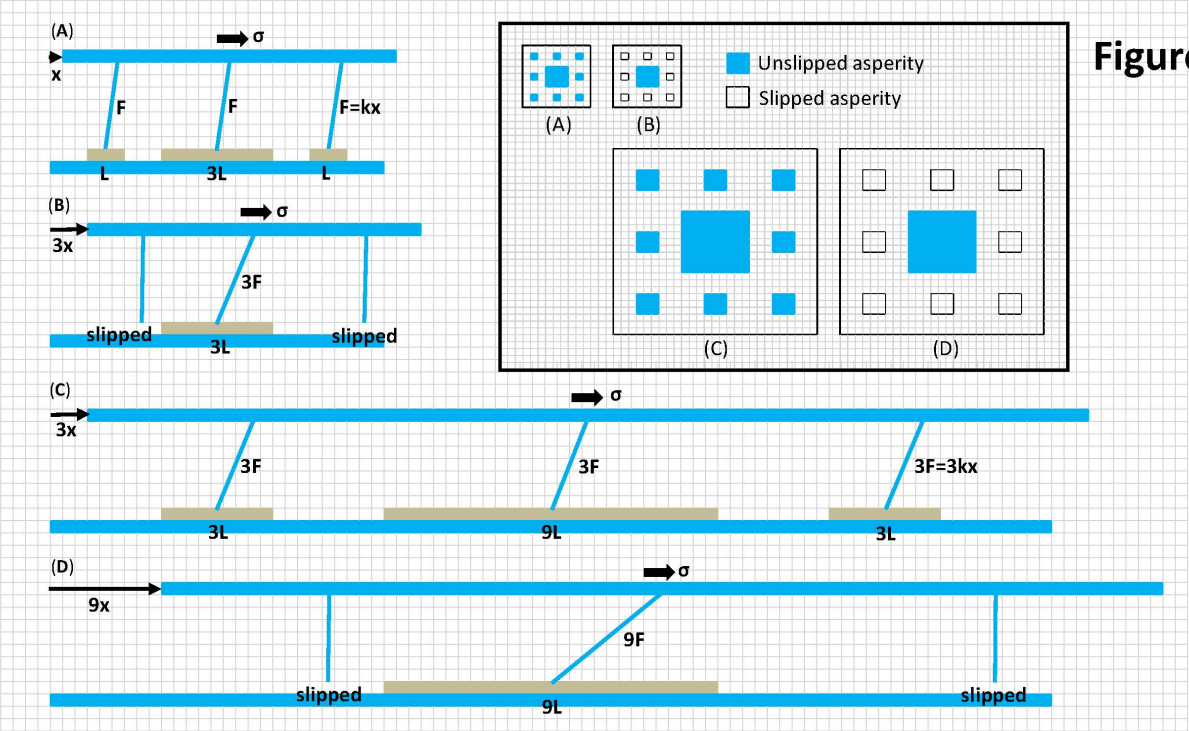


Figure 1

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Radiation-corrected empirical Green's function in slip inversion

*Ritsuya Shibata[1], Genki Oikawa[1], Naofumi Aso[1], Junichi Nakajima[1], Satoshi Ide[2]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2. Department of Earth and Planetary Science, The University of Tokyo

Slip inversion is one of the useful methods to analyze source processes, which have the advantage of being able to estimate the detailed spatial and temporal slip distribution. In this method, the least square problem is solved for the slip amount at each time step and each spatial step to minimize the waveform misfit between the observed waveforms and the synthetic waveforms which are generated by convolving the Green’s functions and the source time functions. Therefore, we need to estimate the accurate Green’s functions for the slip inversion and there have been numerous efforts to accurately estimate Green’s functions. In the case of theoretical Green’s function that is calculated from a given velocity structure, detailed a priori information on seismic velocity structure is required (e.g. Bouchon, 1981; Takeo, 1985). In contrast, empirical Green’s function (EGF), which is obtained by utilizing the seismograms of nearby small earthquakes with similar focal mechanisms, requires the occurrence of such appropriate events nearby the target event (e.g. Hartzell, 1978). To release these strict constraints partially, we proposed “radiation-corrected EGF” by correcting the radiation patterns of the EGF seismograms (Fig. 1). In particular, based on the ray theory, we can calculate the theoretical radiation patterns of the target event and the EGF event. Then, using the ratio of the radiation patterns in each component at each station, we correct the amplitude of the EGF seismogram for each of P, SV, and SH waves.

The effectiveness of the radiation correction was confirmed by the simplest synthetic tests with a triangular source time function in our previous study. Therefore, in this study, we investigate the applicability of the radiation-corrected EGF to the multi-time-window method (Olson and Apsel, 1982; Hartzell and Heaton, 1983). As a first step in applying the radiation-corrected EGF to the multi-time window method, we solve inversion problems in a setting that the fault finiteness is negligible. Therefore, we consider only time steps for the inversion.

At first, we applied this radiation-corrected EGF and the conventional EGF to the real data to confirm the superiority of the radiation pattern correction. We investigated the reproductivity of the synthetic waveforms and the estimated moment using the observed waveforms of three Mw~5 class earthquakes: the 2007 Mw 5.0 Mie earthquake, the 2011 M_w 5.2 Hiroshima earthquake, and the 2016 Mw 4.8 Kumamoto earthquake. We used the underground KiK-net stations of the National Research Institute for Earth Science and Disaster Resilience (NIED) within the epicentral distance of 50 km from each of the target event. To calculate the radiation pattern, we estimated the take-off and incident angles by ray tracing in a horizontally-layered structure of the JMA2001 (Ueno et al., 2002) using the TauP package (Crotwell et al., 1999). As a result of the real data application, we confirmed that the better moment estimations with better waveform fittings can be obtained by the radiation-corrected EGF compared to the conventional method for the three cases.

Next, to investigate the validity of the results obtained in the real data application, we performed recovery tests of the source time functions. In these recovery tests, we verified the reproductivity of the estimated source time functions using theoretical waveforms calculated from given source time functions which were determined randomly under the same station distribution, focal mechanisms, and hypocenter

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location as three analyzed earthquakes in the real data application. The theoretical waveforms are calculated using the FK application (Zhu and Rivera, 2002) in the velocity structure of JMA2001. We made 1,000 randomly determined source time functions and solved the inversion problems with the radiation-corrected EGF and the conventional EGF for each given source time function. As a result of the recovery tests, for all samples, the results with the radiation-corrected EGF have better waveform fittings, better moment estimations, and better reproductivity of the source time functions than those with the conventional EGF for three earthquakes. In addition, we confirm that the inversion results are fairly stable regardless of the shape of the source time functions.

Keywords: empirical Green's function, slip inversion, source process

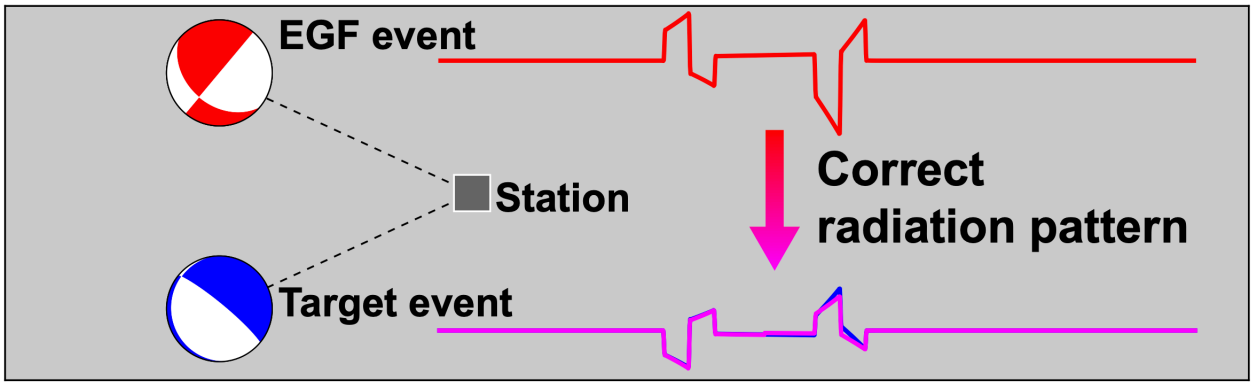


Figure 1. Concept of this study.

The blue beach ball represents a target event and the red beach ball represents the EGF event with different focal mechanism at a different location. The radiation-corrected EGF (purple line), which is generated from the seismogram of the EGF event (red line) by correcting radiation patterns of far-field P and S waves, matches the seismogram of the target event (blue). Two events at depths of 20 km have the same triangle slip rate function with a duration of 1 s and the same moment magnitude. Epicentral distances from the events to the station (grey square) are 10 km. All the seismograms use a velocity record of 15 s from the origin time in vertical component in the same scale. A homogeneous media without a free surface is assumed, where the P-wave velocity is 5.0 km/s and S-wave velocity is 3.0 km/s. A subtle mismatch corresponds to the near-filed and intermediate terms.

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Modeling dynamic rupture and statistical properties of earthquakes with cellular automaton models.

*Kota Fukuda[1], Takahiro Hatano[2], Kimihiro Mochizuki[1]

1. Earthquake Research Institute The University of Tokyo, 2. Department of Earth and Space Science Osaka University

How to understand seismic activity from deterministic rupture mechanics is an important issue in seismology. In recent years, the development of rupture mechanics-based cycle simulations has been remarkable, and we are now at the stage where we need to figure out how to simulate more complex fault structures. However, due to issues such as understanding friction at high speeds and computational costs, rupture mechanics-based earthquake cycle simulations that fully incorporate realistic heterogeneous structures have not yet been realized. In this study, we tackle this issue by considering complex heterogeneous structures as a multibody problem, and using a statistical physics approach that understand the multibody system in a simplified way through good coarse-graining. The goal of this study is to develop a cellular automaton model that reproduces both the fracture and the statistical properties, and to improve our understanding of the coarse-graining that is useful for understanding complex seismic activity. Such an attempt can serve as a useful relay point for understanding seismic activity on a fracture mechanics basis.

Conventional studies of cellular automata models have focused on statistical properties and have not touched on dynamic behavior [Carlson and Langer,1989:Olami et al.] In addition, it has been pointed out that the BK model with a simple friction law has a pulsed rupture behavior with constant slip and does not show the characteristics of a regular earthquake as a rupture behavior [Ide and Yabe, 2019]. Therefore, the OFC model, which is said to reproduce the GR, was extended to include a finite time constant of the rupture chain to create a cellular automaton model that can handle rupture behavior (Dynamic OFC model). The rupture behavior of the Dynamic OFC model shows a behavior similar to that of the tremor, which is one of the slow earthquakes, rather than a regular earthquake.

The Dynamic OFC model that we have been using so far incorporates the assumption that the rupture threshold (corresponding to the strength) does not change even at the end of one rupture step.
This assumption implies that the strength recovery is very fast in relation to the rupture chain (i.e., the rupture chain is slow). In this study, the model was further extended to include a new parameter, the ratio of the time constant of loading and strength recovery to the time constant of the fracture chain. This model is capable of discussing slow phenomena (slow rupture propagation) and fast phenomena (fast rupture propagation) in a unified manner, using the competition between the two time constants of (1) fracture and stress accumulation, and (2) fracture and strength recovery as parameters.

We introduce that this model reproduces both the crack-like rupture behavior, where the moment rate spectrum is proportional to the square of the frequency, and the Gutenberg-Grichter law, where the size frequency distribution is the power law distribution. We will also discuss how such a cellular automaton model can provide a perspective on the coarse-graining of fracture phenomena. The results of the parameter range of the slow phenomenon (slow fracture propagation) will be introduced in the poster presentation in the S-CG39 session.

Keywords: Cellular automaton model, Gutenberg-Grichter law, nonequilibrium statistics, Dynamic rupture, Omega squared model

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Dynamic earthquake triggering in Southern California in high resolution

*Masatoshi Miyazawa[1], Emily E Brodsky[2], Huiyun Guo[2]

1. Disaster Prevention Research Institute, Kyoto University, 2. University of California, Santa Cruz

Earthquake triggering by seismic waves has been recognized as a phenomenon for nearly thirty years. However, our ability to study dynamic triggering has been limited by our ability to capture the triggering stresses accurately and record the resultant earthquakes. Here we use full waveforms from a dense seismic network and a modern, high-resolution seismic catalog to measure triggering in Southern California from 2008 to 2017 based on interevent time ratios. We find that the fractional seismicity rate change, which we term triggering intensity or triggerability, as a function of peak strain change for the period of ~20 s due to distant earthquakes is monotonically increasing and compatible with earlier measurements made with a disjoint dataset from 1984 to 2008. A triggering strain of 1 microstrain is equivalent to the local productivity generated by an *M*1.8 earthquake. This result implies that a prediction of seismicity rate changes can be made based on recorded ground shaking using the same formalism as currently used for aftershock prediction. For a teleseismic event, this small level of triggering occurs throughout the region and thus aggregates to a regional effect. We find that the triggering rate decays after the triggerer follows an Omori-Utsu law, whereas at a much slower rate than a typical aftershock sequence. The slow decay rate suggests that an ancillary process such as creep or fluid flow must be part of dynamic triggering. The prevalence of triggering in areas of creep or fluid involvement reinforces this inference. A triggering cascade of secondary earthquakes is insufficient to explain the data.

Keywords: dynamic triggering, delayed triggering, equivalent magnitude, triggering intensity

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[J] Oral | S (Solid Earth Sciences) | S-SS Seismology

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency), Chairperson:Kohei Nagata(Meteorological Research Institute), Masatoshi Miyazawa(Disaster Prevention Research Institute, Kyoto University)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.20 (Zoom Room 20)

This session aims to improve our understanding on seismicity. Any contribution on behavior of earthquakes as a cluster, such as regional seismicity and aftershocks, are welcomed. We also welcome contribution on temporal and spatial interactions that control seismicity, and tectonic processes, and geological and thermal structures that regulate seismicity.

12:00 PM - 12:15 PM

[SSS06-12]Discussion

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[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.10_2

[S-SS06] Statistical seismology and underlying physical processes

convener:Yasuhiro Yoshida(Meteorological Research Institute, Japan Meteorological Agency)

This session aims to improve our understanding on seismicity. Any contribution on behavior of earthquakes as a cluster, such as regional seismicity and aftershocks, are welcomed. We also welcome contribution on temporal and spatial interactions that control seismicity, and tectonic processes, and geological and thermal structures that regulate seismicity.

[SSS06-P01] Accuracy improvement of DONET seismometer orientations estimated from seismic waveforms

*Shuichiro Yada[1], Takehiro Nishiyama[1], Keisuke Ariyoshi[1], Yojiro Yamamoto[1], Masaru Nakano[1], Kentaro Sueki[1], Takane Hori[1], Narumi Takahashi[2,1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Research Institute for Earth Science and Disaster Resilience)

[SSS06-P02] A preliminary study on data quality characterization for the DONET seismic catalogue

*Kazuyoshi Nanjo[1,2,3], Keisuke Ariyoshi[4], Narumi Takahashi[4,5], Shuichiro Yada[4], Yojiro Yamamoto[4], Takane Hori[4] (1.University of Shizuoka, 2.Shizuoka University, 3.Institute of Statistical Mathematics, 4.Japan Agency for Marine-Earth Science and Technology, 5.National Research Institute for Earth Science and Disaster Resilience)

[SSS06-P03] Aftershock activity of the 2015 M7.1 earthquake and back-arc rifting in the northern Okinawa Trough

*Hirotsugu Yanagida[1], Yukihiro Nakatani[2], Hiroshi Yakiwara[2], Shuichiro Hirano[1], Reiji Kobayashi[1], Yusuke Yamashita[3], Takeshi Matsushima[4], Hiroshi Shimizu[4], Kodo Umakoshi[5], Masanao Shinohara[6] (1.Graduate School of Science and Engineering, Kagoshima University, 2.Nansei-Toko Observatory for Earthquakes and Volcanoes, Kagoshima University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 5.Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 6.Earthquake Research Institute, the University of Tokyo)

[SSS06-P04] Microseismic Monitoring and Stress Inversion: before the 2018 Mw 6.4 Hualien earthquake and 2019 M_L 6.0 Ilan earthquake

*Wei-Jhe Wu[1], Chein-Min Su[1], Strong Wen[1], Yi-Heng Li[2], Chun-Rong Chen[2], Chau-Huei Chen[1] (1.National Chung Cheng University, 2.Industrial Technology Research Institute)

[SSS06-P05] Aftershock activity and its duration following inland earthquakes in Japan

*Taichi Honda[1], Takuji Yamada[2] (1.Ibaraki University, 2.Faculty of Science, Graduate School of Science and Technology, Ibaraki University)

[SSS06-P06] Whether the change in shear strain energy causes change in *b* value? Case study for the 2016 Kumamoto Earthquakes and the interplate coupling along the Nankai Trough

*Kohei Nagata[1], Akemi Noda[1], Koji Tamaribuchi[1], Fuyuki Hirose[1] (1.Meteorological Research Institute)

[SSS06-P07] Inter-plate aseismic slip determined from teleseismic similar earthquakes recorded by the Japanese seismic network

*Toshihiro Igarashi[1], Aitaro Kato[1] (1.Earthquake Research Institute, University of Tokyo)

[SSS06-P08] Seasonal variations in crustal seismicity and surface load

*Taku Ueda[1], Aitaro Kato[1] (1.Earthquake Research Institute, the University of Tokyo)

Accuracy improvement of DONET seismometer orientations estimated from seismic waveforms

*Shuichiro Yada[1], Takehiro Nishiyama[1], Keisuke Ariyoshi[1], Yojiro Yamamoto[1], Masaru Nakano[1], Kentaro Sueki[1], Takane Hori[1], Narumi Takahashi[2,1]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Research Institute for Earth Science and Disaster Resilience

We re-estimated DONET seismometer orientations with 9 years of seismic observation data during the year between 2011 and 2020. With this study, we obtained one digit smaller standard errors of estimated seismometer orientations compared to the former study, thanks to the longer analysis period.

In 2012, Nakano et al. have firstly estimated DONET1 seismometer orientations by the 3 types of analysis method as follows: [1]
correlations of long-period seismic waveforms with land seismometer observation direction of P-wave first motion for distant earthquakes particle motions of airgun signals
This study shows that the orientation difference compared to the measurement data of ROV video is up to 10 degrees for the most seismometers, while the difference comes up about 50 degrees for some others.

Further, Nakano reinforced the information of estimated orientations of seismometers after the construction of DONET2 in 2017 using the method (1) and (2) described in Nakano et al. (2012) as above. Nakano also re-estimated the seismometer orientations of DONET1 with this study. [2]

In this study, Nakano shows that the obtained standard errors of estimated seismometer orientations is around 1 to 2 degrees. However, for some seismometers, estimated orientation figures are considered to have a few degrees of error, because of insufficient distant earthquake event that were available during the study. Since DONET2 construction completed in the middle of this study, enough observation period could not be available for these seismometers.

Therefore, it has been expected to re-estimate the DONET seismometer orientations with longer observation period and with sufficient distant earthquake events that can be used for the analysis.
We re-estimated DONET seismometer orientations by the method (2) described in Nakano et al. (2012) with 9 years of DONET data and obtained the latest figures of estimated orientation after the replacement of seismometer at observation point KMC11 in June 2018. We confirmed that the obtained orientations are basically consistent with the previous studies, e.g. Nakano et al. (2012) and Nakano (2017). Also, 9 years of DONET data enables us to obtain the standard errors of estimated orientation with the order of 0.1 degree for most seismometers. We hope that the most up to date and more accurate figures of estimated DONET seismometer orientations will help the concerned scientists and researchers for their studies.

[1] Masaru Nakano, Takashi Tonegawa, and Yoshiyuki Kaneda. Orientations of DONET seismometers estimated from seismic waveforms. JAMSTEC Rep. Res. Dev., Volume 15, September 2012, 77-89

[2] Masaru Nakano, Orientations of DONET2 seismometers estimated from seismic waveforms, JpGU-AGU Joint Meeting 2017, STT59-P03

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Keywords: Ocean-bottom seismometer, Nankai trough, DONET, Seismometer orientation

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A preliminary study on data quality characterization for the DONET seismic catalogue

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To understand the characteristics of seismicity occurring in the source area of the Nankai Trough earthquake, research based on past observation data is indispensable, and a seismic catalogue that includes earthquakes in and around this area, if available, becomes one of them. It is also necessary to examine whether or not the data in such catalogue can be used for this research, and the results of evaluating the data quality will be the basic information for establishing the research direction. In this presentation, we report preliminary results from a study to evaluate qualities of the seismic catalogue including earthquakes observed by the DONET (Dense Oceanfloor Network system for Earthquakes and Tsunamis).

In this study, quality evaluation was carried out, using three techniques that utilize statistical properties of earthquakes. The first is based on the frequency-magnitude distribution of earthquakes. Using this technique, it is confirmed that larger earthquakes tend to have fewer numbers and smaller ones tend to have more numbers, and that this tendency is well correlated with the Gutenberg-Richter's law. The second approach is to plot the frequency of earthquakes as a function of hour. Natural earthquakes should occur day and night, and it is suggested that if the frequency of earthquake occurrence changes depending on time, it originates from anthropogenic causes (e.g., human activities and artificial earthquakes). The frequency was found to be approximately constant, which is considered to be due to few anthropogenic effects because the DONET is installed offshore. The third approach is based on the assumptions that the smaller magnitude is, the harder earthquake detection is, and that earthquakes with magnitudes, above a certain threshold value, are observed without missing. The threshold is called completeness magnitude, M_c, above which all earthquakes consider to be detected. This is an indicator of the quality assessment of seismic catalogues. As a result of the completeness analysis, we observed spatiotemporal variability of M_c, as observed for other seismic networks such as the ones used to create the catalogue maintained by the Japan Meteorological Agency.

This study on data quality characterization for the DONET catalogue is currently underway. Our results in the presentation will include the most recent findings.

Keywords: Seismicity, Statistical analysis, Data quality characterization, DONET, Nankai Trough

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Aftershock activity of the 2015 M7.1 earthquake and back-arc rifting in the northern Okinawa Trough

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A magnitude (M) 7.1 earthquake occurred on November 14, 2015 at the western margin of the northern Okinawa Trough (OT). The northern OT is assumed to be in an incipient stage of the back-arc spreading [e.g., Iwasaki et al., 1990; Nakahigashi et al., 2004] and the mainshock–aftershock sequence of the 2015 event might be caused by the back-arc rifting. Although the aftershock activity seems to be distributed along the transition area from the East China Sea shelf to the OT [Nishizawa et al., 2019], their focal depths were not well constrained because of the onshore seismic station coverage. In order to better understand the tectonic process which controls the aftershock sequences, we precisely relocated their hypocenters and determined focal mechanisms using long-term ocean bottom seismometer (LOBS) data. We used data from seven onshore stations operated by Kagoshima University and Kyushu University and five LOBSs. We selected the aftershocks equal to or larger than M2.0 (M2.5 in part) in the Japan Meteorological Agency (JMA) catalog data from April 12, 2016 to April 16, 2017. Initial hypocenters were determined by HYPOMH program [Hirata and Matsu’ura, 1987] with manual picks of the P and S phases. Station corrections for the LOBSs were calculated using a time difference between P- and PS-converted wave arrivals for intermediate-deep earthquakes which occurred around Satsuma Peninsula at depths of 80–180 km. We applied the station correction values for all stations to both P and S arrivals, and then obtained the 453 final hypocenters. Due to the station correction, the mean of median values of travel-time residuals for P and S waves decreased from -43 msec to -1 msec and from 421 msec to -158 msec, respectively. We also determined 122 focal mechanisms based on estimating the strike and dip of the two nodal planes satisfying P-wave first-motion polarities.

Final relocated hypocenter distribution shows sharp linear trends, while the JMA one shows two broad clusters. From our results, we can clearly recognize the aftershock activity as three earthquake alignments: a 70-km-long trend along the NNE-SSW direction (Segment A), a 30-km-long trend along the WNW-ESE direction (Segment B) located on the north of Segment A, and a 20-km-long trend along the NNE-SSW trend (Segment C). The relocated focal depths are mainly distributed around 10 km in Segments A and B, and in the range of 0–15 km in Segment C, while the JMA ones are widely distributed within the range of 0–20 km. In Segment A, the spatiotemporal variation of seismicity indicates that the aftershocks seem to migrate from south to north, and most of the focal mechanisms show normal-fault types with NW-SE tension axes. In Segment B, the seismicity is relatively steady during the observation period, and left-lateral strike-slip-fault types with NW-SE tension axes are largely confirmed. In Segment C, an earthquake swarm activity started about half a year after the mainshock and lasted for about two months, and normal-fault types with NW-SE tension axes are dominant.

The activities in Segments A and C are mainly concentrated in the upper crust. These aftershocks might be caused by crustal extension related to the back-arc rifting in the northern OT because their focal mechanisms and the directions of the alignments are consistent with the existing normal faults imaged by the MCS survey [Nishizawa et al., 2019]. The left-lateral strike-slip faulting type events in Segment B could

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be explained by along-axis variation in the back-arc spreading rate and presence of a transcurrent fault [Kakuta and Goto, 2002].

Keywords: OBS observation, the northern Okinawa Trough, back-arc rifting, aftershock activity

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Microseismic Monitoring and Stress Inversion: before the 2018 Mw 6.4 Hualien earthquake and 2019 M_L 6.0 Ilan earthquake<gdiv></gdiv>

*Wei-Jhe Wu[1], Chein-Min Su[1], Strong Wen[1], Yi-Heng Li[2], Chun-Rong Chen[2], Chau-Huei Chen[1]

1. National Chung Cheng University, 2. Industrial Technology Research Institute

In 2020, we have been in difficulty at applying traditional research methods of Earth Science because of the COVID-19 outbreak. This study aims to make the most of the microseismic events, which are often excluded in stress-optical studies in the past, to gain extra information that was not able to measure in the past. Therefore, we will be able to acquire more detailed information on seismogenic structure and stress state in specific areas. Through 3D velocity structure re-location, ray-tracing technique, and stress inversion method of the entire event, this study will be able to apply seismic data more objectively and more accurately. This way will ensure the result more credibility due to the fact that the study avoids the influence of subjective consciousness and introduce the concept of confidence limits. The result shows that the seismogenic structure of Northeast Taiwan is under complex influences of Philippine Sea Plate subduction and Okinawa Trough open. The seismic activity is complicated. Through increasing microseismic data and microzonation, we will be able to understand thoroughly the distribution of the space in the seismogenic structure of that area. Furthermore, this will offer the background stress information that the study needs when we study stress-transfer in the future.<gdiv></gdiv>

Keywords: Northeast Taiwan, stress inversion, microseismic

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Aftershock activity and its duration following inland earthquakes in Japan

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A major earthquake (main shock) will be followed by many smaller earthquakes, which are called aftershocks, around its source area. Aftershock activity of a large earthquake is clearly detectable even in the number of earthquakes in all over Japan as a function of their size (magnitude). The analysis of aftershock activity is also important for disaster mitigation. In this study, we analyzed the number and duration of aftershocks for inland earthquakes in Japan and investigated their relationships to the size of major earthquakes.
In order to distinguish aftershocks from the steady seismic activity, it is necessary to define aftershocks in space and time. We first picked up earthquakes shallower than 30 km in the circular area from the epicenter of a large earthquake with a radius of 10^(0.5Mw-2) km as aftershock candidates, where Mw indicates the moment magnitude of the large main shock. We then define the seismic activity within 180 days before the main shock as the regular activity and investigated the period until the earthquake activity becomes lower than n times of the regular one, which is regarded as the aftershock duration. We analyzed three values of n=3, 5, 7 and confirmed that the conclusion is independent of the n value. Earthquakes with Mj equal to 3 and greater were investigated in this study for confirming the detection completeness, especially immediately after the 2011 Tohoku earthquake, where Mj stands for the magnitude value determined by Japan Meteorological Agency.
Although the temporal aftershock activity seems not to have a clear relationship to the size of main shocks, we detected a strong correlation between the size of main shocks and the number of aftershocks. We also found a weak correlation of the aftershock duration to the size of main shocks. We also investigated the effect of the regular earthquake rate to the results of aftershock duration. Earthquakes in a high seismic rate were likely to have a shorter aftershock duration, but we found no clear correlation between activities of regular earthquakes and aftershocks. These results suggest that the aftershock activity will be affected by other factors in addition to the main shock size, including the complexity of the rupture characteristics and the depth of the fault plane.

Keywords: inland earthquakes, aftershock activity, duration of aftershock activity

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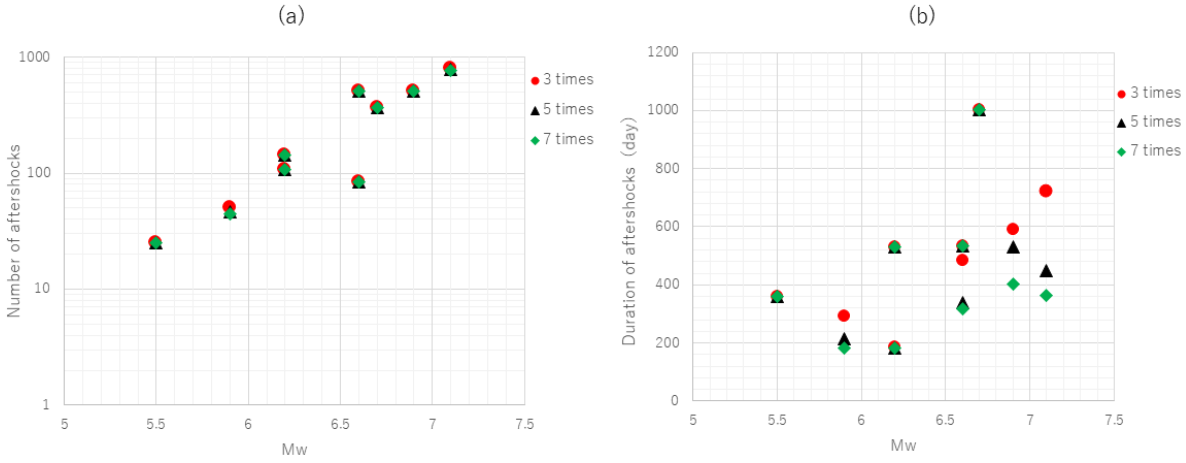


Figure1.
(a) Relationship between the magnitude of the main shock (Mw) and the number of aftershocks (magnitude 3.0 or higher). The symbols indicate results for three different values of n (refer to the main text).
(b) Duration of aftershocks as a function of the main shock size.

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Whether the change in shear strain energy causes change in *b* value? Case study for the 2016 Kumamoto Earthquakes and the interplate coupling along the Nankai Trough

*Kohei Nagata[1], Akemi Noda[1], Koji Tamaribuchi[1], Fuyuki Hirose[1]

1. Meteorological Research Institute

The *b* value in the Gutenberg–Richter law, one of the typical parameters representing the characteristics of seismic activity, is often considered to depend on the differential stress from observations in laboratory experiments and regional differences in seismic activity (Scholz, 2015). Regarding the physical background of the stress dependence, it is reasonable to think that the larger the differential stress, the higher the probability of crack growth and the number of relatively large-scale earthquakes increase, as proposed by Scholz (1968). However, estimating the stress field including its absolute value involves great uncertainty, and it is difficult to estimate the differential stress on a scale corresponding to actual seismic activity. Therefore, when considering the use for real-time monitoring of earthquakes or earthquake forecasts, it would be unrealistic to discuss the change in *b* value focusing only on the relationship with the differential stress.

On the other hand, in recent years, changes in shear strain energy (ΔSSE, hereafter) have been proposed to be used as an index that quantitatively evaluates the degree of shear stress accumulation from relative changes in the stress field without assuming a fault plane (Saito et al., 2018; Matsu'ura et al., 2019; Terakawa et al., 2020; Noda et al., 2020). An increase in shear strain energy means an average increase in shear stress when fault planes are randomly oriented in the crust, and a relationship with an increase in the number of earthquakes has already been reported. If the increase in shear strain energy contributes the growth of rupture in earthquake faults, it is expected that the *b* value will decrease correspondingly.

Based on this view, we investigated the difference in the size distribution of seismic activity corresponding to ΔSSE due to the 2016 Kumamoto earthquakes (Noda et al., 2020). Estimates of shear strain energy have uncertainty mainly due to the uncertainty of the assumed effective friction coefficient. However, unless the effective friction coefficient is 0, the spatial distribution of increase and decrease of shear strain energy is almost constant except in the very vicinity of the fault. Therefore, we first, identified the region where the shear strain energy increased/decreased (positive/negative ΔSSE) in any case with the effective friction coefficient of 0.1 to 0.4. Then, for each region, the earthquakes that occurred in the region were extracted from the Japan Meteorological Agency unified seismic catalog. Using the extracted hypocenter data, *b* values before the Kumamoto earthquakes (January 2000-April 13, 2016), and those after the decrease of detectability due to the largest earthquake has almost recovered (April 16, 2016, 8:00 to August 2020) were estimated with some different lower limit of M(M_{th}, hereafter) in the range from 2.0 to 3.0.

As a result, in the positive ΔSSE region, the *b* value decreased after the Kumamoto earthquakes compared to before the earthquakes. The amount of decrease exceeded the standard error for almost all M_{th}. After the Kumamoto earthquake, the *b* value in the positive ΔSSE region was lower than the *b* value in the negative ΔSSE region for all M_{th}. This difference was slightly smaller than the standard error for most M_{th}. In the negative ΔSSE region, no clear change in *b* value was observed before and after the Kumamoto earthquake. There is no significant difference in the distribution of focal depths in each of

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these comparison targets.

In addition to the above results, we investigate the relationship between ΔSSE due to interplate coupling along Nankai Trough (Saito et al., 2018) and the *b* value. Comparing the size distributions of seismic activity corresponding to the positive and negative of the shear strain energy change in the entire analysis region, the estimated *b* values tend to be slightly higher in the region where the shear strain energy change is negative. Though there are some parts that cannot be simply compared since the comparison is made over a wide area where the regional differences in *b* value can be affected not only by ΔSSE considered here but also by various causes such as focal depth and effective normal stress, on average, the results are consistent with the expectations. We would like to discuss these results together in the presentation.

Keywords: seismicity, shear strain energy, b value

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Inter-plate aseismic slip determined from teleseismic similar earthquakes recorded by the Japanese seismic network

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1. Earthquake Research Institute, University of Tokyo

Similar earthquakes that occur in approximately the same location at different times have the potential to reveal the spatio-temporal changes in aseismic slip rate along plate boundaries. In this study, we identified similar earthquakes with moderate magnitudes in worldwide by calculating the cross-correlations of bandpass-filtered seismograms recorded by the Japanese dense seismic network. As a result, many similar earthquakes were detected along subduction plate boundaries, including the Japan–Kuril–Kamchatka–Aleutian, the Andaman–Sumatra–Java, and the Solomon–Vanuatu–Tonga region. Based on the spatio-temporal evolutions of similar earthquakes, we investigated the spatial distribution and temporal characteristics of inter-plate aseismic slip around the Pacific and Indian oceans. The estimated slip rates in several areas are higher than the relative velocity of the two converging plates. These areas correspond to regions where similar earthquakes with relatively short recurrence intervals were identified following megathrust earthquakes. We infer that these similar earthquakes were induced by postseismic slip along the plate boundary. In other regions, similar earthquake sequences have a constant recurrence interval of several years to several decades. Estimated slip rates are equal to or less than the relative velocities of plate motion, including the back-arc spreading rate. These observations indicate that the plate boundary faults in these regions are strongly locked. These results suggest that spatio-temporal changes in inter-plate aseismic slip around the world can be estimated by analyzing similar earthquake sequences. We believe that additional similar earthquakes will be detected by extending the analysis periods in areas where similar earthquakes were not identified in this study, resulting in slip rates with higher spatio-temporal resolution. A time series of stacked slip rates against the elapsed time since megathrust earthquakes initially increased rapidly following the rupture of each earthquake and then gradually decayed over periods of ~10 years, which correlates with after-slip progressing around the source areas. Around 30 years after megathrust earthquakes, the slip rate begins to increase with approaching the next megathrust rupture. This gradual increase in slip rate during the middle and later stages of the earthquake cycle may be due to an increase in stress levels that accumulate during tectonic loading. A similar earthquake catalog provides a valuable framework for understanding the long-term evolution of slip-rate during megathrust earthquake cycles.

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Seasonal variations in crustal seismicity and surface load

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It has been reported that seismicity rate correlates with phenomena cause temporal changes of stress and fault strength at the surface and shallow subsurface, such as precipitation and irrigation (e.g., Heki, 2003: Amos et al., 2014). For example, in California, previous studies have indicated that seismicity rate varies seasonally in response to stress changes due to annual variations in hydrological loading (e.g., Amos et al., 2014; Johnson et al., 2017). Johnson et al. (2017) calculated the stress change which hydrological loading imposes on the fault plane based on GPS vertical displacement. They showed that seismicity in California is more likely to occur when shear stress increases. The seasonal variations in seismicity in Japan have also been pointed out, and its relationship to snow loading and precipitation has been discussed as the plausible cause (e.g., Heki, 2003; Ueda and Kato, 2019). However, few studies have directly compared the seasonal variations in seismicity with the stress changes brought by surface loading.

In this study, we estimate the spatial and temporal distribution of surface load from the vertical displacement data in the inland Tohoku region and investigate the relationship between the stress change by the surface load and the timing of earthquake occurrence. First, we extract the seasonal variation component from the vertical displacement of the GEONET F5 solution (2017/1/29-2020/5/2) by excluding transient changes such as earthquakes and postseismic deformation using the method proposed by Bedford and Bevis (2018). Then, we calculate the spatial and temporal distribution of surface load using the extracted seasonal variation components according to Johnson et al. (2017). Then, we compute the stress changes at the earthquake occurrence using the observed focal mechanism to quantitatively evaluate the relationship between earthquake occurrence and seasonal stress changes.

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 10:45 AM - 11:45 AM JST | Thu. Jun 3, 2021 1:45 AM - 2:45 AM UTC | Ch.19 Zoom Room 19

[S-SS07] Crustal Structure

convener:Mikiya Yamashita(National Institute of Advanced Industrial Science and Technology), Chairperson:Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology)

The aim of this session is to cover seismological and geophysical studies on the Earth's crust and uppermost mantle. Contribution on seismological and geophysical structure of the crust, processes that develop in the crust which include earthquakes, volcanoes and geological descriptions of the crust are welcomed. We also welcome theoretical and methodological studies that will serve as basics in such explorations.

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

[SSS07-01] Examination of applicability of seismic interferometry in exploration of underground structure under a volcanic body

*Hirofumi Kowari[1], Koji Yamada[1], Tatsuyuki Ueno[1] (1.Hanshin Consultants Co., Ltd.)

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

[SSS07-02] Deep seismic reflection profiling across the Tsugaru peninsula, northern Honshu, Japan

*Hiroshi Sato[1,2], Tatsuya Ishiyama[1], Hideo Saito[3], Mamoru Nakata[3], Naoko Kato[1], Susumu Abe[3] (1.Earthquake Research Institute, The University of Tokyo, 2.Center for integrated Research and Education of Natural Hazards, Shizuoka University, 3.JGI, Inc.)

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

[SSS07-03] Deep crustal seismic profiling from airgun-OBS surveys offshore Niigata-Yamagata: reflection imaging via reverse time migration

*Kazuya Shiraishi[1], Tetsuo No[1], Gou Fujie[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[SSS07-04] Revealing structures in the shallow crust beneath Botswana, southern Africa: considering dip and anisotropy

*Admore Phindani Mpuang[1,2], Takuo Shibutani[2] (1.Graduate School of Science, Kyoto University, 2.Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

Examination of applicability of seismic interferometry in exploration of underground structure under a volcanic body

*Hirofumi Kowari[1], Koji Yamada[1], Tatsuyuki Ueno[1]

1. Hanshin Consultants Co., Ltd.

Reflection seismic survey using a large vibrator is difficult to apply to underground structure exploration of rugged mountain bodies. In addition, it is hard to conduct exploration by blasting because it is practically tough to secure a sufficient number of blasting points. Therefore, we tried to apply the seismic interferometry using microtremors as a part of the study of the underground structure exploration of mountain body. Daisen volcano in Tottori Prefecture, which is known to have had several eruptions, was selected for our analysis.

The data used in this analysis is a continuous velocity records observed by NIED (Hi-net) and Kyoto University, at a total of 16 stations. These stations are located within a distance of approximately 50 km from the summit of Daisen Volcano. The data were collected for one year from January 1, 2019. Missing periods of microtremor recordings were visually searched from the raw data and removed before the analysis.

The analysis method is described. First, processing to reduce large-amplitude events due to natural earthquakes or noise was conducted with the spectral whitening method (Bensen *et al.*, 2007), and the records were bandpass-filtered in the frequency range of 0.05 Hz and 2Hz. Then, data with a length of 409.6 seconds was cut out while moving the time window every 450 seconds, and the cross-correlation function was estimated for each time window. Rayleigh wave and Love wave extracted by interfering the UD component and the transverse component, respectively. In the case of there is no data loss, the maximum number of stacks is 70,080. Cross-correlation function obtained by interfering UD components is shown in Fig. 1. Group velocity between the two observation points was obtained by reading the peak of the nonstationary spectrum which calculated by the multiple filter method for data that folded the cross-correlation function with a delay time of 0. Phase velocity was converted from the group velocity using the phase shift calculated in the previous process. The frequency band to obtain a plausible the group velocity was manually determined. The plot of the obtained the phase velocity with results of Yamada (2018, 2019) is shown in Fig. 2. Finally, 2D tomography was performed using the FMST routine (Rawlinson and Sambridge, 2005) to obtain the spatial distribution of the group velocity and the phase velocity for Rayleigh and Love waves, respectively. The settings are as follows: grid width is 0.05 degrees, the initial value of the model is the average of all ray paths, and iterative calculation was performed 7 times. Fig. 3 shows the spatial distribution of the phase velocity of the Rayleigh wave at 0.4 Hz.

The results are shown below. Most of the cross-correlation functions are asymmetric. In addition, the seasonal change in the ratio of the maximum amplitude for each of the positive and negative delay times of the cross-correlation functions was remarkable in some pair of stations located in the north-south direction. This ratio is highest in January and lowest in June. Therefore, it tends to behave as if there was a wave source at the north of the group of stations (Sea of Japan) in winter. The region where the phase velocity of Rayleigh wave is slow in Fig. 3 is almost coincident with the region where negative gravity anomalies are observed in Fig. 4. Because it reflects a thick sedimentary layer of about 1.5 km (Nishida, 2003), propagation velocity is slow at Yumigahama where negative gravity anomalies are most prominent within the range shown in Fig. 3. In areas where the north-eastern side of the tectonic line from Mt. Koreisan to Mt. Daisen (Ota, 1962) and around of Hiruzen volcanic group, negative gravity anomalies are observed (Komuro *et al.*, 1997), and propagation velocity of surface wave is slow compared to the surrounding area. This tendency was remarkable at low frequencies that are affected by deeper layers. A

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similar tendency appeared in the group velocity of Rayleigh waves and the phase velocity and the group velocity of Love waves. Since these volcanoes are composed of relatively low-density volcanic rocks, they are considered to form contrast with the surroundings where the base rock (plutonic rock) is exposed as a region where surface wave propagation velocity is slow or negative gravity anomaly is observed.

Acknowledgment: we used continuous velocity records observed by NIED (Hi-net) and Kyoto University.

Keywords: exploration of underground structure, seismic interferometry, microtremor, tomography, Daisen volcano

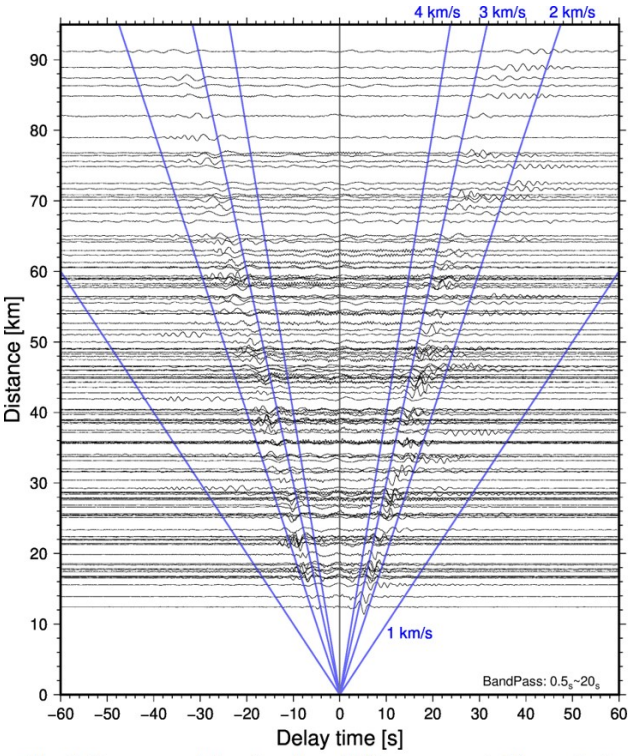


Fig. 1. Cross-correlation function of UD-component. The vertical axis corresponds to the distance between the pair of stations. Bandpass filter 0.05 - 2 Hz is applied.

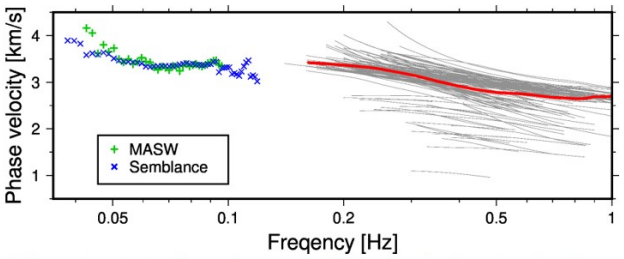


Fig. 2. Obtained dispersion curve of phase velocity of Rayleigh wave (gray line). Red line denotes average of those. Green + and blue x indicate phase velocity estimated by Yamada (2018, 2019).

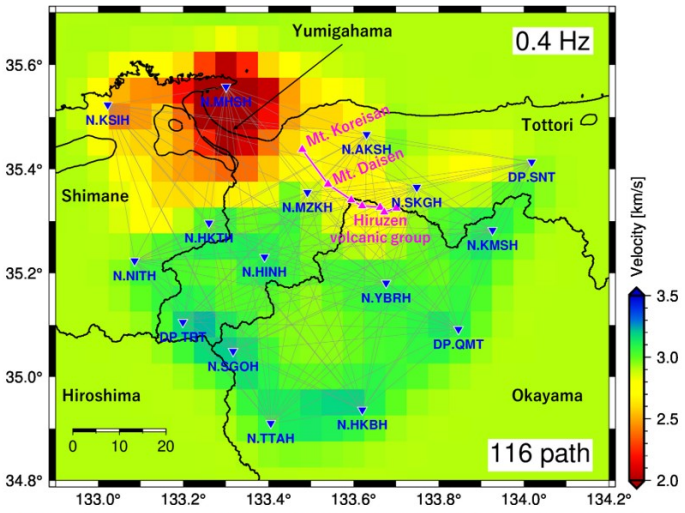


Fig. 3. Spatial distribution of phase velocity of Rayleigh wave at 0.4 Hz. Blue triangles denote stations used for this analysis. Gray lines indicate the ray path coverage. Purple triangles show volcano.

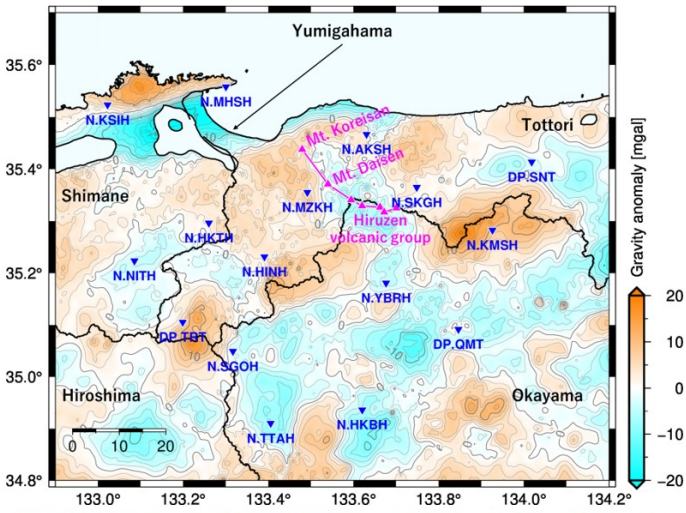


Fig. 4. Bouguer anomaly. Contour lines are drawn every 2 mgal. See the caption of Fig. 3 for explanation of the triangle symbols.

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Deep seismic reflection profiling across the Tsugaru peninsula, northern Honshu, Japan

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A large number of active reverse faults are distributed along the Sea of Japan coast of Norther Honshu. To reveal their deep geometry is significant for better estimates of strong ground motions and tsunami hazards. In 2020, a deep seismic reflection profiling was carried out across the southern part of the Tsugaru peninsula as a part of the “Integrated Research Project on Seismic and Tsunami Hazards around the Sea of Japan” funded by MEXT. The length of the seismic line is 59 km from the coast of the Aomori bay to the coast of the Sea of Japan across the Tsugaru mountains and Tsugaru plain. Seismic source was four vibroseis trucks and seismic signals were recorded by 5 Hz geophones. As a standard mode, receiver interval was 50 m and shot interval was 100 m. In a higher-resolution mode, we used 25 m receiver interval and 50 m shot interval. Fixed 1887 channel were used for the seismic survey. To obtain deeper P-wave velocity structure, 50 to 100 stationary sweeps were carried out at every 4 km along the seismic line. Seismic data were processed using standard CMP-method and refraction tomography method. Geologic were interpreted using geological maps published by Geological survey, Japan.

The seismic sections revealed the geologic structure down to 6 km and portray an anticlinorium with steeper eastern limb beneath the Tsugaru mountains. P-wave velocity profile shows the thick low velocity layer, suggesting basin inversion processes. The reverse faults bounding the eastern limb of the range was generated as normal faults during the opening of the Sea of Japan. The 1766 Meiwa Tsugaru earthquake (M 7.0) damaged the southern part of the Tsugaru plain. The damaged area is located at the hanging wall of the faults bounding the eastern edge of the Tsugaru mountains. Thus, it is highly probable that this fault was the source fault of the earthquake of 1766.

Along the western margin of the Tsugaru plain, west dipping blind-reverse fault is clearly demonstrated on the seismic profile. On the hangingwall of this fault, stage 5e marine terraces are distributed, suggesting the late Quaternary movements along this fault. Based on the Bougue anomaly and distribution of marine terraces, this subsurface active fault extends 40 km trending NS. From the P-wave velocity structure and pattern of reflectors, this fault also shows the basin inversion.

Keywords: Seismogenic source fault, deep seismic reflection profiling, Tsugaru Peninsula, 1766 Tsugaru Meiwa Earthquake

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Deep crustal seismic profiling from airgun-OBS surveys offshore Niigata-Yamagata: reflection imaging via reverse time migration

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In offshore seismic exploration, estimating lithosphere-scale velocity structures by Traveltime tomography and waveforms inversion is general application to the data of ocean bottom seismographs (OBS) with airgun shooting. On the other hand, reflection imaging from the airgun-OBS data, is not general because of low folds from the sparse OBS deployment. However, reflections in the long offset data, which may contain information from the deep like the Moho discontinuity and deeper structures, is important challenge for further understanding of the deep earth structures. Furthermore, reflection profiling of crustal structures from the airgun-OBS is useful when multichannel seismic (MCS) surveys with hydrophone streamer cables are not available due to weather conditions and difficulties on the equipment or vessels.

In this study, we applied reflection imaging by reverse time migration (RTM) to the airgun-OBS data acquired in the Japan Sea by JAMSTEC. The RTM method is based on numerical modeling of the wave equation to simulate forward wavefields from source with a function and backward wavefields from receivers with observed seismic records, then reflections are imaged by the time integration after correlating the two wavefields. Although this method requires more computation costs than conventional ray-based imaging methods, it can provide higher quality images in complicated structures. In case of the airgun-OBS data, the source-receiver reciprocity can be adopted on the relation between airgun shooting and OBSs to save of the computation cost.

We applied this method to the airgun-OBS data of two survey lines in the western offshore area of Niigata and Yamagata: EMJS1003 (297 km) in 2010 and SJ1901 (366 km) in 2019. These two lines were crossed each other at approximately 220 km offshore from the coast line. Airguns were fired every 200 m for both survey lines. OBSs were deployed with 5 km spacing on EMJS1003 and with variable spacing of 2km, 8 km, and 16 km from near the coast to the offshore on SJ1901. Reflections from the Moho were observed on most of the OBS records in both surveys. While MCS data was available on the same line of EMJS1003, MCS survey was not conducted on SJ1901 due to weather condition. Velocity models obtained by traveltime tomography (Sato et al., 2014, JGR; No et al., 2020, SSJ fall meeting) were available for wavefield modeling in the RTM application.
The Moho reflections were clearly imaged on seismic reflection profiles for both lines. The depth of the Moho was traced from approximately 20 km in the Yamato Basin to approximately 30 km near the coast through the Sado Ridge and the Mogami Trough. This result was consistent with the crust thickness inferred from analyses of the airgun-OBS data of EMJS1003 (Sato et al., 2014). The reflection profile from the OBS data showed clear image of the Moho that was difficult to be imaged by the MCS survey on EMJS1003. We also obtained the reflection profile on SJ1901 where the MCS data was not available. These results showed high potential for application of our method to airgun-OBS survey data with different varieties of OBS spacing. Updating velocity models by waveform inversion and using surface-related multiples by mirror imaging or interferometric OBS imaging are useful for better reflection profiles including sediment layers and structures in the crust. Complimentary improvement of subsurface information by both MCS and OBS surveys is important for further understanding of the deep structures.

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Keywords: airgun-OBS survey, deep crustal structure, seismic reflection profile, reverse time migration, Japan Sea

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Revealing structures in the shallow crust beneath Botswana, southern Africa: considering dip and anisotropy

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In receiver function analysis, velocity models developed under the assumption of horizontal isotropic interfaces suffer inaccuracies in the presence of dipping and anisotropic structures. In such cases, the receiver functions exhibit back-azimuthal variation of amplitude and delay time. Such features of receiver functions have been observed in records from stations located in the Okavango rift zone and Limpopo belt in Botswana, with evidence for strong P-to-S conversions from high Vs contrasts in the shallow crust. In this study, the presence and nature of seismic structures at shallow crustal depths beneath Botswana is investigated in order to improve the current understanding of the seismic structure beneath the various tectonic regions in southern Africa. As a first step, 3Hz P-to-S receiver functions are computed for teleseismic events from epicentral distances between 30 and 85 degrees recorded at 37 stations located within Botswana, with magnitudes Mw>5.8. After carrying out a quality assessment, receiver functions with good quality are stacked in 30-degree back azimuth bins. These receiver function stacks are then subjected to harmonic decomposition (Bianchi et al., 2010) to constrain the presence, or lack thereof, of dipping and anisotropic structures in the shallow crust. The resulting harmonic stacks suggest that at shallow depths in the Limpopo belt, the metasedimentary sequences lie unconformably over uneven crystalline metamorphic basement surfaces, while plunging anisotropy may be present in the metamorphosed clastic sediments and basalts of the Kheis belt. In the Okavango rift zone, harmonic stacks indicate presence of very shallow strong heterogeneity in the overlying unconsolidated sediments. Applying a genetic algorithm inversion technique is expected to give optimum estimates for Vs, dip and anisotropy magnitude and orientation of the structures.

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[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.11_1

[S-SS07] Crustal Structure

convener:Mikiya Yamashita(National Institute of Advanced Industrial Science and Technology)

The aim of this session is to cover seismological and geophysical studies on the Earth's crust and uppermost mantle. Contribution on seismological and geophysical structure of the crust, processes that develop in the crust which include earthquakes, volcanoes and geological descriptions of the crust are welcomed. We also welcome theoretical and methodological studies that will serve as basics in such explorations.

[SSS07-P01] Local variations of seismic scattering-attenuation structure around the volcanic front in Hokkaido

*Kiyoshi Yomogida[1], Hidekatsu Masuda[2], Takahiro Shiina[3], Kei Katsumata[4] (1.Department of Earth and Planetary Dynamics, Graduate School of Science, Hokkaido University, 2.Earth and Planetary Dynamics, Faculty of Natural History Sciences, Graduate School of Science, Hokkaido University, 3.National Institute of Advanced Industrial Science and Technology, 4.Institute of Seismology and Volcanology, Hokkaido University)

[SSS07-P02] Study of the delamination structure at the southern end of the Hidaka collision zone-Examination using numerical calculation-

*Masahiro Shimazaki[1], Noriko Tsumura[2] (1.Graduate School of Science and Engineering, Chiba University, 2.Graduate School of Science, Chiba University)

[SSS07-P03] Three-dimensional resistivity modeling in the eastern Iburi district, Hokkaido

*Ryo Ito[1], Takeshi Hashimoto[1], Tomohiro Inoue[1], Makoto Uyeshima[2], Hiroshi Ichihara[3], Yusuke Yamaya[4] (1.Graduate School of Science, Hokkaido University, 2.Earthquake Research Institute, The University of Tokyo, 3.Graduate school of environmental studies, Nagoya University, 4.National Institute of Advanced Industrial Science and Technology)

[SSS07-P04] Measurement of seismic velocity anisotropy in the Tohoku region, NE Japan by shear wave splitting analysis (3)

*Tatsuya Mizuta[1], Tomomi Okada[1], Martha Savage[2], Ryota Takagi[1], Keisuke Yoshida[1], Shin'ichi Sakai[3], Mako Ohzono[3,9], Masahiro Kosuga[4], Yoshiko Yamanaka[5], Hiroshi Katao[6], Takeshi Matsushima[7], Hiroshi Yakiwara[8], Takashi NAKAYAMA[1], Satoshi Hirahara[1], Toshio Kono[1], Toru Matsuzawa[1], _ Group for the aftershock observations of the 2011 off the Pacific coast of Tohoku Earthquake (1.Tohoku Univ., 2.Victoria University of Wellington, 3.Tokyo Univ., 4.Hirosaki Univ., 5.Nagoya Univ., 6.kyoto univ., 7.kyushu Univ., 8.Kagoshima Univ., 9.Hokkaido Univ.)

[SSS07-P05] Velocity structure of the uppermost mantle beneath central Japan

*Akio Katsumata[1] (1.Faculty of Sustainable Design, University of Toyama)

[SSS07-P06] Seismological structure revealed by regional deep-event records beneath the Kii peninsula

*Yasunori Sawaki[1], Takuo Shibutani[2], Yihuan Ruan[1], Yoshihiro Ito[2] (1.Graduate School of Science, Kyoto University , 2.Disaster Prevention Research Institute, Kyoto University)

[SSS07-P07] Deep crustal seismicity in Hiroshima Prefecture

*Azusa Shito[1] (1.Okayama University of Science)

[SSS07-P08] Seismic imaging of the subducting Kyushu-Palau ridge in relation to the distribution of tectonic tremors

*Yanxue Ma[1], Kimihiro Mochizuki[1], Rie Nakata[1], Seiichi Miura[2], Yasuyuki Nakamura[2], Ryuta Arai[2], Gou Fujie[2], Yuka Kaiho[2], Shuichi Kodaira[2] (1.Earthquake Research Institute, University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

[SSS07-P09] **Analysis of JAMSTEC Seismic Survey Database site**

*Yuka Kaiho[1], Seiichi Miura[1], Ayako Nakanishi[1], Tetsuo No[1], Kaoru Takizawa[1], Yasuyuki Nakamura[1], Gou Fujie[1], Koichiro Obana[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology)

Local variations of seismic scattering-attenuation structure around the volcanic front in Hokkaido

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Inhomogeneous seismic structures of various scales exist in and above a subducting plate. Especially for S waves in a frequency range of higher than 1 Hz, the observed waveforms are affected by scattering and attenuation by small-scale inhomogeneous structures. As a result, a wavepacket, generally called coda wave, is formed after the direct S wave, but their features are far from the standard of monotonically decaying in time. The envelope of an S waveform passing through the strong heterogeneous region in the subduction zone has its peak time delayed relative to the expected time of the direct wave, and its duration is generally long, forming a spindle-shaped waveform. Peculiar waveforms are observed especially near the volcanic front. In Kanto and Tohoku regions of Japan, large difference in waveform characteristics has been clearly detected at their volcanic front as a sharp vertical boundary. The characteristics of their fine heterogeneous structures have been studied. For example, characteristic S coda waves are observed with a high frequency component of 8 Hz or higher (Shiina et al., 2021).

In this study, we analyzed S waveforms recorded at stations in Hokkaido, Japan, for deep intraplate earthquakes. The frequency dependency of their S wave envelopes is strong on the north side of volcanic front but weak on its vicinity. We also investigated the spatial variation of S wave envelopes along the volcanic front, in addition to across the front. The arrival delays of envelope peaks are generally small in the central Hokkaido area including the Hidaka mountains while those in the eastern area of Shiretoko Peninsula shows similar characteristics to the Tohoku region. In contrast, the volcanic front near Lake Akan appears to be a sharper discontinuity than in the other regions, that is, there exist highly complex structures with small scales together with a distinctive volumetric body of intensive seismic attenuation.

Keywords: small-scale heterogeneities, scattering, attenuation, volcanic front

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Study of the delamination structure at the southern end of the Hidaka collision zone -Examination using numerical calculation-

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Hidaka Collision Zone (HCZ) is located in the central and southern part of Hokkaido where the Kuril forearc dragged by oblique subduction of the Pacific plate has collided with the Northeastern Japan arc. From upper to upper part of the Kuril’s arc lower crust have been thrusted up along the Hidaka Main Thrust (HMT) and are exposed to the surface. Various seismic surveys have been conducted for the purpose of investigating the subsurface structure of this region.

Reflection survey was carried out across the collision zone at the south end of the HCZ. From obtained depth section, Ito et al. (2013) showed that the lower crust of the Kuril arc is divided into a northeast-dipping ascending layer and a southwest-dipping descending layer at a depth of 23km. Meanwhile, Kita et al. (2012) estimated the three-dimensional P wave velocity structure in the same region by travel time tomography. They interpreted that crustal material of the Northeastern Japan arc has subdected under the thrusting Kuril arc.

In order to understand that how mass excess due to the collision between island arcs will be resolved, it is necessary to know the structure of the deep part of the collision zone. In this study, based on the two interpretations, we prepared two kind of structure models and compared the features of the actual seismic profiles and synthetic seismic profile, and examined which model is appropriate. One of models is a Delami model in which delamination occurs and delaminated lower part of the Kuril arc’s lower crust is continuously subducting to the Pacific plate and the other model is a Non-delami model in which the crustal material of the Northeastern Japan arc is subducting under the thrusting Kuril arc. Numerical calculation was performed using the two models under the similar conditions as in the actual survey, and a synthetic seismic profiles was created by applying the reflection method to the calculated waveforms. As a result, synthetic seismic profile for the Delami model, the features of the descending and thrusting reflectors are almost the same as the actual seismic profile. However, the depth of the reflector that can be traced by the reflected wave from the upper surface of the lower crust below the Kuril arc in the synthetic seismic profile appears deeper than the actual seismic profile. On the other hand, synthetic seismic profile for the Non-Delami model, it was found that only the feature of the thrusting reflector is matched. From this result, it is considered that the delaminated structure of the Kuril arc is needed to explain the result of the actual seismic profile. However, the reflected wave from the deeper extension of the Kuril’s arc subducting lower crust does not reach the receivers within the recording length and can not be imaged on the synthetic seismic profile.

Next, we performed another numerical calculation to know the location where we shot to confirm it if the deeper extension of the subducting Kuril’s arc crust is present. As a result, if we shot at the southwestern point of 45 km from the southwestern end of the actual reflection survey line, the reflected wave from the deeper extension of the Kuril’s arc subducting lower crust will reach about 24 seconds after the shooting to the recievers of the previous reflection survey settled on the land area.

Keywords: collision zone, Hidaka, reflection survey

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Three-dimensional resistivity modeling in the eastern Iburi district, Hokkaido

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A magnetotelluric (MT) survey was carried out in October to November in 2018 at 14 sites around the epicenter of the 2018 Hokkaido Eastern Iburi earthquake (September 6, 2018: Mw 6.6). We inverted full components of the MT impedance and tippers to estimate a three-dimensional (3-D) electrical resistivity model of this area by using the BIRRP (Chave and Thomson, 2004) and ModEM programs (Egbert & Kelbert, 2012). The main shock was located at a depth of nearly 40 km, and its aftershocks were concentrated in a depth range from 20 to 40 km. It is important to investigate the subsurface structure of the seismogenic zone of such an unusually deep intraplate earthquake. Previous studies have suggested that the low resistivity regions in the mid-crust under active faults are saturated with aqueous fluid, and that pore water pressure increases as the fluid migrates to the surroundings, driving earthquakes (e.g., Ogawa et al., 2001). A distinct low resistivity body was also found by Yamaya et al. (2017) at the depth of Ishikari-teichi-toen fault zone (ITFZ), the western neighbor of the target area of our study. They presumed that the pore space created by ductile deformation of the lower part of the thick sediment layer was saturated with fluid. In our 3-D model a low-resistivity layer of about 10 Ωm was found at a depth from the surface down to c.a. 10 km. Similar conductive thick sediments were reported in the previous studies that dealt with the MT data across the Hidaka collision zone (Ichihara et al., 2019), and that investigated the ITFZ (Yamaya et al., 2017). On the other hand, our 3-D model at present is not well constrained for the deeper part including the hypocenter region. In the next step, we are going to incorporate the data from the previous studies into our inversion model to better image an electrical structure in the deeper part.

Acknowledgments: M. Takada, K. Saito (HU), and M. Masuda (ERI, UT) contributed to the fieldwork and data acquisition in 2018. This study was supported by ERI JURP 2018-F2-04 for the MT instruments, and financially supported by MEXT KAKENHI Grant-in-Aid for Special Purposes #18K19952.

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Measurement of seismic velocity anisotropy in the Tohoku region, NE Japan by shear wave splitting analysis (3)

*Tatsuya Mizuta[1], Tomomi Okada[1], Martha Savage[2], Ryota Takagi[1], Keisuke Yoshida[1], Shin'ichi Sakai[3], Mako Ohzono[3,9], Masahiro Kosuga[4], Yoshiko Yamanaka[5], Hiroshi Katao[6], Takeshi Matsushima[7], Hiroshi Yakiwara[8], Takashi NAKAYAMA[1], Satoshi Hirahara[1], Toshio Kono[1], Toru Matsuzawa[1], _ Group for the aftershock observations of the 2011 off the Pacific coast of Tohoku Earthquake

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Shear wave polarization anisotropy in the Tohoku region was measured using shear wave splitting, in which shear wave splits into fast and slow shear waves when a seismic wave passes through an anisotropic elastic medium in the crust. The method used was the Multiple Filter Automatic Splitting Technique (MFAST; Savage et al., 2010). In this method, by inputting the three components of the seismic waveform, the optimum filter is selected from 14 prepared filters, and the orientation and magnitude of the anisotropy in multiple time windows are measured by the method of SC91 (Silver and Chan, 1991). Then, quality evaluation is performed using cluster analysis (Teanby et al., 2004) from values measured from multiple time windows. MFAST is a program that automates this sequence, so it can process large amounts of data automatically, and can obtain objective and reliable measurements.

The analysis was carried out throughout the Tohoku region, and further detailed analysis was performed in the area where earthquakes are swarming in Akita Prefecture. We used temporary earthquake observation data from the Group for the aftershock observations of the 2011 off the Pacific coast of Tohoku Earthquake (the Tohoku-oki earthquake) and others. After the 2011 off the Pacific coast of Tohoku Earthquake, the orientations of anisotropy measured at each station in the whole Tohoku region can be seen as either N-S orientation or E-W orientation. In the Pacific coast from Iwate to Miyagi, the N-S orientation dominated, and in the central inland area, the E-W orientation had a stronger tendency. In addition, at some stations, the observed orientations were different for the deep earthquakes in the subducting plate and for the shallow earthquakes in the crust. The delay time, which indicates the magnitude of anisotropy, tended to increase in the regions where earthquake swarms occurred.

In the inland area of Akita prefecture, the analysis was performed before and after the 2011 Tohoku-oki earthquake. Overall, NE-SW to N-S orientation was predominant, and the orientation did not change much before and after the Tohoku-oki earthquake. Especially around the region where earthquakes swarms occurred, the tendency of the orientation differs for each station, suggesting that the anisotropy changes on a small scale. The delay time was larger overall before and after the Tohoku-oki earthquake than in the whole Tohoku region. In comparison before and after the Tohoku-oki earthquake, both areas with increased delay time and with decreased were observed.

Keywords: anisotropy

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Velocity structure of the uppermost mantle beneath central Japan

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In the central Japan area, complicated tectonic structure is recognized due to the interaction between the Pacific plate and the Philippine Sea plate. The volcanic front bends sharply in this area. There are many volcanoes with wide distribution such as Mt. Asama, those in northern Nagano Prefecture, and Hida mountain range. We estimated velocity structure of the uppermost mantle beneath this area with the tomography method. We used a method by Katsumata (2010), in which velocity structure was estimated from shallower parts to the deeper including depth distributions of discontinuities sequentially.

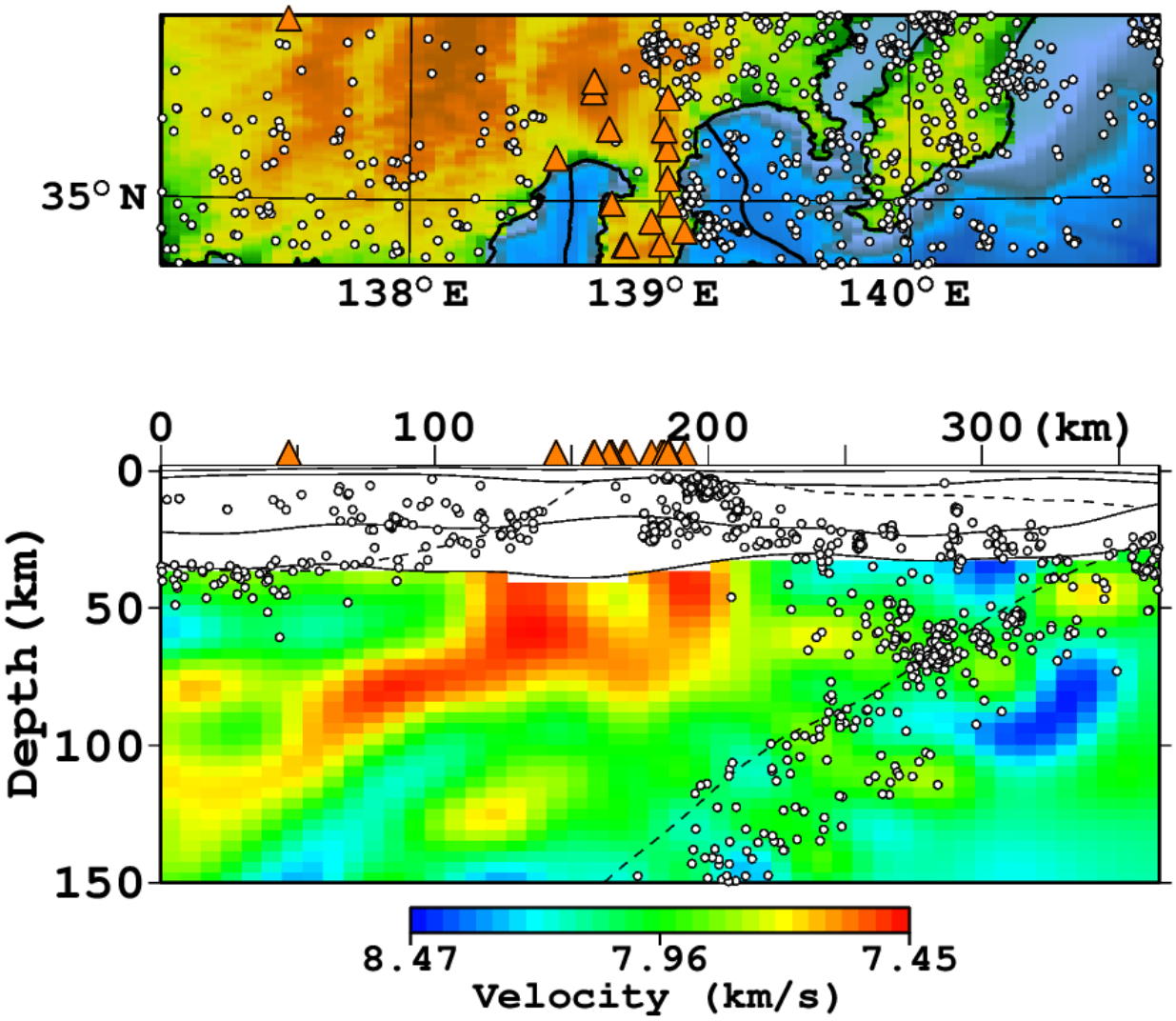
We describe the low velocity areas seen in the result of the tomographic analysis. Low velocity area is recognized beneath Niijima island. The low velocity area is distributed beneath the Philippine Sea plate rather than extending toward the Pacific Plate. In northeastern Japan, characteristic low velocity areas are recognized beneath the volcanic front which is considered to be related to the Pacific plate subduction. It is natural that the low velocity area beneath Izu Islands extends toward the Pacific plate. However, the appearance of the low velocity area is different from the expectation. Beneath the Izu Peninsula, the low velocity area seems to connect to the low velocity area beneath the western area of Shizuoka Prefecture down to about 100 km. It is similar to the low velocity area beneath Mt. Fuji (Figure). We recognize a large low velocity area beneath Yamanashi Prefecture at depth of about 100 km. Low velocity area is recognized beneath Mt. Yakedake above the Philippine Sea plate. Whereas it seems that low velocity area beneath Mt. Nasu extends toward the Pacific plate, low velocity areas beneath Mt. Myoko and Mt. Tateyama seems to extend downward to the west.

These low velocity distributions are just appearance seen in the result of a tomographic analysis, and interpretation on them are an unresolved problem.

Acknowledgements: We used the data provided by the Japan Meteorological Agency with the cooperation of the Ministry of Education, Culture, Sports, Science and Technology of Japan based on data from NIED, Hokkaido University, Hirosaki University, Tohoku University, The University of Tokyo, Nagoya University, Kyoto University, Kochi University, Kyushu University, Kagoshima University, the National Institute of Advanced Industrial Science and Technology, the Geospatial Information Authority of Japan, the Japan Agency for Marine-Earth Science and Technology, the Association for the Development of Earthquake Prediction, the Incorporated Research Institutes for Seismology, the Japan Meteorological Agency, and the governments of Aomori Prefecture, the Tokyo Metropolitan Government, Shizuoka Prefecture, and Kanagawa Prefecture.

Keywords: velocity structure of upper most mantle, volcanic front, Chubu district, Japan

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Seismological structure revealed by regional deep-event records beneath the Kii peninsula

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Elucidating seismological structure around subducting interfaces is essential to understand physical processes on slow earthquakes. Shibutani & Hirahara (2018, SSJ Fall Meeting) showed lateral variations on receiver function (RF) images beneath the Kii peninsula, southwestern Japan. We, here, calculate high-frequency RFs from seismic data recorded at temporary high-dense observation in the whole Kii peninsula from 2004 to 2013, especially using regional deep-focus earthquakes to image the Philippine Sea plate (PHS) around bimodal tremor sources: episodic tremor at the updip portion and continual tremor activity at the downdip portions.

Deep slow earthquakes such as tectonic tremor (tremor; Obara, 2002), low-frequency earthquakes (LFE; e.g., Katsumata & Kamaya, 2003), very-low-frequency earthquakes (VLFE; Ito et al., 2009) have occurred at the transition zone from the shallow brittle region to the deep stable slip region (e.g., Hirose & Obara, 2006) in southwestern Japan. Seismological structures from RFs have configured the shapes of the oceanic plate (e.g., Shiomi et al., 2008; Ueno et al., 2008), and constrained source regions of slow earthquakes; LFEs were located at the mantle wedge corner in the Tokai (Kato et al., 2010) and the western Shikoku (Shiomi et al, 2020). RF phases from the subducting interface become weak at downdip portions due to the entry to hydrous mantle wedge (Akuhara & Mochizuki, 2015; Kato et al., 2014).

Some clusters of continual tremors with minor bursts of shorter durations were also found at downdip portions of the tremor zone (Obara et al., 2010). Sawaki et al. (under review) estimated seismological structures of the subducting slab beneath the northeastern Kii peninsula from high-frequency RFs, and showed that the bimodal tremor source areas are under different seismological structures; the updip episodic tremor occurs beneath the forearc crust on near-lithostatic pore-fluid pressures and the downdip continual tremor occurs at the mantle wedge corner. However, the relationship between the lateral variation of seismological structures and the bimodal distribution of tremor has not been well examined. In this study, we investigate detailed seismic structures by multi-band RF analysis, using records of regional deep-focus earthquakes and teleseisms from the dense seismic observations in the Kii Peninsula from March 2004 to March 2013 (Nishimura et al., 2005, 2006).

For the calculation of RFs, we use the extended-time multitaper method (Shibutani et al., 2008) and the iterative deconvolution method (e.g., Ligorria & Ammon, 1999). Following Sawaki et al. (under review), we select records of the deep earthquakes within about 10˚ of epicentral distance, and remove traces that include direct *S* waves or converted *sP* waves. As result, cross-section RFs along the PHS subduction show structures of the PHS slab and the mantle wedge. The amplitudes of the PHS Moho decrease around the mantle wedge corner on the western survey lines. This may support the eclogitation of the basaltic oceanic crust, which increases the speed of the oceanic crust (e.g., Bostock et al., 2002), or indicate a fluid pathway of dehydrated fluid from the further deep Pacific slab (Kato et al., 2014; Umeda et al., 2012).

Keywords: Receiver function, Slow earthquake, Kii Peninsula, Fluid

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Deep crustal seismicity in Hiroshima Prefecture

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The thickness of the seismogenic layer and the lateral variation are important parameters for understanding the generation mechanism of crustal seismicity and earthquake hazard analysis [e.g., Iio et al., 2002].

The spatial distribution of D90, which corresponds to the cutoff depth for shallow earthquakes is obtained for the entire Japan by Omuralieva et al. [2012]. They showed that the lateral variation of D90 ranges from about 5 km to 40 km. Some remarkably deep D90 areas are found in the fore-arc side of east Japan along the Pacific coast. In the study, the causes of these locally deep D90 are explained by cooling effect of the subducting oceanic plate. There is another locally deep D90 area found in Hiroshima Prefecture, in the southwest part of the Chugoku region in southwestern Japan. The locally deep D90 in Hiroshima Prefecture is also considered to be caused by the cooling effect of the subducting Philippine Sea plate. Beneath this area, the Philippine Sea plate subducts at a very shallow angle, which may effectively cool the above inland crust [Omuralieva et al., 2012].

In this study, we analyze the characteristics of the locally deep seismicity in Hiroshima Prefecture. The seismicity distributes in the area with radius 10 km, centered at 34.5N, 132.7E. The deepest earthquakes occurred at ~ 30 km depths. The most magnitudes of the earthquakes are smaller than 3.0. We also investigate seismic wave velocities in the source region and the surroundings of the locally deep seismicity. The Vp and Vs are relatively high in the southern part of the seismicity area. This may give additional insight to the cause of the locally deep seismicity.

Keywords: crust, seismicity , D90

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Seismic imaging of the subducting Kyushu-Palau ridge in relation to the distribution of tectonic tremors

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Various types of slow earthquakes including slow slip events (SSEs), very low frequency earthquakes (VLFEs) and tectonic tremors occur around the boundary in the region off the Bungo-Channel located between the Kyushu and Shikoku Islands and their distributions appear to vary along depth of the subduction of the Philippine Sea Plate. Such variations are considered to reflect the frictional properties of the interface between the subducting and overriding plates. The morphology and the physical properties of the materials along the plate interface are the major controlling factors of the frictional properties. A subducted seamount has been identified from existing seismic reflection profiles and the magnetic anomaly map as a part of the Kyushu Palau Ridge. The VLFE and tremor activities have been found to occur around this subducted seamount (Yamashita et al., 2015; Tonegawa et al., 2020; Nakata et al., 2020). We conducted a marine active-source seismic survey in August-September, 2020 along four survey lines over the tremor activity region, NE-SW (HYU01), WNW-ESE (HYU02), and two NW-SE (HYU18 and 22) directions, using ocean bottom seismometers (OBSs) and a multi-channel seismic (MCS) hydrophone streamer. The HYU01 profile runs along the strike of the Nankai Trough, and the HYU02 runs over the subducting Kyushu-Palau Ridge in the along-dip direction of the Philippine Sea plate. We analyze and image seismic structures of the along-dip profile (HYU02) as well as the previously acquired KR0114-8 profile (Park et al., 2008) that intersects with HYU02 over the tremor activity region.

For wide-angle reflection / refraction analyses, we deployed 50 OBSs at a 2 km interval, and the 10,600-cubic-inch air gun array was fired at 50 and 200 m intervals along the line HYU02 during the KM20-05 research cruise using R/V *Kaimei* operated by Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The data quality of the OBS records is good. We can trace the refraction first arrivals up to ~70 km offset, and some wide-angle reflections are identified. We will first apply the travel time inversion to reveal a 2D P-wave velocity structure along the subduction of the Kyushu-Palau Ridge. The reflection data were recorded by using 444-channel streamer (5.6 km long) with 12.5 m interval for HYU02 and a 156-channel streamer (4 km long) with 25 m interval for KR0114-8. The HYU02 reflection data are being processed using broadband techniques and pre-stack time/depth migration to generate detailed reflectivity images as deep as the plate interface (Nakata et al., 2021). We reprocess the KR0114-8 line using the same modern methodology and aim to derive the high-resolution image with the focus on the subducted seamount and associated deformation within the overriding plate. By combining the OBS velocity, reflection data and magnetic data, we discuss the relationships between the distribution of the tremor activity, the morphology and physical properties along the plate interface.

Keywords: Kyushu-Palau ridge, Nankai Trough, ocean bottom seismometers, multi-channel seismic, reflection profile

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Analysis of JAMSTEC Seismic Survey Database site

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JAMSTEC provide seismic survey data and outcome through JAMSTEC Seismic Survey Database Website. We introduce database feature and trend of data request.This Website have two major rolls. One is data providing system and the other is publicity of research results.
We can provide survey data by using this website systematically after two years data moratorium. Besides, processed data, published results and derivative data such as seismic velocity model are available. Furthermore, analysis software download page and references list with survey area and cruise ID are in this Website. It is useful for publicity of research results.URL and DOI are follows.
http://www.jamstec.go.jp/obsmcs_db/e/
JAMSTEC (2004) JAMSTEC Seismic Survey Database. JAMSTEC. doi:10.17596/0002069
Our providing data is marine seismic survey data. Multi-Channel Seismic reflection (MCS) data and Ocean Bottom Seismograph (OBS) data can be requested from this Website. Data format of MCS data are SEG-D and SEG-Y. Data format of OBS are SEG-Y format about seismic survey, and SAC and WIN in earthquake observation. As a peculiarity of providing, huge size of survey dataset requires off-line data providing. Metadata about survey cruise and data image are available in Website.
During 17 years, we have over 150 case of data providing. About 15 % case are proposal by student. Number of data request by overseas users is gradually increasing after 2010. Seasonal trend of request number is not remarkable. Popular uses of data are reprocessing of raw data, test-data of analysis technique development, and utilization of continuous raw data are.Popular uses of processed MCS data and MCS profile image are seismic disaster field and preparation of IODP proposal. Derivative data, such as seismic velocity model, are use with various field of earth science.
Though analysis of data providing needs, trends of research project and site management, we will continue GUI maintenance and review of web system.

Keywords: MCS, OBS, Database

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.20 Zoom Room 20

[S-SS08] Fault Rheology and Earthquake Physics

convener:Shunya Kaneki(Disaster Prevention Research Institute, Kyoto University), Makiko Ohtani(Earthquake Research Institute, the University of Tokyo), Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Keisuke Yoshida(Tohoku University), Chairperson:Makiko Ohtani(Earthquake Research Institute, the University of Tokyo), Keisuke Yoshida(Tohoku University)

The goal of this session is to integrate theoretical, experimental, observational, and numerical perspectives from various fields such as seismology, geodesy, geology, mineralogy, and so on, to define what is known about earthquake source processes and the physical and chemical elementary processes of faulting. This session welcomes studies that address such issues as pre-, co-, and post-seismic processes, the rheology of seismogenic faults and fault rocks, laboratory experiments on elementary processes, numerical models based on frictional laws, and estimates of the stress field in the seismogenic zones. We also welcome studies on fault-zone drilling projects and in situ stress measurements.

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

[SSS08-01] **Fault frictional heterogeneities can explain earthquakes with no foreshocks, accelerating foreshocks and earthquake swarms observed in central Alaska**

★Invited Papers

*Yoshihiro Kaneko[1], Nealey Sims[2], Carl Tape[2], Stephen Holtkamp[2], Andrea Perez[3] (1.Kyoto University, 2.University of Alaska - Fairbanks, 3.Victoria University of Wellington)

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

[SSS08-02] Rupture segmentation caused by fault bends in simulated earthquake sequences

*So Ozawa[1], Ryosuke Ando[1] (1.Graduate School of Science, the University of Tokyo)

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

[SSS08-03] Energy-based scenarios for the Nankai trough subduction earthquakes: Stress accumulation model taking historical earthquakes into account

*Akemi Noda[1], Tatsuhiko Saito[2] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS08-04] **Estimation of absolute shear stress in the source region of large earthquakes based on estimates of fault fracture energy**

*Nelson Pulido[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS08-05] Three-dimensional tectonic stress fields estimated from seismic data for long-term periods with direct prior information

*Toshiko Terakawa[1] (1.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

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

[SSS08-06] Spatial and temporal change of stress field in the focal area of the 2016 Kaikoura earthquake, New Zealand (2)

Miu Matsuno[1], Ayaka Tagami[1], *Tomomi Okada[1], Satoshi Matsumoto[2], Yuta Kawamura[2], Yoshihisa Iio[3], Tadashi Sato[1], Takashi NAKAYAMA[1], Satoshi Hirahara[1], Stephen Bannister[4], John Ristau[4], Martha K Savage[5], Clifford H Thurber[6], Richard H Sibson[7] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.Institute of Seismology and

Volcanology, Faculty of Science, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University, 4.GNS Science, New Zealand, 5.Victoria University of Wellington, New Zealand, 6.University of Wisconsin - Madison, United States of America, 7.University of Otago, New Zealand)

Fault frictional heterogeneities can explain earthquakes with no foreshocks, accelerating foreshocks and earthquake swarms observed in central Alaska

*Yoshihiro Kaneko[1], Nealey Sims[2], Carl Tape[2], Stephen Holtkamp[2], Andrea Perez[3]

1. Kyoto University, 2. University of Alaska - Fairbanks, 3. Victoria University of Wellington

While most earthquakes start abruptly, with no evidence for a nucleation process, accelerating foreshock sequences within or in the vicinity of the eventual mainshock rupture zone for some moderate to large crustal earthquakes have been documented previously. In particular, Tape et al. (2018) reported unique observations of nucleation signals of crustal earthquakes in the Minto Flats fault zone in central Alaska, manifested by ~20 seconds of simultaneous high-frequency foreshocks and a very low-frequency earthquake. One potential explanation for such observations is a slow slip front propagating over the fault and triggering these foreshocks as it transitions into the mainshock rupture (e.g., Tape et al., 2018). Another explanation may be that accelerating foreshocks represent cascading sequences of fault ruptures due to static and/or dynamic stress changes, without underlying slow slip, as known as a cascading hypothesis (e.g., Ellsworth and Bulut, 2018). Here we show that a numerical fault model incorporating full inertial dynamics and rate-and-state friction laws with frictional heterogeneities reproduces ~20 seconds long, accelerating foreshock sequence that led to a mainshock as observed in the Minto Flats fault zone. We find that the time scale of accelerating foreshock sequence depends on the degree and size of frictional heterogeneities and tectonic loading rate. Furthermore, an accelerating foreshock sequence occurs in only a transitional regime between an earthquake swarm regime and the regime of mainshocks with no foreshocks. This may explain why the observations of accelerating foreshock sequences are relatively rare. We conclude that reproducing the observations of ~20 seconds long, accelerating foreshock sequence would require slow physical process, such as slow slip, fluid diffusion or rock damage, in between small-scale, seismogenic asperities.

Keywords: Accelerating foreshocks, Fault frictional heterogeneities, Earthquake cycle deformation

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Rupture segmentation caused by fault bends in simulated earthquake sequences

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Observations show, in several faults, earthquake ruptures are segmented by barriers - locations that tend to stop rupture propagations. One plausible mechanism of barriers is geometrical complexity on the fault. For example, Elliott et al. 2018 shows geomorphological evidence for persistent rupture terminations at a restraining bend in the Altyn Tigh fault.

Here, we study how earthquake ruptures are arrested at bends from physics-based modeling and numerical simulations. Specifically, we consider two fault segments connected each other via a restraining/releasing bend as a simple and instructive example. An important mechanical result of slip on a nonplanar fault is the change of normal stresses. Normal stress increases at restraining bends and decreases at releasing bends. The rupture termination occurs when the fracture energy exceeds the static energy release rate at the rupture front. Because the fracture energy is proportional to normal stress, we expect that ruptures is arrested around the center of a restraining bend.

To verify our hypothesis, we perform quasi-dynamic earthquake sequence simulations on two fault segments connected by a restraining/releasing bend. The use of earthquake sequence simulations allows us to obtain the initial condition of ruptures in a self-consistent manner, and to ask how often the bend acts as a barrier. In the case of restraining bends, our simulation shows a clear segmentation due to the bend, and the ratio of partial ruptures increases with increasing cumulative slip. Hypocenters are concentrated at both edges of the bend, where normal stress takes local minimum. Although much less effective than restraining bends, releasing bends could also act as barriers.

We perform systematic geometrical parameter investigation; the length and slope of the bend. The ratio of full ruptures decreases with increasing the slope of the bend. The effect of the bend length on the ratio of full ruptures is more complex because it interacts with the process zone size. Lastly, we compare geometrical barriers and rheological barriers in concept, and discuss unmodeled effects, such as inertia and off-fault plasticity.

Keywords: Earthquake cycle, Fault segmentation, Numerical simulation, Rate and state friction, Barrier, Fault geometry

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Energy-based scenarios for the Nankai trough subduction earthquakes: Stress accumulation model taking historical earthquakes into account

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The occurrence of earthquakes is controlled by the balance between the shear stress that drives faulting and the frictional stress that resists it. This perspective of the mechanics of faulting is necessary to create scenarios of anticipated megathrust earthquakes for preparing for unprecedented events in the Nankai trough subduction zone. Based on such an idea, Noda et al. (2020) proposed a new energy-based method to construct rupture scenarios, which is composed of two steps: (1) Estimating a coseismic slip model from the distribution of shear stress accumulation based on an interseismic slip-deficit rate distribution. (2) Examining whether the model follows the mechanics of faulting by comparing the strain energy released by the fault slip ΔW and the energy dissipated on the fault E_D. They introduced a new parameter "residual energy" defined as $E_R \equiv \Delta W - E_{D.}$ Positive residual energy is a necessary condition for earthquake generation in terms of the law of conservation of energy. The scenario with negative residual energy is supposed to be unreasonable.

Noda et al. (2020) assumed a constant stress accumulation rate and calculated the shear stress accumulation from a reference time when the shear stress was zero over the entire seismogenic region of plate interface along the Nankai trough, for simplicity. However, the slip history of earthquake cycles in the Nankai trough is more complex. For example, the latest great earthquakes, the 1944 Tonankai and 1946 Nankai earthquakes, did not rupture the entire plate interface from the Suruga bay to off Shikoku at once. In addition, the segmentation of historical earthquakes before the 20th century remains controversial because there are insufficient observation records. It has been considered that the source region of the 1854 Ansei-Tokai earthquake comprises segments in the Kumano-nada, Enshu-nada, and Suruga bay (Ishibashi & Satake, 1998); however, Seno (2012) suggested that the source region did not include the segment in the Kumano-nada. Segments that have not ruptured for some time accumulate substantial shear stress and will release a large amount of strain energy during the next event.

In this study, for more realistic earthquake rupture scenarios, we improved the scenarios of Noda et al. (2020) by integrating the earthquake rupture history into the stress accumulation model. First, we assumed that the stress accumulation rate is constant and that the shear stress accumulated since the last event is fully released during the next event. We estimated slip models of the 1854 Ansei Tokai and Nankai earthquakes, the 1944 Tonankai earthquake, and the 1946 Nankai earthquake following the method of Noda et al. (2020) and evaluated the residual energy for each model. We found that the earthquake rupture history of Seno (2012) is more reasonable in terms of energy budget than that of Ishibasi & Satake (1998).

Next, we calculated the distribution of stress accumulation in 2021 based on Seno (2012) and generated various earthquake scenarios including single-segment ruptures and multi-segment ruptures. We found that the strain energy stored in the elastic medium is not enough for generating great thrust earthquakes in 2021 because all scenarios showed negative residual energy. However, as the shear stress continues to

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accumulate at the same rate, the residual energy becomes positive by 2025 in a scenario which ruptures the segment in the Suruga bay, satisfying a necessary condition of earthquake generation. For the scenario rupturing all segments along the Nankai trough, the residual energy becomes positive by 2070. It should be noted that these estimations strongly depend on the assumptions of uncertain parameters such as the dissipated energy on the fault. We will discuss the effects of the assumed parameters on the earthquake scenarios.

Keywords: Earthquake scenarios, Interplate earthquake, Nankai trough, The mechanics of fault rupture

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Estimation of absolute shear stress in the source region of large earthquakes based on estimates of fault fracture energy

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Fault fracture energy (G), a fundamental physical property of earthquake rupture has been widely estimated from the energy budget during earthquake fault rupture. To that purpose a simple relationship between fault slip and shear stress (linear slip weakening friction law without under or overshoot), as well as a constant fault rupture velocity are usually assumed. Under these assumptions, an estimate of fracture energy often referred to as G', can be obtained from the difference of the average stress drop and two times the apparent stress. However fault rupture propagation and shear stress release during large earthquakes can be highly heterogeneous, and therefore the estimation of G from seismic radiation and the aforementioned assumptions, may lead to wrong estimates. To clarify this point, in a previous study I calculated fracture energy of large earthquakes (G) based on a heterogeneous fault rupture process, using the finite width slip pulse dynamic rupture model of Rice et al (2005). I also estimated G' values based on fault average stress drops and apparent stress (earthquake radiated energy normalized by seismic moment times rigidity). To calculate G and G' I used the extensive database of finite fault rupture models of large earthquakes (M>7) by NEIC. My results indicated that G' systematically underestimates G. To provide a physical explanation for this difference I compared the energy budget from earthquakes obtained from simple linear slip weakening friction law, to the one obtained from a more general relationship where dynamic shear stress values (σ_d) can drop below fault residual shear stress (σ_r) during fault rupture. It can be shown that G can be expressed as follows; $G = G' + (\sigma_r - \sigma_d)\ \delta$, where δ is fault slip. Assuming a nearly complete strength drop during fault rupture (namely, $\sigma_d \sim 0$) for large earthquakes (as suggested by recent megathrust earthquakes), residual shear stress can be obtained as the difference between G and G' divided by fault slip. Based on this idea I calculated lower bound estimates of absolute residual fault shear stress (as well as absolute initial shear stress , σ_o, by adding stress drops), using my dataset of G and G' values. My estimations of average fault shear stress ($[\sigma_o + \sigma_r]/2$) range from 0.3 MPa to 40 MPa. These results also enable the estimation of seismic efficiency (the ratio of radiated energy to total available potential energy), which has remained unresolved for earthquakes to date. My estimation of average seismic efficiency for the entire dataset is around 12%. I also obtained that seismic efficiency increases with increasing average fault rupture velocity.
My results also indicate that average shear stress is highly correlated with apparent stress. These results render possible the first order estimation of absolute shear stress in source regions of earthquakes globally, based on available measurements of apparent stress (radiated energy). My results also show that average shear stress and earthquake slip, have a weak negative correlation with seismic efficiency. These results may indicate to some extent that large earthquakes within high background shear stress regions might be less seismically efficient compared to earthquakes in regions with lower background shear stress.

Keywords: fracture energy, large earthquake, shear stress, apparent stress, rupture velocity, fault

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Three-dimensional tectonic stress fields estimated from seismic data for long-term periods with direct prior information

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Stress is one of the important physical quantities for understanding earthquake generation. The CMT data inversion is a statistical method that derives the tectonic stress pattern from centroid moment tensor data of seismicity, based on the Bayesian statistical inference and Akaike’s Bayesian Information Criterion (ABIC) (Terakawa and Matsu’ura, 2008). With this method Terakawa and Matsu’ura (2010) estimated 3-D tectonic stress pattern in and around Japan from 12500 moment tensor data of seismicity (period: January 1997 to January 2007) listed in the F-net moment tensor catalog. More than ten years have passed after the study period of the previous study. New data have been certainly stored in the catalog.

The original method of CMT data inversion incorporates indirect prior information that stress fields are smooth to some degrees into observed data to construct a Bayesian model with hyperparameters. In order to estimate tectonic stress pattern from data for long-term periods, we improved the method of CMT data inversion so that we can consider results of stress fields obtained by a previous analysis as prior information as well as information from new observed data. In the improved method, we can incorporate both indirect and direct prior information into new observed data in a proper way, based on the formulation for geodetic inversion by Matsu’ura et al. (2007). In general, this improvement enables us to estimate the stress pattern from more data with smaller uncertainties. If uncertainties become larger in an analysis with the direct prior information and new data, it will indicate that statistical feature for the new data are inconsistent with the direct prior information obtained from previous data. This suggests that the stress pattern would have changed between the two study periods.

I targeted the Kyushu district in Japan where the 2016 Kumamoto earthquake (Mw 7.0) and the largest pre-shock (Mw 6.1) occurred on 16 and 14 April 2016. I applied moment tensor data of seismicity for 22 years (January 1997 to April 2019) listed in the F-net catalog to the improved method, and estimated the tectonic stress pattern in the district. I divided the whole study period into three periods: the period 1 (1 January 1997 to 31 January 2007), the period 2 (1 February 2007 to 13 April 2016), and the period 3 (14 Aril 2016 to 30 April 2019). Firstly, considering the results of stress patterns estimated from the data during the period 1 (Case 1) as the direct prior information, I estimated the stress pattern from data during the period 2 (Case 2). The stress pattern in the Kyushu district is characterized by normal to strike-skip faulting with north-south tension. The results of the stress pattern in Case 2 are consistent with those obtained only from the original data of the period 1 (Case 1). Furthermore, the uncertainties become smaller on the whole, indicating that we obtained more reliable results of the stress pattern from more data for the longer period. Next, considering the results of Case 2 as the direct prior information, I estimated the stress pattern from data during the period 3. The stress pattern which reflects all the data during the whole period (Case 3) is roughly consistent with those of Cases 1 and 2. However, the stress patterns at a shallow depth around the Futagawa fault, which is the main part of the source region of the Kumamoto earthquake, is different from those in Case 1 and 2, indicating that the stress pattern would have locally changed after the large earthquake. Furthermore, the uncertainties around the Futagawa fault becomes larger than those in Case 2, although the number of data there in Case 3 is larger than that in Case 2. These results suggest that types of earthquake would have changed after the Kumamoto earthquake. Large coseismic slip on the Futagawa fault basically released shear stress at the source

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region. Therefore, temporal changes in types of earthquake may be caused by some factors other than stress changes. A plausible mechanism is a decrease in fault strength due to an increase in pore fluid pressure, which triggers many aftershocks.

Keywords: stress, earthquake, inversion

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Spatial and temporal change of stress field in the focal area of the 2016 Kaikoura earthquake, New Zealand (2)

Miu Matsuno[1], Ayaka Tagami[1], *Tomomi Okada[1], Satoshi Matsumoto[2], Yuta Kawamura[2], Yoshihisa Iio[3], Tadashi Sato[1], Takashi NAKAYAMA[1], Satoshi Hirahara[1], Stephen Bannister[4], John Ristau[4], Martha K Savage[5], Clifford H Thurber[6], Richard H Sibson[7]

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The 2016 Kaikoura earthquake (Mw 7.8) earthquake is one of the most complex earthquakes in the world. In our previous studies (e.g., Okada et al., 2019; Okada et al., 2020, GSNZ), we found seismic low-velocity and high Vp/Vs in and along the focal area of the earthquake. This suggests overpressured fluid promotes the occurrence of the Kaikoura earthquake. Here we consider stress conditions.

We study spatio-temporal change of the stress field due to the 2016 Kaikoura earthquake in the northern area of the South Island of New Zealand. Data from 51 temporary stations and 22 permanent GeoNet stations were used. We determined focal mechanisms, combined with the GeoNet Moment Tensor Solutions, and estimated the stress field in the period from 2013 to 2019 before and after the Kaikoura main shock using stress tensor inversion. We improved the stability of the solution by adopting Vavrycuk (2014)’s method.

If there are many aftershocks on the fault plane of the main shock, the fault plane may be distributed with a bias. Therefore, it is necessary to study the effect of focal mechanisms of aftershocks that occurred off the fault plane of the main shock. So, we attempted to remove the mechanism solution on the fault plane of the main shock using the fault model of Hamling et al. (2017) and the Kagan angle. We found that the stress field did not change significantly independent of the value of the Kagan angle, and we consider that the effect of the aftershocks occurring on the fault plane of the main shock on the result is small.

We carried out the analysis by dividing the hypocenters into several regions. The stress field types are strike-slip types. The maximum horizontal stress direction is about ESE both before and after the Kaikoura earthquake. This would be consistent with shear wave splitting analysis (Graham et al., 2020) which also didn’t show significant coseismic temporal change. This absence of coseismic change of orientations of stress axes suggests large differential stress (sigma1-sigma3) before the Kaikoura earthquake. The stress ratio (R = (sigma1-sigma2)/(sigma1-sigma3)) decreased after the main shock in the northeastern and central regions, and increased in the southwestern region. The coseismic changes in the northeastern and central regions might be interpreted as coseismic stress drops (e.g., Hardebeck and Haukson, 2001).

We considered the possibility that the stress field has a postseismic temporal change after the main shock. We calculated the stress fields in three time windows after the main shock (2016/11/13-2016/11/31, 2016/12/01-2017/5/31, 2017/6/1-2019/12/4), so that the number of events in these three time windows would be approximately the same. In all three windows after the main shock, a stress field of the strike-slip fault type was determined. The value of stress ratio was about 0.8-0.9 in all three windows. This means no significant temporal change after the Kaikoura earthquake through 2019.

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The stress field was obtained by dividing the southwestern region into four regions in order to consider spatial change. The stress fields are all strike-slip fault types except in an eastern area where the stress field was intermediate between reverse and strike-slip fault type. This could be interpreted as stress heterogeneity change due to the Kaikoura earthquake (e.g., Michael et al., 1990). This could be also consistent with the co-existence of strike-slip and reverse faults in the North Canterbury Domain (e.g., Ghisetti and Sibson, 2012).

We calculated the slip tendency (Morris et al., 2016) for the fault model (Hamling et al., 2016) using the stress tensor inversion result before the Kaikoura earthquake. High slip tendency is observed at the sub-faults which correspond to the hypocenter and the large slip, and low slip tendency is at the northernmost sub-fault where the slip process of the Kaikoura earthquake stopped.

We conclude that there was no significant temporal change in stress related to the Kaikoura earthquake and pre-stress could explain the slip process of the Kaikoura earthquake.

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[E] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.23 Zoom Room 23

[S-EM12] Electric, magnetic, and electromagnetic survey technologies and the scientific achievements

convener:Kiyoshi Baba(Earthquake Research Institute, The University of Tokyo), Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China), Chairperson:Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China)

Detailed subsurface images by electric, magnetic, and electromagnetic (EM) surveys are indispensable to investigate the electrical features of the interior of the Earth both for academic and commercial purposes. Technologies, techniques, and methods for surveys, data analysis, and interpretation involve many common aspects that should be solved by scientists and engineers in cooperation since the studies cover a broad range of targets in various spatial-time scales and places on land and seafloor, e.g., natural resource explorations, environment and geohazard evaluations, and the crustal and mantle tectonics and dynamics. In addition, the knowledge should be shared in the international community for further development of this field. The session invites papers on recent advances in the electric and EM survey technologies and techniques including instrumentation, data processing, modeling, inversion and imaging, and scientific achievements including novel ways of interpretations, from the world.

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

[SEM12-01] UNDERSTANDING MAGMATIC SYSTEM OF UNZEN VOLCANO (NAGASAKI, SOUTHWEST JAPAN) INFERRED FROM BROAD-BAND MAGNETOTELLURIC OBSERVATION

*Agnis Triahadini[1], Koki Aizawa[2], Tasuku M. Hashimoto[3], Kazunari Uchida[2], Yuto Yamamoto[1], Keita Chiba[2], Dan Muramatsu[1], Kanta Miyano[1], Yuta Kawamura[1], Satoru ANIYA[1], Ayumu Okubo[1] (1.Department of Earth and Planetary Sciences Graduate School of Sciences Kyushu University, 2.Institute of Seismology and Volcanology Faculty of Science Kyushu University, 3.Earthquake Research Institute The University of Tokyo)

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

[SEM12-02] Near-surface geothermal fluids conduit imaged by audio-frequency magnetotteluric survey in a hydrothermal area, Indonesia

*Tada-nori Goto[1], Shohei Ohba[1], Mohamad Nur Heriawan[3], Irwan Iskandar[3], Taiki Kubo[2], Koki Kashiwaya[2], Katsuaki Koike[2] (1.Graduate School of Science, University of Hyogo, 2.Graduate School of Engineering, Kyoto University, 3.Faculty of Mining and Petroleum Engineering, Bandung Institute of Technology)

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

[SEM12-03] How about using the magnetic field for the tsunami warning? Comparison of the tsunami magnetic field with the sea level change

*Zhiheng Lin[1], Hiroaki TOH[2], Takuto Minami[3] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University, 3.Department of Planetology, Faculty of Science, Kobe University)

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

[SEM12-04] **Offshore–onshore seamless resistivity imaging of freshwater using a controlled source electromagnetic method**

*Keiichi Ishizu[1], Yasuo Ogawa[1] (1.Tokyo Institute of Technology)

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

[SEM12-05] **One-dimensional Deep Learning Inversion of Marine Controlled Source Electromagnetic Data**

*Pan Li[1], Z Du[1], Yuguo Li[1,2] (1.Ocean University of China, 2.Key Lab of Submarine Geosciences and Prospecting Techniques of Ministry of Education)

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

[SEM12-06] **Applicability evaluation of non-conforming deformed hexahedral mesh for marine magnetotellurics**

*Yoshiya Usui[1] (1.Earthquake Research Institute, the University of Tokyo)

UNDERSTANDING MAGMATIC SYSTEM OF UNZEN VOLCANO (NAGASAKI, SOUTHWEST JAPAN) INFERRED FROM BROAD-BAND MAGNETOTELLURIC OBSERVATION

*Agnis Triahadini[1], Koki Aizawa[2], Tasuku M. Hashimoto[3], Kazunari Uchida[2], Yuto Yamamoto[1], Keita Chiba[2], Dan Muramatsu[1], Kanta Miyano[1], Yuta Kawamura[1], Satoru ANIYA[1], Ayumu Okubo[1]

1. Department of Earth and Planetary Sciences Graduate School of Sciences Kyushu University, 2. Institute of Seismology and Volcanology Faculty of Science Kyushu University, 3. Earthquake Research Institute The University of Tokyo

Unzen volcano is an active lava domes complex which grows in Shimabara Peninsula, Nagasaki, Japan. Following the infamous 1991-1995 eruption, numerous studies had been conducted in Unzen Volcano. From the studies, the most widely accepted model is the main magmatic supply comes from 10 km west of the summit, at mid crustal depth under Chijiwa bay, where seismicity also intensified in this region. Prior to the last eruption, the magma was transported obliquely from below this area to eastern direction (Umakoshi et al 2001). Moreover, as pressure sources from geodetic data suggest, there are another possible sub magma chamber which is located in 5-6 km west of the summit (Kohno et al, 2008, Nishi et al 1999). Based on these facts, there must be a transport system to connect the main chamber to the secondary chamber and to the summit vent. However, to the present there is no resistivity structure image of whole area of Unzen volcano and Shimabara Peninsula. On an attempt to image Unzen volcano subsurface structure and its magmatic system, broadband magnetotelluric survey has been conducted between 2017-2020 covering Shimabara Peninsula and Unzen Volcano (Figure 1). In total, the electromagnetic data was collected from 98 sites. Some subsets of the data collected in west flank and summit area have been analyzed by Triahadini et al 2019 and Hashimoto et al 2020 respectively. However, both of the results are unable to image magma chamber. Since our last observation was finished by the end of December 2020, thus the data is currently under processing. Our resistivity structure will be used to improve the conceptual model of Unzen volcano magmatic system. On JPGU 2021 meeting, we would like to show our resistivity structure and compare it to the newest seismic tomography result and also hypocenter distribution prior to eruption until 2020.

Keywords: Unzen Volcano, Magma chamber, Resistivity structure, Magnetotelluric

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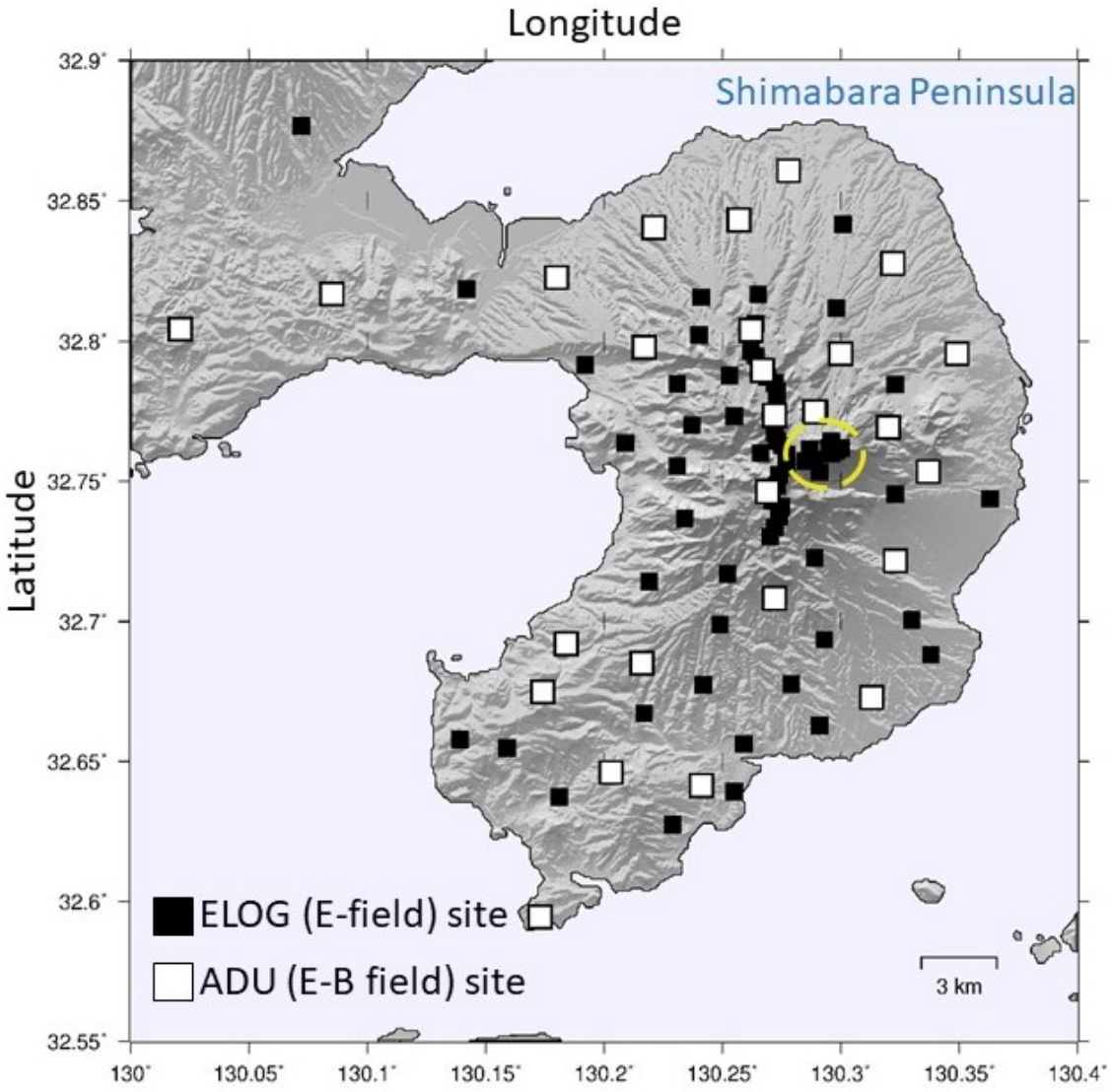


Figure 1. Magnetotelluric sites distribution in Shimabara Peninsula. Yellow dashed circle shows summit area of Unzen Volcano

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Near-surface geothermal fluids conduit imaged by audio-frequency magnetotteluric survey in a hydrothermal area, Indonesia

*Tada-nori Goto[1], Shohei Ohba[1], Mohamad Nur Heriawan[3], Irwan Iskandar[3], Taiki Kubo[2], Koki Kashiwaya[2], Katsuaki Koike[2]

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Natural radioactive gases in volcanic areas (such as radon) are used as indicators of fluid discharges coming from deep geothermal reservoirs. Therefore, soil gas sampling is often used in exploration for geothermal resources. We found the radon concentration in the soil air was found at a hydrothermal site in the Wayang-Windu region, Indonesia. It is probably associated with concealed fracture zones. However, due to a limitation of sampling points, the locations of fracture zones and geothermal fluid conduits were unknown.

The magnetotelluric (MT) survey, one of the electromagnetic (EM) geophysical exploration, is a powerful method for imaging geothermal fields. It requires the natural fluctuation of geomagnetic and electric fields. The observed EM responses at a number of MT sites can be used for quantitative analysis of subsurface resistivity distribution. In this study, we applied the short-dipole audio-frequency magnetotelluric survey (SAMT) in the Wayang-Windu geothermal field. The horizontal spatial resolution is higher than that of the conventional MT exploration. Using the observed data, an inversion algorithm of two-dimensional resistivity structure was performed to clarify the cross section of resistivity distribution down to the depth of 500 meters.

In our result, it was found that a low resistivity layer spreads commonly in the survey area at a depth of several hundred meters or more. This can be interpreted as a hydrothermally altered (clay-rich) layer. This low resistivity layer reaches the surface in some areas; one of the areas has indicated the high radon concentration in the soil air. This near-surface low resistivity zones possibly corresponds to the geothermal alteration zones along the faults. The good coincidence between high Radon and low resistivity implies that the fault is a fluid conduit from a deep reservoir. Thus, we successfully demonstrated the usefulness of combination of geochemical and geophysical surveys for finding the steam spots in the geothermal field.

Keywords: geochemical survey, EM survey, magnetotellurics

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How about using the magnetic field for the tsunami warning? Comparison of the tsunami magnetic field with the sea level change

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Particle motions of the conductive seawater associated with tsunamis can generate induced magnetic fields by cutting the geomagnetic main field in the course of their propagation. There are two important properties of the tsunami magnetic field in terms of tsunami early warning:
1. The tsunami vertical magnetic component Bz has a phase lead with respect to the tsunami sea level change. The amount of the phase lead depends mainly on the ocean depth.
2. The tsunami horizontal magnetic component Bh has two peaks: One corresponding to the leading Bz, which has approximately 90-degree phase lag to Bz, and the other corresponding to the initial rise (Minami et al., 2015) that appears earlier than the leading Bz.

These properties have been revealed by the 2D (Minami and Toh, 2013; Minami et al., 2015) and 3D simulations (Zhang et al., 2014; Minami et al., 2017). However, they have never been confirmed by direct comparison of simultaneous observation of magnetic fields and sea level changes.

Here we show the result of the direct comparison of the two different physical quantities acquired by a geophysical observation on the French Polynesian seafloor in the south Pacific Ocean (TIARES Project: Suetsugu et al., 2012). They observed significant electromagnetic fields of the 2009 Samoa tsunami (Mw 8.1) and the 2010 Chile tsunami (Mw 8.8). The questions that we will address using this data are as follows:
1. Is the phase lead of the tsunami Bz really present in the observation?
2. Does the initial rise in the tsunami Bh really exist?

The TIARES experiment deployed an observation array consisting of 9 Ocean Bottom Electro-Magnetometers (OBEMs) and a Differential Pressure Gauge (DPG) on the 4000~5000m deep seafloor for investigating the electrical conductivity structures of the mantle beneath the Society hotspot. The OBEMs recorded three components of the seafloor magnetic field with a 1-minute sampling rate. In addition, a DPG was installed at Site SOC8 for the observation of ocean bottom pressure. When the earthquake tsunamis passed over the TIARES area, on the 29th of September in 2009 and the 27th of February in 2010 at the times of the Samoa earthquake of Mw 8.1 and the Chile earthquake of Mw 8.8, the observation array captured the signals of the tsunami-generated magnetic field and the ocean bottom pressure change associated the tsunamis.

First, we compared the observed magnetic field with the observed sea level change. The sea level change was successfully deconvoluted from the raw data recorded by the DPG. The sea level change and magnetic time-series were filtered by the same high-pass filter, and then external magnetic fields were further removed from the magnetic time-series by the remote magnetic reference method by Minami et al. (2017). The comparison of the two observations revealed the following facts:
1. The tsunami Bz has clear phase leads to the sea level change for both events.
2. The initial rise in the observed Bh is too small to detect. We need further confirmation by 3-D numerical

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simulation.

Then the simulation of the tsunami magnetic field was done by two steps. First, the simulation of the tsunami velocity field was conducted. In this study, JAGURS tsunami simulation code by Baba et al. (2017) was used for calculation of the tsunami velocity field including the effects of Boussinesq dispersion and elastic loading. The tsunami magnetic field was then simulated using the estimated velocity field in the second step. The 3-D time-domain code by Minami et al. (2017) was used to calculate the tsunami magnetic field. The simulated tsunami magnetic field showed the following two features:
1. The simulation confirms the phase lead of the tsunami Bz with respect to the tsunami sea level change.
2. The simulation implies the presence of the initial rises of the tsunami Bh in both events.

Keywords: Tsunami generated magnetic field, Observed tsunami magnetic signals, 3-D time-domain simulation, Phase leads of the tsunami magnetic components

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Offshore–onshore seamless resistivity imaging of freshwater using a controlled source electromagnetic method

*Keiichi Ishizu[1], Yasuo Ogawa[1]

1. Tokyo Institute of Technology

Coastal freshwater provides a water source for more than one billion people living in coastal regions. For sustainable groundwater management in coastal areas, an understanding of the freshwater distribution is necessary. The freshwater distribution in a coastal area can be across the landward and seaward sides. Offshore–onshore seamless mapping of freshwater helps us to gain a comprehensive understanding of the freshwater distribution in coastal areas. Resistivity imaging using electromagnetic methods has been used to reveal the freshwater distribution in coastal areas because resistivity provides information on porosity and porewater salinity. We used a controlled source electromagnetic (CSEM) method for offshore–onshore seamless resistivity imaging of freshwater at a depth range of 0–500 m below the seafloor. Our CSEM method consists of onshore transmitters and onshore–offshore receivers. We conducted a feasibility study to investigate the ability of the CSEM method for offshore–onshore seamless resistivity imaging of freshwater in a coastal area. We found that the method could image the resistivity distribution of freshwater located at a depth of 500 m below the seafloor. The test results also showed that the detectability of freshwater was high enough at all sea depths between 10 m and 100 m, which is a typical range in coastal areas. These numerical test results imply that the proposed CSEM method is a promising technique for offshore–onshore seamless resistivity imaging of freshwater in coastal areas.

Keywords: Resistivity, Electromagnetic survey, Coastal areas

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One-dimensional Deep Learning Inversion of Marine Controlled Source Electromagnetic Data

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1. Ocean University of China, 2. Key Lab of Submarine Geosciences and Prospecting Techniques of Ministry of Education

The EM inverse problem is highly ill-posed, and often requires significant pre-conditioning and regularization. In this paper we explore the use of a machine learning technique for inversion of the marine Controlled Source Electromagnetic (CSEM) data. We propose a novel approach based on the deep leaning (DL) using both the convolutional neural network (CNN) and the recurrent neural network (RNN) algorithms to reconstruct variations in earth’ s resistivity. Through the learning of a large number of 1D forward synthetic data by CNN and RNN, the mapping relationship between CSEM data and resistivity model is constructed. We built a large number of geological models with different EM structural complexities. Both the resistivity models and the corresponding EM field data represent a good training source for a deep learning network. For the purpose of training and validation where EM models and corresponding CSEM data are used. The trained network is then used to predict the distribution of resistivity in the model by feeding it with CSEM responses. We also explore the sensitivity of DL inversion to different EM field with resistivity targets distributed at different depths, variable amount of noise, and compare the results between DL and a standard Occam’ s inversion approach. The results of the inversion show that the DL method is highly efficient and can robustly reconstruct subsurface resistivity structures. This study suggests that a framework with adoption of various DL methods for 2D and 3D EM inversion is feasible.

Keywords: CSEM, Deep Learning, EM field, resistivity inversion

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Applicability evaluation of non-conforming deformed hexahedral mesh for marine magnetotellurics

*Yoshiya Usui[1]

1. Earthquake Research Institute, the University of Tokyo

Topographic distortion is a major problem in magnetotelluric modeling and interpretation. Especially, observed data of ocean magnetotelluric surveys can be affected by large-scale bathymetry and land-ocean distribution as well as smaller-scale seafloor undulations around observation sites. Some modeling approaches have been proposed to overcome the problem. However, a previously developed inversion approach based on the finite difference method shows the model recovery depends on the prior and initial models. Although the inversion using an unstructured tetrahedral finite element mesh is another effective approach to deal with topographic distortion, it requires a substantial effort to include global-scale land-ocean distribution. Therefore, I made a magnetotelluric inversion code using non-conforming deformed hexahedral mesh to incorporate both large-scale bathymetry and smaller-scale seafloor undulations effectively in the electrical resistivity modeling. The non-conforming hexahedral mesh allows us to make small elements only around observation sites, where smaller-scale undulations need to be represented. Besides, the developed inversion code does not use the prior model because the Laplacian of logarithms of subsurface electrical resistivities is used as the regularization term. I confirmed that, for a sinusoidal seafloor model, the forward calculation using a non-conforming deformed hexahedral mesh gives the apparent resistivity, phase, and vertical magnetic transfer function close to their analytical solutions. Furthermore, a synthetic inversion test demonstrates that the developed inversion code can recover the original electrical resistivity structure.

Keywords: magnetotelluric inversion, non-conforming mesh, finite element method, electrical resistivity structure

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[E] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.11_2

[S-EM12] Electric, magnetic, and electromagnetic survey technologies and the scientific achievements

convener:Kiyoshi Baba(Earthquake Research Institute, The University of Tokyo), Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China)

Detailed subsurface images by electric, magnetic, and electromagnetic (EM) surveys are indispensable to investigate the electrical features of the interior of the Earth both for academic and commercial purposes. Technologies, techniques, and methods for surveys, data analysis, and interpretation involve many common aspects that should be solved by scientists and engineers in cooperation since the studies cover a broad range of targets in various spatial-time scales and places on land and seafloor, e.g., natural resource explorations, environment and geohazard evaluations, and the crustal and mantle tectonics and dynamics. In addition, the knowledge should be shared in the international community for further development of this field. The session invites papers on recent advances in the electric and EM survey technologies and techniques including instrumentation, data processing, modeling, inversion and imaging, and scientific achievements including novel ways of interpretations, from the world.

[SEM12-P01] Characteristic features of the response functions estimated from a wide-band magnetotelluric (MT) data in the southern Tohoku area

*Dieno Diba[1], Makoto Uyeshima[1], Masahiro Ichiki[2], Shin'ya Sakanaka[3], Makoto Tamura[4], Yusuke Yamaya[5], Yoshiya Usui[1] (1.Earthquake Research Insititute, the University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.Graduate school of International Resource Sciences, Akita University, 4.Geological Survey of Hokkaido, Hokkaido Research Organization, 5.National Institute of Advanced Industrial Science and Technology)

[SEM12-P02] Three-dimensional inversion of magnetotelluric data in a geothermal area near Hakkoda volcano

*Toshihiro Uchida[1] (1.National Institute of Advanced Industrial Science and Technology)

[SEM12-P03] **On synthetic marine magnetotelluric inversion study: reproduction of error in data**

*Kiyoshi Baba[1] (1.Earthquake Research Institute, The University of Tokyo)

[SEM12-P04] Discussion

Characteristic features of the response functions estimated from a wide-band magnetotelluric (MT) data in the southern Tohoku area

*Dieno Diba[1], Makoto Uyeshima[1], Masahiro Ichiki[2], Shin'ya Sakanaka[3], Makoto Tamura[4], Yusuke Yamaya[5], Yoshiya Usui[1]

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Following the 2011 great Tohoku earthquake, intense shallow earthquakes were observed at the Iwaki area, which is the fore-arc side of the southern Tohoku, Japan. At the same time, high strain rate accumulation at the back-arc side which corresponds to the Niigata-Kobe Tectonic Zone (NKTZ) was observed before the Tohoku earthquake and continues to this day. In addition, prominent geothermal activities are distributed along the backbone range in the central part of the area. We are encouraged to study the mechanism of those crustal activities from the electrical conductivity structure. By combining the result with the seismic and geodetic data, the physical processes of those activities can be comprehensively understood.

We performed a four years wide-band MT campaign (2015-2018) that consists of 3 survey lines, which respectively contain about 15 stations, along an approximately NW-SE profile running across the southern Tohoku. We simultaneously recorded 5-channel EM data or 2-channel E data with the basic sampling rate of 32Hz (continuous measurement) and 1024Hz (4 hours mid-night). Two-component horizontal magnetic field data at Yamagata prefecture are also used as the remote reference (Gamble et al., 1979). In this presentation, we discuss the preliminary analysis of the 25 days data obtained in 2015 along one of the 3 lines.

The time series were processed using the BIRRP robust inversion code by Chave and Thomson (2004). We computed the MT impedance and the vertical-horizontal magnetic field response. The apparent resistivities of the middle station are very high for the entire period range while those of the neighboring stations are relatively low. The phases also confirmed this laterally alternating structure. The principal 2D strike directions estimated using the phase tensor (Caldwell et al., 2004) seemed period- and site-dependent as well as the normalized skew angle. The consistency between the induction arrows and phase tensors will be discussed in the presentation. In addition, we also estimated the inter-station horizontal magnetic field transfer function in which the spatial variation of the horizontal magnetic field among the stations is examined.

Keywords: resistivity structure, south Tohoku, magnetotelluric observation

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Three-dimensional inversion of magnetotelluric data in a geothermal area near Hakkoda volcano

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1. National Institute of Advanced Industrial Science and Technology

Three-dimensional (3D) inversion was carried out to a magnetotelluric (MT) dataset obtained in a geothermal area on a western flank of northern Hakkoda volcano, Aomori Prefecture, Japan. The 3D inversion code used is WSINV3DMT (Siripunvaraporn and Egbert, 2009). The number of MT stations is 34, and the number of frequencies used as observed data in the inversion is 15, ranging from 0.0067 Hz to 115 Hz. The surface topography was included in the finite-difference mesh with a small vertical discretization in order to achieve accurate forward modeling. The size of a cell at the ground surface for the elevation range where the MT stations are located was set to 150m x 150m x 10m, basically. The resultant 3D model indicated a good correlation with logging data in a few boreholes obtained in the surveys about 30 years ago. The procedure of the 3D inversion and geothermal interpretation of the model are presented in this paper.

Keywords: magnetotellurics, 3D inversion, topography, geothermal exploration

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On synthetic marine magnetotelluric inversion study: reproduction of error in data

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Inversion studies using synthesized data is useful to test a hypothesis that one would like to investigate. Synthesized data should contain errors and they should as realistic as possible to maximize the reliability of the hypothesis test. And therefore, it is important to know the characteristic of the real data. In this study, I investigated a marine MT data set collected in the northwestern Pacific through Normal Oceanic Mantle project (Baba et al., 2017). The data set consists of MT impedance tensors at 24 sites in the period range between ~50 to ~100,000 seconds, which were obtained by processing approximately one-year-long time series data using BIRRP program (Chave and Thomson, 2004). The errors of the MT impedance are generally smaller for the major off-diagonal elements than for the minor diagonal elements. Also, they are smaller in the middle range of the period and become larger to the shorter and longer period ends, which is related to number of samples available to estimate the impedance. Plotting the relative error of the MT impedance to the magnitude of the MT impedance for all tensor elements, all periods, and all sites, I found an empirical linear relation with a smallest limit. This relation can be used to synthesize the error of data. I run one-dimensional inversion for two synthetic data which have constant relative error and error based on the empirical relation, respectively. The comparison of uncertainties in the obtained models gives information how synthetic inversion with the too much simplified assumption for the data error overestimates the sensitivity to the model.

Keywords: marine magnetotellurics, synthetic inversion study

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[E] Poster | S (Solid Earth Sciences) | S-EM Earth's Electromagnetism

[S-EM12] Electric, magnetic, and electromagnetic survey technologies and the scientific achievements

convener:Kiyoshi Baba(Earthquake Research Institute, The University of Tokyo), Tada-nori Goto(Graduate School of Life Science, University of Hyogo), Toshihiro Uchida(National Institute of Advanced Industrial Science and Technology), Yuguo Li(Ocean University of China)

Thu. Jun 3, 2021 5:15 PM - 6:30 PM Ch.11

Detailed subsurface images by electric, magnetic, and electromagnetic (EM) surveys are indispensable to investigate the electrical features of the interior of the Earth both for academic and commercial purposes. Technologies, techniques, and methods for surveys, data analysis, and interpretation involve many common aspects that should be solved by scientists and engineers in cooperation since the studies cover a broad range of targets in various spatial-time scales and places on land and seafloor, e.g., natural resource explorations, environment and geohazard evaluations, and the crustal and mantle tectonics and dynamics. In addition, the knowledge should be shared in the international community for further development of this field. The session invites papers on recent advances in the electric and EM survey technologies and techniques including instrumentation, data processing, modeling, inversion and imaging, and scientific achievements including novel ways of interpretations, from the world.

5:15 PM - 6:30 PM

[SEM12-P04]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.23 Zoom Room 23

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Chairperson:Takuto Minami(Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University), Maki Hata(Earthquake Research Institute, the University of Tokyo)

This session welcomes papers on electromagnetism in the Earth and planetary interiors. The topics include but not limited to electromagnetic phenomena associated with earthquakes and volcanism, electrical conductivity structure, laboratory experiments, results of simulations, new equipment for observation, and methods of data analysis.

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

[SEM14-01] Imaging the magma plumbing system of Mt. Meakandake volcano based on broadband magnetotellurics and three-dimensional resistivity modelling

*Tomohiro Inoue[1], Takeshi Hashimoto[1], Ryo Tanaka[1], Yusuke Yamaya[2], Hiroshi Ichihara[3] (1.Graduate School of Science,Hokkaido University, 2.National Institute of Advanced Industrial Science and Technology, 3.Graduate School of environmental Studies, Nagoya University)

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

[SEM14-02] Three-dimensional resistivity structure of the Tarumae volcanic region using MT data

*Takaya Yamagiwa[1], KENTARO AOYAMA[1], Koichi Suzuki[1], Toru Mogi[2], Yusuke Yamaya[3] (1.Hokkaido University, 2.Faculty of Science, Tokyo Institute of Technology, 3.National Institute of Advanced Industrial Science and Technology)

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

[SEM14-03] 3-D resistivity models beneath Aso caldera by new and old Network-MT dipole data arranged into reticular shapes

*Maki Hata[1], Makoto Uyeshima[1], Mitsuru Utsugi[2], Nobuo Matsushima[3], Yoshikazu Tanaka, Takeshi Hashimoto[4], Ryokei Yoshimura[5], Naoto Oshiman[5] (1.Earthquake Research Institute, the University of Tokyo , 2.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 3.Geological Survey of Japan, 4.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 5.Disaster Prevention Research Institute, Kyoto University)

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

[SEM14-04] Toward joint inversion of AMT and ACTIVE data sets for better understanding of the hydrothermal system of Aso volcano

*Takuto Minami[1], Mitsuru Utsugi[2], Wataru Kanda[3], Marceau Gresse[4] (1.Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University, 2.Aso Volcanological Laboratory, Graduate School of Science, Kyoto University, 3.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 4.Earthquake Research Institute, University of Tokyo)

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

[SEM14-05] Electromagnetic field fluctuations by infrasound during the eruption of Kirishima Shinmoe-dake in 2018

*Satoru ANIYA[1], Koki Aizawa[2], Takeshi Matsushima[2] (1.Department of Earth and Planetary Sciences,Graduate School of Sciences,Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University)

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

[SEM14-06] **Time Series Analyses of EM-ACROSS Data**

*Sohei Serita[1], Yasuo Ogawa[1], Kuo Hsuan Tseng[1], Keiichi Ishizu[1], Takahiro Kunitomo[2], Takuto Minami[3], Hiroshi Ichihara[2], T Grant Caldwell[4] (1.Tokyo Institute of Technology, 2.Nagoya University, 3.Kobe University, 4.GNS Science)

Imaging the magma plumbing system of Mt. Meakandake volcano based on broadband magnetotellurics and three-dimensional resistivity modelling

*Tomohiro Inoue[1], Takeshi Hashimoto[1], Ryo Tanaka[1], Yusuke Yamaya[2], Hiroshi Ichihara[3]

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This study reports an updated resistivity model for Mt. Meakandake, one of the active volcanoes in eastern Hokkaido. On the northeastern foot of the volcano, a remarkable ground inflation was observed during the period from 2016 to 2017 (Geospatial Information Authority of Japan, 2018). We modelled the resistivity structure targeting at the inflation source, based on the BBMT data in 2018 and 2019 (Inoue et al., 2020; SGEPSS) and the AMT/BBMT data in 2010 recorded on the south shore of Lake Akan (Mogi et al., 2011). Our previous resistivity model has imaged a distinct conductive column C1 (about 1-10 Ωm) extending from 0.5 km BSL just below the summit to a deeper part of Mt. Meakandake. However, the geometry and spatial extent of C1 has not been well constrained by the lack of MT observation sites. Therefore, in the fall of 2020, we deployed six additional BBMT sites in the summit area and the western foot of the volcano to achieve a better constraint on C1.

We acquired the time series of five components (2E+3H) for about seven days using the ADU07e system (Metronix Ltd.) for the three sites in the western foot of Mt. Meakandake. On the summit area, we measured only 2E using the Elog-dual recorder (NT System Design Ltd.). In calculating the response functions, we used the BIRRP (Chave and Thomson, 2004) and applied the remote reference processing (Gamble et al., 1997) using the data at the continuous station in Yamagata Prefecture (about 700 km southwest from our study area) that was provided by Geothermal Energy Research & Development Co., Ltd.

The overall characteristics of the apparent resistivity and phase curves suggested the structure of roughly middle–low–high resistivity from the surface toward deeper part. Some of the additional sites showed anomalous phases in Zyx component in a period range over 1000 s. The induction vectors at the western sites directed roughly to Mt. Fuppushidake and east, in constant to those at the sites in the northern to eastern foot of the volcano, pointing to an opposite direction. It suggested another conductive body beneath Mt. Fuppushidake in the north side of Mt. Meakandake.

We performed a provisional inversion using the previous 3D resistivity model (Inoue et al., 2020; SGEPSS) as a starting model and examined how the additional data would affect the result. We inverted the full impedance and tipper of 39 existing sites and six additional sites using by the ModEM (Egbert and Kelbert, 2012; Kelbert et al., 2014).

It resulted in a final RMS misfit about 2.8 for the input data with an error floor of 5 %, comparable to the final misfit of the previous inversion modelling by Inoue et al (2020; SGEPSS). Responses at the additional sites were also well reproduced by this provisional inversion in which no significant modification was made from the previous modelling. The additional data acquisition and modelling in this study confirmed that the C1 was meaningful down to about 30 km BSL. We consider it may be a part of the magma plumbing system. As a next step, we plan to discuss the physical state in the C1 based on the estimation of rock properties such as melt fraction.

Acknowledgments: This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under it’ s the Second Earthquake and Volcano Hazards Observation and Research Program (Earthquake and Volcano Hazard Reduction Research).

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Keywords: magnetotelluric, Meakandake, resistivity, magma plumbing system

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Three-dimensional resistivity structure of the Tarumae volcanic region using MT data

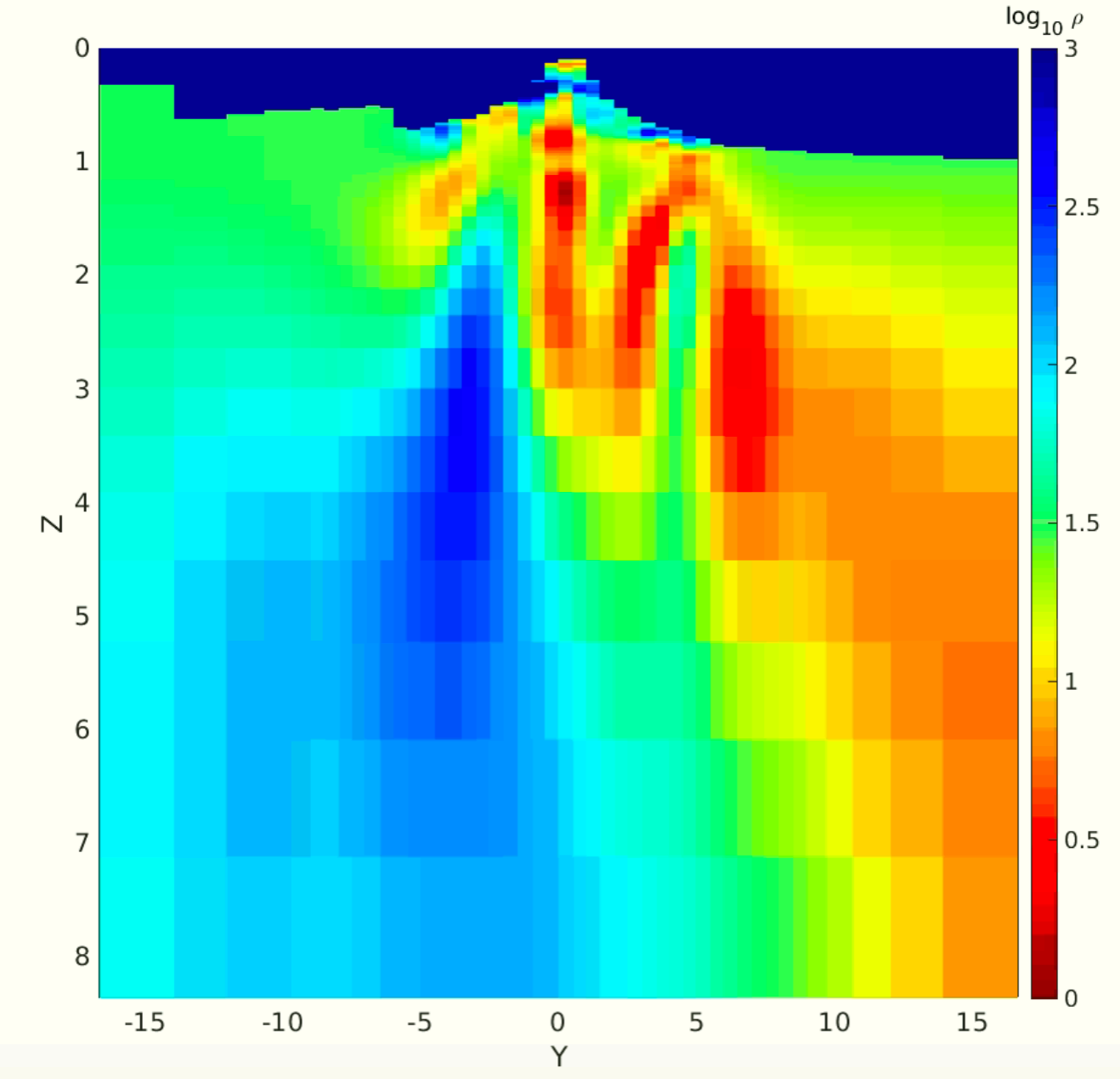
*Takaya Yamagiwa[1], KENTARO AOYAMA[1], Koichi Suzuki[1], Toru Mogi[2], Yusuke Yamaya[3]

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Mt. Tarumae is an active volcano located in the southwestern part of Hokkaido, Japan. 2D resistivity inversion using magnetoterullic (MT) data and 3D resistivity forward modeling using audio-magnetoterullic (AMT) data were performed in this area by Yamaya et al. (2005 and 2009), respectively; however, the structure of the deep subsurface remained unexplored. In this study, we modeled the magma chamber and flow path of hydrothermal fluids and volcanic gases that exist beneath Mt. Tarumae using a recently developed MT 3D inversion method. We used 70 stations to conduct the inversion: 28 stations near Mt. Tarumae and 42 stations in the east of Ishikari lowland, distant from Mt. Tarumae. In the analysis software ModEM (Egbert and Kelbert, 2012), we attempted an iterative calculation using the initial resistivity, the undetermined Lagrange multiplier, and the covariance of the smoothing term as variable parameters. The selected optimal model had the smallest root mean square residual. Consequently, we identified two low resistivity zones—one corresponding to the ascending path of hydrothermal fluids and volcanic gases beneath the summit of the Tarumae volcano and the other leading the Ishikari lowland low-resistivity zone—and a high-resistivity zone corresponding to the Pre-Tertiary strata.

Keywords: Geophysical Exploration, MT method, Mt.Tarumae

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3-D resistivity models beneath Aso caldera by new and old Network-MT dipole data arranged into reticular shapes

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Mt. Aso, an active Quaternary volcano, with a large caldera lie at the Beppu-Shimabara graben in the island of Kyushu. Aso caldera was formed at the central part of the graben by a series of huge eruptions, with a volcanic explosivity index of 7, during 270–90 ka. A post-caldera cone of Naka-dake in Aso caldera is a quite active volcano, at which magmatic and phreatomagmatic eruptions occurred during 2014–2016 and ash eruptions (emissions) have continued since July 2019. In and around Aso caldera, network-MT surveys for measuring the electric potential difference (the electric field) were carried out during 1993–1998 by using long metallic wires/dipoles of the commercial telephone company's networks [e.g., Uyeshima et al., 1995; Tanaka et al., 1998; Hashimoto et al., 1999; Hata et al., 2015]. We determined two components of network-MT response functions between the potential differences for respective dipoles and the two horizontal components of the magnetic field at the Kanoya Geomagnetic Observatory. On the other hand, we newly performed network-MT surveys at Aso caldera during 2019–2020 and determined response functions. Three-dimensional (3-D) inversion analyses were performed by using two data sets in a period up to tens of thousands s for obtaining resistivity models beneath Aso caldera in a crustal depth scale. In the inversion analyses, we used a data-space inversion code, which can be considered the length and direction of respective dipoles [e.g., Siripunvaraporn et al., 2004]. Moreover, the dipoles are distributed as to cover Aso caldera into reticular formation in order to obtain well-resolved 3-D models. In this presentation, we discuss a magma supply system beneath Aso caldera, which are inferred from the two 3-D resistivity models based on the new and old Network-MT data.

Keywords: 3-D electrical resistivity models, Network-MT data, Aso caldera, magma supply system

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Toward joint inversion of AMT and ACTIVE data sets for better understanding of the hydrothermal system of Aso volcano

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1. Division of Frontier Planetology, Department of Planetology, Graduate School of Science, Kobe University, 2. Aso Volcanological Laboratory, Graduate School of Science, Kyoto University, 3. Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 4. Earthquake Research Institute, University of Tokyo

The resistivity structure beneath a volcano is an important proxy for understanding hydrothermal and magmatic systems. The Audio-frequency Magnetotelluric (AMT) survey, which utilizes magnetic variations due to natural ionospheric disturbances and lightning, is a popular method used to investigate shallow resistivity structures. On the other hand, controlled-source electromagnetic (CSEM) methods are also important mainly for the monitoring purpose, because of their stable signal-to-noise ratio. A CSEM volcano monitoring method called ACTIVE (Array of Controlled Transient-electromagnetics for Imaging Volcano Edifice; Utada et al. 2007) can reveal the temporal change in resistivity structures. Minami et al. (2018) applied the three-dimensional (3-D) finite element inversion to the ACTIVE data sets and inferred the temporal variation in the 3-D resistivity structure associated with the magmatic eruption of Aso volcano, Japan, starting in November 2014.

However, to date, there are no effective inversion tools to infer a resistivity structure using AMT and ACTIVE data sets simultaneously. To fill this gap, we are developing an inversion code that can jointly invert AMT (e.g. Kanda et al. 2008) and ACTIVE data sets (e.g. Minami et al. 2018). Since ACTIVE consists of an array of induction-coil receivers that measure the vertical component of the magnetic variation and grounded electric dipole sources, ACTIVE data sets are theoretically free from the effect of galvanic distortion. This is also an advantage of using both AMT and ACTIVE data sets in the same inversion. Furthermore, the AMT-ACTIVE joint inversion can use a common coefficient matrix in solving each linear problem when the Dirichlet boundary conditions are adopted in both ACTIVE and MT problems. This means that the ACTIVE inversion code with a direct solver and the Dirichlet boundary condition developed by Minami et al. (2018) is easily extended to the joint inversion with AMT data sets without modification of the coefficient matrix. In the presentation, we report the algorithm of our joint inversion code and show preliminary results of joint inversions of AMT and ACTIVE data sets obtained at Aso volcano.

Keywords: inversion, resistivity, AMT, volcano, Aso, CSEM

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Electromagnetic field fluctuations by infrasound during the eruption of Kirishima Shinmoe-dake in 2018

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Shinmoe-dake is an active volcano located in the center of Kirishima volcanic area in Kyushu. In January 2011, magmatic eruption occurred for the first time in about 300 years and erupted again in October 2017 and March to June 2018. In this study, we discuss the relationship between electromagnetic signals obtained by broadband MT (magnetotelluric) observation and infrasound and seismic data close to the Shinmoe-dake volcano.

Twenty eruptions during March to June 2018 were selected for an analysis. We use the MT data recorded at two sites ((1): 3.2km WSW of the Shinmoe-dake crater, and (2) 5.0km NW of the Shinmoe-dake crater) and infrasound and seismic observations data recorded at 30m away from (1) MT site and 1km away from (2) MT site. We obtained MT time series data with physical unit (mV/km, nT) by incorporating the frequency responses of instruments. We also got time series data of physical units (Pa, μm/s) from infrasound and seismic data, and recalculated seismic data to the correct displacement waveform (μm) considering the frequency characteristics.

The electromagnetic signals of explosive eruptions well synchronized with the infrasound and seismic vertical motions. It is seemed that infrasound and seismic vertical motion associated with the eruption arrived at the observation point and generated electromagnetic field fluctuations in the very near vicinity of the observation point (Aniya, 2020, JpGU). As in the case in Popocatépetl Volcano (Matoza et al., 2019), the infrasound waveforms are associated with clear air-ground-coupled arrivals on seismometers, and it indicates that the ground is being pushed by infrasound. We conclude that the infrasound is moving the fluid in the aquifer just below the observation point and exciting the electromagnetic field fluctuation. In this study, we focused on the electromagnetic field fluctuation caused by infrasound, which has not been reported so far, and summarized the differences in the amount and particle motion of fluctuation among the stations and the possible mechanism of electrokinetic phenomena at present.

Using the resistivity ρ (ohm-m) and phase (deg) estimated from the impedance tensor Z and the geomagnetic transformation function T at each MT station, we calculated the 1D structural analysis from Ssq impedance (Rung-Arunwan et al., 2017). The result showed that the subsurface structure in the very shallow area just below the station is different, so it might be that the depth and interconnection of groundwater are related to the electromagnetic field variation.

Keywords: electromagnetic signal, explosive eruption, infrasound, seismic motions, electrokinetic phenomena, aquifer

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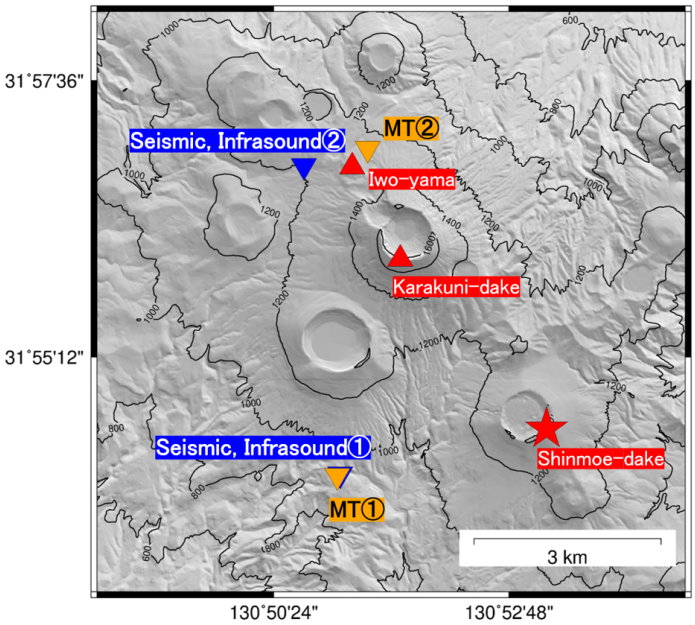


Fig. 1 Map of the study region and observation points. The yellow lower triangle, blue lower triangle indicate MT and Seismic & Infrasound sites, respectively. The Red star and red upper triangle indicate that Shinmoe-dake, Iwo-yama and Karakuni-dake, respectively.

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Time Series Analyses of EM-ACROSS Data

*Sohei Serita[1], Yasuo Ogawa[1], Kuo Hsuan Tseng[1], Keiichi Ishizu[1], Takahiro Kunitomo[2], Takuto Minami[3], Hiroshi Ichihara[2], T Grant Caldwell[4]

1. Tokyo Institute of Technology, 2. Nagoya University, 3. Kobe University, 4. GNS Science

In volcanic eruption prediction research, it is important to image magma and hydrothermal systems and monitor and observe their temporal variations. Resistivity is a geophysical quantity sensitive to magma, hydrothermal fluids, and clay minerals. It is possible to detect resistivity distribution and its temporal variation in the subsurface by electromagnetic exploration. In the Kusatsu-Shirane volcano, the past MT surveys revealed the resistivity structure (Nurhasan et al., 2006; Matsunaga et al., 2020; Tseng et al., 2020a). Time-lapse MT observation is one way to detect the time variation of the resistivity structure (Aizawa et al., 2011; Peacock, 2012), but for signal stability and noise suppression, the method using artificial electromagnetic signals is advantageous (Utada et al., 2007; Hino Ho, 2014; Minami et al. 2018). We installed an EM-ACROSS (ElectoMagnetic-Accurately-Controlled-Routinely-Operated-Signal-System) transmitter system Kusatsu-Shirane volcano (Tseng et al., 2020b). It has two grounded dipoles in two directions, and two signal series consisting of line spectra with slightly different frequency sets are transmitted simultaneously from independent transmitters. We can measure the two series of signals from the received signals at all times.

So far, we have been analyzing the EM-ACROSS data as follows (Tseng et al., 2020b). First, a data window of 1,000 seconds, consisting of 10 sets of 100 seconds, which is the repetition period of the signal, was used as the unit of analysis. The data in each 1,000-second data is detrended and cosine-tapered, and then Fourier transformed. This Fourier component is obtained for each data window and stacked, but of course, this includes noises. If we focus on the frequency of a signal and plot the Fourier components obtained for each data window of 1,000 seconds on the complex plane, we can recognize clusters and outliers. Here, we use the median absolute deviation to discriminate and remove the outliers from the stack. As a result, only good data can be selectively stacked (Tseng et al., 2020b). On the other hand, there is a problem of decreasing the number of stacks by excluding data.

In this new study, we work in the time domain. The data is represented as a sum of a sine wave consisting of signal components and a drift component to extract a weak stationary signal. The drift component represents the non-Gaussian noises, which are constrained to fluctuate smoothly. In the lecture, as a prelude to the analysis of the actual data acquired, test data with the noise of about ten times the known signal's amplitude was prepared for one-day length and analyzed. Then, we apply the method to the field data obtained in 2018.

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.23 Zoom Room 23

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Chairperson:Ken'ichi Yamazaki(Disaster Prevention Research Institute, Kyoto University), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)



This session welcomes papers on electromagnetism in the Earth and planetary interiors. The topics include but not limited to electromagnetic phenomena associated with earthquakes and volcanism, electrical conductivity structure, laboratory experiments, results of simulations, new equipment for observation, and methods of data analysis.

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

[SEM14-07] Accuracy and precision evaluation of the new method for the absolute magnetic measurements

★Invited Papers

*Hideyuki Hirahara[1], Junpei Oogi[1], Megumi Kaito[1], Seiki Asari[1] (1.Kakioka Magnetic Observatory, Japan Meteorological Agency.)

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

[SEM14-08] Piezomagnetic fields associated with a dislocation source in a layered elastic medium

*Ken'ichi Yamazaki[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[SEM14-09] Development and Application of Noise Reduction Method using two-stage MSSA (Multichannel Singular Spectrum Analysis) for MT data in Boso, Japan

*Shu Kaneko[1], Katsumi Hattori[2], Toru Mogi[2], Chie Yoshino[2] (1.Chiba University Graduate School of Science and Engineering, 2.Chiba University Graduate School of Science)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[SEM14-10] Understanding the spatial distribution characteristics of the MT response using Variogram

*Nagi Yamashita[1], Tada-nori Goto[1], Satoru Yamaguchi[2] (1.University of Hyogo, 2.Osaka City University)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[SEM14-11] Development of a 3D inversion code to consider ocean bottom magnetotelluric data including topographic distortion ~forward modeling part~

*Masamitsu Araki[1], Tetsuo Matsuno[1], Nobukazu Seama[1], Takuto Minami[1] (1.Department of Planetology, Graduate School of Science, Kobe University)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[SEM14-12] Discussion

Accuracy and precision evaluation of the new method for the absolute magnetic measurements

*Hideyuki Hirahara[1], Junpei Oogi[1], Megumi Kaito[1], Seiki Asari[1]

1. Kakioka Magnetic Observatory, Japan Meteorological Agency.

The absolute magnetic measurements, which consists of measurements of the total magnetic force (F), the declination (D) and the inclination (I) at a given location and time, are performed for the purpose of precisely acquiring absolute values of the three components of the geomagnetic vector. A scalar magnetometer, such as proton magnetometer, is used for measuring F, and an instrument called `DI-meter' for D and I. The DI-meter is operated manually, for which a certain skill is required for the observers to ensure the accuracy of the measurements (0.1 arcmin or less).
In order to observe the geomagnetic secular variation accurately, it is desirable for the measurements to be repeated as frequently as possible, while it is generally unpractical for observers. The measurements usually take place at intervals of days to months at magnetic observatories, and annually or even less often at repeat stations.
Currently, the DI-meters commonly used at world's major magnetic observatories are those equipped with a uniaxial fluxgate magnetometer mounted on a non-magnetic theodolite, THEO, produced by Zeiss. D and I are determined from a certain number of angular measurements of specific directions perpendicular to either of them, or the “null-directions” (Jankowski & Sucksdorff 1996). The "null method" of the absolute measurements, which has been exclusively used in Japan, requires some manual skills for an operation to strictly align the magnetometer axis to the null-direction.
The proficiency required makes it hard particularly for inexperienced observers to hold the accuracy in circumstances, for instance, where the measurements are conducted outdoors or allowable time is limited. Meanwhile, for its handiness, an alternative method called "residual method" has become more common through the past years (Worthington & Matzka 2017). In the residual method, the null direction is derived indirectly by calculating it from angular measurements of the magnetometer axis roughly oriented in the null direction. Without the delicate manipulation, observers may enjoy multiple advantages: reduction in physical and psychological stresses, quickness in learning, and alleviation of the magnetic cleanliness for observers, etc.
We report the results of an evaluation test the accuracy of the absolute magnetic measurements with the residual method. The test was carried out for 10 months from April 2020 to January 2021.
In the Calibration House of Kakioka Magnetic Observatory, D and I were measured with the residual method using a DI-meter (THEO 010B), to investigate their differences (referred to as instrumental error) from the corresponding values obtained by DI-72, the reference instrument of Kakioka for measuring D and I. The measurements were carried out by seven members of the observatory staff abundantly experienced in the null method.
It was confirmed that the instrumental error was <0.1 arcmin, which compares to that for the null method with the same DI meter. The observation error was also about the same as that for the null method. The observation duration was generally shorter for the residual method.
The duration would be shortened even more effectively under severe situations, such as outdoors, or in cases with limited time, all thanks to the absence of the fine manipulation, and hence of the psychological burden. An experiment of the residual method is now underway for the absolute measurements at Syowa Station, Antarctica, in order to investigate the effect of increasing the measurement frequency on stabilization of the baseline values. Furthermore, the residual method is planned to be introduced in the operation of the magnetic station Chichijima, where the absolute measurements are made outdoors.

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Prof. Hisayoshi Shimizu (ERI, U. Tokyo) provided a great deal of support for one of the authors in this study to receive training of the residual method at Niemegk magnetic observatory in Germany.

Keywords: Geomagnetic field, Observation, Measurement, Accuracy, Secular variation, Residual method

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Piezomagnetic fields associated with a dislocation source in a layered elastic medium

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1. Disaster Prevention Research Institute, Kyoto University

The piezomagnetic effect describes changes in magnetization with applied stress. Changes in the geomagnetic field because of the piezomagnetic effect, referred to as the piezomagnetic field, have been theoretically estimated and compared by previous studies to interpret observed variations in the geomagnetic field. However, the piezomagnetic field estimated in previous studies may not provide an accurate estimation because they ignored spatial variations in elasticity, leading to only a rough approximation of the properties of Earth’ s crust.

In this study, a semi-analytical procedure for calculating the piezomagnetic field arising from a point dislocation source embedded in a layered elastic medium is derived. Following a well-established method of vector surface spherical harmonics, all of the governing equations written in partial differential equations in a real domain, together with the linear constitutive law of the piezomagnetic effect, are converted to a set of ordinary differential equations in a wavenumber domain. Equations in the wavenumber domain are solved analytically, and each component of the piezomagnetic field in the real domain is obtained after applying the Hankel transform. By using the derived procedure, the piezomagnetic and displacement fields due to a finite fault with strike-slip, dip-slip, and tensile-opening mechanisms are estimated for media with layered elasticity structures. Results for a finite fault are obtained by integrating the point source solution over the fault plane.

The results of the numerical analysis allow the effect of heterogeneities in rigidity on the piezomagnetic effect to be examined and implications for the findings of previous investigations to be drawn. In cases where the moment-release at the dislocation source is fixed, the effect of the rigidity differences between upper and lower layers on the piezomagnetic field is minor even in the case where the Curie point depth is near the source of dislocation. This result is in contrast to a previous study that assumed the Mogi model and suggested that heterogeneities in the horizontal direction may be of importance when combined with layered rigidity structures. A contrast is seen between the piezomagnetic and displacement fields corresponding to models with layered rigidity structures: the piezomagnetic field is roughly proportional to the moment-release on a source fault, whereas the displacement field is proportional to slip or opening of the fault. Provided that the rigidity of the crust increases with increasing depth, the calculated piezomagnetic field is likely to have been underestimated in many earlier studies, which assumed uniform rigidity and a geodetically inverted size of slip.

Keywords: piezomagnetic effect, layered-medium, elasticity, displacement field, magnetic field

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Development and Application of Noise Reduction Method using two-stage MSSA (Multichannel Singular Spectrum Analysis) for MT data in Boso, Japan

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There is a triple junction of the Pacific Plate, the Philippine Sea Plate, and the North American Plate off the coast of the Boso Peninsula and it is one of the most active areas of the crustal activity. To investigate the subsurface resistivity structure of the whole Boso area, magnetotelluric (MT) survey with 41 sites (inter-sites distance of 7 km) has been conducted in 2014-2016, using U43 (12 sites, 1 Hz sampling ; Tierra Technica) and MTU-5, 5A, net (41 sites, 15, 150, and 2400 Hz sampling; Phoenix Geophysics). However, the Boso area is greatly affected by leak current from DC-driven trains, factories, and power lines, so the observed data are severely contaminated by artificial noises. When we tried to apply the conventional noise reduction methods (e.g., remote reference (Gamble et al., 1979) and BIRRP (Chave and Thomson, 2004)) in frequency domain, the obtained MT sounding curve was not ideal. In particular, the phases between the periods of 20 and 400 sec were close to 0 degrees. It suggests that these conventional methods are insufficient to reduce the near-field effects for the Boso data. Thus, we developed a new noise reduction method using MSSA (Multi-channel Singular Spectrum Analysis) as a time domain pre-processing method.

The procedure is as follows;
(1) Decompose 6 component data (Hx, Hy, Ex, Ey, Hxr and Hyr: H and E means magnetic and electric field, respectively, x and y indicates NS and EW component, and r denotes the reference field observed at a quiet station) using MSSA into 6×L principal components (PCs). Here, L shows the window length of MSSA.
(2) Check each PC's contribution and periods and eliminate the PCs corresponding to the longer than 400 sec. That means "detrend" of the original data.
(3) Apply the second MSSA to the detrended time series data to separate signals and noises shorter than 400 sec.
(4) Calculate correlation coefficients between H and Hr and between E and Hr for each PC and select the PCs with higher correlation to "reconstruct" time series data to make MT analysis.

Then, we perform MT analysis by BIRRP to estimate MT response functions,
As a result, the MT sounding curve became smoother than those results by the conventional noise reduction methods. It indicates that the effectiveness of the proposed noise reduction.

In the presentation, we report the effectiveness of this method in the MT response function.

Keywords: MT method, Multi-channel Singular Spectrum Analysis, Noise reduction, Boso peninsula

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Understanding the spatial distribution characteristics of the MT response using Variogram

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In the magnetotelluric method (MT method), the subsurface resistivity structure can be estimated based on the apparent resistivity and phase (MT response) for each frequency. Recently, in order to reduce the influence due to the small-scale heterogeneous structure near the surface (static distortion), the analysis of resistivity structure is done based on Zssq, a rotational invariant of impedance tensor. However, the spatial characteristics of Zssq, especially the horizontal distribution feature s, have not been discussed.

In this study, the spatial distribution and the characteristics of the MT response (Zssq) obtained from various two-dimensional resistivity structures are discussed qualitatively. We investigated the spatial correlation of MT response using Variogram often used in geostatistical researches. We prepared seven different types of subsurface resistivity models, and compared the spatial wavelength of the distributions of Zssq apparent resistivity and phase values for three different frequencies. Prior to that discussion, we also investigated the relationship between the range in Variogram and the wavelength of spatial changes, whose wave shape follows the normal distribution function.

As a result, it was found that there is no simple correlation in spatial wavelength between Zssq apparent resistivity and phase, and also found that the range of Zssq apparent resistivity is greater than the range of Zssq phase. Furthermore, it was clarified that the range is up to about 3.6 times the spatial wavelength (standard deviation of normal distribution function), and that the range also depends on the spacing of the resistivity anomalies. From the spatial relationship between apparent resistivity and phase, it was suggested that the degree of static shift, often seen in actual MT exploration, is discussed based on the geostatistical analysis.

Keywords: Magnetotelluric, Variogram, Static shift correction method

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Development of a 3D inversion code to consider ocean bottom magnetotelluric data including topographic distortion ~forward modeling part~

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1. Department of Planetology, Graduate School of Science, Kobe University

In recent years, new experiments using Ocean Bottom ElectroMagnetometers (OBEMs) around Japan have greatly increased the amount of seafloor electromagnetic field data that can be used to estimate sub-bottom resistivity structures using the MT method. In order to analyze such data sets, this study develops a 3D inversion method for seafloor MT data.

In this study, we are developing a code suitable for seafloor EM data based on ModEM (Egbert and Kelbert, 2012), which is a three-dimensional inversion algorithm using the finite difference method. The Flattening Seafloor (FS) technique (Baba and Seama, 2002) is introduced into ModEM to incorporate the undulations of the seafloor topography with fewer computational elements. The seafloor topography corresponds to thickness variations of the ocean and of the underlying crust. With this method, these thickness variations are transformed into variations in the electrical properties of cells that have anisotropic conductivity. As a result, the seafloor topography is represented as flat, with only two layers above and below the seafloor that retain the electrical properties of the topographic undulations. This simplification of the seafloor in numerical calculation also saves computer resources and computation time, which is especially crucial for 3D inversion.

In this study, we first investigate the correlation between the thickness of the grid cells above and below the seafloor and the computed MT response. We consider the case of a one-dimensional structure that is flat and uniformly 100 Ωm below the seafloor. The thickness of the grid cells above and below the seafloor was varied, and the MT response values obtained by forward calculation were compared with the theoretical ones. As a result, for a period of 10 seconds, the difference between the forward calculated MT response value and the theoretical one is about 5% for a thickness of 5 m above and below the seafloor, but it is as large as 80% for a thickness of 200 m above and below the seafloor. In other words, it is clear that the accuracy of the forward calculation can be improved by adding thin layers above and below the seafloor when you use seafloor MT data.

We next used ModEM with the experimental FS method to compare the FS method forward calculation with (A) and without (B) a thin layer of 0.01 m above and below the seafloor, with the forward calculation with a direct grid representation of the seafloor topography(C). The original topography was a two-dimensional topography with a smooth change in water depth from 2750 to 3250m, which is the same as the one used by Baba and Seama (2002). As a result of the comparison of (A) and (C), at a period of 1000 seconds, the apparent resistivity of (A) was 20-40% smaller and the phase of (A) was 30-40° smaller than that from (C). On the other hand, in the case of (B) the MT response values were generally consistent with the results of (C). The error in MT response is about 10% in the undulating part of the topography.

Furthermore, we found that it is necessary to prepare a wide computational domain outside the two-dimensional undulating target region when creating a numerical grid for the ModEM forward

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calculation using the FS method. When the numerical grid is created using only the undulating region, the values at the edge of the numerical grid, mainly for the TM mode of the MT response, show anomalous values. The difference between the anomalous values and normal values that are calculated with the direct numerical grid representation of the topography is about 40-80% for a period of 1000 seconds. In order to avoid these anomalous values in this topography with a period of 1000 seconds, it was necessary to expand the computational domain horizontally by more than 300 km. This is probably due to the fact that the boundary conditions of the ModEM numerical grid are not suitable for the FS method because the boundary conditions in ModEM do not consider the anisotropic conductivity.

Keywords: magnetotelluric

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[J] Oral | S (Solid Earth Sciences) | S-EM Earth's Electromagnetism

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Chairperson:Ken'ichi Yamazaki(Disaster Prevention Research Institute, Kyoto University), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.23 (Zoom Room 23)

This session welcomes papers on electromagnetism in the Earth and planetary interiors. The topics include but not limited to electromagnetic phenomena associated with earthquakes and volcanism, electrical conductivity structure, laboratory experiments, results of simulations, new equipment for observation, and methods of data analysis.

12:10 PM - 12:15 PM

[SEM14-12]Discussion

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[J] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.11_3

[S-EM14] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Maki Hata(Earthquake Research Institute, the University of Tokyo), Mitsuru Utsugi(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

This session welcomes papers on electromagnetism in the Earth and planetary interiors. The topics include but not limited to electromagnetic phenomena associated with earthquakes and volcanism, electrical conductivity structure, laboratory experiments, results of simulations, new equipment for observation, and methods of data analysis.

[SEM14-P01] A research report on the fundamental investigations of an electrical resistivity structure beneath Chugoku and Shikoku regions, southwestern Japan(2020)

*Ichiro Shiozaki[1], Tomofumi Uto[1], Makoto Uyeshima[2], Hideki Murakami[3], Naoto Oshiman[4], Yoshihisa Iio[4] (1.Graduate School of Engineering, Tottori University, 2.Earthquake Research Institute, The University of Tokyo, 3.Research and Education Faculty, Kochi University, 4.Disaster Prevention Research Institute, Kyoto University)

[SEM14-P02] 1-D forward calculation of tidally-induced magnetic variation in the Lau Basin: Comparison of calculation and seafloor magnetic data and sensitivity analysis

*Nakaya Tokuma[1], Takuto Minami[1], Nobukazu Seama[1] (1.Kobe University)

[SEM14-P03] Detection of magnetic field variation induced by tsunami

*Ai Kataoka[1], Ikuko Fujii[1] (1.Japan Meteorological Agency)

[SEM14-P04] Repeated aeromagnetic survey of Tarumae volcano using an unmanned autonomous helicopter

*Keiichi Shibuya[1], Takeshi Hashimoto[2], Tomoya Hayakawa[3], Keitaro Yoshikawa[4] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Nippon Koei Co., Ltd., 4.Hokkaido Regional Development Bureau)

[SEM14-P05] A magnetic inversion method to recover the subsurface block structures based on L1-TV1 regularization

*Mitsuru Utsugi[1] (1.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

A research report on the fundamental investigations of an electrical resistivity structure beneath Chugoku and Shikoku regions, southwestern Japan(2020)

*Ichiro Shiozaki[1], Tomofumi Uto[1], Makoto Uyeshima[2], Hideki Murakami[3], Naoto Oshiman[4], Yoshihisa Iio[4]

1. Graduate School of Engineering, Tottori University, 2. Earthquake Research Institute, The University of Tokyo, 3. Research and Education Faculty, Kochi University, 4. Disaster Prevention Research Institute, Kyoto University

The purpose of this study is to investigate the spatial and structural heterogeneity of the crust and upper mantle by conducting basic resistivity surveys in Chugoku and Shikoku regions in order to contribute to the mitigation of disasters due to earthquakes and volcanic eruptions.

So far, our research group has shown that there is a close relationship between resistivity structure and seismic activity in the San'in and Shikoku regions. For example, in the eastern part of the Sanin region, there are prominent earthquake occurrence areas and belt-shaped seismic activities along the coast of the Sea of Japan, including the Shikano-Yoshioka fault, which is the Tottori earthquake (1943, M = 7.2). MT surveys were conducted on survey lines that cross the active area, and the existence of conductive regions were clarified in the deep part of the crust under the seismogenic layer, which is resistive region, along the seismic active zone extending in the almost east-west direction. If an inland earthquake is caused by local stress concentration caused by an inhomogeneous structure directly under the seismic active zone (Iio, 2009), it is important to carefully examine the homogeneous structure and consider seismic activity and stress concentration / relaxation.

On the other hand, in the Shikoku region, the survey results mainly in the outer zone indicate that there is a remarkable conductive region in the upper crust, and that it is clearly related to aseismic region in the central and western regions. For a unified understanding of seismic phenomena, it is important to elucidate not only the activity pattern of slow earthquakes but also the environment and principle of occurrence (Ohara (2017)), so the regional characteristics of the overall resistivity structure must be deternmined. Fundamental investigation of resistivity structure for this purpose is required.

MT observation point surveys were conducted in the central and northern regions of the Chugoku region, taking into consideration the electromagnetic noise environment, topography, roads and land use conditions. In addition, the existing two survey line data in this area (for example, acquired in the area around Mt. Sanbe and the seismic gap in the eastern part of Shimane Prefecture) were examined. In particular, in the area around Mt. Sanbe, we reevaluated the data obtained from past observations and introduced Phase Tensor (PT) analysis (Caldwell et al. (2004)), which was not included in the previous analysis, to examine the 3-dimensionality of the structure and to compare the findings in the seismic gap area of eastern Shimane to investigate the spatial and electrical characteristics of these areas.

As a result, in the area around Mt. Sanbe, three-dimensional nature was implied for the some period bands, and it is pointed out that further investigation is necessary for the structure elucidation. At present, paying attention to this periodic zone, the strike of the resistivyty structure was estimated to be N50E from the direction of the PT and induction vector analysis, and Groom and Bailey (1989) decomposition was performed to try to extract the two-dimensional structure. From the results of structural analysis obtained

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using the code of Ogawa and Uchida (1996), the crust was generally estimated as a high resistivity region.

The characteristics of this resistivity structure are in harmony with the research results of Shiozaki (1993). The estimated northern conduvtive / resistive boundary may be related to the 2018 Western Shimane Earthquake (M6.1) that occurred around the intersection of the two seismic zones pointed out by Asano et al. (1986). In addition, the seismic activity from around Mt. Sanbe to the southeast direction corresponds to the resistive region.

For the 3D resistivity structure analysis of the Shikoku region, we created the input data according to the format of the 3D analysis program code (Siripinvaraporn and Egbert (2009)) by utilizing and integrating the existing wideband MT observation data. In addition, ETOPO1 Ice Surface data published by NOAA was used for the land and sea distribution information of the created initial model.

Keywords: electrical resistivity, fundamental investigations, Chugoku and Shikoku regions

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1-D forward calculation of tidally-induced magnetic variation in the Lau Basin: Comparison of calculation and seafloor magnetic data and sensitivity analysis

*Nakaya Tokuma[1], Takuto Minami[1], Nobukazu Seama[1]

1. Kobe University

Electrically conductive seawater moving in the geomagnetic main field causes electric currents in the ocean. In recent years, researches aiming at using this phenomenon to infer resistivity structures (Schnepf et al. 2014; 2015, Zhang et al. 2019) attract interests of researchers. It is known that the conventional MT method reduces estimation accuracy of its response function over periods around half a day to a day. The periods of ocean tides can complement this period band and the sounding depth corresponds to the upper mantle. Therefore, combination of MT and subseafloor sounding by the tidally induced magnetic variation possibly improves accuracy of resistivity values of the upper mantle compared to previous studies. Although Grayver et al. (2016) performed inversions of satellite tidally-induced magnetic data observed at the satellite altitude, there have been no reports of inversions of tidally-induced magnetic data observed at the seafloor. At the satellite altitude, one can observe only the poloidal component of the tidal magnetic variation. On the other hand, the seafloor magnetic data can observe both toroidal and poloidal components with shorter horizontal wave lengths compared to the satellite altitude. This implies that the usage of seafloor tidal magnetic variation may provide more accurate resistivity images with higher spatial resolution.

In this study, we developed a one-dimensional (1-D) forward calculation code for the tidally-induced magnetic variation, compared calculation results with seafloor magnetic data observed at the Lau Basin, and further investigated the sensitivity of the tidal magnetic variation to the resistivity structure, toward future inversions of seafloor tidal magnetic data. We focus only on the M2 component in this study. The tidal components of magnetic data were estimated by the least square method for sinusoidal functions. In our 1-D forward calculation, we used the analytical solution from Chave and Luther (1990), the tidal current model from Egbert and Erofeeva (2002), and the geomagnetic main field from IGRF-13 (Alken et al. in print). We prepared a 1-D resistivity structure from the two-dimensional structure in the Lau Basin inferred by Matsukura (2014, Master thesis of Kobe University). Comparison of the vertical component of the tidal magnetic field between the numerical and observation results shows discrepancy apparently correlated with the bathymetry, which implies the effect of bathymetry neglected in our 1-D calculation. On the other hand, the comparison of the horizontal components shows significantly larger amplitudes of the observed magnetic variation compared to the 1-D calculation. This could be due to toroidal magnetic component excited by the baroclinic current due to the internal tidal wave, which was not included in the adopted barotropic tidal model. We further investigated the sensitivity of the seafloor tidal magnetic variation in the Lau Basin to changes of the adopted 1-D resistivity structure. From shallow to deep part, we multiplied the original resistivity values by three within a 50 km thick zone and checked the change of amplitude of the vertical component of the tidal magnetic variation at the seafloor. As a result, we found that tidal magnetic variation in the Lau Basin is most sensitive to the depth of 250 to 300 km, where the amplitude enhanced by 2.5 %. In the presentation, we will explain details of our 1-D forward calculation, and report the results of comparison between the observation and numerical calculation and those of sensitivity analysis mentioned above.

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Keywords: ocean tide, resistivity

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Detection of magnetic field variation induced by tsunami

*Ai Kataoka[1], Ikuko Fujii[1]

1. Japan Meteorological Agency

1. Introduction

When a tsunami moves in the geomagnetic field, an electromagnetic field is induced by the dynamo effect (tsunami induced electromagnetic field, hereafter TIEM). Tyler (2005) shows that the vertical component of TIM is approximately linearly correlated with sea level. TIM appears in the vertical component before tsunami arrive (Tatehata et al., 2015) which shows a possibility to contribute to the tsunami warning. However, there are few reports on TIEM, and their characteristics are known little. Therefore, in this study, we try to investigate the characteristics of TIM at magnetic stations in the Pacific.

2. Analysis

We compared 1-minute values of the vertical geomagnetic field at a seaside station with 1-minute values of the tide level nearby. There are 9 pairs of those stations whose data are available online. Magnetic field data was provided by the JMA, GIS, EIR, and WDC, and tide level data was provided by the JMA, GIS, IOC, and NOAA for the 14 earthquakes which tsunamis have been observed in Japan since 2006.

The trend was removed by 60-minute moving average. Geomagnetic changes originating from the ionosphere and magnetosphere in the vertical component were estimated and removed using the horizontal magnetic field of the same observatory with a Kalman filter.

The significance of the correlation between the vertical geomagnetic field and the sea level change was judged by statistics. The criteria are (1) that both the first-order correlation coefficient in the time domain and the squared coherence in the frequency meets the 95% confidence limit of the uncorrelated test, and (2) that the first-order correlation coefficient has periodic change due to the predominant period of the tsunami.

3. Results

Significant correlation between vertical geomagnetic field and sea level were confirmed in 44 cases out of 98. When the maximum sea level change is 20 cm or less, the correlation tends to be insignificant. That suggests that 20 cm for the maximum wave height is a thresh hold to stably observe TIM. In 19 significant cases whose maximum sea level change are larger than 20 cm the amplitude of the vertical magnetic field is approximately proportional to the amplitude of the sea level change. Furthermore, there are regional differences in the stability of the correlation between geomagnetic field and sea level changes. The significant correlation is often seen on isolated islands in the ocean.

4. Calculation of TIM using tsunami numerical model

To explain causes of regional differences in the correlation, we theoretically calculate TIM from the sea level change and flow velocity obtained from a tsunami numerical model. In this study, we calculated for the 2010 Chile earthquake, which tsunami was observed at many stations.

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One-minute values of the sea level change and flow velocity at every 0.025 degree throughout the Pacific were provided by a two-dimensional plane tsunami calculation model (Minami, personal communication).

Then, TIM were computed around 9 magnetic stations by using Biot-Savart’ s law (Tatehata et al., 2015).

The computed vertical magnetic field was correlated to the modeled sea level change at 7 stations, except 2 in the Southern Hemisphere.
At the 7 stations, the correlation is high for changes at periods longer than 20 minutes and for the tsunami arrival time. The amplitude ratio of TIM to sea level change was large at isolated islands in the Pacific, probably because the current density was available on many grid points, and the tsunami flow around the island tend to be a simple long wave. These imply that topography and land-sea distribution affect the regional differences in correlation. The amplitude ratio is larger than that of the observation. Imposed conditions and assumptions may cause the difference.

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Repeated aeromagnetic survey of Tarumae volcano using an unmanned autonomous helicopter

*Keiichi Shibuya[1], Takeshi Hashimoto[2], Tomoya Hayakawa[3], Keitaro Yoshikawa[4]

1. Graduate School of Science, Hokkaido University, 2. Faculty of Science, Hokkaido University, 3. Nippon Koei Co., Ltd., 4. Hokkaido Regional Development Bureau

Aeromagnetic surveys using an unmanned autonomous helicopter have been conducted at active volcanoes in Hokkaido. In October 2020, we performed the fourth survey at Mt. Tarumae following the previous ones in 2011, 2012 and 2013. In this study, we analyzed the aeromagnetic data in 2020 and compared to the previous surveys in 2011 and 2013. Following the manual correction of the time stamp of the magnetometer for the 2020 data to maximize the correlation with the 2013 data, we obtained the temporal changes between them. The accuracy of the repeated flight was satisfactory as gaps between the actual flight trajectories were mostly within 5m. Then we obtained the temporal changes in the total magnetic field by taking the simple differences of the selected nearest points between the two surveys. We also calculated the temporal changes for the pair between 2011 and 2013 through the same procedure. Both the pairs showed a systematic field pattern suggesting a magnetizing trend beneath the summit lava dome. We accounted for the magnetic field changes in terms of a single dipole source beneath the lave dome with magnetic moment changes of 7.9×10^{6} Am^{2} and 8.0×10^{6} Am^{2}, respectively for the 2011-2013 and the 2013-2020 pairs. The source depth was almost the same (c.a. 400 m deep from the lava dome surface), but the horizontal location of the latter source shifted slightly southeast from the former. The almost same amount of the magnetic moment for the two periods suggested a slowdown in the magnetization rate after 2013. This result was consistent with the ground-based monitoring that was annually performed by the Japan Meteorological Agency and Hokkaido University (Hashimoto et al., 2018).

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A magnetic inversion method to recover the subsurface block structures based on L1-TV1 regularization

*Mitsuru Utsugi[1]

1. Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University

Magnetic inversion is a popular method to obtain information about subsurface structures. However, this method has a serious limitation in that the linear equations to be solved become ill-posed and under-determined, and therefore, the uniqueness of the solution is not guaranteed. Consequently, several different models fit the observed data with the same accuracy. Conventional studies introduced a regularization technique based on a quadratic solution norm to reduce this non-uniqueness of the problem. However, these regularization methods impose a certain level of smoothness into the model, which cause the resultant model to be blurred. Sparse regularization was introduced in many recent magnetic inversion studies to obtain a focused model; some studies investigated methods to recover the blocky feature of subsurface structures with their sharp boundaries to facilitate model interpretation. To this end, this study attempts to use the combination of the L1 norm and total variation (TV) penalty. The TV penalty is widely used in geophysical inversion studies. Although this penalty is written by the L1 norm of the model differentiation, most conventional studies replace this penalty with an alternative quadratic penalty to make it easy to solve the penalized inversion problem. However, in this study, TV1, the original TV penalty written by the L1 norm, is directly incorporated into the inversion method to derive a model that emphasizes the structural boundaries [1]. To solve this L1-TV1 penalized problem, alternating direction method of multipliers (ADMM) is used, which is one of the simple, and efficient algorithm to solve a problem with multi-type L1 penalty terms. In this paper, a scheme of this L1-TV1 penalized magnetic inversion method is proposed, and its effectiveness and the improvements to computational efficiency are discussed. Further, the proposed inversion scheme was applied to a real aeromagnetic data aquired over the Sakainokami pluton of the North Kitakami belt in Tohoku area, northeast Japan, which is a granite plutonic body intruded on Early Cretaceous, and attempted to obtain subsurface magnetic susceptibility model. For this real data test, a part of the aeromagnetic data of the aeromagnetic survey database (AMSurvDB) [2], was used.

[1] Utsugi, M., 2021. Magnetic inversion method to recover the subsurface block structures based on L1-TV1 regularization, G.J.I.(submitted)
[2] Okuma, S. & Nakatsuka, T., 2005. Aeromagnetic Anomalies Database of Japan, Digital Geoscience Maps, 6, Geological Survey of Japan, AIST.

Keywords: 3D magnetic sparse inversion, L1 norm regularization and total variation, ADMM

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.24 Zoom Room 24

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium), Chairperson:Hidenori Terasaki(Faculty of Science, Okayama University), Attilio Rivoldini(Royal Observatory of Belgium)

There are fundamental links between the formation and evolution of planets and their satellites to that of their cores both in terms of magnetic field generation and chemical and physical structure. Defining physical and chemical properties of the cores and core materials of these terrestrial bodies are therefore fundamental for understanding their internal structures and thermal profile. Recent advances in experimental and theoretical studies provide new insights into the Earth's cores and other terrestrial bodies, including the role of light elements in the early history of planets and at current times. Recent, current and future space missions have and will continue to obtain data on the internal structure of terrestrial planets (e.g., Mars and Mercury) and planet-satellite systems. We anticipate presentations on recent advances on the physical and chemical properties of cores and discussions regarding the latest views of their formation and evolution. We welcome contributions from mineral/rock physics, geophysics, geochemistry, geodynamics, and planetary science. We also welcome papers stimulating an interdisciplinary collaboration relating to establishment of the Study of Earth Deep Interior (SEDI)-Japan community.

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

[SIT18-01] Introduction

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[SIT18-02] New compositional insight on the formation of the Earth's core

*William F McDonough[1,2,3], Takashi Yoshizaki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University, Sendai, Miyagi 980-8578, Japan, 2.Research Center for Neutrino Science, Tohoku Uni- versity, Sendai, Miyagi 980-8578, Japan, 3.Department of Geology, University of Maryland, College Park, MD 20742, USA)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[SIT18-03] **Interstitial site occupancy of deuterium in a Fe-Si binary system at high-pressure and high-temperature conditions using a large volume press**

*Yuichiro Mori[1], Hiroyuki Kagi[1], Sho Kakizawa[2], Chikara Shito[1], Riko Iizuka-Oku[1], Katsutoshi Aoki[1], Takanori Hattori[3], Asami Sano-Furukawa[3], Ken-ichi Funakoshi[4], Hirouyki Saitoh[5] (1.The University of Tokyo, 2.Hiroshima Univ., 3.J-PARC Center, JAEA., 4.Neutron Science and Technology Center, CROSS. , 5.QST.)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SIT18-04] Effects of nickel on hydrogenation of iron: High-*PT* neutron diffraction measurements on Fe0.9Ni0.1D*x*

Chikara Shito[1], *Hiroyuki Kagi[1], Sho Kakizawa[2], Katsutoshi Aoki[1], Riko Iizuka[1], Yuichiro Mori[1], Kazuki Komatsu[1], Hiroyuki Saitoh[3], Jun Abe[4], Asami Sano-Furukawa[5], Takanori Hattori[5] (1.Geochemical Research Center, Graduate School of Science, University of Tokyo, 2.Graduate School of Advanced Science and Engineering, Hiroshima University, 3.National Institutes for Quantum and Radiological Science and Technology, 4.Comprehensive Research Organization for Science and Society, 5.Japan Atomic Energy Agency)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SIT18-05] Melting Experiments on the Fe-C-O Ternary System Under Core Pressures

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

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[SIT18-06] Existence of the two-phase mixture of HCP and B2 phases in the inner core

*Eiji Ohtani[1], Daijo Ikuta[1], Serena Dominijanni[2], Catherine McCammon[2], Naohisa Hirao[3], Hiroshi Fukui[4], Hiroshi Uchiyama[3], Alfred Q. R. Baron[4] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2.Bayerisches Geoinstitut, University of Bayreuth, 3.Japan Synchrotron Radiation Research Institute, 4.RIKEN)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

[SIT18-07] Discussion

[E] Oral | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Techtonophysics

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium), Chairperson:Hidenori Terasaki(Faculty of Science, Okayama University), Attilio Rivoldini(Royal Observatory of Belgium)

Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.24 (Zoom Room 24)

There are fundamental links between the formation and evolution of planets and their satellites to that of their cores both in terms of magnetic field generation and chemical and physical structure. Defining physical and chemical properties of the cores and core materials of these terrestrial bodies are therefore fundamental for understanding their internal structures and thermal profile. Recent advances in experimental and theoretical studies provide new insights into the Earth's cores and other terrestrial bodies, including the role of light elements in the early history of planets and at current times. Recent, current and future space missions have and will continue to obtain data on the internal structure of terrestrial planets (e.g., Mars and Mercury) and planet-satellite systems. We anticipate presentations on recent advances on the physical and chemical properties of cores and discussions regarding the latest views of their formation and evolution. We welcome contributions from mineral/rock physics, geophysics, geochemistry, geodynamics, and planetary science. We also welcome papers stimulating an interdisciplinary collaboration relating to establishment of the Study of Earth Deep Interior (SEDI)-Japan community.

9:00 AM - 9:05 AM

[SIT18-01]Introduction

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New compositional insight on the formation of the Earth's core

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A widely held belief is that the earth's core separated from the mantle at mid-mantle conditions. In large part this idea stems from the need to explain the bulk silicate earth's (BSE) chondritic Ni/Co value and absolute Ni concentration. Estimates for the composition of the BSE, particularly the absolute and relative abundance of all of the siderophile elements, have largely provided the motivation for explaining the pressures, temperatures, and evolving oxidation state of metal-silicate equilibration during core formation.

We recently reported on the composition and formation of the terrestrial planets, Earth and Mars. To explain the presence, size, and orbital attributes of the earth's Moon, many have posited that the formation of the earth involved a giant impact event by a bolide that was about 1/10 the mass of the earth. We suggested that this bolide was an oxidized, differentiated body possessing a mars-like composition with a mild depletion in volatile elements (e.g., K, S). The addition by impact and subsequent emulsification of this bolide into the mantle of a reduced proto-Earth, produced a Moon-forming debris ring and largely established siderophile element signature of the BSE. Later, chalcophile and some siderophile elements in the silicate Earth, which were added by the Mars-like impactor, were then extracted into the core by a sulfide melt (0.5% of the mass of the Earth's mantle). Consequently, the BSE's composition was unlikely established at high pressures and temperatures, but is the product of a sequence of lower pressure metal-silicate equilibration steps on the proto-earth and its mars-like impactor.

Keywords: Earth, core, Mars

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Interstitial site occupancy of deuterium in a Fe-Si binary system at high-pressure and high-temperature conditions using a large volume press

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Light elements in the Earth's core have been discussed for a long time as one of the most important issues in earth science. Hydrogen, the most abundant element in the solar system, is one of the most promising candidates for the light elements because it can dissolve into metals under high-pressure conditions (e.g., Fukai et al.,1984) and can significantly lower the melting point of iron (e.g., Sakamaki et al., 2009). The second candidate is silicon. A certain amount of Si has been considered to be dissolved into the core from geochemical studies such as the difference in 30Si/28Si ratio (e.g., Georg et al., 2007) between meteorites and terrestrial rocks, higher Mg/Si ratio of Earth’ s mantle than the solar abundance, and so on (Allegre et al., 1995).

Hydrogen contained in iron is unquenchable to ambient condition and it is impossible to observe hydrogen in iron by X-ray diffraction. In order to make up those shortcomings, neutron diffraction experiments on iron deuteride under high pressure and high temperature have been conducted (Machida et al., 2014, Machida et al., 2019, Saitoh et al., 2020) . Those studies have determined site occupancies of deuterium in FeD_X with fcc, hcp and dhcp structures. The changes in H dissolution and site occupancy when Fe contains other light elements will be a next frontier to be elucidated.

In this study, we focused on Si and H as the candidates of light elements. Two kind of starting materials, $Fe_{0.95}Si_{0.05}$ and FeSi were used for the experiments. At ambient condition, $Fe_{0.95}Si_{0.05}$ takes bcc structure and FeSi takes B20 structure. X-ray diffraction experiments under high-pressure and high-temperature conditions (6 –15 GPa, 300 –1000 K) were carried out at beamline NE7, PF-AR, KEK to estimate the pressure and temperature dependence on hydrogen amount in the Fe-Si binary systems. Amount of dissolved hydrogen in the unit cell was estimated by dividing the volume expansion by the volume expansion rate. In addition to X-ray diffraction experiments, neutron diffraction experiments were conducted on Fe-Si-D ternary system at high pressure and high temperature. Those experiments were carried out using the 6 axis multi-anvil press "ATSUHIME" installed at BL11, MLF, J-PARC. ND_3BD_3 was used for deuterium source. Interstitial site occupancy of deuterium in the ternary alloy was determined from Rietveld refinement on neutron diffraction data of fcc $Fe_{0.95}Si_{0.05}D_x$ (starting x ~ 2) At 7.2 GPa and 988 K, x value of $Fe_{0.95}Si_{0.05}D_x$ was 0.73 and deuterium atoms occupy not only the octahedral site ($g_D(O)$ = 0.700) but also the tetrahedral site ($g_D(T)$ = 0.014). Machida et al., (2014) reported that $g_D(O)$ = 0.700 and $g_D(T)$ = 0.056 in fcc FeD_x under the close *P-T* condition. In this study, it was clarified that the site occupancy in the tetrahedral site of $Fe_{0.95}Si_{0.05}$ alloy is much smaller than that of FeD_x. Compared with previously reported neutron diffraction experiments on FeD_x under high pressure and high temperature, the coexistence of silicon can affect the site occupancies of hydrogen. In addition, we conducted a long-time measurement at ~ 14.5 GPa and 900 K using the MA6-8 assembly for neutron diffraction. The diffraction pattern shows that bcc iron completely transformed to hcp phase, which is the same phase of iron we believe to be present in the inner core. The deuterium content x in hcp-$Fe_{0.95}Si_{0.05}D_x$ was clarified

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to be 0.40 at ~ 14.7 GPa and 800 K.

Keywords: high-pressure and high-temperature experiments, multi anvil press, Hydrogenation, Iron alloy, light element, neutron diffraction

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Effects of nickel on hydrogenation of iron: High-*PT* neutron diffraction measurements on Fe0.9Ni0.1D*x*

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Density of the Earth's inner core is estimated to be about 5% lower than that of $Fe_{0.9}Ni_{0.1}$ alloy. Hydrogen, the most abundant element in our solar system, is one of the most promising light elements contained in the core. We focused on site occupancy of hydrogen and volume expansion induced by incorporation of hydrogen in Fe–Ni–H systems. In the present study, neutron diffraction measurements on $Fe_{0.9}Ni_{0.1}D_x$ were carried out at high-*PT* conditions up to 12 GPa and 1000 K to clarify the effects of nickel on hydrogenation of iron. Crystal structure of $Fe_{0.9}Ni_{0.1}D_x$ including site occupancy of hydrogen was refined using the Rietveld method.

Our results indicated that hydrogen-induced volume expansion coefficients v_D of fcc and hcp $Fe_{0.9}Ni_{0.1}D_x$ are ~11% and ~33% larger than those of FeD_x, respectively. The maximum hydrogen content of the Earth's inner core was calculated to be about one to two times the ocean mass. Hydrogen atoms in fcc $Fe_{0.9}Ni_{0.1}D_x$ did not occupy tetrahedral sites at all while 10–20% tetrahedral-site occupancy was previously reported in fcc FeD_x. Therefore, the effect of 10% nickel on hydrogenation of iron cannot be ignored in the Earth's core. However, the *P-T* conditions in this study were much lower than those of the Earth's core. It is essential to perform neutron diffraction measurements on the iron–nickel–hydrogen systems at higher *P-T* conditions to directly reveal the site occupancies of hydrogen and the density reduction by hydrogenation in the Earth's core.

Keywords: core, iron hydride, neutron diffraction, density deficit, high pressure

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Melting Experiments on the Fe-C-O Ternary System Under Core Pressures

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The light elements included in the iron core of the Earth have been explored for more than 70 years, but it still remains highly controversial. Five light elements, S, Si, C, O, and H are considered strong candidates. In particular, a combination of C and O have been paid much attention. Li et al. (2018) calculated the possible range of inner composition in Fe-S-Si-C and argued that C is an important element to explain the density and compressional and shear velocities of the inner core. Contrarily, O is known to have negligible solubility in solid Fe and thus so in the inner core. This indicates that O may be a major element in the outer core to account for the density difference between the outer core and inner core.

Here we performed melting experiments on the Fe-C-O ternary system by using laser-heating diamond-anvil cell techniques and obtained the liquidus phase relations at ~50 and ~136 GPa. By extrapolationg the present results and earlier data on the relevant Fe-O and Fe-C binary systems (Oka et al., 2019; Mashino et al., 2019) to 330 GPa, we estimated those under the inner core boundary pressure. The outer core liquid composition should be within the liquidus field of Fe to crystallize the dense inner core. We also obtained the partition coefficient of carbon D_C between solid and liquid Fe.

We calculated the liquid compositions that are in equilibrium with the possible inner core compositions proposed by Li et al. (2018) by using D_C, D_{Si}, and D_S. And we found that a narrow range of liquid Fe-S-Si-O-C compositions are compatible with the outer core only when inner core temperatures are 6500 K, according to previous ab initio calculations (Badro et al., 2014; Umemoto & Hirose 2020). Such inner core temperatures are unlikely because otherwise the corresponding temperatures at the core-mantle boundary cause extensive melting in the lowermost mantle. These may suggest that the inner core is not Fe-S-Si-C alloy but includes H as a major impurity element.

Keywords: Outer core, Inner core, Light Elements, Melting Experiments, Fe-C-O Ternary System

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Existence of the two-phase mixture of HCP and B2 phases in the inner core

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1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2. Bayerisches Geoinstitut, University of Bayreuth, 3. Japan Synchrotron Radiation Research Institute, 4. RIKEN

The Earth’ s inner core is composed of Fe-Ni alloy with some light elements. In this study, phase relations, equations of state, and the sound velocity of Fe-Ni and Fe-Ni-Si alloys were investigated at high pressure and temperature by using XRD and IXS at SPring-8.

We observed a wide stability field for of existence of B2 (ordered derivative of BCC structure) phase in these alloys. The B2 phase was observed even in the Fe-7wt%Ni alloy. These experimental results on the phase relations revealed that both nickel and silicon have strong effects on the expansion of the stability field of the two-phase mixture of B2 and hexagonal close-packed phases (HCP) under the core conditions. The high pressure and temperature equation of state of the two-phase mixture can explain the density of the PREM (preliminary reference Earth model) inner core [1].

The sound velocity of B2 phase of Fe0.67Ni0.06Si0.27 (15 wt. % of Si) alloy at high pressure were measured by using IXS spectroscopy. The previous measurements of compressional velocity of Fe [2, 3], $^{57}Fe0_{.91}Ni_{0.09}$ and $^{57}Fe_{0.8}Ni_{0.1}Si_{0.1}$[4] alloys with HCP and BCC structure revealed that the compressional velocity of the BCC phase is similar to that of HCP phase with the same compositions. We found that the estimated compressional and shear wave velocities for the two-phase mixture under the inner core conditions are consistent with those of the PREM. Therefore, the inner core composed of a mixture of B2 and hcp phases could account for the observed properties of the PREM inner core such as the density and velocity deficits [1].

References:
[1] Dziewonski, A.M. and Anderson, D. L. (1981). Phys. Earth Planet. Inter, 25, 297–356. [2] Liu, J. et al. (2014). Physics of the Earth and Planetary Interiors, 233, 24–32. [3] Ohtani, E. et al. (2013). Geophysical Research Letters, 40(19), 5089–5094. [4] Morrison, R. A. et. al. (2019). Physics of the Earth and Planetary Interiors, 294, 106268.

Keywords: Inner core, B2 phase, PREM, FeNiSi alloy, Phase relation, Sound velocity

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[S-IT18] Planetary cores: Structure, formation, and evolution

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Thu. Jun 3, 2021 9:00 AM - 10:30 AM Ch.24 (Zoom Room 24)

There are fundamental links between the formation and evolution of planets and their satellites to that of their cores both in terms of magnetic field generation and chemical and physical structure. Defining physical and chemical properties of the cores and core materials of these terrestrial bodies are therefore fundamental for understanding their internal structures and thermal profile. Recent advances in experimental and theoretical studies provide new insights into the Earth's cores and other terrestrial bodies, including the role of light elements in the early history of planets and at current times. Recent, current and future space missions have and will continue to obtain data on the internal structure of terrestrial planets (e.g., Mars and Mercury) and planet-satellite systems. We anticipate presentations on recent advances on the physical and chemical properties of cores and discussions regarding the latest views of their formation and evolution. We welcome contributions from mineral/rock physics, geophysics, geochemistry, geodynamics, and planetary science. We also welcome papers stimulating an interdisciplinary collaboration relating to establishment of the Study of Earth Deep Interior (SEDI)-Japan community.

10:20 AM - 10:30 AM

[SIT18-07]Discussion

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.24 Zoom Room 24

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium), Chairperson:William F McDonough(University of Maryland College Park), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

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10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

[SIT18-08] Introduction

10:50 AM - 11:05 AM JST | 1:50 AM - 2:05 AM UTC

[SIT18-09] Effect of the core structure on the nutation of Mars

*Attilio Rivoldini[1], Guillaume Morard[2], Daniele Antonangeli[3], Tim Van Hoolst[1], Sébastien Le Maistre[1], Véronique Dehant[1] (1.Royal Observatory of Belgium, 2.Université Grenoble Alpes, 3.Sorbonne Université)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[SIT18-10] Termination of a lunar dynamo inferred from compositionally-driven dynamo models

*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, Faculty of Science, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[SIT18-11] Possibility of percolation of Fe-S melts in asteroidsPossibility of percolation of Fe-S melts in asteroids

*Takumi Miura[1], Hidenori Terasaki[2], Tadashi Kondo[1], Osamu Ohtaka[1], Takashi Yoshino[3] (1.Department of Earth and Space Science, Graduate School of Science, Osaka university, 2. Department of Earth Sciences, Okayama University, 3.Institute for Planetary Materials, Okayama University)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[SIT18-12] **Wetting property of Fe-S melt in solid iron: Implication to core crystallization in planetesimals**

Daisuke Yumitori[1], *Hidenori Terasaki[1], Takashi Yoshino[2], Satoru Urakawa[1] (1.Faculty of Science, Okayama University, 2.Institute of Planetary Materials, Okayama University)

11:50 AM - 12:15 PM JST | 2:50 AM - 3:15 AM UTC

[SIT18-13] Discussion

[E] Oral | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Techtonophysics

[S-IT18] Planetary cores: Structure, formation, and evolution

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10:45 AM - 10:50 AM

[SIT18-08]Introduction

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Effect of the core structure on the nutation of Mars

*Attilio Rivoldini[1], Guillaume Morard[2], Daniele Antonangeli[3], Tim Van Hoolst[1], Sébastien Le Maistre[1], Véronique Dehant[1]

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Nutations are periodic changes in the orientation of the planet mainly due to the gravitational interaction with the Sun. The amplitude of the nutations dependents on a well known forcing and on the interior structure of Mars and in particular on the liquid core. One of the prime objectives of the RISE experiment on the ongoing InSight mission is to measure precisely the nutations of Mars and from the data infer the radius of its core and constrain its chemical composition.

Sulfur is commonly considered to be the main light element in the core of Mars, but the amount required to match the core density inferred from geodesy data is in excess of 25wt%. This is significantly larger than what is expected from geochemical modeling. Another candidate light element that can dissolve appreciably in liquid iron-sulfur at Mars core conditions is oxygen.

In this study, we build a new thermodynamic model of liquid iron-oxygen-sulfur to describe the thermoelastic properties of the core and investigate how the thermal structure of the core and its thermoelastic properties affect nutations.

Keywords: Mars, core, InSight

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Termination of a lunar dynamo inferred from compositionally-driven dynamo models

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4]

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Lunar paleointensity records suggest that the ancient Moon had a magnetic field of several tens of μT from 4.25 to 3.56 Ga, driven by a dynamo action [e.g., Garrick-bethell et al., 2009 ; Shea et al., 2012 ; Garrick-bethell et al., 2017]. It is not clear when and why the lunar dynamo died, and how the strength and morphology of the field evolved. We here pursue a possibility of compositionally-driven dynamo as proposed by thermal history calculations of the lunar core [Laneuville et al., 2014 ; Scheinberg et al., 2015].

We performed three-dimensional numerical dynamo simulations for an incompressible Boussinesq fluid in a rotating shell. Since the inner core grows in a geological time scale, we change non-dimensional parameters such as the ratio of inner to the outer core radii χ, the Rayleigh number Ra, and the Ekman number E. Simulations are carried out along with evolutional curves of Ra and E as functions of χ, guided by thermal history models of the lunar core [Laneuville et al., 2014 and Sheinberg et al., 2015]. Note that χ varies from 0.1 to 0.7 referring to the seismic observations of the Moon [Weber et al., 2011]. The compositional Prandtl number Pr and the magnetic Prandtl number Pm are fixed at 1 and 5, respectively. The inner and outer boundaries are no-slip and electrically insulating, while the fixed mass flux and zero-flux are set at the inner and outer boundaries, respectively.

Results using several evolutionally curves show that a larger Ra is required to sustain the dynamo in a thinner shell than that in a thicker shell. The magnitude of the curves determines whether a dynamo succeeds or fails at a given χ, while a flow structure in the fluid core after the dynamo shutdown have two common properties independent of this magnitude: Firstly, a strong flow exists only inside the tangent cylinder TC (a virtual cylinder tangent to the inner core at the equator and parallel to the axis of rotation) or exists both inside and outside for successful dynamo, whereas this strong flow inside TC is very weak for failed dynamo, except for χ=0.1. Secondly, the large-scale azimuthal westward flow is particularly strong at the equator. This second feature suggests that the strength of the azimuthal flow could be a marker in terminating the dynamo. Thus, we investigate the ratio of the poloidal to the toroidal component of the kinetic energy in the fluid core KEP/KET for all of the simulation results. We find that a higher value of KEP/KET is required to sustain the dynamos in thinner shells, and the dynamo is not maintained at KEP/KET<0.2, with some exception. The exceptional cases are found near the critical Rayleigh number at χ=0.1 and 0.5. In these cases, the magnetic field is non-dipolar at the outer boundary and the Elsasser number Λ is less than 1. In contrast, in most of the cases, the magnetic field is dipolar-dominant and $1<\Lambda<10$. Therefore, there are two possible scenarios for termination of the lunar dynamo. (1) Relatively strong ($1<\Lambda<10$) dipolar field is generated and then stops due to the enhanced azimuthal flow. (2) Weak($\Lambda<1$) non-dipolar field is maintained and then ceases due to the enhanced azimuthal flow. It is suggested that the magnetic fields in (1) and (2) are sustained by different dynamo mechanisms.

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Keywords: Dynamo evolution, Thermal history, Compositional convection, Lunar magnetic field, Inner core growth

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Possibility of percolation of Fe-S melts in asteroidsPossibility of percolation of Fe-S melts in asteroids

*Takumi Miura[1], Hidenori Terasaki[2], Tadashi Kondo[1], Osamu Ohtaka[1], Takashi Yoshino[3]

1. Department of Earth and Space Science, Graduate School of Science, Osaka university, 2. Department of Earth Sciences, Okayama University, 3. Institute for Planetary Materials, Okayama University

Many asteroids and planetesimals have been reported to differentiate to metallic cores and silicate mantles (e.g., Barrat et al., 2015). Due to negligible accretional heating in these small bodies, percolation of liquid iron alloy through solid silicates may play an important role for the core formation process in asteroids. Possibility of the percolation of a core-forming liquid depends on the dihedral angle between liquid iron-alloy and crystalline silicates. If the dihedral angle is less than 60˚, a melt can percolate through the crystals (Bargen and Waff, 1986). In previous experiments, the dihedral angle between Fe-S melt and olivine is reported to be less than 60 ˚below 2-3 GPa depending on olivine Fe#, i.e., redox condition (Terasaki et al., 2008). To understand core formation process in asteroids, it is required to measure the dihedral angle between Fe-S melt and orthopyroxene (opx) which is one of the major mantle minerals of asteroid as with olivine.

In this study, high-pressure experiments were performed up to 2.5 GPa and 1523 K using cubic multi-anvil and piston cylinder devices. Annealing durations range from 180 to 720 min at target temperatures. Starting material were mixtures synthetic opx powder (Fe#=0.23, 0.30) and Fe-S (S=40, 50 at%). Textures of recovered samples and chemical composition were analyzed using SEM-EDS. Dihedral angles were measured from backscattered electron images using Image process software. The measured dihedral angle between FeS and opx increases from 64˚, which is close to the wetting boundary of 60˚, at 1GPa to 92˚- 94˚, well above the 60˚ at 2.5GPa. Based on the results of the dihedral angle, textural feature, and chemical compositions, we will discuss a possibility of percolation of Fe-S melt through opx mantle in asteroid.

Keywords: Percolation, Asteroid, Core formation

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Wetting property of Fe-S melt in solid iron: Implication to core crystallization in planetesimals

Daisuke Yumitori[1], *Hidenori Terasaki[1], Takashi Yoshino[2], Satoru Urakawa[1]

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Wetting property of iron-alloy melts in solid iron-alloys controls whether the melt can percolate through solid iron-alloys or the melt is trapped in solid grain boundaries during core crystallization. Thus, it is closely related to differentiation process between liquid and solid core and efficiency of solid core growth. In this study, we measured dihedral angle between Fe-S melt and solid Fe at 1 GPa and discuss the differentiation process of the planetesimal core.

High pressure experiments were performed at 1 GPa and 1323 K, just above eutectic temperature of the Fe-FeS system, using piston cylinder apparatus at Institute for Planetary Materials. Starting material was composed of a powder mixture of Fe and FeS with Fe-2wt%S composition to obtain small melt fraction and was enclosed into MgO, BN, or Al_2O_3 capsule. Duration time of the experiment ranged from 15 min to 12 hours. Textural observation and chemical analysis of the recovered samples were carried out using SEM-EDS.

Based on the back-scattered electron images, Fe-S melt can be distinguished from solid Fe by a quench texture composed of Fe-FeS mixture, and interconnected networks of Fe-S melt were observed in solid Fe grains regardless of the capsule materials. Measured dihedral angle between Fe-S melt and solid Fe ranges 30-43°, which is much lower than percolation threshold of 60°. Therefore, the Fe-S melt can percolate through solid Fe, suggesting that segregation of Fe-S melt from solid Fe proceeds efficiently during core crystallization in planetesimals.

Keywords: Dihedral angle, Core, percolation, planetesimal

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[E] Oral | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Techtonophysics

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium), Chairperson:William F McDonough(University of Maryland College Park), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.24 (Zoom Room 24)

There are fundamental links between the formation and evolution of planets and their satellites to that of their cores both in terms of magnetic field generation and chemical and physical structure. Defining physical and chemical properties of the cores and core materials of these terrestrial bodies are therefore fundamental for understanding their internal structures and thermal profile. Recent advances in experimental and theoretical studies provide new insights into the Earth's cores and other terrestrial bodies, including the role of light elements in the early history of planets and at current times. Recent, current and future space missions have and will continue to obtain data on the internal structure of terrestrial planets (e.g., Mars and Mercury) and planet-satellite systems. We anticipate presentations on recent advances on the physical and chemical properties of cores and discussions regarding the latest views of their formation and evolution. We welcome contributions from mineral/rock physics, geophysics, geochemistry, geodynamics, and planetary science. We also welcome papers stimulating an interdisciplinary collaboration relating to establishment of the Study of Earth Deep Interior (SEDI)-Japan community.

11:50 AM - 12:15 PM

[SIT18-13]Discussion

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.12_1

[S-IT18] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Faculty of Science, Okayama University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Attilio Rivoldini(Royal Observatory of Belgium)

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[SIT18-P01] Sound velocity of hcp-iron at extreme pressure by inelastic x-ray scattering measurement

*Daijo Ikuta[1], Eiji Ohtani[1], Hiroshi Fukui[2,3], Daisuke Ishikawa[3], Alfred Q. R. Baron[3] (1.Department of Earth Science, Tohoku University, 2.Department of Material Science, University of Hyogo, 3.RIKEN)

[SIT18-P02] **Experimental modelling of seismic wave scattering near the inner-core boundary : preliminary results**

*Tatsuki Ohgishi[1], Ikuro Sumita[1] (1.National University Corporation Kanazawa University)

[SIT18-P03] GHz ultrasonic velocity measurement of iron beyond bcc-hcp transition III: FEM analysis on GHz-DAC ultrasonics

*Akira Yoneda[1], Ryo Tsuruoka[1], Seiji Kamada[2], Hidenori Terasaki[3], Tadashi Kondo[1], Daisuke Yamazaki[4] (1.Department of Earth and Space Science, Osaka University, 2.School of Science, Tohoku University, 3.School of Science, Okayama University, 4.Institute for Planetary Materials, Okayama University)

[SIT18-P04] GHz ultrasonic velocity measurements of iron beyond the bcc-hcp transition II : sample thickness determination using X-ray imaging method

*Ryo Tsuruoka[1], Akira Yoneda[1], Seiji Kamada[2], Hidenori Terasaki[3], Tadashi Kondo[1], Daisuke Yamazaki[4] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University, 2.Graduate School of Science, Tohoku University, 3.Faculty of Science, Okayama University, 4.Institute for Planetary Materials, Okayama University)

Sound velocity of hcp-iron at extreme pressure by inelastic x-ray scattering measurement

*Daijo Ikuta[1], Eiji Ohtani[1], Hiroshi Fukui[2,3], Daisuke Ishikawa[3], Alfred Q. R. Baron[3]

1. Department of Earth Science, Tohoku University, 2. Department of Material Science, University of Hyogo, 3. RIKEN

The Earth's core has supposed to be composed mostly of iron (over about 85 wt%), therefore the physical properties of iron at extreme conditions is one of the most important knowledge to the discussion of Earth's core. Since we cannot directly reach the Earth's core, the most reliable knowledge of the Earth's core comes from seismological observations, which show its density and velocity profile as a function of depth known as the preliminary reference Earth model (PREM). To constrain the Earth's core, sound velocities of iron and iron alloys at high pressures has been measured and compared with seismological observation (e.g., refs. 1-4). So far, the discussion has been based on extrapolation of experimental results around 100-150 GPa, for more detailed constraints, higher pressure experiments without extrapolation are necessary. Recent advances of high-pressure generation techniques using diamond anvil cells (DAC) and strong x-ray by synchrotron radiation have made it possible to perform the inelastic x-ray scattering (IXS) experiments to measure the sound velocity of hexagonal close-packed (hcp) iron at core pressures (e.g., ref. 1). However, a new problem has arisen as the pressure became closer to the core's pressure. That is, the scattering from diamond, which is used for high pressure generation, overlaps the scattering from samples at extreme conditions, thus it is hard to distinguish the IXS signals of the sample from those of the diamond, and the diamond becomes a wall of the IXS measurement limit (e.g., ref. 1). In this study, we have conducted sound velocity measurements for hcp-iron with IXS method by using a newly designed the solar screen system (ref. 5) that reduced noise as much as possible, and challenged the present limitation of sound velocity measurements of hcp-iron close to the "diamond's wall". The experimental density of hcp-iron reached to >12.8 g/cm^3 (exceeding the inner core density at inner-core boundary) and 250-270 GPa, and we succeeded to obtained clear IXS peaks from hcp-iron and derived sound velocity at extreme pressures. We discuss the composition of the Earth's core based on the present sound velocity data by comparing with the PREM.

References:
[1] Sakamaki et al., Sci. Adv. 2, e1500802 (2016).
[2] Sakairi et al., Am. Min. 103, 85-90 (2018).
[3] Dominijanni et al., JpGU-AGU joint meeting 2020.
[4] Ikuta et al., JpGU-AGU joint meeting 2020.
[5] Baron et al., AIP Conf. Proc. 2054, 020002 (2019).

Keywords: Sound velocity, Iron, Inner core, High pressure, Inelastic x-ray scattering

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Experimental modelling of seismic wave scattering near the inner-core boundary : preliminary results

*Tatsuki Ohgishi[1], Ikuro Sumita[1]

1. National University Corporation Kanazawa University

Introduction
Seismic waves transmitted and reflected near the inner-core boundary (ICB) have been observed. These observations have detected the asymmetry of the eastern and western hemispheres (Monnereau et al . (2010)) and P coda (Vidal et al. (2000)). Here the hemispherical asymmetry is such that P waves propagating in the eastern hemisphere is faster and has a larger attenuation (Q^{-1}) than those propagating in the western hemisphere. Monnereau et al . (2010) conducted numerical calculations of seismic waves scattered at the inner core and proposed that the inner core hemispherical asymmetry arises from the difference in grain size of the iron crystal. Alboussiere et al (2010) proposed that melting and solidification occurs in the opposite hemispheres, which has been modelled experimentally by Huguet et al. (2016). However experiments in which transmission, reflection, and scattering are studied using the same sample whose characteristic length scale is well controlled, are limited. In order to better understand the characteristics of seismic wave propagating near the ICB, we conduct ultrasonic measurements using a porous medium with a well-controlled particle size and analyze the waveforms.

We model the partially molten ICB using a random closed packing (packing fraction 0.60) of glass beads which forms a 3 cm layer at the bottom of a water-filled container. The particle size d of the glass beads is in the range of 0.05mm~5mm, and the P-wave is excited using an ultrasonic transducer whose frequency f (hence wavelength lambda) can be varied in the range of f = 0.5-2 MHz. As a result, the ratio, lambda /d is varied in the range of 0.6-46.0. The velocity and attenuation of the P-wave are determined from the waveform.

Results : Transmitted wave
Pulse wave :Pulse waves contain a broadband frequency component near the center frequency of 1 MHz . In the measurement using pulse waves, we vary the particle size d. P-wave velocity increased around lambda / d < 1, suggesting Mie scattering. We confirmed that the velocity is between the Reuss and Voigt averages of the glass beads –water mixture. Using the spectral ratio method, we obtained the attenuation Q^{-1} = 0.51. The waveforms showed that for lambda / d < 5, a forward scattered coda wave is excited.
Burst wave :Burst waves consist of three-cycle sinusoidal wave having a specified frequency in the range of 0.1-2 MHz . We use glass beads with a fixed particle diameter of d = 0.8 mm. The waveform at 0.8 MHz showed dispersion such that the P-wave travels faster when the wavelength is longer. This dependence on lambda /d is of the opposite sense compared to the case using a pulse wave, fom which we infer that Rayleigh scattering as a possible candidate. Similarly, we obtained Q^{-1} = 0.72 with a frequency-dependence of $Q^{-1} \propto f^{1.3}$.

Results : Reflected waves
Pulse wave : We observed a P-wave reflected at the surface of the glass beads layer.For lambda / d < 5, back scattered coda followed the reflected P-wave. For lambda / d = 7~46, we observed a coda whose amplitude was larger than the reflected P-wave. This coda is the wave reflected at the bottom of the container which was then forward scattered. A larger forward/back scattered ratio indicates Mie scattering.

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Burst wave : Similarly , for lambda / d > 3, the ratio of the energy of the wave reflected at the bottom of the container to that at the surface of the glass beads layer became larger than 1. The waves reflected at the bottom of the container consisted mainly of low frequency components, indicating that the high frequency components had attenuated.

Summary and Implications

Transmitted waves indicate dispersion and strong attenuation (Q^{-1} = 0.6) arising from scattering. P-wave velocity which correlate both positively and negatively with lamda/d are observed whose origin (Rayleigh or Mie scattering) is still inconclusive. These results provide an experimental support for the difference of grain size as the origin of the hemispherical dichotomy as revealed by PKIKP waves.

Reflected waves indicate that forward scattering becomes dominant at lambda/d = 5-46 suggesting Mie scattering. This result is consistent with the observation of PKiKP waves followed by a coda with a large amplitude. For such lambda/d range our measurements suggest that a seismic discontinuity within the inner core may be characterized by a large forward / back scattered ratio.

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GHz ultrasonic velocity measurement of iron beyond bcc-hcp transition III: FEM analysis on GHz-DAC ultrasonics

*Akira Yoneda[1], Ryo Tsuruoka[1], Seiji Kamada[2], Hidenori Terasaki[3], Tadashi Kondo[1], Daisuke Yamazaki[4]

1. Department of Earth and Space Science, Osaka University, 2. School of Science, Tohoku University, 3. School of Science, Okayama University, 4. Institute for Planetary Materials, Okayama University

In order to perform the GHz-DAC ultrasonics to measure sound velocities, it is critically important to develop in-situ techniques to measure sample length under high pressure. Here are several possible ways to realize it;

(1) X-ray imaging from the direction perpendicular to the axis of symmetry of the diamond anvil.

(2) Elastic deformation of diamond anvil under constrains of generated pressure and applied load.

(3) Optical observation and refractive index correction from the axis of symmetry of the diamond anvil.

In this presentation, we will report on (2). As for (1), please refer to another presentation with GHz data in this session. (3) will be examined in future study.

The distance between the backs of the diamond anvils can be measured with an accuracy of 0.1 μm using an advanced optical rangefinder. Therefore, if the elastic deformation of the diamond anvil under high pressure can be accurately evaluated, we can constrain the sample length within 0.1 μm accuracy. Finite element method (FEM*) analyses was applied to evaluate elastic deformation of diamond anvil under constraining generated pressure and applied load; generated pressure can be monitored by the ruby-scale method, while applied load can be monitored by a newly devised method measuring contraction of Belleville springs (Sara-bane) in symmetric DAC.

As a result of FEM analysis, it was found that, if the generated pressure and applied load were fixed, the length change in diamond anvil can be evaluated within accuracy of 1 μm or less, even if load distributions in the gasket were varied. As a result of the present systematic FEM assessments, we are confident that the sample length in DAC can be constrained within accuracy of 1 μm or less.

FEM analysis is able to predict travel time of the GHz wave propagating in the diamond anvil. The estimated travel time change was ~ 1ns at 15 GPa pressure generation. On the other hand, we analyzed P and S waves data acquired at15 GPa, and found the accuracy of 1 ns or less expected in both cases If FEM analysis is consistent with travel time variation, we can claim the estimated sample length with high reliability and confidence.

*FEM analysis was conducted by using COMSOL (trademark).

Keywords: iron, GHz ultrasonics, hcp phase, FEM, core

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GHz ultrasonic velocity measurements of iron beyond the bcc-hcp transition II : sample thickness determination using X-ray imaging method

*Ryo Tsuruoka[1], Akira Yoneda[1], Seiji Kamada[2], Hidenori Terasaki[3], Tadashi Kondo[1], Daisuke Yamazaki[4]

1. Department of Earth and Space Science, Graduate School of Science, Osaka University, 2. Graduate School of Science, Tohoku University, 3. Faculty of Science, Okayama University, 4. Institute for Planetary Materials, Okayama University

The sound velocity of iron (Fe) at high pressure is an important physical property for estimating the structure of planetary interiors. We have developed the GHz ultrasonic travel time technique using a diamond anvil cell (DAC). This technique utilize ultrasonic interferometry to determine the travel time of a sample in DAC. The ultrasonic waves travelling through the DAC are reflected at the front and back of the sample and produce interference. The travel time is determined by varying the frequency of the ultrasonic waves and examining the periodicity of the intensity changes in the interference region.

In this poster, we will report
1. the results of travel time measurements on iron (Fe) and the sound velocity estimated by thickness measurements on recovered samples
2. preliminary results of in-situ measurements of sample length using X-ray imaging measurements.

A symmetrical DAC with a culet diameter of 600 um was used. The generated pressure was determined by the ruby fluorescence method. The pressure was increased up to 15 GPa and travel time measurements have been carried out during the decompression process. The sample thickness was determined from scanning electron microscopy (SEM) images of cross sections of the recovered samples. Based on the thickness of the recovered sample and the travel time measurement at 6.7 GPa, the P-wave sound velocity was determined to be 6.68(8) km/s. This value is about 6% higher than of previous studies (Decremps et al., 2014). This is probably due to the preferred orientation of the samples in the non-hydrostatic experiments, or the hcp-Fe remaining in the samples.

In addition, we performed X-ray imaging measurement for future in-situ measurements. Kapton was used as an X-ray transparent gasket. Incident X-rays were applied from a direction perpendicular to the DAC compression axis. Preliminary result shows that the method can be used to determine the thickness of the sample with an accuracy of ~5 μm.

Keywords: GHz ultrasonic measurement, iron, high pressure

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[J] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.24 Zoom Room 24

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology), Chairperson:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Ryuichi Nomura(Kyoto University)

In recent years, collaborative studies on the physical and chemical properties of the Earth's interior, at depths from the mantle to the Earth's core, and on the formation and evolution of the Earth, have led to the elucidation of the dynamic behavior of deep Earth materials, such as core-mantle interaction and coevolution. This session will bring together researchers in Earth science and materials science to exchange information on the development of new technologies, which have the potential to revolutionize studies of the deep Earth's interior. These technologies include high-resolution electron microscopy, large-scale multi-scale computation, and machine-learning methods that allow us to design materials at an atomic scale.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

[SIT21-01] Introduction

1:50 PM - 2:20 PM JST | 4:50 AM - 5:20 AM UTC

[SIT21-02] Time-resolved transmission electron microscopy toward operando-measurement in geoscience

★Invited Papers

*Kuwahara Makoto[1] (1.Nagoya University)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[SIT21-03] Ab initio modeling of antigorite transported by subducting oceanic plates

*Jun Tsuchiya[1], Sayako Inoue[1] (1.Geodynamics Research Center, Ehime University)

2:35 PM - 3:05 PM JST | 5:35 AM - 6:05 AM UTC

[SIT21-04] Properties of liquid Fe mixtures under high-pressure conditions

★Invited Papers

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Institute of Technology, 2.Ehime Univ.)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[SIT21-05] Discussion

[J] Oral | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Techtonophysics

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology), Chairperson:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Ryuichi Nomura(Kyoto University)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.24 (Zoom Room 24)

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1:45 PM - 1:50 PM

[SIT21-01]Introduction

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Time-resolved transmission electron microscopy toward operando-measurement in geoscience

*Kuwahara Makoto[1]

1. Nagoya University

Time-resolved measurement in a transmission electron microscopy (TEM) holds promises of reveling intrinsic feature in nano-materials. Our group had developed time-resolved TEM (TR-TEM) using photocathode-type electron gun which could synchronize with time-structure of pulsed laser. The TR-TEM can provide a narrow energy width of below 0.3 eV and 1-ps pulse duration of electron beam. Furthermore, it has been clarified that the pulsed electron could contribute to observe time evolutions of electromagnetic field. High charge electron pulse in TRTEM also has possibility to realize operando-measurement of rock friction via nanosecond single-shot imaging, which can investigate rock friction at high sliding velocity and effect of ambient temperature, pressure, and pore pressure on friction. The technique will open to access nanometer-scale mechanics of faulting origin in geoscience. We would like to introduce overview of our apparatus and recent status of ultrafast measurement in electron microscopy.

Keywords: operando measurement, transmission electron microscopy, material science

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Ab initio modeling of antigorite transported by subducting oceanic plates

*Jun Tsuchiya[1], Sayako Inoue[1]

1. Geodynamics Research Center, Ehime University

Serpentine is hydrous phyllosilicate known to be formed in the mantle wedge by a reaction between mantle peridotit and upwelling water released by the decomposition of hydrous minerals in the subducting slab [e.g. Schmidt and Poli,1998]. Partially serpentinized peridotite may be a significant reservoir of water in the mantle wedge and the dehydration of serpentine is considered to have an important contribution to the generation of arc magmatism. This was also extensively investigated in connection with intermediate and deep earthquakes [e.g. Irifune et al. , 1996].
In order to investigate the transporting processes of water into the Earth’ s interior, the thermodynamic stabilities and the elastic properties of antigorite should be clarified. Antigorite is the high-temperature polymorph of serpentine and thus the relevant phase in the subduction zone. This phase has been reported to show polysomatism depending on the pressure and temperature conditions. Previous TEM study reported that *m* value (*m* = number of SiO_4 tetrahedra in a wavelength along the *a* axis) increases/decreases with pressure/temperature [e.g. Wunder et al. 2001]. However, there is no sufficient structural and thermodynamic corroboration regarding the stable polysome of antigorite along the pressure and temperature conditions of the subducting oceanic plate.
In the present study, we investigated the structure and elasticity of antigorite with several different *m* values by ab intio calculation and discuss the stable polysome of antigorite in the subducting oceanic plate.

Keywords: ab initio calculation, serpentine

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Properties of liquid Fe mixtures under high-pressure conditions

*Satoshi Ohmura[1], Taku Tsuchiya[2]

1. Hiroshima Institute of Technology, 2. Ehime Univ.

The effects of light elements such as H, C, O, Si, and S on the local structures of liquid Fe under high pressure are investigated by ab initio molecular dynamics (MD) simulations. The simulations clarify that H, C, and O are incorporated into liquid Fe interstitially while Si and S are “substitutional” type impurities. In addition, the interaction between light elements depends on the type of element. The C-C interactions are stronger than those of other light elements. The S-S interactions depend on the S concentration. From our simulations of liquid sulfur, it is found that the liquid sulfur has a covalent-like interactions even in metallic state, and liquid sulfur has a simple liquid structure at 320 GPa and higher pressures.

Keywords: high pressure, ab initio molecular dynamics, liquid

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[J] Oral | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Techtonophysics

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology), Chairperson:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Ryuichi Nomura(Kyoto University)
Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.24 (Zoom Room 24)

In recent years, collaborative studies on the physical and chemical properties of the Earth's interior, at depths from the mantle to the Earth's core, and on the formation and evolution of the Earth, have led to the elucidation of the dynamic behavior of deep Earth materials, such as core-mantle interaction and coevolution. This session will bring together researchers in Earth science and materials science to exchange information on the development of new technologies, which have the potential to revolutionize studies of the deep Earth's interior. These technologies include high-resolution electron microscopy, large-scale multi-scale computation, and machine-learning methods that allow us to design materials at an atomic scale.

3:05 PM - 3:15 PM

[SIT21-05]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.24 Zoom Room 24

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology), Chairperson:Satoshi Ohmura(Hiroshima Institute of Technology), Jun Tsuchiya(Geodynamics Research Center, Ehime University)

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3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SIT21-06] High spatial resolution electronic structure analysis by scanning transmission electron microscopy and electron energy loss spectroscopy

★Invited Papers

*Mitsutaka Haruta[1] (1.Kyoto University)

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

[SIT21-07] Molecular Dynamics Simulation of Shock-Induced Structural Transformation of Silica Using Artificial Neural Network

★Invited Papers

*Masaaki Misawa[1], Kohei Shimamura[2], Fuyuki Shimojo[2] (1.Okayama Univ., 2.Kumamoto Univ.)

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

[SIT21-08] Deformation mechanisms maps of bridgmanite based on high pressure experiments

*Noriyoshi Tsujino[1], Daisuke Yamazaki[1] (1.Institute for Planetary Materials, Okayama University)

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

[SIT21-09] Waveform inversion for the structure of Earth's deep interior: Progress and Prospects

*Kenji Kawai[1] (1.Department of Earth and Planetary Science, School of Science, University of Tokyo)

High spatial resolution electronic structure analysis by scanning transmission electron microscopy and electron energy loss spectroscopy

*Mitsutaka Haruta[1]

1. Kyoto University

Since transition metal (TM) oxides exhibit a variety of physical properties, which are sensitively related to their complex crystal structures and constituent elements, many experimental and theoretical studies has been conducted for not only bulk but also thin film. In particular, the relationship between localized TM *d* -band and oxygen 2*p* band is one of the key factors to control of the property. For further understanding, it is important to examine individual electronic structure with atomic resolution. This is because it has often some nonequivalent atomic sites in a unit cell even a single crystal, and they have different electronic structure for the same element.

In the field of high spatial resolution analysis, scanning transmission electron microscopy (STEM) combined with electron energy-loss spectroscopy (EELS) is the one way to know both elemental and electronic structure with atomic scale. However, while this technique can offer elemental and electronic state mapping with atomic resolution, it is, in principle, difficult to experimentally extract the information with truly atomic resolution due to the physically limited spatial resolution caused by the delocalization of inelastic scattering electrons[1] although sub-Å size electron probe has achieved thanks to the development spherical aberration corrector. Therefore, the interpretation of STEM-EELS with atomic scale is not simple, and careful attention of the mixing of signals from neighboring atomic-columns is required. In our previous researches, we focus on electronic structure of oxygen 2*p* band and transition metal 3d band with high spatial resolution for transition metal oxide which has layered structure. Since the fine structure of O *K*-edge reflects the unoccupied 2p state which hybridized with cation electronic orbital due to its covalent bonding character, it includes much information about chemical bond. In the presentation, I will introduce some applications of high spatial resolution STEM-EELS combined with some theoretical calculations.

Keywords: STEM, EELS

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Molecular Dynamics Simulation of Shock-Induced Structural Transformation of Silica Using Artificial Neural Network

*Masaaki Misawa[1], Kohei Shimamura[2], Fuyuki Shimojo[2]

1. Okayama Univ., 2. Kumamoto Univ.

Artificial neural network (ANN) potential, which is an interatomic potential constructed by machine-leaning, attracts attention as a promising method to achieve extra-large-scale molecular dynamics (MD) simulation with first-principles accuracy (Behler, 2007; Artrith, 2016). Application of this ANN-MD to far-from-equilibrium phenomena, such as fracture and pressure-induced transformation, is important to understand structural properties of materials under extreme conditions. For this purpose, we have tried to perform ANN-MD simulation of shock-induced structural transformation of silica.

To compute shock-compression behaviors within the framework of MD method, the multiscale-shock technique (Reed, 2003) was employed in our simulations. Potential energy of shock-compressed α-quartz obtained by first-principles MD (FPMD) method is used as a reference data for training of ANN-potential. As a result of ANN-MD simulation for elastic shock-wave region, elastic-deformation behaviors of α-quartz was successfully reproduced with high-accuracy (Misawa, 2020). On the other hand, for plastic shock-wave region, the ANN-potential has completely failed on prediction of both structure and energy, because of that irregular structure appears and rapid movement of atoms occurs during the elastic-to-plastic transition process.

In order to improve the predicting ability of ANN-potential, we introduce a more accurate training method that uses not only potential energy but also atomic force and pressure as reference data (Shimamura, 2020). Using this improved ANN-potential, it was succeeded that reproducing the elastic-to-plastic transition behavior and plastic deformation of α-quartz with an accuracy close to FPMD simulation. Thus, the ANN-potential trained with energy, force, and pressure is a potentially powerful tool to investigate wide range of far-from-equilibrium phenomena and will also provide useful information for solid earth physics field in future.

Reference

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Keywords: Molecular dynamics , Machine learning, Shock compression

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Deformation mechanisms maps of bridgmanite based on high pressure experiments

*Noriyoshi Tsujino[1], Daisuke Yamazaki[1]

1. Institute for Planetary Materials, Okayama University

Geophysical observations have revealed that the lower mantle has the largest viscosity in the Earth’s mantle. The lower mantle viscosity would play a key role in the global mantle dynamics. In order to understand the lower mantle viscosity, it is important to determine viscosity of bridgmanite which is regarded as the most dominant mineral of the lower mantle. Nevertheless, experimental data on viscosity of bridgmanite is quite limited due to experimental difficulty. Therefore, we conducted in-situ stress-strain measurements of bridgmanite by uniaxial deformation experiments at the lower mantle pressure conditions by newly developed deformation apparatuses with the Kawai type cell. Experimental conditions covered temperatures of 1473-1673 K and pressures of 23-27 GPa. The obtained stress exponent and activation enthalpy suggest that the dominant deformation mechanism of bridgmanite is climb-controlled dislocation creep. Bridgmanite is found to have the largest creep strength among mantle constituent minerals at same strain-rate even under nominally dry conditions. Based on this results and diffusion coefficient of Si in bridgmanite reported by Yamazaki et al. (2000), the deformation mechanisms map of bridgmanite was constructed. Combining deformation mechanism map of bridgmanite with geophysical observations indicates that grain-size of bridgmanite and stress conditions at top of the lower mantle would be > 8 mm and $< 3\times10^5$ Pa, respectively. The expected grain size of bridgmanite with 3-8 mm is much larger than that of bridgmanite in multi-phase system after the phase transition from ringwoodite across the 660 km discontinuity during convection of the mantle even followed by the grain growth for 1 billion years (e.g., Yamazaki et al., 1996). This fact suggests that large amount of the lower mantle materials would not have experienced the dissociation during the mantle convection and would have been isolated from the mixing by mantle stirring after crystallization of the magma ocean.

Keywords: deformation mechanisms map, bridgmanite, high pressure experiments, rheology

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Waveform inversion for the structure of Earth's deep interior: Progress and Prospects

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We formulated the inverse problem of waveform inversion for localized 3-D seismic structure, computing partial derivatives of waveforms with respect to the elastic moduli at arbitrary points in space for anisotropic and anelastic media (Geller and Hara 1993) and applied our method to the assembled dataset to invert for 3-D seismological structure (Kawai et al. 2014; Konishi et al. 2014). In this presentation, we will introduce the recent progress of mainly our research group (Borgeaud et al. 2017, 2019; Suzuki et al. 2020) and discuss perspectives of waveform inversion studies on the structure of Earth's deep interior.

Keywords: Waveform inversion, Studies of the Earth's deep interior

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[J] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.12_2

[S-IT21] Innovation through the Integration of Solid Earth Science and Materials Science

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Jun Tsuchiya(Geodynamics Research Center, Ehime University), Ryuichi Nomura(Kyoto University), Satoshi Ohmura(Hiroshima Institute of Technology)

In recent years, collaborative studies on the physical and chemical properties of the Earth's interior, at depths from the mantle to the Earth's core, and on the formation and evolution of the Earth, have led to the elucidation of the dynamic behavior of deep Earth materials, such as core-mantle interaction and coevolution. This session will bring together researchers in Earth science and materials science to exchange information on the development of new technologies, which have the potential to revolutionize studies of the deep Earth's interior. These technologies include high-resolution electron microscopy, large-scale multi-scale computation, and machine-learning methods that allow us to design materials at an atomic scale.

[SIT21-P01] Theoretical approach to the pattern formation in spin systems via the time-dependent Ginzburg-Landau equation

*Ryoji Anzaki[1], Shin-ichi Ito[1,2], Hiromichi Nagao[1,2], Masaichiro Mizumaki[3], Masato Okada[4], Ichiro Akai[5] (1.ERI/UTokyo, 2.IST/UTokyo, 3.JASRI, 4.GSFS/UTokyo, 5.IINa, Kumamoto Univ.)

[SIT21-P02] Waveform inversion for localized 3-D transversely isotropic structure in the lowermost mantle beneath the western Pacific using Thai Seismic Array (TSAR) data

*Yuki Suzuki[1], Kenji Kawai[2], Robert J. Geller[2], Satoru Tanaka[3], Weerachai Siripunvaraporn[4], Songkhun Boonchaisuku[4], Noisagool Sutthipong[4], Yasushi Ishihara[3], Taweoon Kim[3] (1.Department of Earth and Planetary Science School of Science Tokyo Institute of Technology, 2.Department of Earth and Planetary Science School of Science University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Faculty of Science, Mahidol University)

[SIT21-P03] Measurements of local stress using TEM in-situ obserbation

*Akira Miyake[1], Satoko Motai[1], Yohei Igami[1], Ryuichi Nomura[1] (1.Kyoto University)

[SIT21-P04] Measurements of local strain in minerals using electron nanoprobe

★Invited Papers

*Yohei Igami[1], Akira Miyake[1] (1.Kyoto University)

[SIT21-P05] Elastic properties of fine-grained polycrystalline clinopyroxene under high *P-T* conditions

*Yumiko Tsubokawa[1,2], Masahiro Ishikawa[2] (1.Kyushu University, 2.Yokohama National University)

[SIT21-P06] Effect of Al on stability and crystal strucutre of superhydrous phase B

*Sho Kakizawa[1,2], Toru Inoue[1,2], Hiroto Nakano[3], Minami Kuroda[4], Takahiro Kuribayashi[5], Naoya Sakamoto[6], Hisayoshi Yurimoto[7] (1.Graduate School of Advanced Science and Engineering, Hiroshima University, 2.Hiroshima Institute of Plate Convergence Region Research (HiPeR), 3.Geodynamics Research Center, Ehime University, 4.Graduate School of Sciences, Hokkaido University, 5.Department of Earth Science, Graduate School of Science, Tohoku University, 6.Creative Research Institution, Hokkaido University, 7.Department of Natural History Sciences, Hokkaido University)

Theoretical approach to the pattern formation in spin systems via the time-dependent Ginzburg-Landau equation

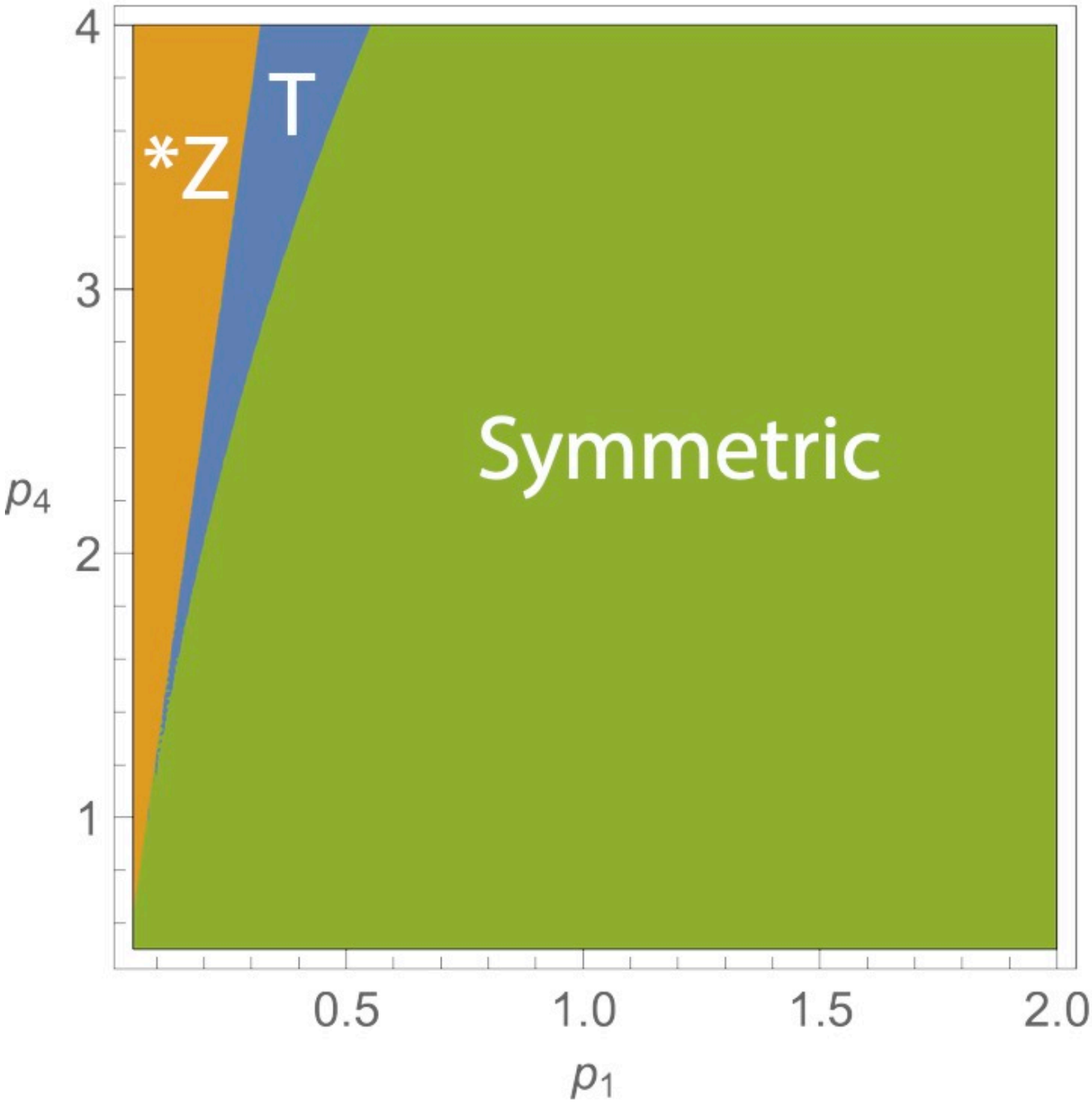
*Ryoji Anzaki[1], Shin-ichi Ito[1,2], Hiromichi Nagao[1,2], Masaichiro Mizumaki[3], Masato Okada[4], Ichiro Akai[5]

1. ERI/UTokyo, 2. IST/UTokyo, 3. JASRI, 4. GSFS/UTokyo, 5. IINa, Kumamoto Univ.

In this research, we study the two-dimensional classical spin model with the time-dependent Ginzburg-Landau equation as a model for magnetic thin materials. We classify the spatial patterns at the equilibrium (i.e., phases) using the spin $\mathbf{Z}_2$ and spatial symmetries. We approximate the equilibrium equation of the system using the RPSA [R. Anzaki *et al., Ann. Phys.* **353** 107 (2015)] and developed a method to predict the type of phases that are realized for each set of model parameters. The figure shows the phase diagram of the system for the system thickness (p_4) and dipole-dipole interaction intensity (p_1). In this figure, 'Symmetric', 'T', and '*Z' indecate the phases with no magnetization, no *total* magnetization but spatial patterns, and others, respectively. The quantities are normalized via coordinate-scale transformations. The finding of this research is accepted as a Regular Article in *Physical Review B*.

Keywords: magnetic materials, pattern formation, symmetry

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Waveform inversion for localized 3-D transversely isotropic structure in the lowermost mantle beneath the western Pacific using Thai Seismic Array (TSAR) data

*Yuki Suzuki[1], Kenji Kawai[2], Robert J. Geller[2], Satoru Tanaka[3], Weerachai Siripunvaraporn[4], Songkhun Boonchaisuku[4], Noisagool Sutthipong[4], Yasushi Ishihara[3], Taweoon Kim[3]

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Previous tomographic studies found a large-scale low S-velocity province (LLSVP) in the lowermost mantle beneath the Pacific. However, due to a lack of resolution it remained unclear whether the LLSVP consists of clusters of small-scale low-velocity anomalies or large-scale anomalies. In a previous study (Suzuki et al., PEPI, 2020) we inverted a new dataset from the Thai Seismic Array (TSAR; Tanaka et al., BERI, 2019) to infer the isotropic 3-D S-velocity structure beneath the western Pacific. We found a high-velocity anomaly extending vertically to 400 km above the core-mantle boundary (CMB) beneath the Philippine Sea and small-scale low-velocity patches with a diameter of ~300 km at the CMB beneath New Guinea. We hypothesized that a vertically continuous high-velocity anomaly could be the sinking Izanagi paleoslab, which subducted ~200 Ma, and interpreted small-scale low-velocity anomalies as a plume cluster that forms at the western margin of the Pacific LLSVP.
To obtain further geodynamical information, in this study we conduct waveform inversion for transversely isotropic structure. We infer high-resolution 3-D models of the S-velocity perturbation δVs and the anisotropy parameter $\delta \xi$ in the lowermost 400 km of the mantle. The inferred anisotropic structure is due to the deformation-induced alignment of the crystal caused by mantle flow for either Mg-perovskite, Mg-post-perovskite, ferropericlase, or a combination thereof because of the high-stress condition in the boundary layer of the mantle convection. When we assume the dominant glide system of each mineral under the lowermost mantle conditions given by previous experimental results, the inferred anisotropic structure shows that vertical flow (upwelling plumes and downwelling of paleoslabs) is dominant in the lowermost mantle beneath the western Pacific.

Keywords: Lowermost mantle, Anisotropy, Waveform inversion, Pacific LLSVP, Plume cluster, D″ region

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Measurements of local stress using TEM in-situ obserbation

*Akira Miyake[1], Satoko Motai[1], Yohei Igami[1], Ryuichi Nomura[1]

1. Kyoto University

[Introduction] Extensive in-situ loading/ indentation experiments have been conducted inside a transmission electron microscope (TEM) to understand the nanomechanical properties of materials (e.g., Wang et al., 2015). In these studies, the stress on the sample were estimated just by dividing the applied load by the area loaded on and/or analyzed by the finite element method. In this study, we succeeded in measuring the stress state within a sample directly from the electron diffraction patterns of a deformed sample.

[Materials and Methods] A thin film of monocrystalline silicon with 100 nm thickness was prepared by a focused ion beam (FIB, Helios NanoLab G3 CX, Thermo Fisher Scientific). In-situ indentation/ compression tests were performed with a diamond indenter inside the chamber of TEM at Kyoto University (JEM-2100F, JEOL), under the load-controlled mode up to 40, 100, 200, and 500 μN (Hysitron PI95 TEM PicoIndenter, Bruker). The film with the crystal zone axis of approximately [01-1] was compressed on the (001) plane along the [001] direction. Diffraction patterns were taken before, during, and after the compression. Digital Microgarph (Gatan, Inc.) and ReciPro (developed by Y. Seto, http://pmsl.planet.sci.kobe-u.ac.jp/~seto/) were used for data analysis. The equation of state of Si by Pandya et al. (2012) was used to calculate the stress from the lattice strain.

[Results and Discussion] The results show that the lattice spacing parallel to the loading axis [001] reduced on compression. On the other hand, the lattice spacing of the [110] direction, perpendicular to the compression axis, did not change during compression. Calculated stresses along the compression axis were ~1.7 GPa at 40 μN, ~2.4 GPa at 100 μN, ~3.7 GPa at 200 μN and ~7.1 GPa at 500 μN, respectively. The lattice parameter along the [110] direction changed negligibly or expanded slightly. The pressure was estimated from the change of a cell volume as ~1.1 GPa at 200 μN, and ~1.4 GPa at 500 μN, assuming that there was no strain along the direction of incident electron beam. The local stress became small with the increase of the distance from the contact point of the indenter. Clarifying the detailed geometry of the contacting point is needed for more accurate analysis.

Wang et al., (2015) Scripta Materialia, 98, 40; Pandya et al. (2012) J. Phys.: Conf. Ser. 377 012097

Keywords: electron microscope, in-situ experiment, nano-deformation

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Measurements of local strain in minerals using electron nanoprobe

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1. Kyoto University

Interface/surface of minerals having complex textures frequently shows local strain, which more or less affects phase transitions and/or relevant micro-texture formations. In addition, strain locally remained in natural minerals may be key information to understand various geophysical events such as tectonics or meteorite impacts. There exist some measurement methods to determine strain in minerals, for example, X-ray diffraction or micro-laser Raman spectroscopy [e.g., 1,2], but higher spatial resolution/selectivity is required to precisely analyze specific regions in nanometer order. The high spatial resolution analysis would become also important for future challenging experiments to simulate extreme environments in the Earth because amount of such experimental products is frequently very small.
As for semiconductor devices of which miniaturization rapidly progresses, local strain is utilized to control electric function, thus some strain measurements with nanometric order have already been performed [e.g., 3]. In particular, diffraction imaging method which uses scanning electron nanoprobe to obtain many diffraction patterns from nanometric regions should be able to measure local strain precisely with corresponding high magnification images [4]. This would be effective to study mineral samples, but minerals have large diversity in phase, size, morphology and/or crystal orientation, whereas experimental conditions to study the semiconductor devices can be relatively limited. Because appearance of electron diffraction pattern varies sensitively to sample conditions, it would be important to establish experimental/analytical procedures of the method adequate for mineral samples.
In this study, we obtained and analyzed diffraction imaging datasets from mineral samples by scripting control of a transmission electron microscope (TEM) and a CCD camera. Illumination electron beam was adjusted to be mostly parallel with its spot size smaller than 10 nm in diameter, which gives spotty diffraction patterns and allows us to easily determine reciprocal basis of each illuminated point. Sample damage could be reduced because electron dose in the illumination condition is much smaller than that of the convergence beam generally used in STEM (scanning TEM) method. No damage textures or contaminations due to the experiments were observed in TEM images. The obtained datasets were analyzed to construct strain maps and diffraction-contrast images by virtual objective apertures with arbitrary shapes.

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Keywords: electron microscopy, strain analysis

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Elastic properties of fine-grained polycrystalline clinopyroxene under high *P-T* conditions

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1. Kyushu University, 2. Yokohama National University

Grain size may play an important role in determining the physical properties of rock-forming minerals under some conditions. Even though the occurrences of minerals with grain size of < 1 μm are limited, they might have a significant effect on geophysical processes due to its high surface area to volume ratio; for example, nanocrystalline forsterite is more compressible than forsterite with micron-scale grains due to the weakening of elastic properties of grain boundary and triple junction (Couvy et al., 2010; *PCM*). In this study, we demonstrated ultrasonic wave velocity measurements of polycrystalline clinopyroxene with submicron grain sizes under high *P-T* conditions, and compared its elastic properties with those reported from samples with much larger grain size.
Fine-grained polycrystalline clinopyroxene with average grain size of ~400 nm were sintered from pulverized clinopyroxene crystals ($Ca_{0.92}Na_{0.07}Mg_{0.93}$ $Fe_{0.01}Al_{0.06}Mn_{0.01}Si_2O_6$). The V_p and V_s values of the fine-grained clinopyroxene were measured up to 1.0 GPa and 640 ˚C for V_p and 750 ˚C for V_s with a piston-cylinder type high-pressure apparatus. At room temperature, V_p increases rapidly with increasing pressure up to 0.5 GPa, whereas it exhibit a gradual increase between 0.5 and 1.0 GPa, suggesting closure of porosity at > 0.5 GPa. The velocity increase at pressures from 0.5 to 1.0 GPa is ~1 %, and the velocity reduction at temperatures from 25 to 640 ˚C at 1.0 GPa is ~3-5 %. At 1.0 GPa and 640 ˚C, V_p of fine-grained polycrystalline is ~7.6 km/s, which is smaller than those of polycrystalline clinopyroxene with grain size of < 100 μm (Liebermann and Mayson, 1976; *PEPI*). The calculated bulk modulus for fine-grained clinopyroxene is relatively small, and this V_p difference may be attributed to this small value of bulk modulus in this study. This decrease of bulk modulus for fine-grained clinopyroxene is consistent with the grain-size-sensitive elastic behavior of nanocrystalline forsterite. According to our results, we found that fine-grained polycrystalline clinopyroxene exhibit low bulk modulus, causing the decrease in V_p and V_p/V_s, and this might be associated with the decrease of grain size to submicron scale.

Keywords: clinopyroxene, submicron, elastic velocity, piston-cylinder type high-pressure apparatus

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Effect of Al on stability and crystal strucutre of superhydrous phase B

*Sho Kakizawa[1,2], Toru Inoue[1,2], Hiroto Nakano[3], Minami Kuroda[4], Takahiro Kuribayashi[5], Naoya Sakamoto[6], Hisayoshi Yurimoto[7]

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We determined the stability and chemical composition of Al-bearing superhydrous phase B at 20–24 GPa and 1400–2000 ˚C to discuss the mechanism of water transport in the mantle transition zone and uppermost lower mantle at temperatures close to the mantle geotherm. Superhydrous phase B[$Mg_{10}Si_4O_{14}(OH)_4$] is one of the important dense hydrous magnesium silicates (DHMSs) in hydrous peridotite system for understanding the deep water cycle in the Earth’ s interior. It contained significant amounts of Al_2O_3, from 14 to 32 wt%, and Al-bearing superhydrous phase B remained stable, even at 2000 ˚C and pressures of approximately 20–24 GPa. Moreover, two types of superhydrous phase B with different chemical compositions coexisted at 20–24 GPa and 1600 ˚C. The Al_2O_3 and H_2O contents increased, and the MgO and SiO_2 contents decreased as the pressure and temperature increased up to 1600 ˚C. Above 1600 ˚C, the MgO and Al_2O_3 contents increased, and the SiO_2 and H_2O contents decreased as the temperature increased. We found two substitution mechanisms: (1) $2Mg^{2+} + Si^{4+} = 2Al^{3+} + 2H^+ + V_{Mg}$ (Mg site vacancy) $(2Mg^{2+} = Al^{3+} + H^+ + V_{Mg}):(Si^{4+} = Al^{3+} + H^+) = 1:1$, (2) $Si^{4+} + 16H^+ = 4Mg^{2+} + 4Al^{3+}$. The maximum H_2O content of Al-bearing superhydrous phase B is 11.1(3) wt%, which is ~1.9 times larger than that of the Mg-end-member. The crystal structures of the two coexisting superhydrous phase B values are expected to be slightly different from each other. The present results indicate that Al-bearing superhydrous phase B can be stable in a subducted slab with a high Al content compared to pyrolite (e.g, chlorite) at temperatures typical of the mantle transition zone and the lower mantle. Thus, water can be transported to the lower mantle by Al-bearing superhydrous phase B in the subducting slab, even at the typical mantle geotherm.

In addtion, we investigated the crystal structure of Al-bearing superhydrous phase B ($Mg_{8.1}Si_{2.0}Al_{1.9}H_{5.9}O_{18}$) by single crystal X-ray diffraction (XRD), Raman and Fourier Transform infrared spectroscopy (FT-IR) to determine the Al positions and to predict the H positions in Al-bearing superhydrous phase B. As a result of the crystal structure refinement, Al was clarified to be located in octahedral Mg1, Mg2, and Si1 sites in superhydrous phase B with *Pnnm* space group. The result is consistent with $2Mg^{2+} + Si^{4+} = 2Al^{3+} + 2H^+ + V_{Mg}$ substitution. The obtained FT-IR spectra, difference Fourier maps, and bond-valence considerations leaded to new H positions. They are located at (1) O6-H···O4, which is a part of AlO_6 octahedron, (2) O5-H···O3, which is the same as Mg-endmember superhydrous phase B, and (3) O4-H···O1, which is share edge of $Mg2O_6$ and $Mg4O_6$ octahedra.

Keywords: Earth's deep mantle, water, hydrous mineral, superhydrous phase B

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.25 Zoom Room 25

[S-VC30] Volcanic and igneous activities, and these long-term forecasting

convener:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), 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:Tomohiro Tsuji(Division of Earth Science The Graduate School of Science and Technology for Innovation Yamaguchi University), Chisato Anai(Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

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

[SVC30-01] Paleomagnetic evidence for polygenetic origin of Mamiyadake tephra ring, Ohachidaira maar-caldera complex, Hokkaido, Japan

*Yuki Yasuda[1] (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University)

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

[SVC30-02] Constraining residence times of plagioclase phenocrysts at the latest activity of Zao volcano

*Motohiro Sato[1], Masao Ban[1] (1.Graduate School of Science and Technology, Yamagata University)

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

[SVC30-03] Inverse crystallization order of phenocrysts in high-Mg basalt from Ryozen Formation, Fukushima prefecture

*Tsukasa Ohba[1], Tokiya Ando[1] (1.Faculty of International Resource Sciences, Akita University)

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

[SVC30-04] Discovery of new block and ash flow deposit from Azuma-kofuji volcano, Fukushima, Japan

*Takeshi Hasegawa[1], Suzuki Kazuma[1] (1.Department of Earth Sciences, College of Science, Ibaraki University)

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

[SVC30-05] Reexamination of the characteristics and eruption style of Haruna-Hakoda tephra found from the southern foot of Akagi Volcano to the eastern foot of Haruna Volcano in North Kanto, Northeast Japan

*Junichi Sato[1], Takehiko Suzuki[2] (1.Department of Geography, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 2.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University)

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

[SVC30-06] What have been erupted from the 2020 eruption of Nishinoshima?

*Yoshihiko Tamura[1], Tomoki Sato[1], Kenta Yoshida[1], Fukashi Maeno[2], Osamu Ishizuka[1,3], Yasuhiro Hirai[1], Noriko Tada[1], Kiyoshi Baba[2], Daisuke Suetsugu[1], Maiko Miyoshi[4], Shigeaki Ono[1] (1.Research Institute for Marine Geodynamics, Japan Agency for Maine-Earth Science and Technology, 2.ERI, Univ. of Tokyo, 3.GSJ/AIST, 4.NHK)

Paleomagnetic evidence for polygenetic origin of Mamiyadake tephra ring, Ohachidaira maar-caldera complex, Hokkaido, Japan

*Yuki Yasuda[1]

1. Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University

Maar volcanoes are surrounded by tephra rings that consist of well-bedded tephra layers. Due to the undisturbed nature of the successive tephra layers, tephra-ring deposits are generally considered to be emplaced over a short time interval (days to years) without significant time breaks; hence, maars are generally interpreted as being monogenetic. In this presentation I describe paleomagnetic evidence for polygenetic origin of the Mamiyadake tephra ring which was formed during maar-forming eruptions at Ohachidaira volcano, central Hokkaido, Japan. In this study, oriented block samples (mostly scoria clasts) were collected from >30 sites throughout the sequence of the Mamiyadake tephra ring for paleomagnetic analysis. Like other maar-tephra-ring deposits elsewhere, pyroclastic layers making up the Mamiyadake tephra ring show no sedimentological evidence for significant time breaks, but with one unconformity between the layers occurring in the southwest rim. The paleomagnetic directions obtained from the ring deposits significantly vary vertically through the sequence. This significant variations in paleomagnetic directions between the sites are interpreted as recording snapshots of paleomagnetic secular variation (PSV) of the geomagnetic field over time. By using the average rate of PSV in Japan calculated from the Holocene archaeomagnetic and paleomagnetic records, I conclude that the deposits of the Mamiyadake tephra ring were emplaced intermittently over a time span of at least 1000 yr. The results of this study suggest a possibility of maar’ s longer lifespans (hundreds to thousands of years) that are at least three orders of magnitude longer than previously thought.

Keywords: paleomagnetic direction, tephra ring, maar-caldera complex

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Constraining residence times of plagioclase phenocrysts at the latest activity of Zao volcano

*Motohiro Sato[1], Masao Ban[1]

1. Graduate School of Science and Technology, Yamagata University

1. Introduction

Time scales of magmatic processes are critical information to reveal eruption mechanisms and evaluate volcanic hazards. To estimate magmatic time scales, diffusion modeling of crystals has been used recently. Plagioclase, a ubiquitous phenocryst in volcanic rocks, provides the benefit of detecting magmatic processes. We report the residence times of plagioclase phenocrysts and constrain the pre-eruptive processes at the latest activity of Zao volcano.

2. Samples and analytical methods

Juvenile bomb samples are collected from Okama activity products (OKP), which were erupted between 12 and 19C. These samples are medium-K and calc-alkaline series basaltic andesite to andesite (56-57% SiO2), including plagioclase, orthopyroxene, clinopyroxene, and rare olivine as phenocryst.

Mg and CaAl-NaSi in plagioclase were used to estimate residence times. Zoning profiles of plagioclase were measured by electron probe microanalysis. High spatial resolution An zoning profiles are required to detect the nm-scale diffusion of CaAl-NaSi. An zoning profiles were also obtained by calibrated BSE images using the ImageJ software.

3. Processes recorded by plagioclase textures and compositions

Textures and compositions of plagioclase phenocrysts record various crystallization histories. Four populations of plagioclase phenocrysts are present in OKP samples. Type A has oscillatory zoned cores. The oscillatory zoning reflects cyclic changes of the chemical and physical conditions induced by injections of hotter magma into the shallow reservoir. Type B and C have patchy zoned cores of low- and high- An, respectively. The patchy texture was formed by partial dissolution. The former was formed by injection of hotter magma, whereas the latter was formed by decompression at calcic and H2O-undersaturated melt conditions. Type D shows the honeycomb texture, which was formed by skeletal growth under supercooling conditions. The dusty zoned or high-An rim, which is observed in type A, B, and C, reflects the interaction of hotter and calcic melt before eruptions. The low-An outermost rim observed in all types was produced by supercooling or an increase in the liquidus temperature due to water exsolution induced by magma ascent.

4. Residence times of plagioclase phenocrysts

Residence times of plagioclase phenocrysts were calculated using Mg and CaAl-NaSi diffusion modeling. The former one includes the effects of coupling with An content and provides more precise determinations than the other steady-state diffusion models. However, this model failed to calculate residence times of type A and B plagioclase phenocrysts because of strong changes of the An composition in small steps. To avoid this problem, we used type C and D phenocrysts which have a lower degree of partial dissolution. The initial Mg concentrations were estimated from measured An content. The boundary conditions were assumed to be in equilibrium with the groundmass composition. The diffusion equation was calculated numerically by a finite-difference scheme.

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We first used the one-step model, which assumes that diffusion starts only after the entire crystal grew. The calculated profiles at the crystal cores reach the measured Mg concentrations within 50-300 yrs. However, this model could not obtain good fits in the dusty and high-An rim. We used the multi-step model, which provides the time scales of different processes recorded in different parts of the crystals. An example of a type C plagioclase gave first step residence time of 100 yrs for the core profile resulted from diffusion in a high-temperature melt and gave second step residence time of < 5 yrs for the rim profile by the diffusion in a low-temperature melt. This model obtained better fits to the dusty and high-An rim.

In contrast, the CaAl-NaSi diffusion time scales indicate shorter residence times (10-50 yrs) than Mg diffusion. In a simple case, we evaluated the effect of multi-dimensional diffusion in the case of Mg diffusion and found this becomes significant when diffusion progresses to the center part of the crystal. Compared to the two-dimensional diffusion model, the one-dimensional one gives several times longer results. The results of the two-dimensional model are in good agreement with those of CaAl-NaSi diffusion modeling. These results indicate that the shallow magma reservoir had been mixed continuously with the newly injected high-temperature magma just before the eruption.

Keywords: Diffusion modeling, Plagioclase, Zoning profile, Zao volcano

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Inverse crystallization order of phenocrysts in high-Mg basalt from Ryozen Formation, Fukushima prefecture

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Since the proposal of Bowen’s reaction theory (Bowen, 1928), chemical and mineralogical diversities of basaltic rocks have been attributed to crystallization differentiation. In primitive basalt magmas, olivine is assumed to be the initial crystallization phase followed by crystallization of pyroxene and plagioclase. The orders of crystallization are often determined with microscopic observations for natural basalt samples (e.g., Aoki, 1989). Recently, an inverse crystallization order (pyroxenes - olivine - plagioclase) from basaltic magma was identified by Rafren et al. (2020) from Manguao basalt, Palawan Island, Philippines. The inverse crystallization order was accounted for by decompression crystallization during magma ascent. They explained the crystallization process based on mineral chemistry, mineral textures, and MELTS simulation (Gualda and Ghiorso, 2014). Decompression crystallization models have been applied for some basaltic volcanoes (Kuritani, 1999; Ohba et al., 2009), but is still not a widely accepted model. Ohba et al. (2009) pointed out that chemical variation trends from Hakkoda are not consistent with the fractionation of phenocryst minerals, and explained that cryptic crystallization at MOHO resulted in the chemical trends whereas phenocrysts were formed in the shallow crust during ascent.

The Miocene Ryozen Formation, Fukushima, northern Honshu Japan, is a basaltic volcanic suite composed of high-Mg basalt. Shuto et al. (1985) identified four types of phenocryst mineral assemblages. The least differentiated basalt is one of the basaltic samples containing olivine phenocrysts solely and is one of the highest in MgO content of the samples. However, a pyroxene-bearing rock has a similar while rock chemistry. When whole rock compositions of Ryozen Formation are plotted on variation diagrams, pyroxene-free rocks show a wide MgO range, and pyroxene-bearing rocks overlaps the entire trend of pyroxene-free rocks. An evolved mineral assemblage in the gauge of Bowen’s reaction theory (olivine + clinopyroxene + orthopyroxene + plagioclase) has a similar chemical composition to the rocks with the primitive mineral assemblage (olivine alone). This fact indicates that the variation of observed phenocryst assemblage is not necessarily relevant to the chemical differentiation.
We re-examined whole rock chemistry and mineral chemistry of some basaltic rocks from Ryozen. The analyzed basaltic rock samples contain olivine and clinopyroxene as phenocrysts. Plagioclase is contained in a sample. In these samples, clinopyroxene phenocryst cores have higher Mg# than those of olivine. At the basaltic temperature of 1200 C which is consistent with the plagioclase-melt geothermo- hygrometer for the plagioclase-bearing sample, Mg-Fe partitioning between olivine and clinopyroxene is close to 1. The difference of Mg# between olivine and clinopyroxene cores indicates earlier crystallization of clinopyroxene than olivine. The observation is consistent with MELTS modeling of isothermal decompression, resulting in the early crystallization of clinopyroxene and later crystallization of olivine. The model calculation also resulted in early crystallization of Low-Ca pyroxene (pigeonite or orthopyroxene) which is contained in some other samples but not in the examined samples. Low-Ca pyroxene may be replaced by olivine through the peritectic reaction during the decompression.

Keywords: Order of crystallization, basaltic magma, Ryozen

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Discovery of new block and ash flow deposit from Azuma-kofuji volcano, Fukushima, Japan

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Azuma volcano is located on the west side of Fukushima-city. The volcanic complex consists of three volcanoes, called Nishi-Azuma, Naka-Azuma and Higashi-Azuma (from west to east). The Higashi-Azuma volcano has a large (2 km in diameter) summit crater, Jododaira, with an opening to the east side. It formed by sector collapse/Plinian eruption and produced debris avalanche deposits on eastern foot of the volcano at around 140 ka. Azuma-kofuji is one of the active volcanoes in the Azuma volcanic complex generated on the Jododaira crater during 6 ky to 5 ky ago. Azuma-kofuji is composed of a scoria cone, and widely distributed lava flows that covers the debris avalanche deposits at the eastern base of Higashi-Azuma. In this study, we discovered a new block and ash flow deposit (BAF) from Azuma-kofuji that has not been recognized and has not been considered for volcanic hazard assessment of Fukushima-city before. Here, we present the geological (lithofacies, stratigraphy, distribution) and petrological (petrography, bulk-rock chemistry) characteristics of the deposit (Azuma-kofuji block and ash flow deposit: Ak-BAF) and discuss its generation/emplacement processes.

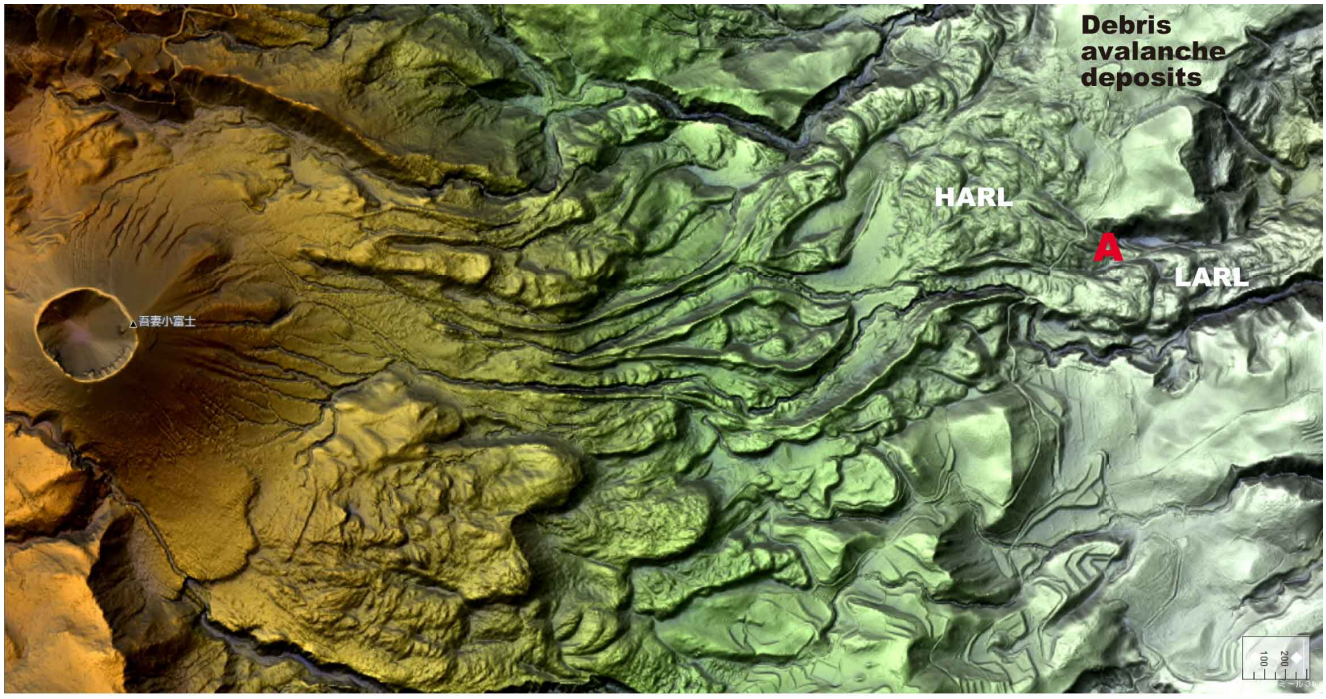
Ak-BAF is distributed at the valley between the eroded cliffs of the debris avalanche deposit and the edge of the most extensive lava flow (Shiratugawa lava flow) 10 km east from Azuma-kofuji cone. On the basis of the estimated distribution area and the average thickness (10~20 m) of the deposit, the volume of Ak-BAF can be estimated to be 1 x 10^{-3} cubic km. Ak-BAF is a gray colored, coarse ash matrix, supported and lava block rich pyroclastic flow deposit covered by the Nm-NK tephra that was derived from Numazawa volcano around the 5 ka. Large mega-blocks (> 2~3 m in diameter) of lava flow are contained at the most upstream outcrop (loc. A at attached figure). Smaller (< 1 m) vesiculated gray blocks are commonly included and can be determined as juvenile materials in Ak-BAF. Petrologic features of the smaller gray blocks are homogeneous, whereas those of mega-blocks are relatively various. Bulk-rock compositions of these blocks are basaltic andesite to andesite (SiO2=59-62%) and are almost as same as those of lava flows of Auzma-kofuji except for some mega-blocks.

Ak-BAF is not recognized at upper-stream area from the edge (tip) of the Shiratugawa lava flow inferring the Ak-BAF was not derived from Azuma-kofuji cone. There exist at least two multiple flow units at the end of Shiratsugawa lava flow. One flow unit flowed down a longer distance with smoother surface/lava levees indicative of a more fluidal nature (= lower aspect ratio lava: LARL). Another unit (adjacent to the north side of LARL) shows a characteristic morphology, it is more rugged (blocky) and has a spreading distribution (= higher aspect ratio lava: HARL). The distribution of Ak-BAF starts at the southern edge (lobe) of the HARL (loc. A at attached figure) at the steep cliff of the debris avalanche deposit. We suggest that the HARL unit occurred and grew slowly after the emplacement of LARL unit. Then, the southern edge, which might have hardened thick crust, finally reached and collapsed at the steep cliff to generate Ak-BAF. We are investigating a more detailed distribution on the downstream side for volcanic hazard evaluation of Fukushima city.

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Keywords: Azuma volcano, Block and ash flow, Fukushima, Lava

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Shaded relief (Kashmir 3D) map of Azuma-kofuji volcano. See text for details.



A photograph of outcrop of Ak-BAF at loc. A in the upper figure.

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Reexamination of the characteristics and eruption style of Haruna-Hakoda tephra found from the southern foot of Akagi Volcano to the eastern foot of Haruna Volcano in North Kanto, Northeast Japan

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1. Department of Geography, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 2. Faculty of Urban Environmental Sciences, Tokyo Metropolitan University

Haruna Volcano on the volcanic front at the Northeast Japan Arc is located in the center of Gunma Prefecture. Tephra such as Haruna-Hassaki (Hr-HP), Haruna-Futatsudake Shibukawa (Hr-FA), and Haruna-Ikaho (Hr-FP) that erupted from the Late Pleistocene to the Holocene from this Haruna Volcano have been studied in detail (Soda, 1989; Oishi et al. 2011, etc.). In addition, Haruna Miharada pumice deposited about 32ka (Takemoto, 2008) was called Miharada pumice firstly (Takemoto, 1985), and its source was presumably provided from Haruna Volcano (Takemoto, 1998). On the other hand, Soda (1996) called the same tephra bed Haruna-Hakoda tephra (Hr-HA). Its stratigraphic position shown by previous researches is above Hr-HP and Akagi Kanuma tephra (Ag-KP: Machida and Arai, 2003), and below Aira-Tn tephra (AT: Machida and Arai, 2003). However, the mineral assemblage differs depending on the literature, such as the composition of heavy minerals contained in this tephra. Furthermore, although it has been reported that this tephra has a distribution axis in the northeast direction from Haruna Volcano (Takemoto, 1998), but its distribution range has not been clearly determined. Therefore, the purpose of this study is to clarify the heavy mineral composition, refractive index of hornblende and orthopyroxene, the distribution and eruption style of this tephra. The name of this tephra is called Haruna-Hakoda tephra according to Soda (1996). However, the abbreviation Hr-HA called in the same thesis is derived from Haruna-Hassaki Ash (HA), which was the former name of this tephra, so we newly named it Hr-Hkd.

As a result of investigating from the southern foot of Akagi Volcano to the eastern foot of Haruna Volcano, outcrops exposing Hr-Hkd were found at eight locations. These outcrops are distributed in the range of 8 to 30 km in the east-northeast direction from Haruna Volcano. Hr-Hkd was divided into four units A to D from the bottom. Unit A is a light brown to gray falling ash layer containing accretionary lapilli. At some locations, white fall pumice is clustered at the bottom of unit A. Unit B is a white fall pumice layer composed of poorly sorted and fine-grained pumice. Unit C is a white fall pumice layer composed of poorly sorted and coarse-grained pumice. The matrix of unit C is gray to brown volcanic ash containing gray lapilli of about 1 mm in diameter. Unit D is a pyroclastic surge deposit containing white fall pumice. Furthermore, from the thickness of tephric soil deposits including Hr-Hkd, AT, and Ag-KP determined at several outcrops, it can be inferred that the eruption age of Hr-Hkd is around 37.4-40.0 ka.

Analyses of the heavy mineral composition of Hr-Hkd is shown below in descending order. Unit A, B, and D is hornblende, orthopyroxene, titanomagnetite, and cummingtonite, and unit C is hornblende, orthopyroxene, cummingtonite, and titanomagnetite. Furthermore, the measurement of the refractive index by RIMS2000 revealed that the refractive indices of hornblende and orthopyroxene contained in Hr-Hkd differed from unit to unit. Comparing the modes for each unit. For hornblende, unit A is 1.671-1.681 (1.677), unit B is 1.674-1.683 (1.680), unit C is 1.670-1.682 (1.675), and the unit D is 1.671-1.682 (1.676). Thus, the refractive index of hornblende decreases from unit A to D. For orthopyroxene, unit A is 1.706-1.714 (1.710), unit B is 1.705-1.713 (1.709), unit C is 1.703-1.713 (1.708), and the unit D is 1.701-1.712 (1.709). Thus, the refractive index of orthopyroxene tends to decrease from unit A to D. These indicates that the upper unit has less iron.

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In addition, the series of eruptive event which provided Hr-Hkd can be estimated as below. Unit A contained abundant accretionary lapilli, and pumice was contained at the bottom of unit A at 8 to 19 km from the Haruna Volcano, these are consistent with the characteristics of the phreatomagmatic eruption ejecta mentioned in Hiroi et al. (2015). Therefore, it is considered that the first Hr-Hkd eruption was a phreatomagmatic eruption. Then, in transition to the Plinian eruption, white fall pumice of unit B and unit C erupted. Of these, unit C had multiple fall units at two locations about 8 km east and about 15 km northeast of the Haruna Volcano. Therefore, the eruption of unit C is considered to be multiple eruptions with almost no time-gap. Finally, it is probable that the pyroclastic flow flowed down unit D was deposited.
In the future, if the outcrops of Hr-Hkd are found in a wider area, more detailed distribution and eruption style can be considered. It will be important basic data for studying the history of eruptive activity of the Haruna Volcano.

Keywords: Haruna Volcano, Haruna Hakoda tephra, volcanic product, distribution, refractive index

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What have been erupted from the 2020 eruption of Nishinoshima?

*Yoshihiko Tamura[1], Tomoki Sato[1], Kenta Yoshida[1], Fukashi Maeno[2], Osamu Ishizuka[1,3], Yasuhiro Hirai[1], Noriko Tada[1], Kiyoshi Baba[2], Daisuke Suetsugu[1], Maiko Miyoshi[4], Shigeaki Ono[1]

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Nishinoshima, a submarine volcano in the Ogasawara Arc, erupted in 2013 after 40 years of dormancy. Andesites erupted from Nishinoshima that were produced in the recent history of the volcano have been generated by olivine fractionation of primary andesitic magmas (Tamura et al., 2018). These primary andesitic magmas are derived from the partial melting of hydrous mantle (plagioclase peridotites) at relatively low pressures because the lithosphere is currently thin in this region of the Ogasawara arc. A “stockpile” of continental crust (andesitic magma) might be produced when most crust was thin (Tamura et al., 2016).

The eruption mode of Nishinoshima changed from a Strombolian characterized by effusive andesite lava flows to a violent Strombolian in the middle of June, 2020. The eruption plume reached a maximum altitude of ~8 km on July 4th. Does the sudden and drastic change of the eruption styles suggest some advance warning of a large volume violent eruption in the near future?

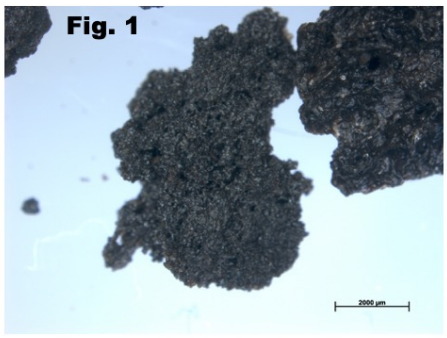
Caldera-forming eruptions sometimes happen in oceanic arcs (e.g. Yuasa et al., 1991). Sumisu-jima in the Izu arc and West Rota volcano in the Mariana arc, for example, have large submarine calderas of ~10 km in diameter, which have been resulted from a large volume eruption of pumices. The alternations of black and white tephra layers were observed by using submersibles and ROVs along the sections of caldera walls just below the top of caldera walls consisting of large pumice layers (Tamura et al, 2005; Shukuno et al., 2006; Tani et al., 2008; Stern et al., 2008). Thus, these violent caldera-forming eruptions were preceded by bimodal volcanisms. Had the 2020 eruption of Nishinoshima been bimodal in composition or not?

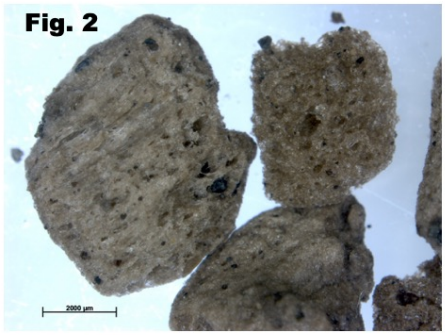
Volcaniclastic rocks erupted in 2020 were sampled on two separate occasions from December 2020 to January 2021. Samples at water depths between 1,000 m and 1,500 m were collected by a Box Corer using R/V Kairei during KR20-E06 from December 15th to December 29th, 2020. Fresh scorias (Fig. 1) and pumices (Fig. 2) were collected by the Box Corer. Northern submarine flank of Nishinoshima, ~15 km north of the island at the water depths of ~2,500 m, has been observed and sampled using the remotely operate submersible HyperDolphin and the R/V Shinseimaru during KS-21-2 from January 21st to January 30th, 2021. Small faults on the surface of submarine flank showed outcrops, suggesting bimodal volcanism of the recent eruption (Fig. 3), in which white layers consist of dacitic pumices having 67 % SiO_2.

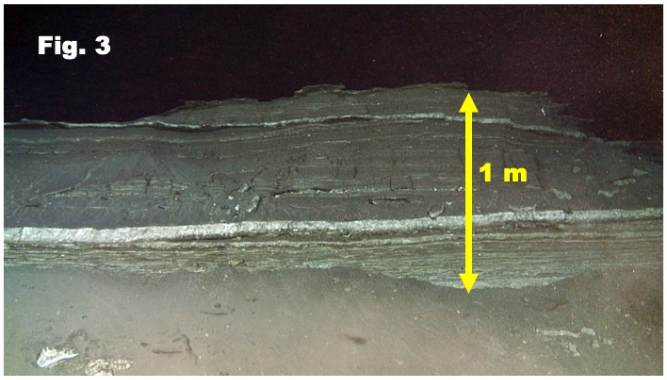
The 2020 violent Strombolian eruption of Nishinoshima was a bimodal volcanism consisting of basaltic andesite and dacite. It is possible that the magma system of Nishinoshima has changed from andesitic to basalt-dacite bimodal volcanisms, so it is essential to monitor the future course of the activity from the view point of disaster reduction.

Keywords: violent stronbolian eruption, andesite magma, bimodal volcanism

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.25 Zoom Room 25

[S-VC30] Volcanic and igneous activities, and these long-term forecasting

convener:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), 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:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Yuki Yasuda(Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University)

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.

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

[SVC30-07] Estimating magma flux from contact metamorphic aureoles

*Ken Yamaoka[1], Simon Richard Wallis[1], Akira Miyake[2], Catherine Annen[3] (1.The University of Tokyo, 2.Aichi University of Education, 3.University of Bristol)

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

[SVC30-08] Petrogenesis of Quaternary Yokota alkaline basalts, southwestern Japan

*Tetsuya Sakuyama[1], Izumi Kirishiki[1], Jun-Ichi Kimura[2] (1.Faculty of Science, Osaka City University, 2.JAMSTEC)

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

[SVC30-09] The history of 54 ka eruption of Kuju volcano

*Tomohiro Tsuji[1], Kishimoto Hiroshi[2], Koji Fujita[3], Chisato Nakamura[4], Tomohiro Nagata[4], Kazunari Kimura[4], Kozo Onishi[5], Michiharu Ikeda[6], Naoki Nishizaka[5] (1.Division of Earth Science The Graduate School of Science and Technology for Innovation Yamaguchi University, 2.kagoshima Meteorological Office, 3.Asia Air Survey Co. Ltd., 4.Naiba, 5.Shikoku Electric Power Co. Inc., 6.Shikoku Research Institute, Inc.)

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

[SVC30-10] Reappraising the Eruptive Age and Classification of Holocene Volcanic Products around Nakadake Crater, Aso Volcano Using Paleomagnetic and Rock Magnetic Methods

*Chisato Anai[1], Yasuo Miyabuchi[2], Mitsuru Utsugi[1], Shin Yoshikawa[1], Nobutatsu Mochizuki[3], Hidetoshi Shibuya[3], Takahiro Ohkura[1] (1.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2.Center for Water Cycle, Marine Environment and Disaster Management, Kumamoto University, 3.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University)

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

[SVC30-11] Petrogenesis of Nekodake magma in Aso volcano

*Soko Kado[1], Katsuya Kaneko[1] (1.Department of Planetology, Graduate school of science, Kobe university)

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

[SVC30-12] Silicic magma formations in the Aira caldera region during the last 100,000 years inferred from geochemical characteristics of plagioclase

*Ayumu Nishihara[1,2], Katsuya Kaneko[1], Qing Chang[3], Nobuo Geshi[2] (1.Department of Planetology, Graduate School of Science , Kobe University, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology., 3.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology)

Estimating magma flux from contact metamorphic aureoles

*Ken Yamaoka[1], Simon Richard Wallis[1], Akira Miyake[2], Catherine Annen[3]

1. The University of Tokyo, 2. Aichi University of Education, 3. University of Bristol

The distribution of melt beneath volcanos and how it coalesces during large eruptions are major unresolved issues and better knowledge of these features would contribute to improving our ability to forecast destructive eruptions. Plutons are a clear record of magma emplacement into the crust and studies of these domains are an important source of information on sub-volcanic processes. However, in nearly all cases exposure of the pluton at the earth’ s surface is associated with the erosion and removal of the overlying volcanic edifice and only very rarely can the relationship between plutonic and eruptive processes be examined in the same region. The magmatic flux into the pluton region is the most important controlling factor in determining whether the magma will be eruptible or not during incremental growth of a pluton. Previous estimates of this flux have mainly been based on zircon geochronology (e.g. de Saint-Blanquat et al., 2011). An alternative but relatively unexplored approach is to use thermal modeling to investigate whether a pluton has been associated with large amounts of a magmatic eruption (Schöpa & Annen, 2013).

In this study we use thermal modeling of an unusually broad contact metamorphic aureole around a pluton to estimate the associated magmatic flux. Although it is generally difficult to discuss magma that is no longer in the pluton, we suggest that broad contact metamorphic aureoles around plutons that imply enthalpy input disproportionately large compared to the volume of the pluton are good markers of magmatic centers associated with significant magma flux and volcanic eruption.

Recent zircon geochronological studies have established that numerous plutons exposed in central Japan are coeval with a series of extensive ignimbrite deposits associated with caldera-forming eruption formed in around 70 Ma and with a present volume reaching 5000–7000 km^3 (Koido, 1991; Sonehara & Harayama, 2007; Hoshi et al., 2016; Takatsuka et al., 2018). The existence of this world-class volcano-plutonic complex provides a valuable opportunity to discuss the relationship between pluton characteristics and amount of associated volcanic ejecta. In this study, we focus on a contact metamorphic aureole around the Shinshiro tonalite that formed around 70 Ma at ~9 km depth. The thermal structure is well defined by changes in the crystallinity of carbonaceous material, Ti content in quartz, and mineral assemblages of metamudstone and the dimensions of the intrusion are well constrained by field observations and gravity anomaly data. Numerical modeling shows that the contact metamorphic aureole is too broad to be simply explained by the volume of the intrusive body. However, a model that incorporates continuous magma replenishment and tapping of magma can yield the observed broad contact metamorphic aureole with > 550 km^3/myr as a long-term magma influx rate. The estimated minimum magma influx rate can maintain an eruptible magma chamber and suggest the Shinshiro tonalite acted as one of the magmatic cores to a large caldera-forming eruption during the ~70 Ma magmatic flare-up event of SW Japan.

A new compilation of the thickness of the contact metamorphic aureoles around plutons where there is information on the depth and shape of the intrusion shows a wide range of pluton thermal types. Several plutons are similar to the Shinshiro tonalite and show much broader contact metamorphic aureole than can be accounted for by intrusion models that do not incorporate fluxes of erupted magma irrespective. We suggest that for a wide range of different crustal conditions and magma types, the thickness of contact

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metamorphic aureole can be used to identify those associated with the passage of large amounts of erupted magma.

Keywords: pluton formation, thermal modeling, magma flux, caldera-forming eruption, contact metamorphic aureole, Ryoke plutonic rocks

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Petrogenesis of Quaternary Yokota alkaline basalts, southwestern Japan

*Tetsuya Sakuyama[1], Izumi Kirishiki[1], Jun-Ichi Kimura[2]

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Upwelling of the asthenosphere associated with the opening of the Japan Sea in addition to the subduction of the Philippine Sea plate has been considered to be the origin of the late Cenozoic volcanism in the Chugoku district. The Yokota basalts erupted 2.17 - 0.97 Ma and temporally expanded outwards from the center of the volcanic cluster to the margin forming a volcanic cluster with a diameter of 40km over Shimane and Tottori prefectures. The Yokota basalts have been divided into two subtypes in terms of Nd-Sr isotopes: the ABL with lower $^{87}Sr/^{86}Sr$ and the ABH with higher $^{87}Sr/^{86}Sr$ for the same $^{143}Nd/^{144}Nd$ (Kimura *et al.*, 2014). The ABH basalts are distributed at the periphery of the cluster in the late stage of the activity. Such concentric expansion of the volcanic activity may suggest that the magmas were produced by the diapiric mantle upwelling. However, petrogenesis of the Yokota basalts remains unclear because primary magma water content has not been petrologically constrained from natural samples. We analyzed whole-rock major and trace element and mineral compositions of the fresh basaltic samples newly collected from the Yokota basalts in order to determine the water content of the basalts and estimate the mantle melting conditions.

The Yokota samples have primitive and alkaline basaltic compositions, ranging from 47.7 to 54.2 wt% SiO_2 and from 0.67 to 1.31 FeO*/MgO. There is no clear difference between ABL and ABH in major element compositions except that the ABL have systematically higher K_2O content than the ABH. Whole-rock multi-element trace element patterns for the ABL and ABH normalized to the Primitive mantle composition are generally similar to those of typical arc-type alkaline volcanic rocks (Kimura *et al.*, 2014). No significant Eu anomaly is observed in the REE concentration patterns of the ABH and ABL samples. The modal abundance of phenocrysts is typically less than 10 vol%. Olivine and clinopyroxene phenocrysts are common but olivine is the major phenocryst phase for all the samples. Most olivine and clinopyroxene phenocrysts are normally-zoned and euhedral to subhedral. Several samples of the ABL and ABH additionally contain small amount of normally-zoned euhedral plagioclase phenocrysts. The An content of the plagioclase cores is 66 - 71.8 and 74 - 82.4 for the ABL and ABH, respectively, and their distributions are unimodal.

We estimated the water content of the ABL and ABH magmas using plagioclase-melt hygrometer at an assumed pressure condition of 0.3 GPa. Estimated water content of the ABL and ABH magmas was 3.6 wt% and 4.6 wt%, respectively, which are the highest among the volcanic activities of the same period in the Chugoku region. The estimated melting conditions were 1330 ˚C and 2.4 GPa for the ABL and 1300 ˚C and 2.6 GPa for the ABH. The mantle potential temperature for the Yokota basalts was estimated to be ~1280 ˚C, which was as high as that of the mantle beneath normal mid-ocean ridges, suggesting that the upper mantle beneath Yokota was not hot.

If magmas were progressively generated and released from a single mantle diapir, water content of the magmas should decrease as the mantle diapir uprises due to progressive dehydration from the mantle. However, more hydrous ABH magma erupted at the later stage than less hydrous ABL, suggesting that simple mantle diapir model cannot reproduce spatiotemporal geochemical variation of the Yokota basalts. We propose that the following model. (1) Mantle metasomatized by the ancient sediment-derived

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fluid upwelled from the mantle transition zone. (2) Fluid derived from the sediment on the Philippine Sea slab mixed with the upwelled metasomatized mantle and melted to produce the ABL magma. (3) As the contact area between the upwelled metasomatized mantle and the Philippine Sea slab increases, more fluid were from the slab supplied to the upwelled metasomatized mantle and enhanced further melting to generate more hydrous ABH magma.

Keywords: alkaline basalt, Quaternary, southwestern Japan, Yokota, Chugoku district, water content of the magma

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The history of 54 ka eruption of Kuju volcano

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The 54 ka eruption of Kuju volcano released various pyroclastic deposits including ash, surge, large-scale pyroclastic flow deposits and plinian pumice fall deposits, which is the largest scale in the eruption history of Kuju volcano. However, there is no consensus on the eruption history. Then, in this study, to examine the history of Kuju volcano 54 ka eruption, geological investigation of the pyroclastic deposits, especially focusing on Kj-D which is the key tephra to elucidating the stratigraphy.

In this study, we use the classification of Matsumoto (1983) and Ohta (1991) on the pfls: the pfl that has formed Handa highland at the northern to northwestern foot is Hnd pfl (Matsumoto, 1983), and the one that has formed Kuju highland at the southern foot is K pfl (Kpf of Ohta, 1991). At the bottom of the whole ejecta, Kj-D tephra is overlain by Hnd pfl deposits. There are pumice flow deposits including bi-cpx bearing opx-hbl dacite pumice. Large-scale secondary pyroclastic flows were deposited after the deposition of both pfls, and Kj-D and Kj-P1 overly them. Kj-P1 is constituted with Kj-P1 lower and upper layer, and a small pyroclastic flow of K2 pfl that overlies K pfl at Kuju highland.

Kj-D is overlain by Kj-P1 at the eastern foot. Kj-D is composed of lower lapilli layers and upper volcanic ash layers. The upper layer of Kj-D was classified into five unites; Kj-D-u1, 3 and 5: lowermost, middle and uppermost bluish gray ash layers, and Kj-D-u2 and 4: lower and upper light brown volcanic ash layers. The blue-gray volcanic ash layer in the upper layer is a stack of dozen of thin layers mainly composed of fine-grained sand-sized volcanic fragments. Kj-D-u2 and 4 are both fine-grained sand-sized volcanic ash, mainly composed of pumice-type glass, and contains mafic minerals of hbl, opx, cpx and bi as decreasing order that is similar mineral composition of that of K pfl. The lower part of Kj-D-u4 contains a pumice layer with a maximum grain size of ~5 cm in diameter. The pumice is opx-hbl dacite. Based on the Kj-D-u2 and 4 isopach maps, the source of each is found in the area of the Hnd pfl and K plf. The source of the Kj-D-u4 pfa is found in the central or eastern part of Kuju volcano based on the isopach map.

The history of the eruption is considered as follows: The eruption began with two lapilli layers (Kj-D l1 and 2). After that, relatively small-scale explosive eruptions occurred repeatedly, and deposited Kj-D-u blue-gray ash layers. During this repeated adh deposit, three large-scale pyroclastic flow eruption occurred in the central part of the volcano. In the first two times, Hnd pfl flowed down to the northerm foot and released Kj-D-u2 as co-ignimbrite ash. A plinian eruption occurred to deposit the Kj-D-u4 pumice layer in the late Kj-D upper ash deposition, and the K pfl, an intra-plinian pfl, was deposited at the southern foot. Along with this, Kj-D-u4 was deposited as a co-ignimbrite ash. The eruption of Kj-D-u5 blue-gray ash continued for a while, and two huge plinian eruptions occurred at the end of the eruption, depositing the lower and upper layers of Kj-P1. The last eruption deposited K2 pfl, an intra-plinian pfl at the southern foot.

Keywords: Kuju volcano, eruption history, stratigraphy

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Reappraising the Eruptive Age and Classification of Holocene Volcanic Products around Nakadake Crater, Aso Volcano Using Paleomagnetic and Rock Magnetic Methods

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Nakadake volcano, the current active center of the Aso central cones (Kyushu), is one of the most active volcanoes in Japan. It has been active since ca. 22-21 ka, and has formed the old edifice (22-21 ka), the young edifice (around 5 ka) and a younger pyroclastic cone (up to the present). The lava flows from the young edifice spread on the flank of the cone several times in recent 5 ka. These lavas are supposed to give stratigraphic markers for constructing the eruptive history of Nakadake volcano, but the similarity in chemical composition and lithology hampers distinguishing and correlating them. We have conducted a paleomagnetic study to distinguish and correlate the lavas of different ages since the paleomagnetic secular variation (PSV) provides a high-resolution age information. If lava units have a temporal difference of more than 50 years, they could be distinguished by their paleomagnetic directions. The samples were collected from 14 lava flows and 6 agglutinates layers (welded scoria-fall deposits) and were subjected to the paleomagnetic and rock-magnetic measurements. These samples appear to be influenced by chemical alteration in the surface of the outcrop by sulfides of volcanic gases. To check a rock-magnetic effect of the chemical alteration of the lavas and agglutinates, thermomagnetic analyses were made on chip samples from the top (surface of rock) and bottom (inside of rock) of the collected paleomagnetic cores. The thermomagnetic analyses indicate that the core top and bottom samples show the same behaviors, in spite of the difference in color, and the carrier of magnetization of each core is either titanium rich (titanium content, x, is about 0.6) or poor (x is about 0.15 to 0.3) titanomagnetites. The natural remanent magnetization of each sample shows a simple, single vector component in alternating field demagnetization experiments, which well defines the primary component. Site mean directions can be divided into three different direction groups. These data suggest that the eruption producing lava flows and/or agglutinates occurred at three different ages. One of the direction group is not consistent with the directions of the eruptive ages of Nakadake young edifice assigned from the previous stratigraphic studies. Comparing these directions with the paleomagnetic secular variation curve drawn from basaltic volcanoes in the Aso central cones, the ages of the direction groups can be assigned to around 6.0-4.3 ka and 3.5 ka. The present result will contribute not only to the volcanology, but also to the disaster prevention and disaster risk reduction.

Keywords: Aso Nakadake, paleomagnetic secular variation (PSV)

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Petrogenesis of Nekodake magma in Aso volcano

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Caldera volcanoes, which cause large-volume explosive eruptions (more than tens cubic kilometers), have magma plumbing systems producing voluminous magma. Aso volcano is one of the largest caldera volcanoes in Japan, and its activities are characterized by four large-scale eruptions (Aso-1, -2, -3, and -4) and many small eruptions (e.g., Ono and Watanabe, 1985). Previous studies have shown that the Aso magmas with high K_2O content to SiO_2 content (high-K series) are petrologically distinctive from magmas of other quaternary volcanoes around Aso volcano (e.g., Ono and Watanabe, 1985) and are generated by melting of the lower crust (Kaneko et al., 2015).
Nekodake is a small volcano with about 3 km in diameter and about 700 m higher than its base and located near the eastern rim of the Aso caldera like the post-caldera central cones in Aso volcano. Geological study and radiometric dating indicate that the activity of Nekodake occurred during the activities of Aso volcano although the activity age is not strictly determined (before Aso-3 or near Aso-4). On the other hand, the Nekodake magma is clearly lower in K_2O content than the Aso magmas. Then, it has been considered that the Nekodake magma came from a different magma plumbing system from Aso volcano. The purpose of this study is to clarify petrogenesis of the Nekodake magma. The distinctive feature of the Nekodake magma means that a different type of magma was generated adjoining to the large magma plumbing system of Aso volcano. Understanding this is important to elucidate the entire magma plumbing system of caldera volcanoes.

We carried out detailed petrological description and compositional analyses of whole-rock, groundmass, and phenocryst minerals. Important petrological features are in the following.
(1) Whole-rock compositions of the the Nekodake rocks are 53 - 60 wt.% SiO_2.
(2) All the rocks are very porphyritic (47- 69 vol.% in modal composition) and commonly contain plagioclase, clinopyroxene, orthopyroxene, and opaque minerals as phenocryst. Rocks with less SiO_2 content contain olivine phenocryst while with more SiO_2 content hornblende phenocryst.
(3) The whole-rock compositions show a single linear trend on each of the Harker diagrams.
(4) Anorthite (An) contents of plagioclase phenocrysts are bimodal; the peak An-contents are 58 and 76, respectively. Corroded textures are observed in plagiocalse, pyroxene, and olivine phenocrysts. Part of plagioclase phenocrysts have reverse zonation in An-contents and part of pyroxene and hornblende phenocrysts in Mg/Fe ratio.
(5) Sr isotopic ratio of the Nekodake rocks is higher (0.7041-0.7047) than those of the Aso magmas (0.7040 –0.7042)(Shinmura, 2013).

Features 3 and 4 suggest that the Nekodake magmas were formed by two-component mixing of mafic and intermediate magmas. We estimated the endmember magmas using our original calculation method on the basis of number of An-contents distribution of plagioclase phenocryst and whole-rock composition. The estimated mafic magma is 49 –52 wt.% SiO_2, which is compositionally similar to the mafic magma of Aso volcano. The estimated intermediate magma is 59 - 60 wt.% SiO_2 and compositionally different from the Aso magmas, and is not generated by fractional crystallization from the estimated mafic magma. This result and Feature 5 suggest that this high Sr isotopic ratio comes from the intermediate endmember magma which was produced by melting of some shallower crust than the magma generation level of the Aso magmas. We conclude that the magma plumbing system of Nekodake is not completely different from

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Aso volcano but only the magma generation process of the SiO_2-rich magma is different from Aso magmas. Our result shows that crustal melting occurs at the shallower level as well as in the lower crust in Aso volcano.

We thank Dr. Takehiro Koyaguchi and Mr. Hiroshi Ikemoto for their providing rock samples of Nekodake.

Keywords: Aso volcano, Caldera volcano, Nekodake, Magma plumbing system, Magma mixing

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Silicic magma formations in the Aira caldera region during the last 100,000 years inferred from geochemical characteristics of plagioclase

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Plagioclase phenocrysts record geochemical characteristics of magmas when they crystallize and grow. Chemical and isotopic variations on the plagioclase micro area enable us to unravel the hidden magma formation processes. The Aira caldera was formed by the 30 ka VEI-7 supereruption (the AT eruption), and two VEI-6 eruptions occurred at 90 and 60 ka as the pre-AT volcanism. After the AT eruption, two eruptive activities of the Sakurajima volcano and the Wakamiko volcano have continued, and their largest eruptions occurred at 12.8 ka and 13 ka, respectively. The latest plinian eruption of the Sakurajima volcano occurred in AD 1914. These eruptions have mainly discharged silicic (>60 SiO_2 wt.%) magmas having different geochemical characteristics in whole-rock compositions. In order to clarify the genesis of the silicic magmas produced in the Aira caldera region, we examined $^{87}Sr/^{86}Sr$ values of the plagioclase phenocrysts contained in juvenile pumice clasts of the above six eruptions.
All the clasts contain plagioclase with cores of both low-An (<An_{60}) and high-An (>An_{60}). Except for the 13 ka Wakamiko clasts, $^{87}Sr/^{86}Sr$ values of the low-An plagioclase in the clasts of the five eruptions are within the range of 0.7049-0.7062. On the other hand, the high-An plagioclases can be classified into three types based on the $^{87}Sr/^{86}Sr$ values; the identical to the low-An (0.7049-0.7061), the lower $^{87}Sr/^{86}Sr$ (0.7043-0.7049), and the higher $^{87}Sr/^{86}Sr$ (0.7063-0.7076). The high-An plagioclases having $^{87}Sr/^{86}Sr$ identical to the low-An are contained in the 90 ka, 60 ka, 30 ka, and 12.8 ka clasts. The 30 ka clasts also contain the high-An plagioclase with high $^{87}Sr/^{86}Sr$. The low-$^{87}Sr/^{86}Sr$ and high-An plagioclase are contained in the AD1914 clasts. The 13 ka Wakamiko clasts contain plagioclase of high-$^{87}Sr/^{86}Sr$ (0.7073±3, 1SD).
Bimodal distributions of An-contents observed in all the clasts indicate that the silicic magmas in the Aira caldera region experienced mixing between felsic and mafic magmas crystallizing the low-An and high-An plagioclases, respectively. The similar $^{87}Sr/^{86}Sr$ values of the felsic magmas suggest that, except for the Wakamiko clasts, the felsic magmas in the Aira caldera region have a same source material during the last 100,000 years. The identical $^{87}Sr/^{86}Sr$ values of the low-An and high-An plagioclase imply that a dominant process producing the magmas is an anatexis of a mafic crustal rock, which can produce both felsic and mafic magmas by difference of degree of partial melting. This process produced the silicic magmas discharged by the 90 ka, 60 ka, and 12.8 ka eruptions. The geochemical variation observed in the 30 ka clast indicates that the silicic magma discharged by the 30 ka supereruption was produced by mixing between the crust-derived low-$^{87}Sr/^{86}Sr$ magma and a high-$^{87}Sr/^{86}Sr$ mafic magma. The low-$^{87}Sr/^{86}Sr$ plagioclases in the AD 1914 clasts suggest that the AD 1914 silicic magma experienced mixing with a low-$^{87}Sr/^{86}Sr$ mantle-derived basaltic magma. Origin of the high-$^{87}Sr/^{86}Sr$ magmas discharged by the 13 ka Wakamiko eruption can be explained by fractionation of the high-$^{87}Sr/^{86}Sr$ mafic magma or partial melting of another crustal material with high-$^{87}Sr/^{86}Sr$. In conclusion, crustal melting is the crucial process to produce magmas in the Aira caldera region, and the variable origin of the mafic magmas generates the geochemical variations of the silicic magmas.

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Keywords: Aira caldera, Sr isotope ratios, silicic magma, caldera-forming eruption

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[J] Poster | S (Solid Earth Sciences)：S-VC Volcanology

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.13_1

[S-VC30] Volcanic and igneous activities, and these long-term forecasting

convener:Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), 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.

[SVC30-P01] Yield strength obtained from lava flow and lava tube cave of Undara volcano

*Tsutomu Honda[1] (1.Vulcano-speleological Society)

[SVC30-P02] Survey on Fissure Cave and Lava Tube Cave in Kansuyama Lava Flow of Mt.Fuji

*Tsutomu Honda[1], Masaru Hatanaka[1], Takayoshi Katumata[1] (1.Vulcano-speleological Society)

[SVC30-P03] The origin of bimodal magmatism in the Okinawa Trough, Japan

*Arran Peter Murch[1], Kenichiro Tani[1], Takashi Sano[1], Shigekazu Yoneda[1] (1.National Museum of Nature and Science, Tsukuba, Ibaraki, Japan)

[SVC30-P04] Reinvestigation of Holocene eruption history of Nikko-Shirane Volcano, central Japan

*Yuki Kusano[1], Yoshihiro Ishizuka[1], Teruki Oikawa[1], Osamu Ishizuka[1] (1.Geological Survey of Japan, AIST)

[SVC30-P05] Construction of Geochemical database of Kikai Caldera magmas for understanding the magmatic evolution prior to caldera-forming eruptions

*Satoru Haraguchi[1,2], Kenta Ueki[2], Kenta Yoshida[2], Tatsu Kuwatani[2], Morihisa Hamada[2], Iona McIntosh[2], Takashi Miyazaki[2], Takeshi Hanyu[2] (1.Earthquake Research Institute, University of Tokyo, 2.JAMSTEC)

[SVC30-P06] Reconstruction of the volcanic history of Nakadake volcano in Kirishima volcano group, Kyushu, Japan (1)

*Yasuhisa Tajima[1], Atsushi Yasuda[2], Mitsuru Okuno[3] (1.Research & Development Center, Nippon Koei Co.,LTD., 2.Earthquake Research Institute, University of Tokyo, 3.Faculty of Science Department of Earth System Science, Fukuoka University)

[SVC30-P07] The effect of dissolved water induced by lithostatic pressure on lava migration

*Akio Goto[1] (1.Center for Northeast Asian Studies, Tohoku University)

[SVC30-P08] An attempt to detect volcanic materials of Ogasawara Ioto (Iwojima) Volcano from the core sample of the turbidite layers deposited in the Palace Bella Basin

*Masashi NAGAI[1], Takahiro Miwa[1] (1. Volcano Research Department, National Research Institute for Earth Science and Disaster Resilience)

Yield strength obtained from lava flow and lava tube cave of Undara volcano

*Tsutomu Honda[1]

1. Vulcano-speleological Society

[Introduction]

The Undara Cave is a huge lava tube system with a maximum height of 20 m and a maximum width of 32 m, formed on a gentle slope with an average inclination angle of 0.3 °,in a lava flow length of 160 km(Fig.1) which was erupted by Undara volcano 190,000 years ago[1,2]. The lava eruption temperature of Undara volcano is said to be 1170-1220 ℃, and the silicic acid weight fraction is 48.9wt% [1,2]. By using the published data of Atkinson et al.[1,2,3], the lava yield strength is estimated by two methods [4]: the lava flow stop condition and the lava tube formation limit condition.

[Yield strength obtained from the thickness of the Undara volcanic lava flow]

Table 1 shows the lava flow thickness, slope angle and yield strength obtained for each lava flow section. The column ① to ③ in Table1 are based on reference [1]. ④ is yield strength obtained from the values of column ② and ③. The yield strength was obtained from the lava flow stop condition [4]: $f_B = H (\rho g \sin\alpha)$. The high apparent yield strength f_B = 4.3 to 6.4x10^3 Pa may be due to lava inflation and/or lava superposition. The true lava yield strength is considered to be the lower yield strength f_B = 1.5 ~ 2.1x10^3 Pa.

[Yield strength obtained from the height of the cavity in Undara Cave]

Table 2 shows the cavity height, width, and slope angle of representative parts of the Undara cave system [3]. The columns ① to ⑤ in Table2 are based on the reference [3]. The column ⑥ is yield strength obtained from the values of ③ and ⑤. The longest among these caves, Bayliss cave and Barkers cave, clearly show the tube like structure[1]. Others are fragmentary caves that occupy a small part of the lava cave system due to the burial of the floor. As shown in ⑥ of Table 2, the yield strength by using the limit condition for lava tube cave formation [4]:$f_B = H (\rho g \sin\alpha) / 4$ is obtained from this cavity height and slope angle. Tayler cave, Bayliss cave, and Barkers cave show high yield strength, on the other hand, other small caves show low yield strength due to low cavity height with buried floor. It is considered that several layers of lava flow have accumulated and the cavity height has decreased, showing a low apparent yield value f_B = 272 to 834 Pa. High lava yield strength obtained from Tayler cave, Bayliss cave, and Barkers cave:f_B = 1.4 ~ 3.4x10^3 Pa is considered to be close to the true yield strength. This yield strength is also consistent with the lava yield strength f_B = 1.5 ~ 2.1x103 Pa obtained from the lava flow stop condition.

[Conclusion]

The lava yield strength f_B = 1.4 ~ 3.4x10^3 Pa obtained from Tayler cave, Bayliss cave, and Barkers cave is a reasonable value for basalt with a silicic acid weight fraction of 48.9 wt%. For other small fragmentary caves with low apparent yield values, the floor is buried and the cavity height is decreased. It is necessary to judge whether the estimated yield strength is a reasonable value or not by observing the structure inside the cave in detail.

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Keywords: Lava tube, Yield strength, Lava flow, Undara volcano

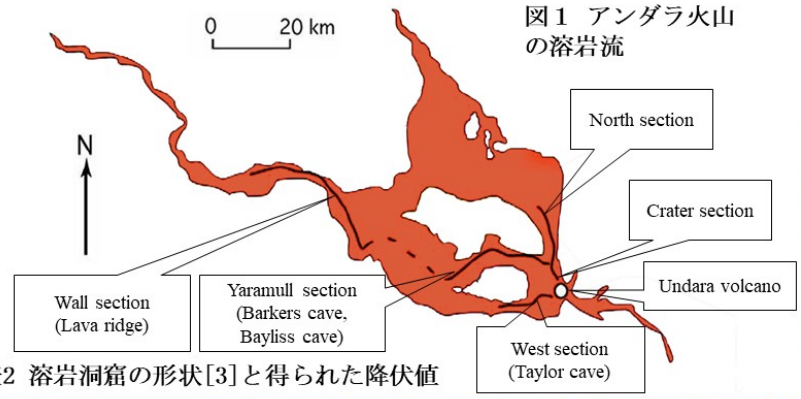


図１ アンダラ火山の溶岩流

表1 溶岩流の厚さ・傾斜度[1]と得られた降伏値

①溶岩流領域	②溶岩厚さH	③傾斜角度α	④ 降 伏 値f_B
Crater section	~5m	1°	2138 Pa
West section	~20m	0.75°	6414 Pa
North section	~20m	0.5°	4276 Pa
Yaramull section	~20m	0.7°	5986 Pa
Wall section	~40m	0.09°	1540 Pa

表2 溶岩洞窟の形状[3]と得られた降伏値

①洞窟名	②洞窟長さ	③最大空洞高さH	④最大空洞幅	⑤平均傾斜角度α	⑥溶岩降伏値f_B
Taylor cave	108m	10.8m	16.3m	2.92°	3367 Pa
Ollier cave	49.4m	3.2m	10.4m	0°	-
Greeley cave	103m	3.8m	12.4m	1.75°	711 Pa
Peterson cave	102m	3.7m	17.1m	0.67°	272 Pa
Stevens cave	70.4m	3.0m	8.8m	1.33°	427 Pa
Pinwill cave	150m	8.8m	21.0m	0.83°	781 Pa
Road cave	220m	9.4m	21.2m	0.83°	834 Pa
Bayliss cave	901m	11.5m	18.9m	1.17°	1438 Pa
Darcy cave	99m	6.3m	16.3m	0°	-
Barkers cave	561m	13.5m	19.8m	2.17°	3131 Pa

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Survey on Fissure Cave and Lava Tube Cave in Kansuyama Lava Flow of Mt.Fuji

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1. Vulcano-speleological Society

[Introduction]

Kansuyama lava flow (Juriki marubi lava flow) is a low-viscosity lava flow of SiO2 50.9 wt% ejected around AD710-800 and covers Kurozuka lava flow[1)]. The length of Kansuyama lava flow is about 5 km, and the existence of Kaminari-ana cave, Jurigi koori ana, Suzumi fuketu, and Jurigi tree mold groups are known in the lava flow[2,3,4)]. Recent investigations have revealed that Kaminari-ana cave is a fissure cave located in the channel-like flow path from Kansu yama pyroclastic cone , and that there are several small lava tube caves in the upstream and downstream on the channel-like flow path surface. We estimate the yield strength and lava temperature from surface lava tube cave. Figures 1 shows the locations of Kaminari-ana cave and surface lava tube caves.

[Kaminari ana cave located in lava channel structure]

Kaminari ana cave shown in Fig. 2 and Table1 is a cave with horizontal hole cavity that communicates with the deep vertical hole openings (Photo 1 and 2). The deep vertical hole opening of Kaminari ana cave is traditionally called the gas ejection hole [2,4)], and it is one of the fissure vent because it is on the extension of the fissure vent row according to a survey by Hiroshi Tachihara and Osamu Ohshima in 2010. It is pointed out that the horizontal hole cavity at the bottom has no characteristics as a lava tube cave (roopy lava on the floor, lava shelf on the wall, arched ceiling, etc.), and the fissure wall is covered by lava. It can be clearly regarded as a fissure cave created by draining back of magma. The cavity is sandwiched by parallel walls on both sides, and a scoria layer can be seen behind the collapsed side wall.

[Lava tube cave on the surface of lava channel]

On the surface layer just in the upstream and downstream of Kaminari ana cave, there is a small rectangular lava tube caves (for large one, cavity height: 1 m, width: 4.8 m, length: 5.8 m) shown in Table 1 and Photo 3. Judging from the contour lines, the downstream one has an inclination angle of about $\alpha =$ 8 degrees ($\sin \alpha = 0.143$), and with the tube cavity height H = 1m, g = 9.8m / sec^2, $\rho = 2500kg / m^3$, the lava yield strength[5)] can be obtained as f_B = 1168 Pa from $f_B = (H\ g\ \rho \sin \alpha) / 3$. This yield strength is a reasonable value for basalt. Here, the temperature was calculated as 1068 ˚C by using the temperature-dependent equation [7)] based on the data created by Ishibashi & Sato[6)]from Mt. Fuji 1707 eruption basalt.

[Conclusion]

Several surface lava tube caves are formed on the surface of a channel-shaped depression with Kaminari an fissure cave extending from Kansu yama to the south. The yield strength of 1168 Pa obtained from the surface lava tube cave is a reasonable value for basalt. The temperature at which the surface lava tube cave was formed was estimated from this yield value as 1068 ˚C.

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Keywords: Mt.Fuji, Lava flow, Lava tube, Lava cave, Fissure vent

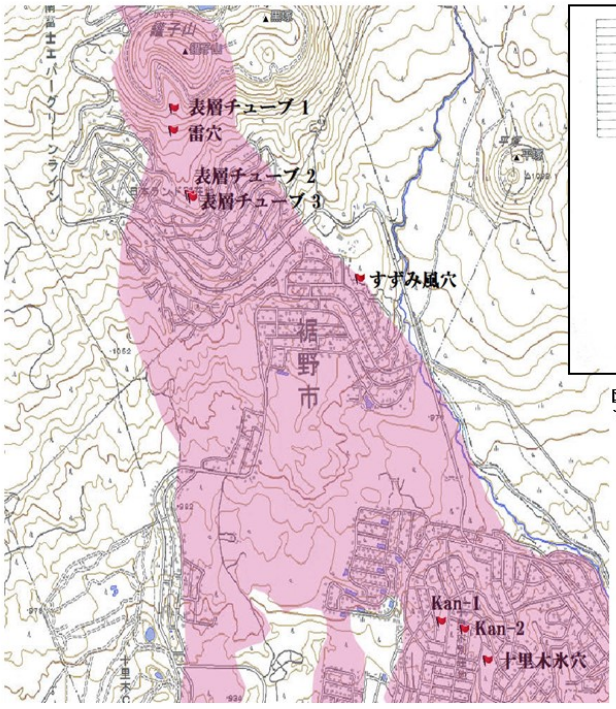


図1 鐘子山と雷穴及び表層溶岩チューブ洞窟及び調査した樹型の位置(カシミール3Dを使用)

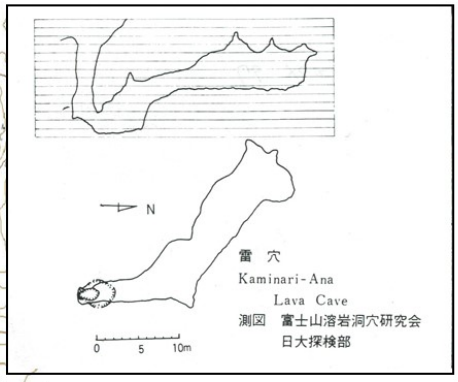


図2 雷穴の測量図(内部の横穴は鐘子山の方向に向いている)

表1 鐘子山溶岩流の洞窟に関するデータ

上流部洞窟	洞窟の形状と寸法	傾斜度
表層チューブ1	矩形断面チューブ,約1.0m(高さ)x3.7m(長さ)	-
雷穴	竪穴+横穴(文献2,4),竪穴深さ:13m,横穴長さ:35m	-
表層チューブ2	矩形断面チューブ,約0.5m(高さ)x3m(長さ)	-
表層チューブ3	矩形断面チューブ,1m(高さ)x4.8m(幅)x5.3m(長さ)	8°



写真1 雷穴の竪穴





写真2 雷穴の横穴

写真3 表層チューブ3の内部

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The origin of bimodal magmatism in the Okinawa Trough, Japan

*Arran Peter Murch[1], Kenichiro Tani[1], Takashi Sano[1], Shigekazu Yoneda[1]

1. National Museum of Nature and Science, Tsukuba, Ibaraki, Japan

The Okinawa Trough (OT) is an incipient continental back-arc basin that extends ~1200 km south from Kyushu to Taiwan, and can be split in to three segments, the Northern (NOT), Middle (MOT), and Southern (SOT). Back-arc volcanism in the OT is bimodal (basaltic to rhyolitic) and restricted to volcanic centres located in en-echelon grabens the MOT and SOT.

Here we present petrological descriptions, along with major, trace element and Sr–Nd isotopic data for a bimodal sample suite collected during the R/V Sonne HYDROMIN1 and 2 cruises in 1988 and 1990, respectively. Samples were recovered as lavas and pumice dredged from various seafloor knolls and ridges located in the Io and Iheya grabens and from Izena Hole in the MOT, and from a single volcanic ridge in the Yaeyama graben and a single isolated knoll in the SOT.

The mafic end member ranges from ~50 to 56 wt% SiO_2. Samples from the SOT show a fractionation trend with an initial enrichment of FeO indicating a tholeiitic trend, while MOT samples are characterised by a calc-alkaline trend. Major and trace element data also suggests at least two groups of basalt in the MOT defined by the relative depletion in incompatible elements (K, Na, Si, Zr, Nb, Rb, Ba, Th, Ce, etc.), and enrichment in Al_2O_3, V, Cr, Sr of one group vs the other. However, the entire mafic end member sample suite records a strong subduction signature with MORB normalised spider plot patterns showing enrichment of incompatible elements, especially LIL, and Pb, along with the depletion of Nb and Ta. Chondrite normalised REE trends also show enrichment in LREE.

The silica end member ranges from ~71 to 77 wt% SiO2. However, major and trace element data shows the silica end member is highly diverse with at least four identifiable groups based on differences in the degree of enrichment in incompatible elements (K, Rb, Ba, Nb, Zr, Y, Th). Chondrite normalised REE diagrams indicate the same diversity with variable $(La/Sm)^N$ ratios. While MORD normalised spider diagrams show the same subduction signature present in the mafic end member. Each group contains at least one dense lava sample suggesting the chemical diversity is a primary feature of magmatism in the Okinawa Trough rather than a result of the floating in of pumiceous material from various locations.

Using petrological descriptions and the chemistry of samples along with MELTS modelling we plan to evaluate the conditions and processes of magma formation and evolution. In doing so we hope to provide a model to explain the magma chemistry in the MOT and SOT.

Keywords: Okinawa Trough, Bimodal volcanism, Magma Formation

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Reinvestigation of Holocene eruption history of Nikko-Shirane Volcano, central Japan

*Yuki Kusano[1], Yoshihiro Ishizuka[1], Teruki Oikawa[1], Osamu Ishizuka[1]

1. Geological Survey of Japan, AIST

Holocene eruption history of Nikko-Shirane Volcano was reinvestigated, based on the geological mapping, 5–10 m digital elevation model reading, and 14C ages, and correlated with the tephra stratigraphy. Nikko-Shirane Volcano (peak Mt. Shirane: 2578 m) is located on the border of Gunma and Tochigi prefecture, central Japan. It has three crater area, located at Mt. Shirane, Chinoikejigoku and Mt. Zazen (2317 m). The oldest Marunuma Lava is overlying Miocene basement, Kinugawa Rhyolites, and covered with thin soil and Asama-Itahana yellow (As-YP) tephra of 17 ka suggesting that Nikko-Shirane Volcano has been started eruption around 17 ka. Mt. Zazen is composed of Zazen Lava and Zazen'yama Pyroclastic Cone which has a 200 m-long crater on top. Eruption age of Zazen Lava is estimated to 7.6–5.7 ka (cal: calendar age).

There are seven tephra layers on Zazen Lava, from the lowest to the upper layers, Nks-G, Nks-F, Nks-E, Nks-D (defined in this study), Haruna-Futatsudake-Ikaho (Hr-FP: 6th century: Machida and Arai, 2003), Nks-C and Nks-A (Kusano and Ishizuka, 2020). Eruption age of Nks-G and Nks-D are estimated to 5.7–5.5 ka (cal) and 3.1–2.9 ka (cal). These ^{14}C ages and soil sedimentary rate between these tephra suggest that Nks-F was erupted in 5.2 ka, and Nks-E was erupted in 4.7 ka. Based on the volcanic stratigraphy, modal composition of tephra, petrography and geochemistry, Nks-F, Nks-E and Nks-D are correlated with Goshikinuma Pyroclastic Cone, Shirane-gongen Pyroclastic Cone and Shiranesan Lava, respectively.

We described Jigokunagi Pyroclastic Flow Deposit along a western valley of Mt. Shirane. It has more than 7 m in thickness, and consists of unwelded, block and ash flow deposit. It composed of volcanic blocks with fresh, dense and weakly vesiculated andesite with cooling joints, ash matrix of the same composition, and some charcoals. The pyroclastic flow deposit is covered with soil and Hr-FP. Petrographic feature and bulk-rock composition of these volcanic blocks is similar to that of Shiranesan Lava. Charcoal in the pyroclastic flow deposit show 3.3–3.2 ka. These lines of evidence indicate that the latest Shiranesan Lava was erupted around 3 ka and the crumbling of the lava formed Jigokunagi Pyroclastic Flow Deposit.
We conclude that magmatic eruption in Nikko-shirane Volcano occurs once in 300–1,500 years in recent 7,500 years.

Keywords: Nikko-Shirane Volcano, Eruption history, Geology, Active volcano, Volcanic stratigraphy, Radio carbon age

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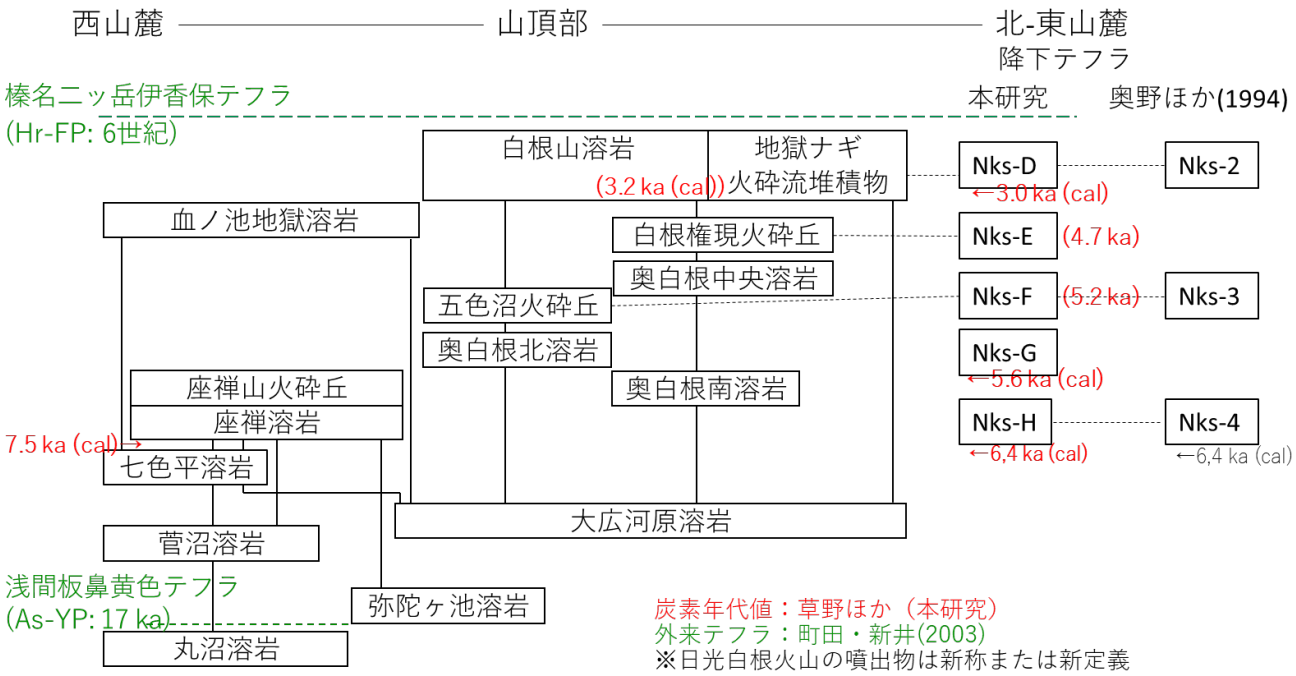


図1　日光白根火山の層序関係図
Fig. 1 Stratigraphic relationships of geologic units of Nikko-Shirane Volcano

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Construction of Geochemical database of Kikai Caldera magmas for understanding the magmatic evolution prior to caldera-forming eruptions

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1. Earthquake Research Institute, University of Tokyo, 2. JAMSTEC

The Kikai Caldera, located in southern Kyushu, experienced a caldera-forming eruption at 7.3 ka, which was the youngest and largest one on Earth during the Holocene, and caused voluminous deposits of pyroclastic flow and tephra (known as the Akahoya ash). In order to evaluate such past supereruptions and prepare for future eruptions, we compile a database that integrates available geochemical data from throughout the eruptive history of the Kikai Caldera. Based on the database, we will discuss the evolution and diversity of magmas responsible for past activities of the Kikai Caldera.
To track and correlate the widespread tephra from past Kikai eruptions, it is necessary to collate and compare information on volcanic ash collected from various parts of Japan. Recent advances in analytical techniques have allowed us to conduct microanalyses of various major and trace elements and multiple isotope ratios of glass and minerals in volcanic ash. To date, geochemical data of eruption products derived from the Kikai Caldera are; (1) whole-rock analytical data of proximal lavas and pyroclastic flows around the Kikai Caldera, such as those on Satsuma-Iwojima and Takeshima islands, using wet analysis or XRF, and (2) microanalytical data of volcanic glass of widespread tephra such as Kikai-Akahoya from a wide area ranging from Kyushu to Kanto, using EPMA and LA-ICP-MS. The former covers a wide range of ages, from pre-caldera activities to the eruptions during 1934-1935 that formed Showa-Iwojima, although available data are limited to major elements and specific trace elements. On the other hand, detailed geochemical data of eruption products including multiple trace element data for the widespread tephra from the Kikai Caldera, have been reported and become available over the past decade.
We will introduce the outline of the constructed database and the characteristics of available geochemical data related to the Kikai Caldera. Based on analysis using the database, the compositional variation of magmas throughout the period of Kikai Caldera activity will be evaluated. The database will be provided on a publicly available website.

Keywords: Kikai Caldera, Caldera-forming eruption, Wide-spread tephra, Database, Analytical Technique, Magma genesis

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Reconstruction of the volcanic history of Nakadake volcano in Kirishima volcano group, Kyushu, Japan (1)

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The long-term eruption histories of Ohachi, Shinmoedake, and Ebinokogen-Ioyama volcanoes in Kirishima volcano group were revealed through recent geologic observations (Tsustui et al., 2007; Tajima et al., 2013, 2014). However, detailed eruption histories of the Nakadake and Ohatayama volcanoes, which erupted during the Holocene, remain unknown. It was found that Nd1 and Nd2 lava were covered by the K-Ah tephra, whereas for Nd3 and Nd4 lava, the key tephra relationship has not been investigated. Nd7 lava is likely newer than Nd6 lava, while Nd8–Nd11 lava were the youngest Nakadake lava (Inoue, 1993). Based on ^{14}C ages and the key tephra layer relationship, the earlier 10 tephra layers of the Nakadake volcano are known to originate from eruptions occurring from 4700 to 2200 cal BP (Tsutsui et al., 2005, 2007). However, the beginning ^{14}C age of the Nakadake lava above the K-Ah tephra is unknown.

We investigated the lava and tephra layers around Nakadake volcano by using chronology and geochemical techniques. The earlier stage of the Nakadake volcano likely originated from Nd3 lava, as it sits at the bottom layer of the earlier Nakadake tephra layers above the Miike tephra. Additionally, the ^{14}C ages of 3680±40 BP (JAT-14,003) and 3500±40 BP (JAT-14,002) in the earlier Nakadake tephra layers above the Sm-Sy tephra (4.5 cal BP) were measured for humic soils. The AMS^{14}C dating was carried out at Tono Geoscience Center of Japan Atomic Energy Agency (JAEA).

Keywords: Kirishima volcano group, Nakadake volcano, volcanic history

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The effect of dissolved water induced by lithostatic pressure on lava migration

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1. Center for Northeast Asian Studies, Tohoku University

The apparent viscosity of Unzen lobe lava had been estimated to be 0.9–4.2×10^{10} Pa s from the observed lava surface velocity (2~5 m/h) in 1991, using Jeffreys model with lava density 2300 kg/m^3, lava thickness 40~70 m and slope angle 25~30 °, based on the assumption that the lava was a Newtonian or Bingham fluid (Fukui et al., 1991; Suto et al., 1993). In contrast, the viscosity of synthetic groundmass glass derived from Unzen lava (~79 wt.% SiO_2) had been measured in the laboratory at expected lava temperatures (780°C–880°C: Nakada and Motomura, 1999) to be 10^{11}–10^{13} Pa s (Goto, 1999). On the basis of Einstein–Roscoe equation, Goto (1999) concluded that ~50 vol.% crystallized Unzen lava lobes probably did have a few orders of magnitude higher viscosity than was observed, and he speculated that the lava-migration mechanism was different from that of Newtonian flow. On the other hand, Cordonnier et al. (2009), who obtained higher viscosity values from laboratory experiments than the field-based values for Unzen natural-lava samples, pointed out that, based on Hess and Dingwell's (1996) hydrous-melt viscosity model, 0.2 wt.% water in the groundmass glass (Nakada and Motomura, 1999) compensates for the gap between observed and experimental viscosity. In the present study the effect of dissolved water on lava migration was numerically investigated, based on synthetic dry Unzen groundmass glass viscosity data by Goto (1999), with the aids of water solubility model by Liu et al. (2005) and the degree of viscosity decrease by dissolved water derived from hydrous rhyolitic melt viscosity by Goto et al. (2005). In the following we fix the lava temperature to be 825°C.

Liu et al. (2005) provided empirical water solubility model for rhyolitic melt as functions of pressure and temperature. Using this model water solubility in rhyolitic groundmass glass was calculated for the interior of 70 m-thick Unzen dacite lava at each depth: e.g., 0.44 wt.% at the base of lava (1.71 MPa), 0.29 wt.% at 30 m form the surface (0.79 MPa) and 0.10 wt.% at the surface under atmospheric pressure (0.1 MPa). Empirical viscosity from hydrous rhyolitic melt (~77 wt.% SiO_2) by Goto et al. (2005) was fitted well as a function of water content at fixed temperature, expressing exponential decrease in logarithmic viscosity with increasing water content: -1.89, -1.62 and -0.83 by 0.44, 0.29 and 0.10 wt.% dissolved water, respectively. Supposing that the effect of dissolved water on the degree of rhyolitic melt viscosity decrease is identical, hydrous Unzen groundmass glass viscosity is estimated from dry melt viscosity by Goto (1999) to be 1.4×10^{10} Pa s at the base of lava, 2.7×10^{10} Pa s at 30 m from the surface and 1.7×10^{11} Pa s at the surface. These values are similar to or higher than the field-based viscosity, but integrated shear velocity at each depth gives surface velocity ~5 m/h, similar to the highest end of the observed velocity, mainly from the contribution of low viscosity zone on the bottom. These are the cases if the lava is crystal-free, but Unzen lava contains ~50 vol.% crystals. It is difficult to evaluate the effect of crystals on Unzen lava viscosity correctly because there is no universal viscosity model applicable to differing suspensions of crystals of various size and shape distributions, but simple Einstein–Roscoe equation expects a few order increase in viscosity by suspended crystals. The highest end of estimated effusion temperature (880°C) gives one order lower groundmass glass viscosity than the above evaluations, but insufficient to compensate for the viscosity increase by suspended crystals.

The present study indicates the importance of dissolved water induced by lava lithostatic pressure and resultant viscosity decrease, but insufficient to compensates for the gap between observed and experimentally-predicted viscosity of Unzen lava.

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Keywords: Unzen volcano, lava viscosity, dissolved water

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An attempt to detect volcanic materials of Ogasawara Ioto (Iwojima) Volcano from the core sample of the turbidite layers deposited in the Palace Bella Basin

*Masashi NAGAI[1], Takahiro Miwa[1]

1. Volcano Research Department, National Research Institute for Earth Science and Disaster Resilience

Ogasawara Ioto (Iwojima) Volcano is a volcanic Island with a 10 km-width caldera, and intense post-caldera volcanic activity ongoing. There are many unclear points about the products deposited on the surrounding seafloor, and little is known about the entire history of volcanic development. Therefore, not so much information is available on the timing, scale, eruption style, and impact on the surrounding environment, which is necessary for evaluating the disaster potential of Ioto volcano.
We focused on existing seafloor core samples and examined whether products from Ioto could be confirmed. The subject is the piston core KR98-01 P1 collected in the Palace Bella Basin. This core sample was analyzed in detail by Ikehara et al.(1998) and Kawamura et al.(1999 ; 2002), and considered to alternating layers of the turbidite layer and the pelagic clay layer. The depositional age was estimated to be younger than 460,000 years ago by microfossil analysis. Since the turbidite layer contains large amounts of volcanic glass particles and calcareous microfossils even though it was a core sample located deeper than CCD, it was probable that pyroclastic materials and microfossils once deposited shallower than the CCD were reworked by turbidity current. From the examination of paleocurrent direction and the seafloor topography, it was considered that the source was the relatively shallower seafloor around Ioto volcano at the southern end of the Izu-Ogasawara arc, which is more than 300 km away from the core site. However, the origin of pyroclastic material particles has not been investigated in detail. On the other hand, volcanoes in Ioto and surrounding submarine volcanoes are known to produce more alkaline rocks than adjacent areas, and have properties that are advantageous for identifying source volcanoes based on petrological characteristics.
This time, we mainly report the results of the major element composition analysis of volcanic glass particles by SEM-EDS using the core samples stored in the Kochi Core Center, Kochi University / JAMSTEC. According to the analysis results, most of the particles are rich in alkali elements and range from trachyandesite to trachydacite. In all the SiO_2 variation diagram of the measured elements, there is a part that overlaps with the composition range of the known Ioto volcanic products, and it is considered that particles originating from Ioto volcano are included in core samples. On the SiO_2-Na_2O diagram, there are two major composition trends. On the SiO_2-Na_2O diagram, there are two major composition trends. The Na_2O-rich composition trend is more consistent with Ioto volcano, and the Na_2O-poor trend is in the position slightly poorer in Na_2O than the whole rock composition of Fukutoku-Okanoba volcano (Kato, 1988 ; Ossaka et al., 1990 ; Nakano and Kawanabe, 1992 etc.), and the corresponding volcano is unknown at present. Because each turbidite layers always contain particles that match both trends, it is thought that the direct origin is mixture of the products from Ioto and unknown volcanoes. In addition to the above, trace amounts of high-silica rhyolite glass particles similar to AT tephra have been confirmed from the pelagic clay layer, and there is a possibility that the depositional age can be further narrowed down.
The results of this study support the estimation of the source area by Ikehara et al.(1998) and suggest that large-scale mass transport were repeated in seafloor around Ioto area. It is considered that the components of each turbidite layer reflected the surface deposits in the area around the volcanoes at the time of the turbidity current had occurred, so by analyzing each layer in detail, temporal changes such as

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eruption magma properties might be obtained.
Acknowledgment : We thank JAMSTEC for permitting the use of the piston core samples. We also thank Dr. Toshio Hisamitsu and other staff members of the Kochi Core Center for support of collection of analytical samples.

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.23 Zoom Room 23

[S-TT34] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Shigeo Okuma(Geological Survey of Japan, AIST), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Chairperson:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Shigeo Okuma(Geological Survey of Japan, AIST), Yuji Mitsuhata(AdvancedIndustrial Science and Technology)

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

[STT34-01] Introduction

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

[STT34-02] Comparison of airborne magnetic surveys by different types of aircrafts - A case of Izu-Oshima Volcano

*Shigeo Okuma[1], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Masahiko Makino[2], Shogo Komori[3], Takao Koyama[4], Takayuki Kaneko[4], Takao Ohminato[4], Atsushi Yasuda[4], Yoshiaki Honda[5] (1.Institute of Geology and Geoinformation, AIST, 2.Geological Survey of Japan, AIST, 3.Research Institute for Geo-Resources and Environment, AIST, 4.Earthquake Research Institute, Univ. of Tokyo, 5.Center for Environmental Remote Sensing, Chiba univ)

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

[STT34-03] Aeromagnetic survey in Kusatsu-Shirane volcano by unmanned helicopter

*Takao Koyama[1], Wataru Kanda[2], Mitsuru Utsugi[3], Takayuki Kaneko[1], Takao Ohminato[1], Atsushi Watanabe[1], Hiroshi Tsuji[1], taro nishimoto[1], Yoshiaki HONDA[4] (1.Earthquake Research Institute, The University of Tokyo, 2.Tokyo Institute of Technology, 3.Kyoto University, 4.Chiba University)

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

[STT34-04] Automatic estimation of regression curves indicating average depths of causative layers from power spectrum of gravity anomaly or gravity gradient (g_{zz}) data

*Shigekazu Kusumoto[1], Motonori Higashinaka[2] (1.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2.JGI, Inc.)

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

[STT34-05] Study on the behavior of the groundwater in the slope in the heavy rain using Drone Airborne TEM

*Atsuhiko Kinoshita[1,2], Suguru Shibata[2], Takao Yamakoshi[1], Hiroaki Nakaya[1], Atsuyoshi Jomori[3], Tetsuya Toyama[3], Akira Jomori[3], Kentaro Kanayama[4], Minoru Okumura[4], Katsushi Kawato[4], Muneki Mitamura[5], Tamotsu Matsui[6] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, 3.NEOSCIENCE CO.LTD., 4.NIPPON ENGINEERING CONSULTANTS CO.,LTD., 5.Osaka City University, 6.Osaka University)

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

[STT34-06] Discussion

[J] Oral | S (Solid Earth Sciences) | S-TT Technology & Techniques

[S-TT34] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Shigeo Okuma(Geological Survey of Japan, AIST), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Chairperson:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Shigeo Okuma(Geological Survey of Japan, AIST), Yuji Mitsuhata(AdvancedIndustrial Science and Technology)

Thu. Jun 3, 2021 3:30 PM - 5:00 PM Ch.23 (Zoom Room 23)

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

[STT34-01]Introduction

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Comparison of airborne magnetic surveys by different types of aircrafts - A case of Izu-Oshima Volcano

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1. Institute of Geology and Geoinformation, AIST, 2. Geological Survey of Japan, AIST, 3. Research Institute for Geo-Resources and Environment, AIST, 4. Earthquake Research Institute, Univ. of Tokyo, 5. Center for Environmental Remote Sensing, Chiba univ

The Geological Survey of Japan (GSJ) has been developing drone magnetic survey systems for geophysical survey in volcanic areas these years. In 2019, we introduced a newly developed UAV-enabled magnetometer "MagArrow" and conducted practical test flights of the magnetometer in Izu-Oshima Volcano, south of Tokyo (Okuma et al., 2020). On Izu-Oshima Island, many airborne magnetic surveys have been conducted by using various types of aircrafts so far. In this study, we compare the results of magnetic surveys using an unmanned autonomous helicopter and a drone (multicopter).

The Earthquake Research Institute (ERI), Univ. of Tokyo conducted airborne magnetic surveys using an unmanned autonomous helicopter in March and November 2008 inside the summit caldera of the volcano. The former and latter surveys cover the northern and southern parts of the summit caldera including Mt. Mihara, respectively. The survey was flown using a portable Cesium magnetometer at an altitude of around 50 m above terrain along survey lines spaced around 50 m apart. They conducted apparent magnetization mapping from the observed anomaly and indicated magnetization highs in the northwestern flank of Mt. Mihara (Kaneko et al., 2011) and in the southeastern flank of Mt. Mihara (ERI and Chiba Univ., 2009) both trending NW aligned to a major tectonic direction on the island. These results of magnetization mapping suggest subsurface intrusions overlain by surface volcanic products, which are very interesting interpretation about the subsurface structure. However, the evaluation of magnetic anomalies itself might be insufficient since they did not produce a detailed magnetic anomaly map. Hence, a compilation of such a magnetic anomaly map has been newly conducted. Magnetic anomalies (total magnetic intensity) were reduced onto a smoothed observation surface assuming equivalent anomaly below the observation surface and reduction to the pole anomalies are also calculated on the same surface. The resultant reduction to the pole anomaly map clearly shows magnetic highs on the northern and southern flanks of Mt. Mihara. Magnetic lows are dominant over the eruptive crater and the northeastern foot of Mt. Mihara. A local magnetic high seems to lie over one of B craters of the 1986 eruption. 3D magnetic imaging was then applied to terrain-corrected magnetic anomalies and the result was compared with preceding studies. These newly compiled aeromagnetic maps and interpreted subsurface structures have finer space resolution than those of airborne magnetic surveys using airplanes at a higher altitude (e.g. Makino et al., 1988).

According to the compilation of detailed magnetic anomaly maps using ERI's data, GSJ specified a survey area of drone magnetic survey using MagArrow on the island. In 2019, a drone magnetic survey was flown at an altitude of 25 m above terrain along E-W survey lines spaced 25 m apart in the northern part of the summit crater (Okuma et al., 2020). Unfortunately, many typhoons attacked Izu-Oshima Island in 2019, causing difficulties in surveying on calm days with a wind speed less than 2 m/s. Because of the harsh weather, the flights covered only a half of the provisional survey area. Magnetic anomalies (total magnetic intensity) were reduced onto a smoothed observation surface assuming equivalent anomaly below the observation surface and reduction to the pole anomalies are also calculated on the same surface. Many

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magnetic highs and lows are distributed on the maps. Comparing the result of the drone magnetic survey with that of the unmanned autonomous helicopter survey, it is obvious that the former is superior to the latter in spatial resolution. Many short-wavelength anomalies can be attributed to topography consisted of volcanic products on magnetic maps of the drone magnetic survey. Even the magnetization heterogeneity of the 1986 lava can be estimated on the same maps.

Keywords: magnetic survey, drone , unmanned autonomous helicopter, airplane, volcano, Izu-Oshima

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Aeromagnetic survey in Kusatsu-Shirane volcano by unmanned helicopter

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1. Earthquake Research Institute, The University of Tokyo, 2. Tokyo Institute of Technology, 3. Kyoto University, 4. Chiba University

Kusatsu-Shirane volcano is one of the active volcanoes in Japan, and phreatic explosions have occurred in Mt. Shirane in 1983 and most recently, Mt. Motoshirane in 2018. Information on the subsurface structure is crucial for understanding the activity of volcanoes with well-developed hydrothermal systems where phreatic eruptions occur.
Here, we report aeromagnetic surveys conducted at low altitudes using an unmanned helicopter. The survey aimed to obtain magnetic data of high spatial resolution to map the magnetic anomaly and infer the magnetization intensity structure in the region, just after the 2018 Mt. Motoshirane eruption. The helicopter used in the survey was YAMAHA FAZER R G2, an autonomously-driven-model that can fly along a programmed course. The flight height above the ground and a measurement line spacing were set to ~150 m and ~100 m, respectively, and the total flight distance was 191 km. The measured geomagnetic total intensity was found to vary by ~1000 nT peak-to-peak.
The estimated magnetization intensity structure derived from measured data showed a magnetized surface layer with a normal polarity of a few hundred meters thick, composed of volcanic deposits of recent activities. Underneath, a structure with reverse-polarity magnetization was found. This probably corresponds to the Takai lava flow in the Early Quaternary period (~1 Ma) to which, it is believed that the basement rock of this region can be dated back to. Just beneath the crater lake of Mt. Shirane (Yugama) and Mt. Motoshirane, normally magnetized structures were inferred even at 1500 m depth from the surface. This may have been caused by the replacement of old lava with a new one because of frequent repetition of volcanic events which occurred through the two main pathways.

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Automatic estimation of regression curves indicating average depths of causative layers from power spectrum of gravity anomaly or gravity gradient (g_{zz}) data

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1. Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2. JGI, Inc.

In this study, we propose a method of automatically estimating regression lines or curves indicating the average depths of causative layers from the power spectrum of gravity anomaly or gravity gradient data (g_{zz}).

To estimate the average depth of a causative layer, we select a frequency range and apply linear or curve approximation to the power spectrum of gravity anomaly or gravity gradient data and estimate the optimum regression line or curve for the data. In general, the frequency range is selected by an analyst; therefore, the analysis depends on the skill level of the analyst. If the effective-frequency range for each causative layer can be automatically determined from the power spectrum according to a suitable index, we can estimate the regression line or curve more objectively. If a technique for the automatic and direct determination of the regression curve from the data with one indicator is developed, it would be the best way for performing quantitative analysis of gravity anomaly or gravity gradient data.

In this study, we focused on estimating the regression line and employed the coefficient of determination (R^2) as the indicator. R^2 was used to measure the goodness of fit for the regression line. It generally distributes in the range of less than 1.0; the closer R^2 is to 1.0, the better the explanation of data by the estimated regression line.

In the analysis, the data in all the frequency zones were set as the initial data, and the regression line indicating the depth of the deepest layer was first estimated. The regression lines were estimated by sequentially reducing data from the higher frequency side, and R^2 was also calculated each time the regression line was estimated. When R^2 of one line assumed the highest value, we used the line as the optimum regression line. Next, we applied the same process to the residual data (high-frequency side) and obtained the regression line indicating the second-deepest layer. By repeating these processes, we automatically determined the number of causative layers and the regression lines indicating the layer depths.

The radial average of the power spectrum of gravity is known to draw a relatively smooth curve. Instead of L_2 norm minimisation (least square method), we employed L_1 norm minimisation, which is robust, for estimating the regression line from these data. R^2 has been used to measure the goodness of fit for the regression line via the least square method and is not a suitable indicator for evaluating the goodness of fit for the regression line provided by L_1 minimisation but only an indicator. However, as shown in Fig. 1, we could extract the regression lines indicating the average depths in the regional, local, and noise frequency zones by evaluating R^2.

Keywords: Gravity anomaly, Power spectrum, Automatic estimation of average depth of causative layer

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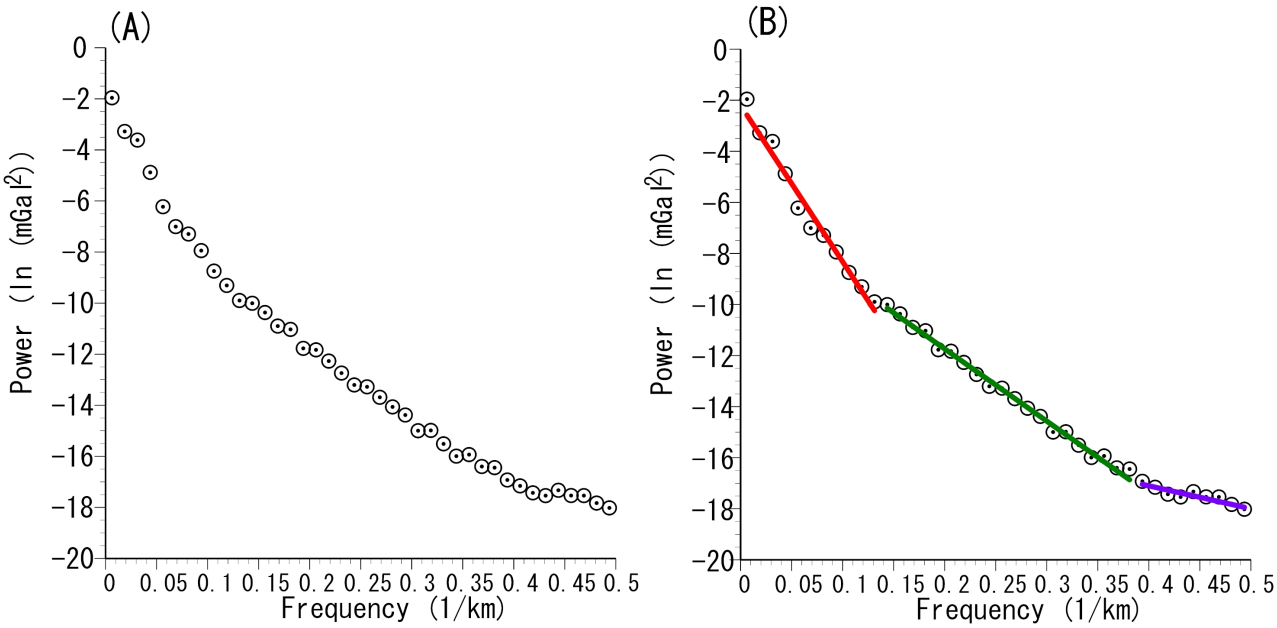


Fig. 1. Power spectrum and regression lines. (A) Power spectrum of Bouguer anomaly in Toyama prefecture. (B) Regression lines estimated automatically by the proposed method. Red, green, and purple lines represent the regression lines indicating average depths in the regional, local, and noise frequency zones.

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Study on the behavior of the groundwater in the slope in the heavy rain using Drone Airborne TEM

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1. National Institute for Land and Infrastructure Management, 2. Sediment Disaster Prevention Technology Center, 3. NEOSCIENCE CO.LTD., 4. NIPPON ENGINEERING CONSULTANTS CO.,LTD., 5. Osaka City University, 6. Osaka University

In the survey by Drone Airborne Transient Electromagnetics (TEM), a cable of about 100 to 1000 m is laid on the ground and the cable is energized. By causing a rapid time change of the magnetic field (primary magnetic field) generated there, an induced current proportional to the resistivity of the underground is generated on the ground. The resistivity value in the underground is obtained by measuring and analyzing the time change (transient response) of the new magnetic field (secondary magnetic field) generated by this. With the development of this technology, we could verify the landslide mechanisms after the sediment-related disasters and the design method of the countermeasures would change significantly in the future. The reasons for this are that it is cheaper than the electrical prospecting and the Airborne Electromagnetic Survey by helicopter that have been often used so far, and that it can be measured immediately after the heavy rain. In this study, we conducted a survey in the Iya district in Tanabe City, Wakayama Prefecture, where the deep-seated landslide was occurred due to Typhoon Talas in 2011. Drone Airborne TEM was conducted to clarify the behavior of groundwater in the slope during the heavy rain.

A survey line of about 700 m length was set at the upper right of the landslide slope. And Drone Airborne TEM was conducted in the flood season and in the dry season. From the results of the field survey, multiple fault crush zones were distributed around the area where the survey line was set. The measurement day in the flood season was three days after the end of rainfall of 217 mm in total rainfall of Typhoon CHAN-HOM in 2020 (October 13, 2020). The measurement day in the dry season was set on December 2, 2020, when there was no rainfall for 11 days. By taking the difference between the measurement results of the resistivity values, the behavior of the groundwater during Typhoon CHAN-HOM in 2020 was estimated.

By Drone Airborne TEM, we could estimate the behavior of groundwater in the slope during the heavy rain, which was previously unknown without observing the water level under the ground using the boring hole. As a result, it was found that the four fault crush zones distributed in the Iya area induce groundwater and block the flow of the groundwater in the slope. We think that the deep-seated landslide in the 2011 disaster was caused due to the effects of these fault crush zones. In this way, we would evaluate the roles of the fault crush zones during the heavy rains can be evaluated by using Drone Airborne TEM.

Keywords: Drone Airborne TEM, groundwater, deep-seated landslide

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[J] Oral | S (Solid Earth Sciences) | S-TT Technology & Techniques

[S-TT34] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Shigeo Okuma(Geological Survey of Japan, AIST), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Chairperson:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Shigeo Okuma(Geological Survey of Japan, AIST), Yuji Mitsuhata(AdvancedIndustrial Science and Technology)
Thu. Jun 3, 2021 3:30 PM - 5:00 PM Ch.23 (Zoom Room 23)

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.

4:45 PM - 5:00 PM

[STT34-06]Discussion

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[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.14_1

[S-TT34] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Shigeo Okuma(Geological Survey of Japan, AIST), Takao Koyama(Earthquake Research Institute, The University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology)

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.

[STT34-P01] Geological structure survey by drone airborne electromagnetic survey method

*Youichi Yuuki[1], Akira Shinsei[1], Zenshiro Saito[1], Satoshi Tomimori[1], Akiyo Yamaguti[1], Akira Jomori[2], Atsuyoshi Jomori[2], Tatsuya Toyama[2] (1.Oyo corporation, 2.Neo Science)

[STT34-P02] Development of a Portable Infrared Camera system for Measuring Volcanic Surface Phenomena

*Tetsuya Jitsufuchi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

Geological structure survey by drone airborne electromagnetic survey method

*Youichi Yuuki[1], Akira Shinsei[1], Zenshiro Saito[1], Satoshi Tomimori[1], Akiyo Yamaguti[1], Akira Jomori[2], Atsuyoshi Jomori[2], Tatsuya Toyama[2]

1. Oyo corporation, 2. Neo Science

The drone airborne electromagnetic survey method (D-GREATEM) has been in practical use for several years, and has been used for tunnel route surveys and landslide surveys. We have developed a new transmission device that can be mounted on a drone, and obtained the resistivity structure by using a method called D-TEM, in which two drones towing a transmission device and a reception device are flown simultaneously to measure the resistivity structure. The survey was carried out in the Seino region to understand the structure and hydraulic properties of fan-shaped sand and gravel, which are the recharge sources of groundwater in the Nobi Plain, alluvial clay that causes groundwater to be pressurized, and faults that can regulate groundwater flow. In order to capture seasonal changes in groundwater, the study was conducted twice, during the high rainfall season (September-October 2019) and the low rainfall season (December 2019), and these results were reported at the Japan Geoscience Union 2020 Conference (Yuki et al., 2020).
In this paper, we report on the results of the D-GREATEM and D-TEM expeditions conducted in 2020, following last year's report. Two surveys were carried out in September and December 2020 on the same survey line. The results of D-GREATEM were compared with the results of the previous exploration to confirm the reproducibility of the exploration technique and to examine the geological and hydraulic structures by differentiating the two periods. The D-TEM was conducted on the same survey line as the D-GREATEM, and the depth and resolution of the D-TEM were verified by comparing the results.
The survey area was a non-dense populated area with a lot of farmland, but it was also dotted with private houses and factories, and the roads were lined with power distribution lines. In some areas, underground lines for high-voltage power transmission were buried, and the influence of these measurement environments on the exploration results was also examined.
This paper reports the results of the comparison of the results of the two surveys, D-GREATEM and D-TEM, and discusses the characteristics and limitations of each method, estimation of geological and hydraulic structures, and the effects of measurement conditions.
This survey was conducted by the Strategic Innovation Program (SIP) "Strengthening National Resilience (Disaster Prevention and Mitigation)" of the Council for Science, Technology and Innovation (CSTI), Cabinet Office, Government of Japan (administrator: Disaster Prevention Research Institute).

Keywords: drone, Airborne electromagnetic survey, Drone airborne electromagnetic survey, D-GREATEM, D-TEM

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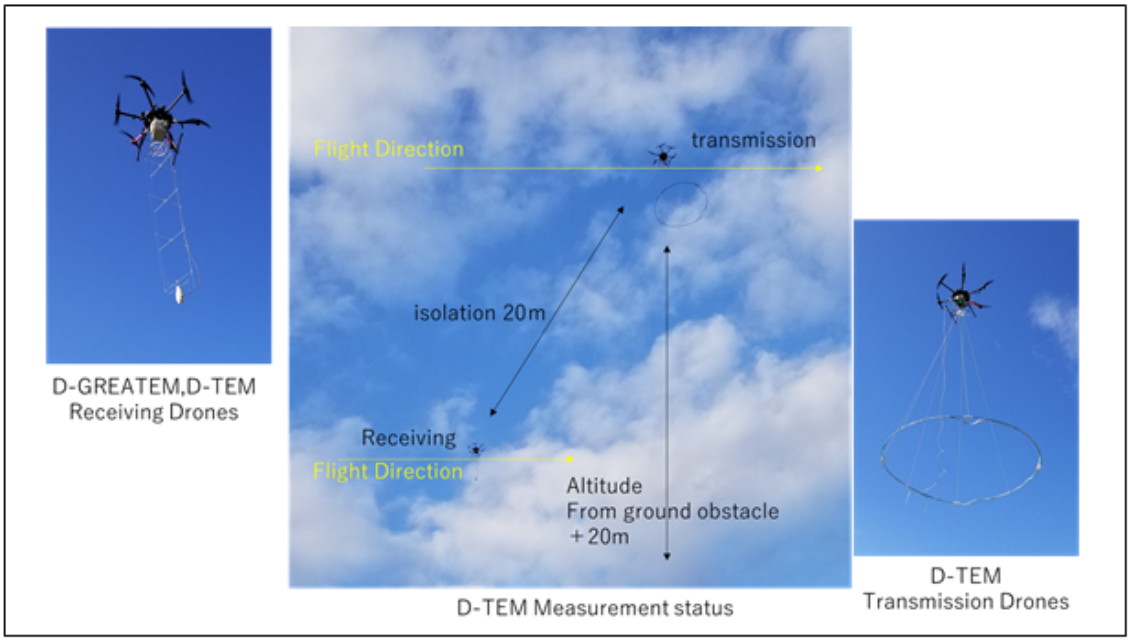


Figure 1: Drone airborne electromagnetic survey measurement

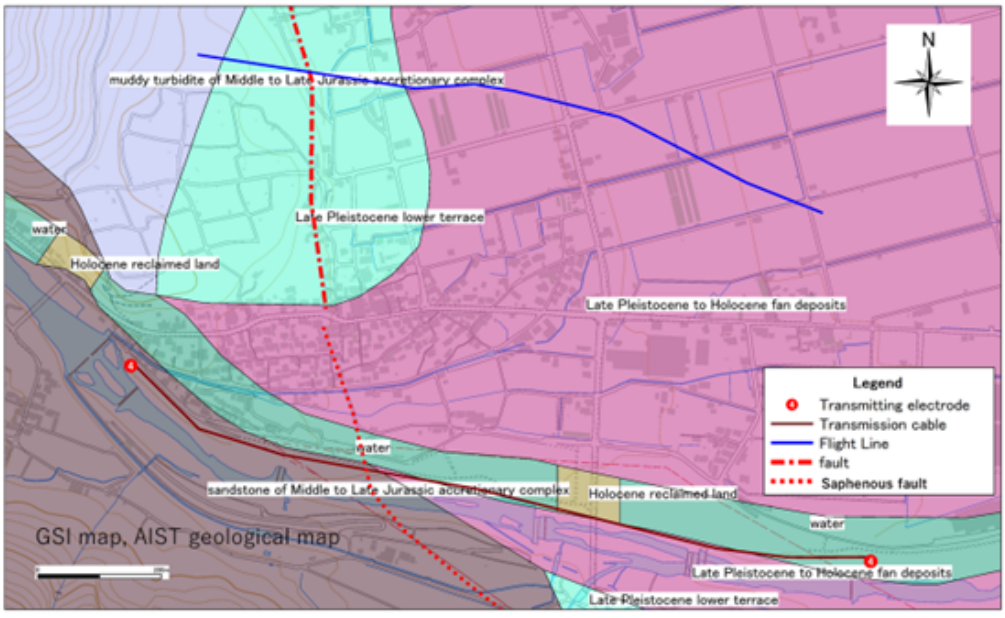
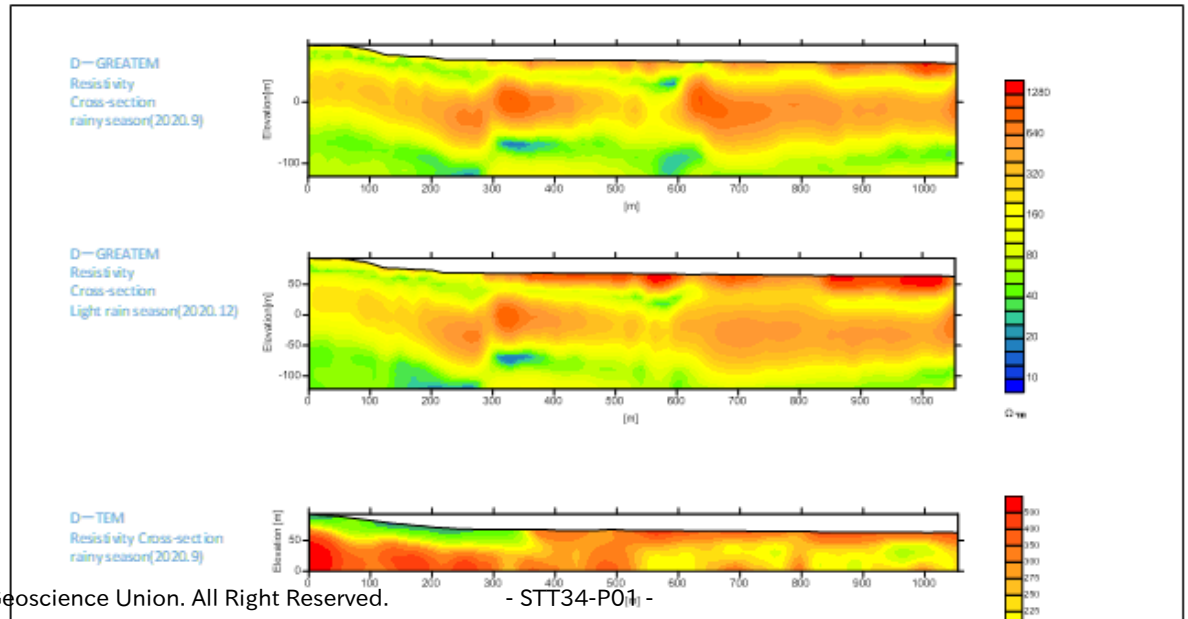


Fig. 2 Geological map



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Development of a Portable Infrared Camera system for Measuring Volcanic Surface Phenomena

*Tetsuya Jitsufuchi[1]

1. National Research Institute for Earth Science and Disaster Resilience

The National Research Institute for Earth Science and Disaster Resilience (NIED) developed a portable infrared camera system, Structure and Thermal Information Capture-Portable (STIC-P) for volcano observations in March of 2020. STIC-P is a handheld portable system that can be used for observations on the ground and for handheld observations from an aircraft.

NIED has been conducting research, development and utilization of their own airborne remote sensing system for volcano observation since 1988. The first airborne spectral imaging system, the VAM-90A, was developed in 1990. In 2006, the second airborne hyperspectral sensor, the ARTS, was developed. In June 2015, the ARTS was remodeled into the ARTS-SE. ARTS-SE consists of a modified system of push-broom imaging spectrometer (ARTS) and a newly developed camera system, the Structure and Thermal Information Capture (STIC). The STIC consists of four cameras. These cameras are the two visible cameras and the two uncooled infrared cameras. The STIC specifications provide images data sets for the Structure from Motion (SfM) technique for operational volcanic observations to assess volcanic activity. In November and December 2015, we conducted observations with the ARTS-SE at the Hakone volcanoes and Asama volcanoes. These results indicated that the structure from motion (SfM) processing of image data (framed images) captured by the newly developed STIC can derive digital surface models (DSMs) and ortho-corrected images of the ground surface. We also demonstrated that the uncooled infrared camera can measure brightness temperature distributions under installed on a moving platform at approximately 270 km/h (groundspeed: 75 m/s).

Based on these results, we developed a new device that realizes the functions of STIC as a portable device, and in March 2020, a portable infrared camera system: Structure and Thermal Information Capture-Portable (STIC-P) was developed. The SPIC-P consists of three cameras. These cameras are the two visible cameras and the one uncooled infrared camera. All cameras can measure frame images or videos (30Hz) images. The STIC-P is a portable system and can realize ground-based observations and oblique observations from the sky. NIED is conducting experimental flight of mountain topography (Gifu prefecture) and experimental volcano observations (Mt. Hakone (Owakudani)) for performance evaluation of STIC-P using a helicopter. From these observation results, a geothermal distribution analysis and SfM processing will be performed to assess its accuracy.

Keywords: a portable cameras system, airborne remote sensing, volcano observations, infrared camera, visible camera

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.18 Zoom Room 18

[S-TT37] Seismic Big Data Analysis Based on the State-of-the-Art of Bayesian Statistics

convener:Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Keisuke Yano(The Institute of Statistical Mathematics), Takahiro Shiina(National Institute of Advanced Industrial Science and Technology), Chairperson:Ryo Kurihara(Earthquake Research Institute, The University of Tokyo), Takayuki Nagata(Tohoku University)

Recently, a big seismic database has been being constructed that collects data of vibrators implemented in such as buildings, lifelines and smartphones, in addition to seismic data of the conventional continuous/temporal dense seismic observation arrays. Development of methodologies and algorithms, which are inadequate at this moment, optimized to comprehensively analyze the seismic big data is essential in order to utilize the big database as much as possible for prevention/mitigation of earthquake disasters and clarification of earthquake phenomena. On the other hand, recent progress of Bayesian statistics is significant, which is the mathematical basis of various methodologies, such as machine learning, especially deep learning, to extract valuable information from big data. The state-of-the-art of Bayesian statistics is expected to substantially advance seismic big data analyses.
This session mainly accepts presentations that focus on analyses of seismic big data, especially related to analysis methods based on Bayesian statistics such as machine learning, sparse modeling and data assimilation, and their applications to real seismic data. Presentations related to mathematical or statistical theories beneficial to data analyses, feasibility studies of algorithms eventually applicable to real seismic data, and the current status of seismic observations and analysis results are also highly welcome.

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

[STT37-01] Seismic noise reduction in MeSO-net during COVID-19 pandemic

★Invited Papers

*Suguru Yabe[1], Kazutoshi Imanishi[1], Kiwamu Nishida[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Earthquake Research Institute, University of Tokyo)

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

[STT37-02] MCMC-based joint determination of earthquake hypocenters and 1-D velocity structures around a fault zone

*Takahiro Shiina[1], Masayuki Kano[2] (1.National Institute of Advanced Industrial Science and Technology (AIST), 2.Graduate School of Science, Tohoku University)

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

[STT37-03] Application of structured regularization to seismic tomography for adaptation to discontinuities

*Sumito Kurata[1], Yohta Yamanaka[1], Keisuke Yano[2], Fumiyasu Komaki[1], Takahiro Shiina[3], Aitaro Kato[1] (1.The University of Tokyo, 2.The Institute of Statistical Mathematics, 3.National Institute of Advanced Industrial Science and Technology)

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

[STT37-04] Bayesian Dynamic Mode Decomposition

★Invited Papers

*Hideitsu Hino[1] (1.The Institute of Statistical Mathematics)

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

[STT37-05] Sensor Selection for Seismic Wavefield Reconstruction based on Sparse Observation (Part I. Proposal and Evaluation on Method based on Linearized Model of Governing Equation)

*Kumi Nakai[1], Takayuki Nagata[1], Yuji Saito[1], Taku Nonomura[1], Masayuki Kano[1], Shin-ichi Ito[2], Hiromichi Nagao[2] (1.Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

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

[STT37-06] **Modeling space-time heterogeneities of hypocenter catalog**

*Yosihiko Ogata[1], Koiti Katsura[1] (1.Research Organization of Information and Systems, The Institute of Statistical Mathematics)

Seismic noise reduction in MeSO-net during COVID-19 pandemic

*Suguru Yabe[1], Kazutoshi Imanishi[1], Kiwamu Nishida[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Earthquake Research Institute, University of Tokyo

Japanese society has been forced to change due to COVID-19 pandemic started in 2020. Japanese people were requested to stay home when the state of emergency was declared in April 2020. The number of commuters was decreased by introducing remote working. Such changes in social activities have been visualized through location information of smartphones. We report that seismic noise at high frequency (>1 Hz) in Metropolitan Seismic Observation network (MeSO-net) also records social activity changes due to COVID-19.

It has been known that seismic stations record noise generated by social activities at frequency higher than 1 Hz. The noise level is usually higher on weekdays than on weekends, on daytime than on night, which corresponds to social activeness. The noise level becomes lower during long holidays, such as new-year holidays, which also corresponds to social activeness. However, we have not had opportunities to compare seismic noise level with any quantitative indexes of social activities. This study compares seismic noise level with population data around train stations, which is published during COVID-19 pandemic as an opportunity.

The seismic noise level varies temporally at several timings. Its first small drop was occurred at the beginning of March, which corresponds to when schools were shut down. A larger drop was recorded when the Governors of the Tokyo metropolitan area requested citizens to stay home (the end of March 2020) and when the state of emergency was declared for the Tokyo metropolitan area by the government (8th April 2020). The noise reduction reached 10-20% at most in many stations. On the middle of May 2020, the noise level in turn started to increase, which occurred before the state of emergency was lifted on the end of May. The noise level recovered to that of normal years in June at many stations, though the noise level at some stations (especially at central Tokyo) are kept at ~5 % lower than that of normal years. The state of emergency was declared again on 8th Jan 2021, though seismic noise level just shows a slight drop.

The observed temporal changes in seismic noise level are correlated with social activeness visualized though the location information of smartphones. We refer population data around train stations published by Agoop corp. According to their data, population drops occurred at the same timing when seismic noise level reduction occurred. Population recovery at the middle of May also corresponds to seismic noise-level recovery. On the other hand, there are also several inconsistencies between population data and the seismic noise level. For example, population after the state of emergency in 2020 was lifted did not recover to that before COVID-19 pandemic started, though seismic noise level was recovered at many stations. Population after new-year holiday is fewer than that before the holiday, though the seismic noise level just shows a slight decrease. These observations suggest that, although the primary noise source at high frequency is social activities, the population data does not directly reflect activeness of seismic noise source.

Seismic noise source is considered to be mobility such as cars and trains and machine vibrations in buildings and factories. However, we do not understand how they actually contribute to the observed

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seismic noise. There should be various indexes for social activities other than the population data we referred in this study. Data mining with such various indexes will enables us to develop a social monitoring method through seismic data.

Keywords: Seismic noise, COVID-19, Social activity

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MCMC-based joint determination of earthquake hypocenters and 1-D velocity structures around a fault zone

*Takahiro Shiina[1], Masayuki Kano[2]

1. National Institute of Advanced Industrial Science and Technology (AIST), 2. Graduate School of Science, Tohoku University

Determination of earthquake hypocenters is the fundamental analysis in seismology. For example, locations of a large earthquake and its aftershocks provide information for understanding generation mechanisms of the mainshock and spatiotemporal activity of the aftershocks. Earthquake locations are estimated from arrival times of P and S waves picked from observed seismic records. In order to calculate theoretical travel times to compare with observed ones, velocity structure between earthquakes and stations has to be given. In general, a pre-estimated velocity model (e.g., JMA2001 model [Ueno et al., 2002]) is used to determine the earthquake locations. Meanwhile, the activity of earthquakes often concentrates on structural boundaries. Across such structural boundary, seismic velocity varies to reflect spatial variations of materials. Methods for simultaneously estimating earthquake locations and velocity structures were proposed to accurately determine earthquake hypocenters in such heterogeneous structures [e.g., Zhang and Thurber, 2003; Ryberg and Haberland, 2019].
For simultaneous determination of earthquake locations and velocity structures from a limited amount of dataset, e.g., in the case when immediately after a large earthquake, it would be practical to assume a one-dimensional (1-D) velocity model that varies only in the depths. The structural boundary related to the inland earthquakes often has a nearly-vertical dip angle. In that case, the estimation accuracy of earthquake hypocenters can be improved by assuming a different 1-D velocity model in each station group divided by the structural boundary [Sakai et al., 2004; 2005]. However, because prior constraints of subsurface heterogeneity should be necessary for dividing station groups, applications for determining earthquake locations using several 1-D velocity models are limited in the region where the subsurface velocity structure has been investigated well.
In this presentation, we propose a method for simultaneously determining earthquake hypocenters and 1-D velocity models, in addition to station clustering reflecting subsurface velocity structure. The target is considered to be an active earthquake area where velocity structures vary horizontally. In the proposed method, we perform the estimation based on the Markov chain Monte Carlo (MCMC) method: the Metropolis-Hasting algorithm for estimating locations of hypocenter and station corrections in travel times, and the reversible-jump MCMC algorithm [Green, 1995] for determining 1-D velocity models with the number of layers. The stations are clustered in a data-driven manner using the framework of the Metropolis-Hasting algorithm. Numerical experiments will demonstrate to verify the proposed method. Moreover, we estimate earthquake locations and velocity structures around the source area of the 2004 mid-Niigata prefecture earthquake by the proposed method to examine the application to real seismic data.

Acknowledgment: This study is supported by JST CREST [Grant Number JPMJCR1763] and JSPS KAKENHI [Grant Number JP18K03796].

Keywords: MCMC, Hypocenter determination, 1D velocity structure

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Application of structured regularization to seismic tomography for adaptation to discontinuities

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1. The University of Tokyo, 2. The Institute of Statistical Mathematics, 3. National Institute of Advanced Industrial Science and Technology

Seismic tomography is a method for estimating the velocity structure of seismic waves propagating in the Earth, based on arrival times of seismic waves recorded by seismic observation networks. Grid points are placed in three-dimension to estimate velocity parameters and their heterogenous distributions. A value of velocity at an arbitrary point is calculated by interpolating them at the nearest eight grids. The SIMUL2000 (Thurber, 1993) is a widely-used estimation algorithm that estimates velocity parameters based on minimizing the sum of squared residuals.
In seismology, it is well known that there are regions of varying velocity drastically, such as the Moho discontinuity, in the vertical (depth) direction. On the other hand, in the horizontal direction, velocity changes are generally smooth, that is, rapid changes of the velocity is less likely to occur. In this presentation, we propose a new tomographic method based on structured regularization to incorporate such structural properties of the Earth's interior.
We use different penalty terms in the vertical and horizontal directions to express the above-mentioned properties in seismic velocity changes. For the depth direction, we employ a penalty term that has a form of l1-sum of l2-norm of the second-order differences of the horizontal units. This penalty term is intended to represent the sharp velocity jumps associated with the presence of discontinuities, by making average velocities in the depth piecewise linear. On the other hand, in the horizontal direction, we set a penalty term based on the l2-norm to express smooth velocity trends.
In the presentation, we conduct numerical experiments to discuss properties of the proposed methods by comparing to conventional methods, SIMUL2000 with the Laplacian regularization. We show that the proposed method is superior to the conventional ones in estimating velocity structures, especially in terms of accuracy in the presence of discontinuous increasing in seismic velocity.

Keywords: Seismic tomography, Velocity structure, Computational seismology, Velocity discontinuity, Structured regularization

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Bayesian Dynamic Mode Decomposition

*Hideitsu Hino[1]

1. The Institute of Statistical Mathematics

Dynamic mode decomposition (DMD) is a data-driven deterministic method that has substantially contributed to our understanding of dynamical systems. In this work, a Bayesian formulation of DMD is proposed. It first determines the subspace of observables, and then compute the modes on that subspace. Variational matrix factorization makes it possible to realize a fully-Bayesian scheme of DMD. The proposed Bayesian DMD is capable of dealing with incomplete or missing data, which demonstrates the advantage of probabilistic modeling. Finally, both nonlinear simulated and real-world datasets are used to illustrate the potential of the proposed method. This is joint work with Mr. Takahiro Kawashima and Dr. Hayaru Shouno.

Keywords: Bayesian modeling, mode decomposition

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Sensor Selection for Seismic Wavefield Reconstruction based on Sparse Observation (Part I. Proposal and Evaluation on Method based on Linearized Model of Governing Equation)

*Kumi Nakai[1], Takayuki Nagata[1], Yuji Saito[1], Taku Nonomura[1], Masayuki Kano[1], Shin-ichi Ito[2], Hiromichi Nagao[2]

1. Tohoku University, 2. Earthquake Research Institute, The University of Tokyo

In the present study, we propose a sparse sensor selection method for the accurate reconstruction of the seismic wavefield. The sensor candidate matrix, which presents the sensitivity of each sensor candidate to the wavefield, is constructed using simulations of the seismic wavefield with the horizontally layered subsurface structure model. Then, the sparse sensor positions are determined by the greedy method based on D-optimality for the optimal experimental design. Finally, the parameters related to the source and local subsurface structure are estimated using the selected sensors, and the proposed method is evaluated by comparing to the results using random sensor selection.

Keywords: Sparse sensor optimization, Low-dimensional model, model-based approach

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Modeling space-time heterogeneities of hypocenter catalog

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A spatio-temporal model of earthquake detection rate was devised and implemented to enable unbiased prediction of seismic activity and probability from long-term heterogeneous data, even if the earthquake magnitude threshold is reduced.

As seismographs and seismic observation networks develop over time, the number of detected earthquakes will increase significantly over time. In addition, the detection rate of small and medium earthquakes is decreasing with respect to distant offshore from the Japanese archipelago. Thus, the catalog of earthquakes over a long period of time is not homogeneous. In addition, there are many aftershocks immediately after major earthquakes, but many of them cannot be detected and located because their waveforms overlap each other on the seismograph records, making it difficult to determine their hypocentre coordinates. For example, the spatiotemporal changes in detection rates before and after the M9 Tohoku earthquake are extreme and large-scale.

In order to fit a seismic activity model with an analysis that avoids bias, conventional methods limit the time interval and analysis area, and use data restricted to use only earthquakes of magnitude or greater that are fully detectable, but this results in the loss of a large amount of data. This is not only fatal for research and analysis related to long memory and self-similarity, which are common in geophysical sciences, but also seriously hampers research and prediction of seismic activity to be applied to seismic activity directly beneath inland areas, active offshore areas, and the world at large.

On the other hand, we can consider a seismic model that uses non-homogeneous earthquake data by assuming the Gutenberg-Richter law for magnitude frequency and modeling the detection rate of earthquakes of magnitude. For this, we use the cumulative function of the Normal distribution. That is, the parameter of the mean of the Normal distribution (mu value) represents the magnitude at which half of the earthquakes are detected, and the parameter of the standard deviation value (sigma value) relates to the range of magnitudes over which the earthquakes are partially detected. In fact, these parameters are generally assumed to be expressed as a function of time and location, rather than as constants, to investigate spatio-temporal heterogeneity. The best Bayesian inverse solution for this purpose is to use all detected earthquakes to analyze changes in b-values and seismic activity.

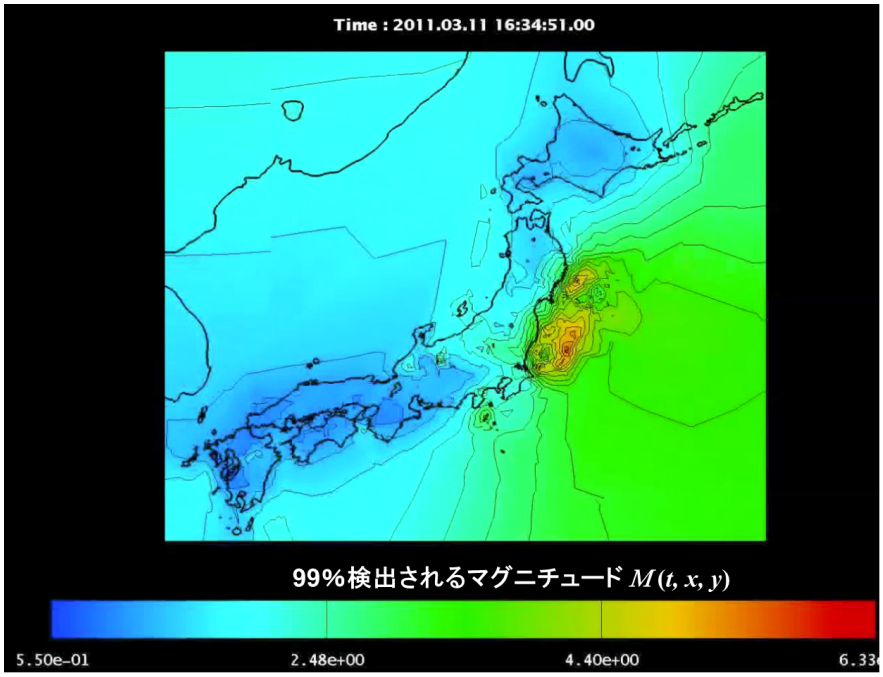
In this presentation, we present the results of the analysis in 2D space plus 1D axis for the epicenter and time of occurrence, ignoring the depths of the earthquakes in the JMA catalog. Therefore, the Delaunay tetrahedral partition by using the earthquake coordinates is effectively constructed. Namely, it is effectively designed to control the computational complexity caused by the huge increase of data after the unification of the sources, and to quantify the sharp incompleteness during a period immediately after large earthquakes. The spatio-temporal b-, mu- and sigma-values are represented by spline functions defined by piecewise linear functions on Delaunay tetrahedra, and the respective weights of the spatial and temporal constraints of smoothing are properly devised and determined by the Akaike Bayesian Information Criterion (ABIC).

The calculated results of the spatio-temporal detection rates and b-value changes for the inland and

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offshore periphery of Japan obtained in this way are visualized in a movie.

Keywords: earthquake magnitude, Detection rates of earthquakes, Gutenberg-Richter law, Space-time partition by Delaunay tetrahedra, Bayesian inversion solution, Akaike Bayesian Information Criterion



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[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.14_2

[S-TT37] Seismic Big Data Analysis Based on the State-of-the-Art of Bayesian Statistics

convener:Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Keisuke Yano(The Institute of Statistical Mathematics), Takahiro Shiina(National Institute of Advanced Industrial Science and Technology)

Recently, a big seismic database has been being constructed that collects data of vibrators implemented in such as buildings, lifelines and smartphones, in addition to seismic data of the conventional continuous/temporal dense seismic observation arrays. Development of methodologies and algorithms, which are inadequate at this moment, optimized to comprehensively analyze the seismic big data is essential in order to utilize the big database as much as possible for prevention/mitigation of earthquake disasters and clarification of earthquake phenomena. On the other hand, recent progress of Bayesian statistics is significant, which is the mathematical basis of various methodologies, such as machine learning, especially deep learning, to extract valuable information from big data. The state-of-the-art of Bayesian statistics is expected to substantially advance seismic big data analyses.
This session mainly accepts presentations that focus on analyses of seismic big data, especially related to analysis methods based on Bayesian statistics such as machine learning, sparse modeling and data assimilation, and their applications to real seismic data. Presentations related to mathematical or statistical theories beneficial to data analyses, feasibility studies of algorithms eventually applicable to real seismic data, and the current status of seismic observations and analysis results are also highly welcome.

[STT37-P01] Clustering seismic noises using semi-supervised learning

*Kotaro Sato[1], Keisuke Yano[2], Komaki Fumiyasu[1] (1.The University of Tokyo, 2.The Institute of Statistical Mathematics)

[STT37-P02] Convolutional Neural Network to Detect Deep Low-Frequency Tremors from Seismic Waveform Images

*Ryosuke Kaneko[1,2], Hiromichi Nagao[2,1], Shin-ichi Ito[2,1], Kazushige Obara[2], Hiroshi Tsuruoka[2] (1.Graduate School of Information Science and Technology, The University of Tokyo, 2.Earthquake Research Institute, The University of Tokyo)

[STT37-P03] A Convolutional Neural Network based classification of local earthquakes and tectonic tremors in Sanriku-oki using a single station S-net data and its generalization ability

*Masayuki Kano[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Keisuke Yano[2] (1.Graduate school of science, Tohoku University, 2.The Institute of Statistical Mathematics)

[STT37-P04] Forecasting temporal variation of aftershocks immediately after a main shock using Gaussian process regression

*Kosuke Morikawa[1], Hiromichi Nagao[2,3], Shin-ichi Ito[2,3], Yoshikazu Terada[1,4], Shin'ichi Sakai[2,5], Naoshi Hirata[2,6] (1.Osaka University, 2.Earthquake Research Institute, The University of Tokyo,, 3.Graduate School of Information Science and Technology, 4.Center for Advanced Intelligence Project, 5.Interfaculty Initiative in Information Studies, The University of Tokyo, 6.National Research Institute for Earth Science and Disaster Resilience)

[STT37-P05] Detection of deep low-frequency earthquakes based on matched filter technique using mutual information

*Ryo Kurihara[1], Aitaro Kato[1], Hiromichi Nagao[1,2], Sumito Kurata[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Graduate School of Information Science and Technology, The University of Tokyo)

[STT37-P06] Adjoint-based uncertainty quantification of frictional inhomogeneity on slow-slipping fault

*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1] (1.The University of Tokyo, 2.Tohoku University)

[STT37-P07] Sensor selection for seismic wavefield reconstruction based on sparse observation (Part II: Preliminary study on method based on data-driven low-dimensional model)

*Takayuki Nagata[1], Kumi Nakai[1], Yuji Saito[1], Taku Nonomura[1], Masayuki Kano[1], Shin-ichi Ito[2], Hiromichi Nagao[2] (1.Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

Clustering seismic noises using semi-supervised learning

*Kotaro Sato[1], Keisuke Yano[2], Komaki Fumiyasu[1]

1. The University of Tokyo, 2. The Institute of Statistical Mathematics

Seismic records contain various kinds of seismic activity (such as normal and weak tectonic tremors) and noise signals. An example of noise signals is ambient noise signals caused by atmospheric pressure fluctuation[1], temperature change[2], waves and wind[3]. Another example is noise signals due to human activities such as automobiles, trains, air-planes, and wind power generation[3]. Appropriate classification of a wide variety of seismic activities and noises leads to not only the improvement of seismic detection accuracy but also the understanding of surrounding ground and site characteristics[4].

Noise is usually classified by unsupervised learning because it is difficult to label noise signals. Johnson et al.[5] used the K-means method to cluster the noise signals after removing obvious earthquake signals. Complete earthquake detection is difficult so noise signals contain earthquake signals that have been manually missed [6]. However, we found that regular earthquake signals are uniformly distributed when we apply the model trained by Johnson et al.'s method to regular earthquake signals.

In this study, we propose a semi-supervised learning method that uses known seismic records as labeled data to appropriately cluster other weak noise waveforms while organizing labeled seismic data into a cluster. We first employ t-Distributed Stochastic Neighbor Embedding(t-SNE) to reduce the dimensionality. We next use a semi-supervised mixed Gaussian model and perform classification using its likelihood.

The accuracy of the proposed method is verified using the vertical acceleration waveform records acquired by the seismograph array of the Metropolitan Area Seismic Observing Network (MeSO-net). As a result, we confirmed that the seismic waveforms are clustered more tightly in terms of the log-likelihood. The characteristics of the frequency and amplitude of the data belonging to each cluster will be reported.

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Keywords: seismic noise, semi-supervised learning, classification

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Convolutional Neural Network to Detect Deep Low-Frequency Tremors from Seismic Waveform Images

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1. Graduate School of Information Science and Technology, The University of Tokyo, 2. Earthquake Research Institute, The University of Tokyo

The establishment of Hi-net [1, 2] led to the discovery of deep low-frequency tremors [3]. Considering the expected relations between tremors and large earthquakes (*e.g.*, [4]), it is important to investigate tremors that occurred before establishing the dense seismometer arrays. Past seismometers used more than 50 years ago drew waveforms continuously on paper wrapped on a drum. The digitization of seismograph paper records by tracing the waveforms is effective for investigating large earthquakes because such waveforms are distinctive and consequently extractable given the low frequencies and large amplitudes. In contrast, tremors have much smaller amplitudes and higher frequencies than large earthquakes, so their digitization is much more difficult due to overlapping waveforms. Therefore, we use a convolutional neural network (CNN) aiming to detect evidence of tremors from seismograph paper records. The CNN is a representative deep learning method that exhibits high performance in tasks such as image recognition and handwriting recognition. A CNN can automatically tune its internal parameters by learning the characteristics of tremors from input images without requiring prior knowledge of tremors or manually adjusting the parameters. Training a CNN from scratch with real data polluted by a variety of noises may hinder the model construction and hyperparameter tuning. Thus, we conducted numerical experiments to train a CNN with synthetic images generated according to seismograph paper records. We constructed the CNN based on the ResNet [5] architecture for better performance. The results show that the trained model can learn tremor features and correctly determine the presence of tremors in the seismic waveforms. In addition, heatmaps generated based on gradient-weighted class activation mapping (Grad-CAM) [6] clearly indicate the tremor location on each image. These suggest that a CNN can be a promising alternative for effective tremor detection compared to individual waveform extraction through digitization. Based on the finding from the experiments, we will conduct CNN training with real data and apply the trained model to seismograph paper records.

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on Computer Vision (ICCV). pp. 618–626 (2017). doi: 10.1109/ICCV.2017.74

Keywords: Deep low-frequency tremor, Convolutional neural network, ResNet, Grad-CAM

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A Convolutional Neural Network based classification of local earthquakes and tectonic tremors in Sanriku-oki using a single station S-net data and its generalization ability

*Masayuki Kano[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Keisuke Yano[2]

1. Graduate school of science, Tohoku University, 2. The Institute of Statistical Mathematics

Slow earthquakes characterized by a longer duration compared to regular earthquakes in the same magnitude have been widely detected in many tectonic zones (e.g., Obara and Kato, 2016). Tectonic tremors are a kind of slow earthquakes and have been often located in the adjacent areas of megathrust zones. Therefore, monitoring spatio-temporal activities of tremors provides important clues to slow fault slips.

Envelope correlation method (ECM) has been widely used to detect tremors. Although the ECM is a powerful tool for tremor detections, it principally detects signals of earthquakes as well. To classify local earthquakes, tremors and noise, Nakano et al. (2019) developed a supervised, convolutional neural network (CNN)-based method. They adopted spectrograms obtained by DONET ocean seismometers deployed in the Nankai subduction zone as input images for the CNN and attained 99.5% accuracy of classifications.

Here, we attempt to classify local earthquakes, tremors, and noise observed by S-net in northeast Japan following the approach developed by Nakano et al. (2019). However, S-net seismometers have a characteristic period of 15 Hz and thus are less sensitive to the dominant frequencies of tremors (2-10 Hz) compared to the DONET seismometers. Therefore, we modify the structures and retrain the parameters in the CNN developed by Nakano et al. (2019) to adjust the S-net data. As a first step, this study attempts to classify the known local earthquakes, tremors, and noise by the CNN using a single station to investigate how our CNN works for our final purpose of monitoring tremor activities.

We used spectrograms of three component velocity waveforms for 2 minutes in the time domain and for 2-10 Hz in the frequency domain that are obtained from 16 August 2016 to 14 August 2018, at N. S4N21, located off-Sanriku. As training data for CNN, we utilized JMA unified catalog for local earthquakes with epicentral distances smaller than 80 km, and tremor catalog (Nishikawa et al. 2019). We divided the whole data periods into two data sets; waveforms from 16 August 2016–2 December 2017 were used for training and those December 2017–14 August 2018 were used for validation.

As a result, the CNN truly classified 100, 96 and 98 % of local earthquakes, tectonic tremors and noise, respectively. The output probabilities for the true classification of earthquakes and tremors have become smaller with an increasing epicentral distance and that for the true classification of earthquakes with a smaller magnitude. This indicates that the probabilities to be judged as a true classification depend on the signal to noise ratio of the original record.

In this presentation, we will also show the classification results when applying the CNN trained at N.S4N21 to the untrained surrounding S-net stations and discuss the generalization ability of the CNN.

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Keywords: Slow earthquakes, S-net, CNN

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Forecasting temporal variation of aftershocks immediately after a main shock using Gaussian process regression

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Uncovering the distribution of magnitudes and arrival times of aftershocks is a key to comprehending the characteristics of earthquake sequences, which enables us to predict seismic activities and conduct hazard assessments. However, identifying the number of aftershocks immediately after the main shock is practically difficult due to contaminations of arriving seismic waves. To overcome this difficulty, we construct a likelihood based on the detected data, incorporating a detection function to which Gaussian process regression (GPR) is applied. The GPR is capable of estimating not only the parameters of the distribution of aftershocks together with the detection function, but also credible intervals for both the parameters and the detection function. The property that the distributions of both the Gaussian process and aftershocks are exponential functions leads to an efficient Bayesian computational algorithm to estimate hyperparameters. After its validation through numerical tests, the proposed method is retrospectively applied to the catalog data related to the 2004 Chuetsu earthquake for the early forecasting of the aftershocks. The results show that the proposed method stably and simultaneously estimates distribution parameters and credible intervals, even within 3hours after the main shock.

Keywords: Statistical seismology, Time series analysis, Gaussian Process Regression

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Detection of deep low-frequency earthquakes based on matched filter technique using mutual information

*Ryo Kurihara[1], Aitaro Kato[1], Hiromichi Nagao[1,2], Sumito Kurata[2]

1. Earthquake Research Institute, The University of Tokyo, 2. Graduate School of Information Science and Technology, The University of Tokyo

Matched filter technique is often used to detect microearthquakes such as deep low-frequency(DLF) earthquakes occurred in plate subduction zones or volcanic regions. Matched filter technique is usually based on the summed correlation coefficients between the template waveform and the observed data at multiple observation stations. However, the detection accuracy decreases when there are not enough observation stations or enough templates. Then, matched filter technique is able to be applied to only limited cases. In this study, we developed a new method of the matched filter technique using only one station data to evaluate the similarity of waveforms by calculating not only the correlation coefficient but also mutual information.

In the method, waveforms in a wide frequency band were used and the product of mutual information and correlation coefficient was used as an index for detection. Mutual information is an index which show relationships between two variables including non-linear relationship. Mutual information was calculated by normalizing the amplitude of the template waveform and the amplitude of the continuous waveform for all time steps in the time window. The normalized amplitudes were divided into a cell out of 5×5 cells.

First, we tested the new method on a dataset of artificial noise waveforms in which a waveform of DLF earthquakes is added to. As a result, it was confirmed that for both cases of white noise and sinusoidal noise of 1.25 Hz which corresponds to the dominant frequency of DLF earthquakes, the product of mutual information and correlation coefficient has a clear peak corresponding to the signal of the earthquake, compared to the case which only correlation coefficient is used.

Next, we used 200 template waveforms and applied the method to the data of Kirishima volcano in December 2010 before the eruptions of 2011. We detected 354 DLF earthquakes using the new matched filter technique using the product of mutual information and correlation coefficient at one station, while only two earthquakes were detected in the catalog of Japan Meteorological Agency in this term. Compared to the results of the matched filter technique using summed correlation coefficient of six stations, we missed only 8 events out of 88 events that had a high probability of DLF earthquakes, and 302 out of 354 events were events to be regarded as events with low probability of false detection.

In the case of using six stations, only small peaks which is not over a threshold value were obtained for some templates because the correlation coefficient changes due to slight differences in the source location and waveform characteristics of the templates. Therefore, it is necessary to use a large number of templates for the matched filter technique of multiple stations. On the other hand, in the case of one-station matched filter technique, even such template had a clear peak over the threshold value of detection.
In conclusion, it is considered that even when using data of only one station, it is possible to create an accurate catalog of DLF earthquakes by using the matched filter technique using the product of the correlation coefficient and the mutual information as the index of detection.

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Keywords: Matched filter technique, Deep low-frequency earthquake, Mutual information

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Adjoint-based uncertainty quantification of frictional inhomogeneity on slow-slipping fault

*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1]

1. The University of Tokyo, 2. Tohoku University

Slip motion along a fault largely depends on the inhomogeneity of friction that occurs between the fault interfaces. Thus, it is a crucial task to estimate the spatial-dependent frictional features from the observations of the slip motion and then to identify essential parts that contribute to the principal slip motion by quantifying uncertainties involved in the estimates. This study considers an uncertainty quantification problem of the spatially-dependent frictional features based on a fault motion model that mimics the slow-slipping region along the Bungo Channel in the southwestern part of Japan. The fault motion model employs a rate-and-state dependent friction law, in which the frictional parameters are spatially dependent. Although uncertainty quantification in high-resolution is needed to attain the above task, such quantification based on the conventional statistical ways is computationally hard since the complexity exponentially increases with the spatial resolution. This study employs a variational data assimilation method based on a second-order adjoint method to avoid such complexity. Since the data assimilation method enables a selective extraction of the uncertainty of interest, we can attain a fast uncertainty quantification of the frictional parameters in high-resolution. The application of the data assimilation to the fault motion model together with the synthetic observational data of the slip velocity quantifies the spatial dependency of the uncertainty involved in the frictional parameters in high-resolution and reveals how the amount or quality of the observational data of the slip motion influences to the spatial distribution of the frictional parameters. Such quantification provides valuable information to the observational design.

Keywords: Uncertainty quantification, Frictional feature

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Sensor selection for seismic wavefield reconstruction based on sparse observation (Part II: Preliminary study on method based on data-driven low-dimensional model)

*Takayuki Nagata[1], Kumi Nakai[1], Yuji Saito[1], Taku Nonomura[1], Masayuki Kano[1], Shin-ichi Ito[2], Hiromichi Nagao[2]

1. Tohoku University, 2. Earthquake Research Institute, The University of Tokyo

In the present study, we conducted a preliminary study on data-driven sensor selection for seismic wavefield reconstruction based on sparse observation. Simulations of the seismic wavefield with the horizontally layered subsurface structure model were performed under various conditions and were extracted the modes of the seismic wavefield. Sensors suitable for accurate seismic wavefield reconstruction were selected based on the modes of the extracted seismic wave.

Keywords: data-driven science, low-dimensional model, sparse sensing

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[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.17 Zoom Room 17

[S-CG42] Frontier of Understanding Earth's Interior and Dynamics

convener:Hiroko Watanabe(Research Center for Neutrino Science, Tohoku University), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Chairperson:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology)

The physical, compositional, and biological state of the present day Earth is a product of a myriad dynamical process over the last 4.5 billion years resulting in a complexly layered structure (core-mantle-crust-biosphere-atmosphere) with various exchanges between layers. Accretion and early differentiation resulted in a gravitationally stabilized metallic core, and a silicate Earth that rapidly degassed and differentiated to form a crust-ocean system and a distinctive distribution of the radiogenic, heat producing elements in the Earth.
Significant discussion continues on the planform of mantle convective, the structure, mineralogy and composition of the mantle. The role of biology in shaping the oxygen content of the atmosphere, the oxidation state and composition of the crust and possibly that of the mantle is increasingly being recognized and documented. Paramount in the advancement of our science is the role that technological development. Advances in seismic imaging of Earth's interior, drilling deep into the crust and mantle, sensing the deep biosphere, measuring differences in the surface flux of geoneutrinos are transforming our understanding of the Earth.
Contributions from biology, seismology, geochemistry, geodynamics, mineral physics and neutrino geophysics are welcomed to this interdisciplinary session that will provide new constraints on and insights into Earth.

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

[SCG42-01] Study of the Earth’s interior with high energy neutrinos

★Invited Papers

*Carsten Rott[1,2] (1.University of Utah, 2.Sungkyunkwan University)

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

[SCG42-02] Exploring the deep biosphere-frontier beneath the ocean: A geobiological perspective on the oceanic crust and the underlying upper mantle

★Invited Papers

*Fumio Inagaki[1] (1.Mantle Drilling Promotion Office, Institute for Marine-Earth Exploration and Engineering (MarE3), Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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

[SCG42-03] **Reference models of Earth’s bulk structure and heterogeneity from full-spectrum tomography**

★Invited Papers

*Pritwiraj Moulik[1], Göran Ekström[2] (1.Department of Geology, University of Maryland, College Park, MD, USA, 2.Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA)

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

[SCG42-04] On the long-term evolution of the geomagnetic field: A link between geodynamics and planetary habitability

★Invited Papers

*Takashi Nakagawa[1,2] (1.Kobe University, 2.Hiroshima University)

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

[SCG42-05] **Mohole to Mantle *M2M*** Drilling Project and ***951*-Full Proposal**: Drilling Mature Oceanic Crust on North Arch Off-Hawaii

★Invited Papers

*Susumu Umino[1,2], Fumio Inagaki[2], Damon A H Teagle[3], Mikiya Yamashita[2,4], Gregory F Moore[5], Benoit Ildefonse[6], Steven D'Hondt[7], Laura Crispini[8], Takeshi Hanyu[2], Michael O Garcia[5], Tomoaki Morishita[1,2] (1.Kanazawa University, Japan, 2.JAMSTEC, Japan, 3.University of Southampton, UK, 4.Geological Survey of Japan, AIST, Japan, 5.University of Hawaii, USA, 6.University of Montellier & CNRS Best B, France, 7.University of Rhode Island, USA, 8.University of Genova, Italy)

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

[SCG42-06] Discussion

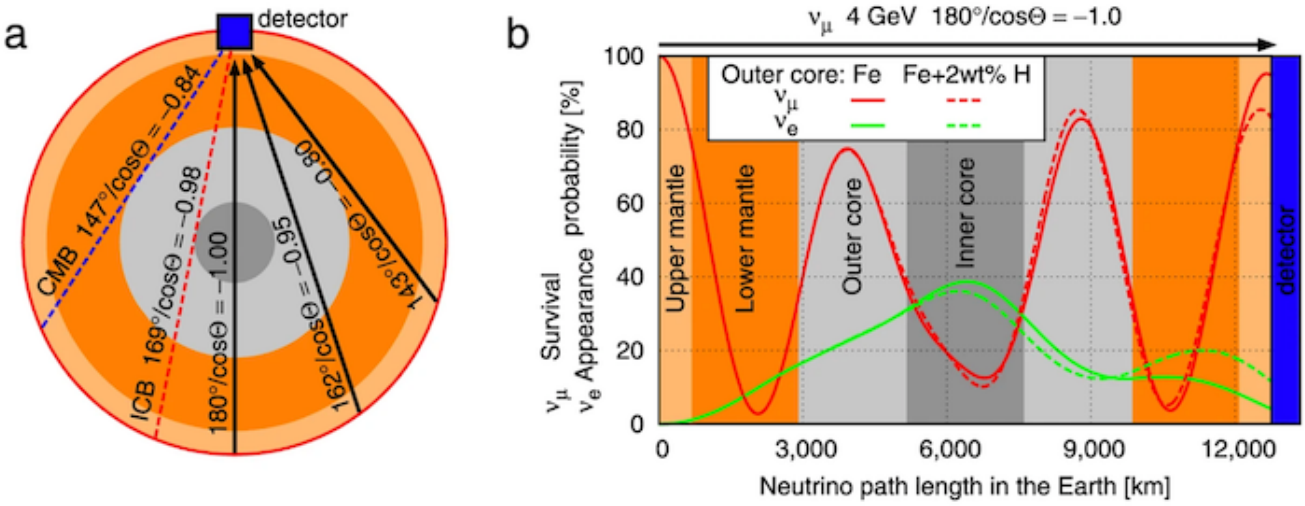
Study of the Earth’ s interior with high energy neutrinos

*Carsten Rott[1,2]

1. University of Utah, 2. Sungkyunkwan University

Neutrinos produced naturally in the atmosphere or at astrophysical sources traverse the Earth and can provide clues about our home planet's interior structure and composition.
Matter induced neutrino oscillations depend on the Earth's electron density, while seismic measurements are sensitive to the matter density. This difference provides sensitivity to test the Earth's chemical composition by combining observations from large neutrino detectors with seismic measurements.
Further highest energy neutrinos get absorbed in the Earth with a probability that depends on the mass density along their path providing sensitivity to measurements of the density profile. The presentation will introduce current measurements conducted with IceCube Neutrino Telescope and discuss the science potential of the next generation of large volume neutrino detectors and telescopes including Hyper-K, KM3NeT, IceCube-Gen2.

Keywords: Neutrino Oscillation Spectrography, Neutrino Absorption Tomography, Neutrino Telescopes, IceCube, Neutrinos



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Exploring the deep biosphere-frontier beneath the ocean: A geobiological perspective on the oceanic crust and the underlying upper mantle

*Fumio Inagaki[1]

1. Mantle Drilling Promotion Office, Institute for Marine-Earth Exploration and Engineering (MarE3), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Over the last two decades, multiple scientific ocean drilling explorations have revealed the existence of an abundant and diverse microbiome deep beneath the ocean floor, which is comparable to those living in the top-soils and seawater on the Earth's surface [1]. Although their activity is maintained at levels close to the theoretical limits of sustaining essential life functions on geological time scales, they are revivable [2], temperature-sensitive [3], and contribute to global material cycles associated with plate tectonics. What are the conditions and limits to life in the Earth's interior deep beneath the ocean floor? What are their origins, evolution, and consequences? How will life continue to shape Earth? Given the fact that the subseafloor biosphere is situated on a thin, mobile layer between the ocean and the mantle on our planet Earth, these questions ultimately be linked to the water-life-crust/mantle interactions and its dynamics. Exploring the entire sequence of oceanic crust down to drilling's accessible limit in the upper mantle will significantly expand our current knowledge of planetary systems [4]. Continued international, transdisciplinary collaborations among geoscience communities are essential for illuminating the trajectory of our planet's habitability and sustainability.

[1] Hoshino, T., Doi, H., Uramoto, G.-I., Wömer, L., Adhikari, R. R., Xiao, N., Morono, Y., D'Hondt, S., Hinrichs, K.-U., and Inagaki, F. (2020) Global diversity of microbial communities in marine sediment. Proc. Natl. Acad. Sci. USA, 117, 27587-27597.
[2] Morono, Y., Ito, M., Hoshino, T., Terada, T., Hori, T., Ikehara, M., D'Hondt, S., and Inagaki, F. (2020) Aerobic microbial life persists in oxic marine sediments as old as 101.5 million years. Nature Communications, 11, 3626.
[3] Heuer, V. B., Inagaki, F., Morono, Y., et al. (2020) Temperature limits to deep subseafloor life in the Nankai Trough subduction zone. Science, 370, 1230-1234.
[4] Inagaki, F., and Taira, A. (2019) Future opportunities in scientific ocean drilling: Illuminating planetary habitability. Oceanography, 32, 212-216.

Keywords: scientific ocean drilling, deep subseafloor biosphere, planetary habitability

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Reference models of Earth’s bulk structure and heterogeneity from full-spectrum tomography

*Pritwiraj Moulik[1], Göran Ekström[2]

1. Department of Geology, University of Maryland, College Park, MD, USA, 2. Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA

Radial reference Earth models describe average (1-D) physical properties indicative of the bulk composition and dominant processes within the Earth's interior. Tomographic (3-D) models represent contiguity, strength and extent of heterogeneity in intrinsic properties like temperature, composition, grain size, or crystal structure. In contrast to classical radial reference models, we account for the intertwined theoretical and observational effects of lateral heterogeneity on the inferences of bulk structure. Reference datasets and modeling concepts introduced here provide an accurate way to calibrate, validate and infer the average properties of a heterogeneous Earth.

Progress in modeling the Earth’s interior is driven by diverse seismic data, ranging from full seismic waveforms and derivative measurements of body waves (~ 1 –20 s), surface waves (~ 20 –300 s), and normal modes (~ 250 –3300 s). Full-spectrum tomography employs these observations to constrain physical properties –seismic velocity, anisotropy, density, attenuation and the topography of discontinuities. We construct a reference bulk Earth dataset with normal-mode eigenfrequencies and quality factors, surface-wave dispersion curves, body-wave impedance constraints and travel-time curves, and astronomic-geodetic observations. This dataset represents better geographic coverage, wider variety of techniques, reduced uncertainties, and broader frequency range than those used in earlier radial models. New observations indicate reduced seismic velocities in both top and bottom boundary layers of the mantle and strong gradients in the outermost outer core.

We describe three concepts that account for the influence of lateral heterogeneity in the modeling of average elastic, anelastic and density variations from reference datasets. First, horizontal wavelength of the heterogeneity is widely assumed to be much greater than that of the corresponding normal mode in both ray-theoretical and finite-frequency modeling of traveling waves. Discrepancies in local eigenfrequencies due to the unaccounted for volumetric sensitivity with this approximation exceed the data uncertainty for both long-period fundamental spheroidal (Rayleigh waves, T ≧ 200 s) and toroidal modes (Love waves, T ≧ 100 s). Second, non-linear effects from the strongly heterogeneous crustal structure are substantial even for waves that are within the validity limits of the local-eigenfrequency approximation. Non-linear crustal effects on the propagation phase velocity at short periods (T ≦ 100 s) can be substantial compared to the average dispersion observed globally (≧ 40%); contributions from lateral heterogeneity cannot therefore be averaged out linearly in derivations of radial models. Third, current ray coverage of traveling waves results in a substantial bias towards the continental structure in the Northern Hemisphere from available seismic networks.

A new radial reference model (NREM1D) is constructed to account for nonlinear effects due to strong crustal variations and geographic bias in sampling heterogeneities. All physical parameters in NREM1D vary smoothly between the Moho and 410-km discontinuity, thereby excluding the 220-km discontinuity imposed *a priori* in some earlier models. Radial anisotropy in the upper mantle, with revised estimates (1--2% $v_{SH}>v_{SV}$) in the mantle lithosphere (24.4 –80 km) and peak anisotropy (~3.5% $v_{SH}>v_{SV}$) corresponding to a deforming asthenosphere (~ 150 km), is necessary to fit recent average dispersion

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curves between 25--250 s. The upper mantle is more attenuating than deeper regions with the lowest Q_{μ} ~ 80 between 150--180 km depth. NREM1D is the first anisotropic model that predicts arrival times of major mantle and core phases in agreement (±0.5 s) with widely used isotropic velocity models that were optimized for earthquake location. NREM1D is readily extendable due to its modular construction and represents accurately the average properties of Earth's bulk constituents.

Keywords: Mantle, Surface Waves, Body Waves, Normal Modes, Geodesy, Core

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On the long-term evolution of the geomagnetic field: A link between geodynamics and planetary habitability

*Takashi Nakagawa[1,2]

1. Kobe University, 2. Hiroshima University

Here, I introduce a brief review on how the long-term evolution of the geomagnetic field plays a key role in dynamics and evolution of Earth’s deep interior. For revealing the long-term variations of the geomagnetic field, the measurement of paleointensity is used, but it is quite controversial for giving various interpretations on dynamics and evolution of Earth’s deep interior by using the paleomagnetism data only. In order to provide a better interpretation, the geodynamics approach is essential because the long-term evolution might be controlled by the plate tectonics driven by the mantle convection, which is a coupled core-mantle evolution model in mantle dynamics simulations or semi-analytical computations of parameterized mantle dynamics. For evaluating the magnetic evolution, there are two approaches –1. Estimate of heat by the magnetic dissipation and 2. Evaluation of the convective power. Both approaches give similar results and interpretations, but the convective power approach gives a better interpretation on the magnetic evolution, because this approach may use all the required energy sources on generation of the magnetic field. For understanding the current constraints on paleomagnetic data, the heat flow across the core-mantle boundary is the most important quantity, ranging from around 10 to 15 TW at the present-day in geodynamics modeling. An additional important quantity is the thermal conductivity of Earth’s core because this quantity strongly affects the convective power of Earth’s core, which should be less than around 110 W/m/K to maintain the magnetic field generation before the inner core nucleation got started. The long-term evolution of the geomagnetic field also plays a significant role in planetary habitability because the geomagnetic field can work for shielding us from the harmful solar radiation. I also discuss this aspect in presentation.

Keywords: Paleomagnetism, Core-mantle dynamics, Habitability

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Mohole to Mantle *M2M* Drilling Project and *951*-Full Proposal: Drilling Mature Oceanic Crust on North Arch Off-Hawaii

*Susumu Umino[1,2], Fumio Inagaki[2], Damon A H Teagle[3], Mikiya Yamashita[2,4], Gregory F Moore[5], Benoit Ildefonse[6], Steven D'Hondt[7], Laura Crispini[8], Takeshi Hanyu[2], Michael O Garcia[5], Tomoaki Morishita[1,2]

1. Kanazawa University, Japan, 2. JAMSTEC, Japan, 3. University of Southampton, UK, 4. Geological Survey of Japan, AIST, Japan, 5. University of Hawaii, USA, 6. University of Montellier & CNRS Best B, France, 7. University of Rhode Island, USA, 8. University of Genova, Italy

The goal of the ***MoHole to Mantle*** (***M2M***) project is to drill into the upper mantle, through intact oceanic crust formed at a fast spreading rate. The bathymetry and seismic structure of fast-spread crust are relatively uniform, and the great majority of crust subducted into the mantle during the past 200 Ma was produced at fast spreading ridges. Many first-order hypotheses about crustal accretion and interaction between the lithosphere, hydrosphere, and biosphere can and will be tested by drilling to the Mantle.

Full penetration and sampling of the upper mantle, the Mohorovičić discontinuity (Moho), and intact crust in oceanic lithosphere will provide hitherto unattainable information on the composition, microstructure, and melting of the upper mantle, the construction and cooling of oceanic crust, the biological and chemical exchanges between the crust and oceans, and the linkages between these processes.

Despite more than a half century's effort, we have not yet managed to reach kilometers below the seafloor to the Moho and the underlying mantle. A major technical obstacle to establishing a drill hole several kilometers deep is collapse of an uncased borehole, due to substantial lithostatic load and increasing temperatures. To prevent borehole collapse, riser-drilling technology is required to stabilize the borehole and remove cuttings. In 2005, the riser-drilling vessel *D/V Chikyu* was commissioned with the expressed ultimate goal to explore the upper mantle. After 15 years of riser operations by *Chikyu*, mantle drilling now comes into the realm of technical feasibility. Consequently, it is imperative to initiate the foundational steps for upper-mantle drilling in the near future, to prepare for successfully drilling a complete section of the oceanic crust and upper mantle during the 25 to 30 years of *Chikyu* operational lifetime.

In October 2021, we submitted **IODP proposal 951-Full** to use *Chikyu* on the North Arch off Hawaii, to drill a complete section down to cumulate gabbros of mature 80-Ma upper oceanic crust at a half spreading rate of 3.5 cm/a. This region is one of the three candidate sites of the ***M2M*** project. Our overarching goal is to drill a pilot hole to inform the design of a future MoHole and gain experience in deep hard-rock drilling with *Chikyu*.

The average age of Earth's oceanic crust is ~63 Ma and the average age of oceanic crust being subducted is ~79 Ma. Although, there are some drillholes in old (>110 Ma) and young (<20 Ma) oceanic crust, there is no deep hole (>100 m) into mature intact average-age oceanic crust that records the full history of seawater-basalt exchange.

With the proposed drilling, we will investigate the physical, chemical, and biological architecture and evolution of the oceanic crust to test three major hypotheses, that: 1) the North Arch crust spread at an intermediate rate will comprise an intact 740–820 m-thick extrusive sequence, overlying a thick

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(880-1770 m) sheeted dike complex; 2) hydrothermal exchanges between the oceanic crust and seawater are episodic and the extent of fluid-rock exchange does not just reflect the age of the crust but also external factors that enhance fluid flow and reaction; and 3) in oceanic crust cooler than the thermal limit to life, water-rock interactions sustain microbial life as deeply as seawater-derived fluid penetrates. Drilling will provide additional insights into North Arch volcanism and hazardous giant landslides from the Hawaiian volcanoes.

The drilling operation will be conducted in three stages. Stage 1 will entail coring sediment to below the sediment-basalt interface (Hole A), drilling and coring basement to 1130 mbsf and setting casing (Hole B). Stage 2 (Hole B) will be coring and setting casing to 1730 mbsf. Stage 3 will entail coring to 2500 mbsf and penetrating through the Layer 2-3 transition and into the uppermost cumulate gabbros without casing.

Keywords: MoHole, Off-Hawaii upper crust drilling 951-full proposal, Upper crustal architecture, Hydrothermal process, Deep biosphere, Seafloor Drilling

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[E] Oral | S (Solid Earth Sciences) | S-CG Complex & General

[S-CG42] Frontier of Understanding Earth's Interior and Dynamics

convener:Hiroko Watanabe(Research Center for Neutrino Science, Tohoku University), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan), Chairperson:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology)

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.17 (Zoom Room 17)

The physical, compositional, and biological state of the present day Earth is a product of a myriad dynamical process over the last 4.5 billion years resulting in a complexly layered structure (core-mantle-crust-biosphere-atmosphere) with various exchanges between layers. Accretion and early differentiation resulted in a gravitationally stabilized metallic core, and a silicate Earth that rapidly degassed and differentiated to form a crust-ocean system and a distinctive distribution of the radiogenic, heat producing elements in the Earth.

Significant discussion continues on the planform of mantle convective, the structure, mineralogy and composition of the mantle. The role of biology in shaping the oxygen content of the atmosphere, the oxidation state and composition of the crust and possibly that of the mantle is increasingly being recognized and documented. Paramount in the advancement of our science is the role that technological development. Advances in seismic imaging of Earth's interior, drilling deep into the crust and mantle, sensing the deep biosphere, measuring differences in the surface flux of geoneutrinos are transforming our understanding of the Earth.

Contributions from biology, seismology, geochemistry, geodynamics, mineral physics and neutrino geophysics are welcomed to this interdisciplinary session that will provide new constraints on and insights into Earth.

3:00 PM - 3:15 PM

[SCG42-06]Discussion

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[E] Poster | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.15_1

[S-CG42] Frontier of Understanding Earth's Interior and Dynamics

convener:Hiroko Watanabe(Research Center for Neutrino Science, Tohoku University), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Tamano Omata(Japan Agency for Marine-Earth Science and Technology), F William McDonough(Department of Earth Science and Research Center for Neutrino Science, Tohoku University, Sendai, Miyagi 980-8578, Japan)

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Accretion and early differentiation resulted in a gravitationally stabilized metallic core, and a silicate Earth that rapidly degassed and differentiated to form a crust-ocean system and a distinctive distribution of the radiogenic, heat producing elements in the Earth.
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Contributions from biology, seismology, geochemistry, geodynamics, mineral physics and neutrino geophysics are welcomed to this interdisciplinary session that will provide new constraints on and insights into Earth.

[SCG42-P01] Model for anomalies in the Love wave dispersion

*Ranjith Kunnath[1] (1.Mahindra University)

[SCG42-P02] Study of Ocean Bottom Detector for observation of geo-neutrinos from mantle

★Invited Papers

*Taichi Sakai[1], Hiroko Watanabe[1], Kunio Inoue[1], William F McDonough[1,2,3], Kenta Ueki[4], Natsue Abe[4], Noriaki Sakurai[4], Masanori Kyo[4], Eiichiro Araki[4], Takafumi Kasaya[4], Hiroshi Yoshida[4] (1.Tohoku University,Research Center for Neutrino Science, 2.Tohoku University, 3.University of Maryland, 4.JAMSTEC)

[SCG42-P03] Understanding the Earth's Interior and Dynamics : Interdisciplinary Approach

*Hiroko Watanabe[1], Kunio Inoue[1], Taichi Sakai[1], William F McDonough[1,2,4], Natsue Abe[5], Eiichiro Araki[3], Takafumi Kasaya[3], Masanori Kyo[3], Noriaki Sakurai[3], Kenta Ueki[3], Hiroshi Yoshida[3], Tamano Omata[3,6], Yasuhiro Yamada[3] (1.Research Center for Neutrino Science, Tohoku University, 2.Department of Earth Science, Tohoku University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Department of Geology, University of Maryland, 5.Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology, 6.Tohoku University Museum)

[SCG42-P04] The origin of Indian Mantle inferred from Re-Os isotopes of chrome spinel

*Yoko Yamashita[1], Susumu Umino[1], Ryoko Senda[2] (1.Kanazawa Univ., 2.Kyushu Univ.)

Model for anomalies in the Love wave dispersion

*Ranjith Kunnath[1]

1. Mahindra University

As is well known, there is a sharp change in the shear wave velocities across the interface between the crust and the upper mantle. If welded contact occurs at the interface, Love waves are generated when the earth is excited such as during an earthquake. However, anomalies in the Love wave dispersion have been observed, for example, by Ekström (2011). A model is presented which seems to capture the observed anomalies. In this model, slipping contact is assumed at the crust-mantle interface and a slip-weakening friction law is assumed to hold. When slipping contact occurs, a new type of an interfacial elastic wave, called the slip wave (Ranjith, 2017) can exist. The slip wave is a companion wave to the Love wave. The occurence of slip waves can explain the anomalies in the observed Love wave dispersion.

Keywords: Love wave, dispersion, slip wave

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Study of Ocean Bottom Detector for observation of geo-neutrinos from mantle

*Taichi Sakai[1], Hiroko Watanabe[1], Kunio Inoue[1], William F McDonough[1,2,3], Kenta Ueki[4], Natsue Abe[4], Noriaki Sakurai[4], Masanori Kyo[4], Eiichiro Araki[4], Takafumi Kasaya[4], Hiroshi Yoshida[4]

1. Tohoku University,Research Center for Neutrino Science, 2. Tohoku University, 3. University of Maryland, 4. JAMSTEC

Observation of geo-neutrinos originating from radioactive isotopes in the Earth (238U,232Th, etc.) can be converted to the amount of radioactive isotopes and the heat generated by their decays which governs the Earth dynamics.
KamLAND experiment achieved world's first observation of geo-neutrinos in 2005. Improvement of observation accuracy allowed us to reach the level where we can obtain geoscientific knowledge. However, it is hard to obtain information of the mantle because 70% of neutrinos observed by detector currently operating or planned are derived from the crust.
Ocean Bottom Detector can observe geo-neutrinos originating from the mantle directly. Unlike existing other neutrino detectors, OBD detects neutrinos on the seafloor. Given that the oceanic crust is thinner than the continental crust and has lower densities of U and Th, ~70% of anti-neutrinos at OBD come from the mantle. Another unique feature of OBD is keeping the distance from the reactors which are the main background sources for continental detectors. In addition, this movable detector can observe at multiple points in the ocean.
Scientists at the University of Hawaii started to discuss the idea of observing the geo-neutrinos on the sea floor 15 years ago as the detector called "Hanohano". Unfortunately, the idea has not been realized yet. In 2019 joint research between Tohoku University and JAMSTEC was started to lead the comprehensive research relating to understanding the Earth's deep interior and realize OBD. We are now working for the prototype detector.

Keywords: geo-neutrino, mantle, solid earth science

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Understanding the Earth's Interior and Dynamics : Interdisciplinary Approach

*Hiroko Watanabe[1], Kunio Inoue[1], Taichi Sakai[1], William F McDonough[1,2,4], Natsue Abe[5], Eiichiro Araki[3], Takafumi Kasaya[3], Masanori Kyo[3], Noriaki Sakurai[3], Kenta Ueki[3], Hiroshi Yoshida[3], Tamano Omata[3,6], Yasuhiro Yamada[3]

1. Research Center for Neutrino Science, Tohoku University, 2. Department of Earth Science, Tohoku University, 3. Japan Agency for Marine-Earth Science and Technology, 4. Department of Geology, University of Maryland, 5. Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology, 6. Tohoku University Museum

The interior of the Earth remains a mystery. It is some 6400 km to the center of the Earth, but we have only drilled 12 km deep and not yet reached the mantle. Seismologists have imaged Earth’ s interior and defined its first order physical structures (e.g. core, lower and upper mantle, and Moho). The compositions of these structures are unknown, at some level, and must be interpret as we do not have techniques to measure their chemistry. To achieve new and unimagined insights into the Earth, we need to broaden our perspective and work across different disciplinary boundaries. New 21st century technologies are providing transformative insights into deep Earth processes and chemistry. We started to construct interdisciplinary community to bring together scientists from physics, engineering and geoscience with a shared goal of the understanding the Earth’ s interior and resolving the mysteries.

Various images of the Earth’ s interior are based on the each investigating methods, such as geoneutrinos, scientific drilling, seismology, simulation, isotope study etc. Integrating the information enable us to create new knowledge and insights into the nature and processes occurring inside the Earth. This presentation will introduce current situation and future prospects of the interdisciplinary approach.

Keywords: geoneutrino, mantle drilling, Earth's deep interior, dynamics

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The origin of Indian Mantle inferred from Re-Os isotopes of chrome spinel

*Yoko Yamashita[1], Susumu Umino[1], Ryoko Senda[2]

1. Kanazawa Univ., 2. Kyushu Univ.

Highly variable isotopic nature of the Indian MORB mantle including Os isotopic ratios ($^{187}Os/^{188}Os$) inherited from long-term depletion and fertilization by convecting mantle since the Archean Eon. Highly depleted harzburgites with low Os isotopic ratios are known as xenoliths in plume-related magmas and the serpentinite seamounts in the Izu-Bonin-Mariana (IBM) forearc regions. Recently, boninites from the IBM forearc were demonstrated to have derived from such depleted harzburgite blocks, which were remnants of the subcontinental lithosphere dispersed beneath the Indian to western Pacific. Fertile component is suggested to have produced by recycled subducted oceanic crust.

Podiform chromitites from ophiolites are generated through interaction of the shallow mantle peridotite and ascending magmas including boninite. The Eocene Zambales Ophiolite in the western Philippines and the late Cretaceous Oman Ophiolite in the Arabian Peninsula yield boninites and podiform chromitites with high Cr# spinel, which are proposed to have crystallized from boninitic magmas. We report textures, mineralogy, and Re-Os isotopic compositions of 6 chromitite samples from the Acoje (AC30) and Coto (CO30) blocks in the Zambales Ophiolite and the Fizh block in the Oman Ophiolite (OM19-63A, OM19-63C, K1-25 and K1-19), and discuss the origin of high Os isotopic ratios of those chromitites.

Major elements were analyzed by EPMA (JEOL JXA-8800) and Re and Os isotopes by N-TIMS (TRITON PLUS, Thermo Fisher SCIENTIFIC) and ICP-MS (Agilent 7500cx), and Re and Os concentrations were calculated by isotope dilution method.

Chromitite samples have chrome spinel with Cr#=40~85 and Mg#=55~75 and olivine with Fo93~97 and NiO <0.9 wt%. High Fo and NiO in olivine resulted from re-equilibration with coexisting spinel at low temperatures (500-800℃). TiO_2 against Cr# of chrome spinels indicates that CO30 of Zambales Ophiolite and OM19-63C and K1-19 of Oman ophiolite were crystallized from MORB-like magma. On the other hand, AC30 of Zambales Ophiolite, OM19-63A and K1-25 of Oman Ophiolite with high-Cr#s are considered to have crystallized from arc magma derived from the more depleted source mantle.

The chromitites with higher Cr# and $\Delta\log(FMQ) > +3$ are consistent with an arc environment, whereas the chromitites with lower Cr# and $\Delta\log(FMQ)$ are more compatible with a back arc origin. It is concluded that CO30, OM19-63C and K1-25 with lower Cr# and $\Delta\log(FMQ)$ formed in a back arc basin, while AC30, OM19-63A and K1-19 with higher Cr# and $\Delta\log(FMQ)$ formed in an arc environment.

The Os isotopic ratios of chrome spinels in chromitites range from 0.127 to 0.130, higher than the depleted MORB mantle of 0.1259 and equal to or slightly higher than the primitive mantle of 0.1296 and chondritic value of 0.1276. These high Os isotopic ratios indicate the presence of materials with high Os isotopic ratios in the mantle. It is possible that recycling and assimilation of crustal material with higher Re contents into the shallow upper mantle yielded the enriched Os isotopic ratios through time, which became the sources of the Zambales and Oman chromitites.

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Keywords: Indian MORB mantle, Podiform chromitite, Zambales Ophiolite, Oman Ophiolite, Re-Os isotope

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.21 Zoom Room 21

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University), Chairperson:Akinori Hashima(Japan Agency for Marine-Earth Science and Technology), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University)

The dynamic behaviors of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses associated with plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, geology, petrology, and geochemistry is necessary, as is the integration of observational, theoretical and experimental approaches. In particular, rheological properties, which are physically affected by fluids in the crust and chemical reactions assisted by fluids, can be resolved only through such an interdisciplinary approach. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, geochemistry and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviors of mobile belts.

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

[SCG50-01] 3D numerical simulation of island arc deformation due to steady plate subduction: Effects of a bend along a trench axis

*Yutaro Mori[1], Yukitoshi Fukahata[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SCG50-02] Effect of the Philippine Sea slab–overriding plate contact on the stress field in the Southwest Japan arc

*Akinori Hashima[1], Takashi Iidaka[1] (1.Earthquake Research Institute, The University of Tokyo)

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

[SCG50-03] A Framework to Understand Deformation in Japanese Islands: Inter-arc Deformation and Intra-arc Deformation

*Yukitoshi Fukahata[1], Tomohisa Okazaki[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.RIKEN)

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

[SCG50-04] Visualization of crustal deformation in a high-strain shear zone by geodetic, geomorphologic, and geologic approaches

★Invited Papers

*Masakazu Niwa[1], Koji Shimada[1], Tsuyoshi Watanabe[1], Akira Goto[1], Shinya Hiratsuka[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency)

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

[SCG50-05] Deciphering 3-dimensional crustal movements before and after the 2011 Tohoku-oki earthquake using principal component analysis

Shuntaro Fukaya[2], *Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University, 2.Graduate School of Environmental Studies, Nagoya University)

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

[SCG50-06] Effects of a crustal heterogeneity in the postseismic deformation of 2008 Iwate-Miyagi Nairiku Earthquake

*Youichiro Takada[1], Yoshiki Takei[2], James Daniel Paul Moore[3], Mako Ohzono[4] (1.Faculty of Science, Hokkaido University, 2.Graduate School of Science, Hokkaido University, 3.Nanyang Technological University, Earth Observatory of Singapore, 4.Earthquake Research Institute, University of Tokyo)

3D numerical simulation of island arc deformation due to steady plate subduction: Effects of a bend along a trench axis

*Yutaro Mori[1], Yukitoshi Fukahata[2]

1. Graduate School of Science, Kyoto University, 2. Disaster Prevention Research Institute, Kyoto University

Island arc-trench systems are characterised by a pair of topography and free-air gravity anomaly that is high on the island arc and low around the trench. These features are observed worldwide without exceptions. However, the physical mechanism of island-arc deformation has not been well understood. To this problem, based on the elastic dislocation theory, Fukahata and Matsu'ura (2016, GJI) calculated the deformation of the island arc lithosphere due to steady plate subduction for a two-dimensional elastic-viscoelastic layered half space. They explained the deformation mechanism of the island arc-trench system by the combination of block rotations of the oceanic and island-arc lithospheres and gravitational restoring of them. However, we cannot neglect the effect of three-dimensional geometry for actual island arc-trench systems. For example, we observe the trench axis has a bend at the junction of the Japan Trench and the Kuril Trench (off the Shimokita Peninsula), where large negative free-air gravity anomalies are observed (Sandwell and Smith. 1997, JGR). The large negative free-air gravity anomalies have been reproduced by numerical models (Hashimoto et.al., 2004, 2008, PAGEOPH), but the physical mechanism of them has not been well understood.

In this study, developing a 3-D numerical model for an elastic-viscoelastic layered half-space (Fukahata and Matsu’ura, 2005, 2006, GJI), we compute displacement rates in the lithosphere caused by steady slip on a plate interface, which has a bend along the trench axis. By changing the bending angle of the trench axis, we investigated the effect of bending on island-arc deformation when the bend of a trench axis is convex toward the island arc. The computation shows that a significant subsidence area appears on the island arc lithosphere around the bend and that the amount and spatial scale of the subsidence become larger as the bend of the trench axis is larger. On the other hand, when the trench axis bends convexly toward the ocean, the significant uplift occurs on the island arc lithosphere around the bend. We also observed that the uplift became larger as the bend of the trench axis is larger.

These results can be reasonably explained by the following mechanism. When the oceanic plate subducts across the trench axis, with a convex bend toward the island arc, the surface mass of the subducting oceanic plate becomes excessive, as understood from the analogy of a tablecloth. Since the upper surface of the oceanic plate and the lower surface of the island arc plate move exactly in the opposite direction due to dislocation, mass deficit inevitably occurs in the island arc plate, which lead to subsidence. When the trench axis bends convexly toward the ocean, the same idea can be applied, that is to say mass deficit on the upper surface of the oceanic plate. Based on this mechanism, the larger the bend angle of the trench axis is, the larger the excess or deficit of mass on the top of the oceanic plate. This is consistent with the results of numerical computation in this model.

Keywords: island arc-trench system, plate subduction, free-air gravity anomaly, crustal deformation, arc-arc junction

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Effect of the Philippine Sea slab–overriding plate contact on the stress field in the Southwest Japan arc

*Akinori Hashima[1], Takashi Iidaka[1]

1. Earthquake Research Institute, The University of Tokyo

The Southwest (SW) Japan arc is formed by the subduction of the Philippine Sea plate, the movement of which is currently northwestward. The regional stress field is east-west compression in general. While the Philippine Sea slab has almost no deformation at the beginning of the subduction, which is inferred by the linear geometry of the Nankai Trough, it is strongly deformed at depth, which is rare compared with the other subducted slabs. In particular, a remarkable folded geometry can be seen under the Nobi plain and the Kii Peninsula, in the middle of the SW Japan arc. A recent receiver function analysis revealed that the Philippine Sea slab strongly indents into the bottom of the lower crust of the overriding plate under the Nobi plain. Above and west of the slab-crust contact zone, a lot of reverse faults develop forming a part of the deformation zone of the Kinki triangle. East of the slab-crust contact zone is the zone of strike slip faults, including the source faults of the 1891 Nobi earthquake, which has been the maximum inland earthquake (M8) ever observed in the Japanese islands. The recently revealed slab-crust contact raises the problem of how it has contributed to such a pattern of crustal activity.

In order the investigate the slab-crust contact, we construct a 3D finite element model including the region. The geometry of the plate interface in the model is taken from the previous study based on the distribution of interplate earthquakes. Previous studies show that the regional inland earthquakes can be explain by the long-term east-west compression. Therefore, we impose the boundary condition of lateral compression, while we ignore the direct effect of subduction of the Philippine Sea slab. On the plate interface, we impose the constraint of no relative vertical movement and allow the relative horizontal movement only in the direction along the Philippine Sea subduction. We also assume that the overriding lithosphere and the slab are elastic and that the region under them are viscoelastic, since we consider the long-term stress loading. We consider the variation of the thickness of the overriding lithospheric between 20 km and 70 km while we fix the thickness of the slab to be 70 km. Taking the standard viscosity value of 10^{19}Pa s, the model achieves the steady stress loading state. In this state, we perform the parameter study for the lithospheric thickness, the angle of the lateral compression, and the maximum depth of the slab.

We first take the lithospheric thickness to be 35 km, the angle of lateral compression to be 0 degree (east-west), and the maximum slab depth to be 100 km, as the reference model, and computed the stress loading rates. The stress rate field at the depth of the seismogenic zone (5-20 km) shows the pattern of reverse-type stress above and west of the slab-crust contact zone and strike-slip type stress east of the slab-crust contact zone. This pattern is well consistent with the observed stress pattern. Then we examine the stressing pattern change with the change of the lithospheric thickness. We obtained similar stressing pattern to the reference model for the lithospheric thickness of or below 40 km, but uniform reverse-type stress pattern for the lithospheric thickness of or more than 50 km. The effect of the angle of lateral compression and the maximum slab depth is negligible.

These results suggest the significant effect of slab-crust contact on the east-west compression in the SW Japan. The lithospheric thickness under the SW Japan is estimated to be 40 km. This model cannot explain the stress pattern of the western SW Japan (the Chugoku district). In this area, the direct effect of the subduction of the Philippine Sea plate might be dominant.

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Keywords: Stress loading, Southwest Japan arc, Philippine Sea slab, Kinki triangle, 1891 Nobi Earthquake, Finite element method

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A Framework to Understand Deformation in Japanese Islands: Inter-arc Deformation and Intra-arc Deformation

*Yukitoshi Fukahata[1], Tomohisa Okazaki[2]

1. Disaster Prevention Research Institute, Kyoto University, 2. RIKEN

Deformation of Japanese islands is quite complicated. Japanese islands are composed of five island arcs: Kuril, Northeast Japan, West Japan, Izu, and Ryukyu. In this paper, we propose to understand deformation of Japanese islands by decomposing it into inter-arc deformation and intra-arc deformation. Of course, we notice that many researchers have already used similar ideas consciously or unconsciously, but we propose to use this idea as a framework to consider Japanese island deformation with a help of a cutting edge result of GNSS data analysis (Okazaki, Fukahata & Nishimura, 2021, JpGU).

Before considering inter- and intra-arc deformation, we need to consider the relation between island arc deformation and subducting oceanic slabs. Subduction of oceanic slabs cause large crustal displacements, but most of them are cyclic. However, subducting oceanic slabs are often the causes of inter- and intra-arc deformation.

Kuril and Northeast Japan arcs are colliding in the EW direction in Hokkaido, which results in Hidaka Mountains. The cause of the collision is the southwestward motion of Kuril arc as a forearc sliver due to oblique subduction of the Pacific plate, but large active faults are not known to bound the forearc sliver. Probably because of that, large strain rates are observed in the forearc of eastern Hokkaido (Okazaki et al., 2021).

Northeast and West Japan arcs are contracting in the EW direction, due to the northwestward motion of the triple junction off Boso (Takahashi, 2006). The boundary of them are usually taken at the Itoigawa-Shizuoka tectonic line, but the result of GNSS data analysis (Okazaki et al., 2021) suggests a wider deformation zone.

Izu arc is colliding with Northeast and West Japan arcs. On the other hand, Ryukyu arc is splitting from West Japan arc in the NS direction in central and southern Kyusyu. According to recent GNSS data, the splitting is more active in southern Kyusyu than in central Kyushu, where Beppu-Shimabara graben passes through (Okazaki et al. 2021).

Representative intra-arc deformations are dextral movement of Median tectonic line, EW extension of Izu arc, and back-arc spreading of Ryukyu arc, which are caused by subduction of oceanic plates. We observe considerable contraction along the Ou-backbone range, while the forearc region from Ibaraki to Nara has relatively small deformation (Okazaki et al., 2021). Some volcanoes also show significant deformation locally (Okazaki et al., 2021).

Keywords: inter-arc deformation, intra-arc deformation, GNSS, strain rate field, Japanese islands

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Visualization of crustal deformation in a high-strain shear zone by geodetic, geomorphologic, and geologic approaches

*Masakazu Niwa[1], Koji Shimada[1], Tsuyoshi Watanabe[1], Akira Goto[1], Shinya Hiratsuka[1]

1. Tono Geoscience Center, Japan Atomic Energy Agency

In Japanese Islands, most active faults were activated millions to 500,000 years ago, and there is no known fault emerged 100,000 years ago or later (Doke et al., 2012, Active Fault Res.). However, it is probable that newborn faults could not be identified by previous surveys, because tectonic landform attributed to such faults is likely unclear.

Owing to a nationwide GNSS network installed since mid-1990s, several high-strain shear zones defined as concentrated regions of strain rates have been recognized (Sagiya et al., 2000, PAGEOPH; Nishimura and Takada, 2017, EPS). Newborn faults are likely concealed in such high-strain shear zones.

As a case study to visualize crustal deformation induced by concealed faults and related structures, we applied integrated approaches of geodesy, geomorphology, and geology to a high-strain shear zone in southern Kyushu, Japan. Previous GNSS data analyses have suggested an occurrence of a sinistral, E-W trend high-strain shear zone in the study area (Nishimura and Hashimoto, 2006, Tectonophysics; Wallace et al., 2009, Geology). Our GNSS observation for recent 4.7 years by a network composed of 10 stations revealed that locking depth and slip velocity of the deeper extension of the fault were estimated to be 8 km and left-lateral slip of 10 mm/year.

In the geomorphological approach, active faults and lineaments in southern Kyushu were mapped by aerial photograph interpretation (Goto et al., 2020, JAEA-Research 2020-013). Whereas there are few active faults with tectonic landforms, concentration of E-W trend lineaments is identified in northwestern Kagoshima, near the center of the sinistral high-strain shear zone detected by the GNSS observation and along the E-W trend aftershock distribution by the 1997 Northwestern Kagoshima Earthquakes (Faculty of Science, Kagoshima Univ., 1997, Rep. CCEP). Based on the aerial photography, we conducted field survey in the area of 20 ×20 km, including the concentrating area of E-W trend lineaments.

The field survey showed that minor faults were common in the study area, though occurrences of crush zones including fault gouge, breccia, and cataclasite were sparse and not continuous. Thus, we estimated stress field from slip data of the minor faults, and compared it with the stress field corresponding to the sinistral high-strain shear zone. First, present stress field in the study area was calculated by inversion from focal mechanisms of microearthquakes (n=181) observed from 06/2002 to 12/2015, using the method by Michael (1987, JGR). The calculated best-fit stress is NE-SW trending σ_1 and NW-SE trending σ_3, consistent with the sinistral high-strain shear zone. Next, we calculated the direction of maximum shear stress when the present best-fit stress affects each minor fault. Then we further calculated misfit angles between real slip directions of minor faults and the calculated directions of maximum shear stress. Spatial distribution of minor faults with small misfit angle (<30°) shows that the densest cluster occurs in the concentrating area of E-W trend lineaments along the aftershock distribution by the 1997 Earthquakes. In addition, the second densest cluster is also E-W trend and occurs in 4 km north of the densest cluster.

In addition, we applied the multiple inverse method (Yamaji, 2000, JSG; Sato et al., 2017, J. Geol. Soc.

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Jpn.) to the slip data of minor faults to determine the orientations of paleostress fields. The calculated stress field in the densest cluster is NW-SE trending σ_3 showing sinistral strike-slip to normal sense for the E-W trend shear zone. The stress field in the second cluster is somewhat different from the densest cluster, but partly includes sinistral sense NE-SW trending σ_1. These findings suggest that the subsurface deformation is localized rather than dispersed in the sinistral high-strain shear zone estimated from the GNSS observation.

This study was funded by the Ministry of Economy, Trade and Industry, Japan as part of its R&D supporting program titled “Establishment of Advanced Technology for Evaluating the Long-term Geosphere Stability on Geological Disposal Project of Radioactive Waste (FYs 2018-2020)”.

Keywords: High-strain shear zone, GNSS observation, Lineament, Multiple inverse method, Southern Kyushu

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Deciphering 3-dimensional crustal movements before and after the 2011 Tohoku-oki earthquake using principal component analysis

Shuntaro Fukaya[2], *Takeshi Sagiya[1]

1. Disaster Mitigation Research Center, Nagoya University, 2. Graduate School of Environmental Studies, Nagoya University

In northeast Japan, significant crustal deformation has been observed by the continuous GNSS network (GEONET) and its pattern drastically changed before and after the 2011 Tohoku-oki earthquake, reflecting various processes such as locking or slipping on the plate subduction interface, activities of inland active faults and volcanoes, and the mechanical properties of the island arc crust. In this study, we attempt to separate the components caused by different deformation sources by applying the principal component analysis (PCA) to 3-dimensional GNSS data. In this study, data matrices for the PCA analysis are created for the preseismic (2004/1-2010/12) and postseismic period (2011/5-2019/12), respectively. As a result, crustal deformation pattern in each time period is represented as a superposition of multiple modes. Each mode is represented by a simple product of a spatial mode representing a spatial pattern of the displacement and a temporal mode representing temporal changes common to all the GNSS stations and their components. The first mode of the preseismic period shows steady-state deformation due to interplate coupling. E-W strain shows a broad contraction field and a localized large contraction (-2.1×10^{-7}/year) along the Ou-backbone range. In contrast, in the postseismic period, relaxation processes with different time constants are found for the first two modes. Depending on the time constant and spatial distribution, the first mode corresponds to steady-state displacement and viscoelastic relaxation with a larger time constant (~213 days), while the second mod corresponds to afterslip with a smaller time constant (~58 days). The contribution of the first mode accounts for 99.8% of the original data, representing the overwhelming dominance of a single mechanism in the postseismic deformation. The E-W strains of the first two modes show extensional strains in the wide area pattern. However, along the Ou-backbone range, the first mode shows a contraction while the second mode shows a larger extension than the surrounding area. The former implies contribution of an inelastic deformation driven by the absolute stress which does not change significantly before and after the earthquake, while the latter reflects an elastic response of elastically heterogeneous medium to rapid stress changes.

Keywords: principal component analysis, crustal deformation, GNSS, 2011 Tohoku-oki earthquake, inelastic deformaiton, postseismic deformation

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Effects of a crustal heterogeneity in the postseismic deformation of 2008 Iwate-Miyagi Nairiku Earthquake

*Youichiro Takada[1], Yoshiki Takei[2], James Daniel Paul Moore[3], Mako Ohzono[4]

1. Faculty of Science, Hokkaido University, 2. Graduate School of Science, Hokkaido University, 3. Nanyang Technological University, Earth Observatory of Singapore, 4. Earthquake Research Institute, University of Tokyo

The Iwate-Miyagi Nairiku Earthquake (hereafter IMNE) occurred on June 14, 2008 (Mj 7.2) at the eastern flank of Mt. Kurikoma, an active volcano. The IMNE is characterized by conjugate fault rupture: west-dipping and east-dipping faults brought about complex surface deformation (e.g., Takada et al., 2009). A relatively large amount of post-seismic deformation has been observed by GNSS surveys (e.g., Ohzono et al., 2012) and InSAR analyses. The post-seismic displacement field at high spatial resolution detected by InSAR should reflect multi-scale crustal heterogeneities in the hypocentral area (e.g., Yoshida, 2001), which, however, has not been investigated so far.

In this study, first, we executed InSAR time-series analysis (SBAS by Berardino et al. 2002) to elaborate the post-seismic displacements in the hypocentral area using a series of SAR images taken by ALOS from descending orbit. During 2.2 years after IMNE, we detected the following signals: (1) LOS length increase at the footwall of the west-dipping fault, (2) LOS shortening at the hanging wall of the east-dipping fault, and (3) LOS shortening to the west of Mt. Kurikoma. We also found that these three signals accumulate with time. The first and the second signals would be due to afterslip on the west- and the east-dipping faults, respectively. The third signal reaches more than 10 cm in ~2 years, which indicates the existence of rheological heterogeneity to the west of Mt. Kurikoma. Interestingly, the location of the third signal coincides with the area of localized subsidence triggered by the 2011 Tohoku-Oki Earthquake (Takada and Fukushima, 2013).

To understand the physical effects of such a crustal heterogeneity, we construct a physical model of the postseismic deformation following IMNE using a numerical code Unicycle (Barbot et al., 2017; Moore et al., 2017) with which we consider fault slip, viscoelastic flow, and those interactions through the stress redistribution. We set the coseismic slip distribution as proposed by Iinuma et al. (2009). We also assume that the fault slip obeys the rate-and-state friction law (Dietrich, 1979; Ruina, 1983). First, we modeled crust-mantle structure as an elastic layer of 20 km thickness overlying a Maxwell viscoelastic substratum following Ohozono et al. (2012). Next, we put a localized viscoelastic volume at 8-20 km depth to the west of Mt. Kurikoma where the viscosity is three times lower than that of the substratum. The numerical result indicates that the postseismic slip on the west-dipping fault expands to the shallower and the deeper portion of the coseismic rupture area with time. Furthermore, the deeper extension of the postseismic slip reaches the low viscosity region to the west of Mt. Kurikoma, and it causes volumetric flow which strongly enhances surface uplift to the west of Mt. Kurikoma and explains LOS shortening there. As a result, our model well explains the time-series of postseismic LOS change obtained by the SBAS analysis. Our model also well explains the LOS length increase to the east of the west-dipping fault through the shallow postseismic slip. Thus, we suggested that localized crustal heterogeneities have the potential to cause a large-scale postseismic deformation through physical interaction with fault slips. Combining our result with the instantaneous subsidence in this area due to the 2011 Tohoku-Oki earthquake (Takada and Fukushima, 2013), we may say that the shallower portion of Mt. Kurikoma is characterized by heterogeneously low elasticity, and the deeper portion is characterized by heterogeneously low viscosity. For the east-dipping fault, the coseismic slip area overlapped with the

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postseismic slip area especially at the shallower portion, which indicates the importance of pre-stress. In the presentation, we mention how the postseismic slip depends on the pre-stress distribution.

Keywords: Intra-plate Earthquake, Viscoelasticity, InSAR, postseismic deformation, crustal heterogeneity

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.21 Zoom Room 21

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University), Chairperson:Katsushi Sato(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo)

The dynamic behaviors of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses associated with plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, geology, petrology, and geochemistry is necessary, as is the integration of observational, theoretical and experimental approaches. In particular, rheological properties, which are physically affected by fluids in the crust and chemical reactions assisted by fluids, can be resolved only through such an interdisciplinary approach. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, geochemistry and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviors of mobile belts.

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

[SCG50-07] The evolving structure and material of normal fault in Yonaguni Island, Okinawa prefecture, Japan

*Kiyokazu Oohashi[1], Haruya Miyaki[1], Makoto Otsubo[2] (1.Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 2.Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology)

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

[SCG50-08] Tectonic development in the Median Tectonic Line and surrounding regions during the Late Cretaceous to Paleogene periods: Spatiotemporal development

★Invited Papers

*Toru Takeshita[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University)

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

[SCG50-09] Relationship between the Northern Osaka Prefecture earthquake and the Arima-Takatsuki Tectonic Line estimated from dense aftershock observations

*Yoshihisa Iio[1], Satoshi Matsumoto[2], Joint aftershock observation group of the Northern Osaka Prefecture earthquake (1.Disater Prevention Research Institute, Kyoto University, 2.Institute of Seismology and Volcanoloty, Kyushu University)

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

[SCG50-10] Fracture as an electrical conduction path under pressure

*Tohru Watanabe[1], Arina Tomioka[2] (1.Faculty of Sustainable Design, University of Toyama, 2.Graduate school of science and engineering, University of Toyama)

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

[SCG50-11] Grain-boundary diffusion creep of olivine and the rheology of the oceanic upper mantle

★Invited Papers

*Kosuke Yabe[1], Takehiko Hiraga[1] (1.Earthquake Research Institute, the University of Tokyo)

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

[SCG50-12] An inversion method of fault-slip analysis to deteremine stress tensor and friction coefficient

*Katsushi Sato[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

The evolving structure and material of normal fault in Yonaguni Island, Okinawa prefecture, Japan

*Kiyokazu Oohashi[1], Haruya Miyaki[1], Makoto Otsubo[2]

1. Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 2. Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology

Map-scale normal faults which trending NE-SW, NW-SE, and E-W directions are widely recognized in Yonaguni Island, the westernmost island of Japan, and these faults clearly displaces the ground surface which is composed of upper Pleistocene coral reef deposits (the Ryukyu Group). Since Yonaguni Island is surrounded by various tectonic elements such as the subducting Philippine sea plate (the Ryukyu trough), the spreading back-arc basin (the Okinawa trough), and the arc-continent collision zone (Taiwan), it is important to know how and when these faults are created to understanding the tectonic process and crustal evolution of island arc. Thus, we have analyzed fault zone structure and paleo-thermal structure in the eastern coast of the island.

In the eastern coast of the island, one of the NE-SW trending faults is widely exposed along the shoreline. The fault zone strikes ENE-WSW direction and dipping 60 degree to the north. In the outcrop, the Ryukyu Group and the Yaeyama Group (middle Miocene) are distributed in the hanging wall and footwall, respectively, suggesting about 70 m normal offset after the deposition of the Ryukyu Group. ~3 m wide fault gouge and fault breccia zone is recognized between the hanging wall and footwall. Also ~40 m wide damage zone is developed in the footwall of the fault. In this presentation, we will discuss the temporal evolution of structure and material of the fault zone.

Keywords: The Okinawa Trough, Fault core, Damage zone, Vitrinite reflectance, Clay mineral, Yaeyama Group

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Tectonic development in the Median Tectonic Line and surrounding regions during the Late Cretaceous to Paleogene periods: Spatiotemporal development

*Toru Takeshita[1]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University

The tectonic development of the Median Tectonic Line (MTL) during the period from the Late Cretaceous to Paleogene has been studied for a long time, and a synthesis on it was given in the Special Issue entitled “Median Tectonic Line of Southwest Japan” published by the Geological Society of Japan in 1980. Here, it has been summarized that the proto-MTL was originated as mylonitic shear zones in the Ryoke granitoids in the Late Cretaceous (Kashio phase), and then the Uppermost Cretaceous Izumi Group was deposited in pull-apart basins formed at the north side of MTL. Subsequently, the Sambagawa metamormorphic rocks in the outer belt was greatly elevated, and juxtaposed against the Ryoke granitoids and Izumi Group before the deposition of the Eocene Kuma Group (the formation of the MTL sensu stricto at the so-called Ichinokawa phase). Further, it has been believed that the Uppermost Cretaceous Izumi Group thrusted over the Eocene Kuma Group at the Tobe phase in the Eocene.

The tectonic development of the MTL had not been studied much since then until Takeshita and co-workers made new discoveries about it after 1990s. Although the fault rocks and kinematics of the MTL at the Kashio phase in the Late Cretaceous have been intensely investigated by e.g. Hara et al. (1986) and Takagi (1986), the kinematics of the MTL during the Paleogene period has remained to be unclear. This is not only because the kinematics of the so-called Ichinokawa phase has not been described at the type locality, but also because most of the Kuma Group has been found to be the Early Miocene, not Eocene in age (Kashima and Takechi, 1996; Narita et al., 1999; Takeshita et al., 2000). In the following, the tectonic development of the MTL from the Late Cretaceous to Paleogene will be summarized including the new discoveries, including some geophysical implications.

(a) Kashio phase in the Late Cretaceous

It has been known that large-scale sinistral shearing occurred along the proto-MTL based on the foliation deflection and microstructures in mylonites (e. g. Hara et al., 1980; Takagi ,1986). Similarly, a top-to-the-west sense of shear was recorded in the Sambagawa metamorphic rocks (e. g. Takeshita and Yagi, 2004). The movement around the MTL can be ascribed to the oblique subduction of the Izanagi plate in the NNW direction relative to the NNE-SSW trending proto-Japanese arc.

(b) So-called Ichinokawa phase at c. 59 Ma in the Paleocene

It has been discovered by Kubota and Takeshita (2008) for the first time that the Ichinokawa phase is characterized by top-to-the-north, large-scale normal faulting based on the occurrence of a few hundred meter thick boudinaged belt and the north-vergent drape folds in the Izumi Group at the north side of the MTL (Kubota and Takeshita, 2008). On the other hands, in the Sambagawa metamorphic rocks, not only numerous low angle normal faults developed at the Ichinokawa phase, but also it has been found by seismic reflection studies (Sato et al., 2005; Ito et al., 2009) that the original shape of the MTL itself was a low-angle north dipping fault. This low-angle normal faults, which are common to those seismogenic faults in Italy, perhaps resulted from the anisotropic ductile strength of the Sambagawa metamorphic rocks, which are more prone to ductile flow parallel to the foliation.

(c) pre-Tobe phase at c. 47 Ma in the Eocene

The Kumamoto earthquake in 2016 in fact made it clear that the MTL has been still fairly active during the Quaternary period. It should be known however that the position of the active MTL systems does not

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coincide with the one of the MTL sensu stricto, but located in the Izumi Group at the north of the MTL (e. g. Okada, 1973). While there has been no information on when and under what kinematics the active MTL systems were originally formed, it has been newly discovered that the faults systems were originally formed under the setting of sinistral transpression at c. 47 Ma in the Eocene (Kubota et al., 2020). This phase of movement of the MTL has been named as the pre-Tobe phase, because the Tobe thrusting has been now found to occur at 15 Ma (Takeshita et al., 2000).

Keywords: Median Tectonic Line, The Late Cretaceous to Paleogene, Kinematics, Oblique subduction, Low-angle normal faulting, Sinistral transpression

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Relationship between the Northern Osaka Prefecture earthquake and the Arima-Takatsuki Tectonic Line estimated from dense aftershock observations

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The 2018 Northern Osaka Prefecture Earthquake (Mj6.1) occurred at a depth of 10 to 15 km immediately below the Arima-Takatsuki Tectonic Line (ATL) in the northern part of the Osaka Plain, however, the relationship with nearby active faults is well understood. In this study, the location of the deeper part of the Arima-Takatsuki fault zone was estimated using the arrival time data of aftershocks, and the relative location between the estimated source fault of the northern Osaka Prefecture earthquake and the deeper part of ATL was investigated.

At each observation station, the relationship between O-C (observed - calculated value) of P wave arrival times in the hypocenter calculation and aftershock locations was investigated, assuming uniform horizontal layer structures. At the observation stations located on the north side of ATL, O-C was almost the same for the aftershocks occurring in the north of ATL, however for the aftershocks south of a certain point, O-C tended to increase toward the south. This is probably because there is a low velocity zone near ATL. When this relationship was best fitted with the flat-ramp function to determine the bending position, the bending position was estimated within an error of about 1 km at 15 observation stations. On the other hand, at the observation stations located on the south side of ATL, O-C tended to increase as the aftershocks in the north. In addition, at the observation stations, aftershocks north of ATL are considered to have a shorter distance through the low-velocity zone than aftershocks in the low-velocity region, but the delay of seismic waves is larger. Thus, it is estimated that the northward and shallower the low velocity anomaly is larger. This suggests that the seismic velocity anomaly near the aftershock zone is due to the fault damage zone, not the geological boundary (material boundary) between the Tamba zone on the north side and the Ryoke zone on the south side.
It was found that the position of the northern end of the estimated low velocity zone is located so as to limit the northern end of the estimated source fault by Asano (2018). Regarding the southern end of the low velocity zone, aftershocks have not occurred far to the south of the estimated fault, and even if there is a flat part, its length is short, so it cannot be reliably estimated at this time. Although it was not, it is suggested that the source fault of the northern Osaka Prefecture earthquake may have occurred inside the fault damage zone of ATL. In particular, the fact that the northern limit of the source fault is limited by the ATL implies that although the earthquake started from the deepest part, the fault was limited to a depth of about 10 km or deeper and the rupture did not propagate to the shallow part.

Keywords: Intraplate earthquake, Active fault, Arima-Takatsuki Tectonic Line, Aftershock observation

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Fracture as an electrical conduction path under pressure

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Geophysical mapping of fluids is critical for understanding crustal processes. Interpretation of seismic velocity and electrical resistivity structures requires a thorough understanding of the pore structure that governs physical properties under high pressures. Watanabe et al. (2019) showed that wide aperture parts in cracks remain open to govern physical properties under high pressure. In the crust, there should be cracks with various sizes: from grain boundary to large faults. In order to understand the role of a fracture as a conduction path under high pressure, we have made measurements of elastic wave velocities and electrical conductivity in a brine-saturated granitic rock with single fracture. A cylindrical rock sample (D=26 mm, L=30 mm) with a single fracture was cored from a block (20 cm x 20 cm x 20 cm) of Aji granite, which was artificially fractured. The fracture goes through the sample from top to bottom. 3D structure of a fracture was imaged by X-ray micro CT before measurements. A sample was filled with 0.1 M KCl aqueous solution, and velocity and conductivity were simultaneously measured by using a 200 MPa hydrostatic pressure vessel. The pore-fluid was electrically insulated from the metal work by using plastic devices. Compressional wave velocity was measured in the direction subperpendicular to the fracture, while electrical conductivity in the axial direction.

Compressional wave velocity increases and electrical conductivity decreases with increasing confining pressure. The electrical conductivity at the atmospheric pressure was around one order of magnitude higher than that in intact samples. It greatly decreased from 0.1 MPa to 5 MPa and showed a gradual decrease at higher pressure. The conductivity at 150 MPa is only a few times as high as that in intact samples. Compared with grain boundary cracks, this fracture cannot work as a remarkably good conduction path. A misfit of fracture surfaces must increase conductivity at high pressure.

Keywords: crack, electrical conductivity, fluid

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Grain-boundary diffusion creep of olivine and the rheology of the oceanic upper mantle

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The mantle is known to have anisotropic elasticity, which is primarily explained by crystallographic preferred orientation (CPO) of olivine that forms during mantle flow. Because the CPO has long been considered to result uniquely from dislocation processes, diffusion creep has received less attention than dislocation processes. Recently, olivine CPO has been found to develop during diffusion creep under a condition that seems to correspond to the depth of seismically anisotropic mantle (Miyazaki et al., 2013). This led us to examine mantle viscosity in terms of olivine diffusion creep.
Diffusion creep of olivine is, however, a subject of some debate. Differences of up to two orders of magnitude in viscosity at the same grain sizes and temperatures have been reported from experimental diffusion creep studies. Impurity content can range significantly among samples synthesized by different methods and is known to affect diffusional properties through grain-boundary segregation.
Motivated by our previous findings on the segregation of Ca and Al at olivine grain boundaries, we synthesized and reported experimental creep results for fine-grained Fe-bearing olivine ($Mg_{1.8}Fe_{0.2}SiO_4$; so-called Fo_{90} olivine) aggregates that were variably doped with $CaO \pm Al_2O_3$ to explore the effect of Ca and Al on creep rate. By comparing creep properties of undoped and doped olivine aggregates, we identified the roles of Ca and Al in enhancing grain-boundary diffusion creep at $>0.92T_s$ (T_s: solidus in K), an effect which became significant with increasing temperature. We considered the enhancement to result from grain-boundary disordering promoted by grain-boundary segregation. Based on the Arrhenius-like behavior of the disordering effect, we established an olivine diffusion creep law that suitably describes the creep rates in both temperature ranges of $<0.92T_s$ and $>0.92T_s$.
We estimated solidus temperatures of the samples used in the previous diffusion creep experiments. These temperatures were used to compare previously reported diffusion creep rates for olivine with our established diffusion creep law. We found that the law explains a difference of up to two orders of magnitude in olivine creep rates at the same temperatures, stresses, grain sizes, and water contents in the previous studies. The geotherm normalized by the mantle solidus was calculated for the upper mantle with water contents up to 200 wt. ppm, which predicts depths where weak (low-viscosity) mantle is expected to occur due to enhanced grain-boundary diffusion creep.
Constructed viscosity–depth profiles based on our diffusion creep law reveal a very thin mantle lithosphere beneath mid-ocean ridges, with development of the lithosphere away from the ridge, leaving a low-viscosity region below. Given a grain size of 1 mm and depending on the water content, a viscosity of $2–5*10^{19}$ Pa s is predicted for the low-viscosity asthenospheric mantle beneath 50-million-year-old seafloor.

Keywords: olivine aggregates, Grain-boundary diffusion creep, The rheology of the oceanic upper mantle

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An inversion method of fault-slip analysis to deteremine stress tensor and friction coefficient

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Stress tensor inversion techniques are widely used to infer crustal stress state from fault-slip data and seismic focal mechanisms. A majority of the techniques is based on the assumption that a fault slips along shear stress direction on the fault planes (Wallace-Bott hypothesis). Such inversion techniques try to minimize the misfit angles between observed slip directions and calculated shear stress directions.
Since the orientations of fault planes themselves are expected to reflect mechanical condition of faulting, Sato (2016) proposed a method to calculate friction coefficient of observed faults by maximizing the fault instability (Vavrycuk, 2014). This method has a defect that it does not consider the precision of the optimal stress tensor separately determined by the preceding stress tensor inversion. In order to solve this problem, this study proposes a new method to simultaneously infer stress condition and friction coefficient from a set of fault-slip data. The present method combines the objective functions of inversion techniques to minimize the misfit angles and to maximize the fault instability.
Some artificial fault-slip data were analyzed to understantd the performance of the present method. As the result of the numerical experiments, the folowing two advantages were found. Firstly, the present method enhances the detectability of stresses when fault planes are concentrated in the orientations of high fault instability, although it was difficult to accurately determine the friction coefficients from heterogeneous (caused by multiple stresses) fault-slip data. Secondly, the method is moderately robust to the change in stress state after formation of fault planes.
The new method was applied to some examples of natural outcrop-scale faults. The first example is from the Pleistocene Oita Group, southwest Japan, which filled the Beppu-Shimabara graben. A NNE-SSW trending tensional stress and the friction coefficient of 0.58. The second example is from the Awa Group in the Boso Peninsula, central Japan, which filled a forearc basin of the Sagami Trough. The analysis showed NE-SW and NW-SE trending tensional stresses clearly. Additionally, a N-S trending compressional stress was detected, which has been difficult to detect with Wallace-Boot hypothesis-based stress tensor inversion techniques.

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Keywords: fault-slip analysis, stress tensor inversion, friction coefficient, fault instability

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.21 Zoom Room 21

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University), Chairperson:Keisuke Yoshida(Tohoku University), Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University)

The dynamic behaviors of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses associated with plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, geology, petrology, and geochemistry is necessary, as is the integration of observational, theoretical and experimental approaches. In particular, rheological properties, which are physically affected by fluids in the crust and chemical reactions assisted by fluids, can be resolved only through such an interdisciplinary approach. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, geochemistry and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviors of mobile belts.

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

[SCG50-13] Spatio-temporal patterns of inland stress field: Characteristics revealed by a new method using focal mechanisms and interseismic plate coupling, and its tectonic implication

★Invited Papers

*Kazutoshi Imanishi[1], Akemi Noda[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Meteorological Research Institute)

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

[SCG50-14] Effects of ETS on seismicity and stress in the subducting oceanic plate

*Saeko Kita[1], Heidi Houston[2], Suguru Yabe[3], Sachiko Tanaka[4], Youichi Asano[4], Takuo Shibutani[5], Naoki Suda[6] (1.Building Research Institute, 2.University of California, 3.AIST, 4.NIED, 5.DPRI, Kyoto University, 6.Hiroshima University)

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

[SCG50-15] Prevailing updip ruptures in small interplate earthquakes along the Japan Trench revealed from land-based and offshore observations

*Keisuke Yoshida[1], Naoki Uchida[1], Hisahiko Kubo[2], Ryota Takagi[1], Shiqing Xu[3] (1.Tohoku University, 2.National Research Institute for Earth Science and Disaster Resilience, 3. Southern University of Science and Technology)

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

[SCG50-16] Spatiotemporal change in the inelastic strain rate due to aftershock activity of the 2016 Kumamoto earthquake sequence, in central Kyushu, Japan

*Ayaho Mitsuoka[1], Satoshi Matsumoto[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University)

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

[SCG50-17] **Toward understanding earthquake mechanism based on theories of strain energy**
★Invited Papers

*Tatsuhiko Saito[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SCG50-18] Reconsideration of the energy balance in earthquake faulting - I: The origin of the background stress field

*Mitsuhiro Matsuura[1] (1.Institute of Statistical Mathematics)

Spatio-temporal patterns of inland stress field: Characteristics revealed by a new method using focal mechanisms and interseismic plate coupling, and its tectonic implication

*Kazutoshi Imanishi[1], Akemi Noda[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Meteorological Research Institute

It is known that the activity of shallow inland earthquakes in the Kinki region, southwest Japan, increased from about 50 yr before to 10 yr after the occurrence of large interplate earthquakes along the Nankai trough (Utsu 1974; Hori & Oike 1999). We also know that inland seismic activity significantly changed before and after the 2011 Tohoku-oki earthquake. These observations indicate that the shallow inland earthquakes occur in response to the interseismic plate coupling, facilitating further research on the causal relationship between the inland earthquake activity and the interplate coupling state.

Imanishi and Noda (The 2020 SSJ Fall Meeting) proposed a method to investigate the inland stress field by examining whether the focal mechanisms of inland small earthquakes align with the stress field due to the plate coupling or not. The basic concept of this method is as follows:
(1) The total stress field is described as the background stress plus the temporally varying stress due to the plate coupling.
(2) There exist pre-existing faults with various orientations in the crust, most of which are close to a critically stressed state.
(3) Earthquakes will preferentially occur on faults whose slip direction is close or in agreement with the stress field due to the plate coupling, although earthquakes may occur on faults that are favorably oriented to the background stress field.

When an earthquake occurs in agreement with the stress field caused by the plate coupling, the misfit angle (i.e., the angle between the observed slip direction and the tangential traction predicted by the reference stress tensor) is expected to be a small value, and vice versa. Therefore, we can visualize the spatio-temporal patterns of inland stress field with respect to the plate coupling by taking the spatio-temporal average of the misfit angles.

We applied the method to inland earthquakes in southwestern Japan. We merged the JUNEC catalog (Ishibe et al. 2014) and the JMA catalog to produce the consolidated one, which results in a 35-year-long catalog. For the calculation of the stress tensor caused by the plate coupling, we adopted the slip-deficit model of Noda et al. (2018). The spatio-temporal distribution of misfit angles was obtained by taking a one-year moving average for each mesh at 0.25 ˚intervals. The results indicate that the misfit angle fluctuates considerably both temporally and spatially. We observe that earthquakes with a magnitude of 6 or larger, including the 2016 Kumamoto earthquake, tend to occur when the misfit angle was small. This is consistent with the observation that inland earthquakes occur in response to the interseismic plate coupling. On the other hand, the misfit angle fluctuates at a high level in the Chugoku region compared to other regions. We infer that a stress loading by the San-in shear zone (Nishimura and Takada, 2017) dominates the stress field in this area. It is also noted that the misfit angles change with a period of a few years in some regions. Such a cyclic stress change has also been reported by repeated measurements of in-situ stress in northern Kinki (Tanaka et al., 1998). Because the present method evaluates the effect of the plate coupling, this cyclic fluctuation can be attributed to the change of the state along the plate

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boundary (e.g., occurrence of slow slip event).

In summary, the subtle spatio-temporal variation of inland stress field can be detected by this method, which will lead to the elucidation of the relationship between the subduction process and the stress field in the Island-arc and the mechanism of inland earthquake generation. In the presentation on the day, we will report the characteristics of inland stress field before and after the Tohoku-oki earthquake by applying this method to the Tohoku region.

Keywords: inland stress field, spatio-temporal pattern, focal mechanism, interseismic plate coupling, tectonics

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Effects of ETS on seismicity and stress in the subducting oceanic plate

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Slow slip phenomena appear related to geofluids, but the detailed relationships among slow slip, geofluids, and intraslab earthquakes remain unknown. Here we report changes in seismicity rates, b-values, and stresses in the oceanic slab before and after slow slip episodes beneath Kii Peninsula, Japan. One month before slow slip occurrence, the seismic rate and b-value become high, consistent with the effects of fluid-induced seismicity. Intraslab stress orientations below the plate interface in the ETS zone change only slightly, whereas below the plate interface updip of ETS, the intraslab stress orientations rotate by a larger amount, suggesting that transient aseismic slip occurs on the interface updip. The existence of repeating earthquakes and seismicity on the plate boundary also implies that aseismic slip occurs on the updip zone after the ETS, which could reset the stress state of the slab and the boundary to its prior condition. The proposed methodology, which is based primarily on intraslab earthquakes, may help monitor plate boundary conditions and slow slip phenomena, which can signal the beginning stages of megathrust earthquakes in subducting plates.

Keywords: Slow slip, intrslab earthquake, stress field, seismicity, the southwestern Japan, Kii peninsula

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Prevailing updip ruptures in small interplate earthquakes along the Japan Trench revealed from land-based and offshore observations

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A physical understanding of earthquakes involves not only the static characteristics of the ruptures but also the dynamics. Rupture directivity is a fundamental characteristic of earthquake growth and is essential for improving our current physical understanding of earthquakes. The recent development of seafloor seismic observations facilitates reliable estimation of the rupture directivities of offshore earthquakes. The present study used seismic waveforms obtained by a new seafloor seismic network (S-net) and onland stations to systematically examine the rupture directivities of interplate earthquakes along the Japan trench.

We first selected interplate earthquakes and estimated the apparent moment rate functions (AMRFs) by using the empirical Green’ s functions. We then estimated the rupture directions by applying the simple unilateral rupture model of Haskell (1964) to the duration of the AMRFs. As a result, the rupture directions were derived for 206 M_w 3.5–5 events, most of which occurred near the base of the seismogenic zone.

We found that most earthquake ruptures (>80 %) were directional. They primarily propagated in the updip direction, which is the opposite of the prediction from the bimaterial effect. On the contrary, deep, steady creep and upward fluid migration along the plate interface can facilitate rupture initiation near the deeper edge of the seismic patch and propagation in the updip direction, given that the nucleation size is sufficiently smaller than the final rupture area. The predominance of updip rupture in interplate earthquakes suggests that other effects, such as deep creep and upward fluid migration, can overtake the bimaterial effect in affecting earthquake ruptures in the subduction zone.

The updip ruptures redistributed the accumulated shear stress from the base of the seismogenic zone to the shallow large seismic patches. The updip ruptures may also open up ways for deeper fluids to migrate further upward along the plate interface. Both effects facilitate the occurrence of shallow megathrust earthquakes.

Keywords: Rupture directivity, interplate earthquakes, S-net

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Spatiotemporal change in the inelastic strain rate due to aftershock activity of the 2016 Kumamoto earthquake sequence, in central Kyushu, Japan

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For a purpose of understanding physical process of earthquake generation, we investigate the stress and strain field around the hypocentral area of the 2016 Kumamoto earthquake sequence. The stress field around the region is normal or strike-slip type, and the magnitude of the stress tensor was estimated to be comparable to the stress change due to the maximum foreshock (Mj 6.5) and mainshock (Mj 7.3) [Mitsuoka et al., 2020]. Aftershock activity following the mainshock has persisted in the region to the present day.

Aftershock activity can be considered as an inelastic response to stress loading by large co-seismic slip of a mainshock. As known the modified Omori' s law [Utsu 1957], earthquake rate of the aftershocks follows the power law of lapse time from occurrence of the mainshock. Similarly, inelastic strain rate by aftershock activity follows a power law ($d\varepsilon/dt \propto t^{-p}$) [Matsumoto et al., 2020]. We defined the power -p in this relation as the *p-value* and investigated the spatial distribution of the p-value in the aftershock area of the 2016 Kumamoto earthquake sequence. We estimated the inelastic strain tensor in a spatial bin by summing the moment tensors [Kostrov, 1974] at several lapse time windows, and calculated the inelastic strain rate by the time length of each time window. In addition, we estimated the p-value by the least squares method, assuming that the inelastic strain rate follows the power law ($d\varepsilon/dt \propto t^{-p}$).

The p-value around large co-seismic slip area [e.g., Asano and Iwata, 2016; Mitsuoka et al., 2020] is high ($p>1$), therefore the deformation at this area can be interpreted as a response to elastic strain by the co-seismic faults when considering exponentiation fluids [e.g., Nanjo, 2007].

At extensions of the co-seismic fault (i.e. the southern Hinagu fault and the western of the Futagawa fault), we found the low p-value ($p<1$). The low p-value areas correspond to the area of the low co-seismic stress change (approximately less than 1 MPa) by the maximum foreshock and mainshock. The low p-value indicates the slow decay rate of the strain rate, and $p<1$ condition is that the inelastic strain increase over time. This suggests that post-earthquake activities such as afterslip cause the low p-value area. We discuss a fault slip model or an inelastic deformation in and around the target area that can explain the inelastic deformation in this low p-value region.

Keywords: inelastic strain rate, stress field, aftershock activity

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Toward understanding earthquake mechanism based on theories of strain energy

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Earthquake faulting releases some strain energy from the earth. Some of the energy is dissipated on the fault and the rest of the energy radiates from the fault (e.g., Kostrov 1974; Rudnick & Freund 1981). This energy transformation is irreversible for earthquake faulting. We introduce our recent results using the theories of strain energy.

(i) Seismicity and strain energy
When the strain energy increases, the seismicity would become active. We developed a method to calculate the strain energy change caused by a dislocation in a stressed medium. Using this method, we evaluated the energy change distribution in the inland area of southwestern Japan caused by the Nankai-trough plate locking. In most of the inland area, the shear strain energy decreases by the NS compressional stress due to the plate subduction. In some areas, on the other hand, the shear strain energy increases because the plate coupling varies in space. We found that the seismicity tends to be high in the area where the shear strain energy increases (Saito et al. 2018 JGR; Noda et al. GRL 2020).

(ii) Minimum stress necessary for earthquake faulting
Since the amount of the released strain energy is identical to the sum of the energy dissipated on the fault and the radiated energy (e.g. Kostrov 1974), the strain energy, represented by the seismic moment, the initial stress, and the stress drop, needs to be larger than the radiated energy (Terakawa et al. 2018; Noda et al. 2020 GRL). Using this relationship, the minimum initial stress necessary for the earthquake generation can be derived (Saito and Noda 2020 GJI). Note that elastic dislocation theory predicts that seismic waves radiated from the fault are independent of the initial stress (e.g., Aki and Richards 2002). However, we can constrain the minimum initial stress by considering the energy transformation from the elastic energy to the radiated energy (e.g., Yoshida et al. 2020 JGR).

(iii) Necessary conditions for multi-segment ruptures.
If we assume a simple slip-weakening law in the energy conservation, we can estimate the fracture energy from the available energy and the radiated energy (Abecrombi and Rice 2005). The fracture energy is reported to be increased with the seismic moment (e.g., Viesca et al. 2015).
The available energy needs to be larger than the radiated energy for earthquake generation. We propose a necessary condition for multi-segment ruptures (Noda et al. 2020 EGU). We first estimated the stress rate distribution along the Nankai Trough by analyzing GNSS records (Noda et al. 2018 JGR) and recognized 4 peak stress-rate areas (off Cape Muroto, off Kii channel, Kumano-nada, and Enshu-nada) as asperity. We created various rupture scenarios including multi-segment ruptures of these asperities and evaluated available energy. If the stress accumulation rate is constant during the intersismic period, the available energy increases with the square of time since both average slip and the stress drop increases linearly. On the other hand, the fracture energy empirically increases more slowly than the available energy (e.g. Viesca et al. 2015; Ye et la. 2016). The available energy evaluated for each scenario increases with time, and eventually becomes larger than the fracture energy. Based on this idea, we introduce a necessary stress-accumulation time for each multi-segment rupture.

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We presented the energy conservation for an earthquake. It is also important to consider energy conservation over seismic cycles. Since the Nankai Trough has historical earthquake data, it is important to evaluate the energy balance taking into account the historical events for creating possible rupture scenarios (Noda and Saito 2021JpGU).

Keywords: strain energy, seismicity, multi-segment rupture

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Reconsideration of the energy balance in earthquake faulting - I: The origin of the background stress field

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The occurrence of earthquakes can be regarded as brittle shear fracture at a fault, which releases a part of the total potential energy of the earth. Since the 1950s, many researchers have studied the energy balance in earthquake faulting, but there seems to be some incoherence among these studies. The essential reason is probably in various scientific developments during the last half-century; the introduction of the new paradigm of plate tectonics, the concept of moment tensor as source representation, and the fault constitutive law governing shear rupture. So, it will be worthwhile to reconsider the energy balance in earthquake faulting from the current perspective. In the first presentation of this study, we focus on the static energy balance and discuss the origin of the background stress field in the earth.

At the end of the 1950s, Steketee (1958) introduced the elasticity theory of dislocation into geophysics and considered the static energy balance for the formation of dislocation (tangential displacement discontinuity) in a prestressed elastic body bounded by a traction-free surface. He concluded that the strain energy is always increased, independently of the initial stress state, when a dislocation is formed (Steketee's paradox). An essential question is how the prestressed state can be made in the isolated elastic body. At the end of the 1960s, Savage (1969) gave a geophysical interpretation of the interaction energy between two stress systems (Eshelby, 1956) and shown that the formation of dislocation can decrease the elastic energy of the total system including a loading machine to produce the prestressed state. To sum up, in the case of the non-gravitating earth model, the release of elastic potential energy balances with the work done for shear faulting. I will give a straightforward derivation of the energy balance equation mentioned above. The point is that the loading process must be inelastic as well as the formation of dislocation, because the earth is an isolated body.

In reality, the earth is a self-gravitating body, and so we should consider the change in gravitational potential energy as well as the change in elastic potential energy. In the case of the self-gravitating earth model, as shown by Kostrov (1974) and Dahlen (1977), the release of the total (elastic and gravitational) potential energy balances with the work done for shear faulting. In their formulations, the total release of the gravitational potential energy is represented by the volume integral of the scalar product of gravity force and coseismic displacement over the entire earth. Savage & Walsh (1978) found that this volume integral could be transformed into the surface integral of the scalar product of gravity-origin deviatoric stress vector and tangential displacement discontinuity vector over the fault. The point is that the isotropic part of gravity-origin stress is independent of the work done for shear faulting. Anyway, they evaluated the change in gravitational potential energy due to earthquake faulting in a homogeneous, isotropic, elastic earth model, and concluded as follows: For dip-slip faulting in the earth, the gravitational energy change may be several orders of magnitude greater than the energy released; that large change in gravitational energy is compensated for by a similar change in stored elastic initial energy. If it is true, to evaluate the coseismic change in elastic potential energy alone will be meaningless.

In actuality, considering the rheological property of the earth's mantle and the steady seafloor spreading and oceanic plate subduction in long time scale, the stress field caused by self-gravitation must be nearly

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isotropic, and so it affects the strength of faults but not the energetics of earthquake faulting substantially. In other words, we may use the energy balance equation for the non-gravitating earth model in a good approximation, where the background deviatoric stress field is tectonic origin.

Keywords: earthquake faulting, elastic potential energy, gravitational potential energy, background stress field, inelastic strain

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[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.15_2

[S-CG50] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Hikaru Iwamori(Earthquake Research Institute, The University of Tokyo), Kiyokazu Oohashi(Graduate School of Sciences and Technology for Innovation, Yamaguchi University)

The dynamic behaviors of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses associated with plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, geology, petrology, and geochemistry is necessary, as is the integration of observational, theoretical and experimental approaches. In particular, rheological properties, which are physically affected by fluids in the crust and chemical reactions assisted by fluids, can be resolved only through such an interdisciplinary approach. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, geochemistry and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviors of mobile belts.

[SCG50-P01] Seismic anisotropy of the dipping Pacific slab and adjacent mantle

*Dapeng Zhao[1], Zewei Wang[1] (1.Department of Geophysics, Tohoku University)

[SCG50-P02] Magnitude of east-west contraction forces acting to Japanese Islands since 3Ma estimated from altitude changes

*Ryohei Sasajima[1], Yukitoshi Fukahata[1] (1.Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

[SCG50-P03] Earthquake simulation based on Coulomb stress change on inland faults during megathrust earthquake cycles in southwest Japan

*Tsukasa MITOGAWA[1], Takuya NISHIMURA[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

[SCG50-P04] GNSS observation around the shear zone in southern Kyushu, southwest Japan (5)

*Tsuyoshi Watanabe[1], Koichi Asamori[1], Akiomi Shimada[1], Atsushi Saiga[1], Hiroki Ogawa[1], Umeda Koji[2], Akira Goto[1], Koji Shimada[1], Tsuneari Ishimaru[1] (1.Japan Atomic Energy Agency, 2.Graduate School of Science and Technology, Hirosaki University)

[SCG50-P05] Classification of faults using vertical gravity gradient data by machine learning

*Yuya Honda[1], Kohei Hotta[1] (1.University of Toyama)

[SCG50-P06] Hierarchical clustering of reduced stress tensors based on angular stress distance

*Noriaki Abe[1], Katsushi Sato[1] (1.Kyoto University)

[SCG50-P07] Characteristic of fault geometry and the subducting plate boundary in the focal area of the 2016 Mw7.8 Kaikoura earthquake, New Zealand inferred from high precision aftershock distribution

*Yuta Kawamura[1], Satoshi Matsumoto[1], Tomomi Okada[2], Miu Matsuno[2], Yoshihisa Iio[3], Tadashi Sato[2], Stephen Bannister[4], John Ristau[4], Martha Savage[5], Richard Sibson[6] (1.Kyushu University, 2.Tohoku University, 3.Kyoto University, 4.GNS Science, 5.Victoria University of Wellington, 6.University of Otago)

[SCG50-P08] Analysis of fault kinematics and internal structure of fracture zone at ISTL

*HIBIKI CHIBA[1], Kenta Kobayashi[1], Keita Takahashi[1] (1.Gradate School of Science and Technology Niigata University)

[SCG50-P09] Non-double-couple earthquake in the focal area of the 2000 Western Tottori earthquake by “0.1 manten” hyperdense seismic observation

*Takumi Motokoshi[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Shin'ichi Sakai[4], Aitaro Kato[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Earthquake Research Institute , the University of Tokyo)

[SCG50-P10] Transition from radial to parallel dike swarm in Amakusa, Japan and their paleostress analyses

*Kentaro Ushimaru[1], Atsushi Yamaji[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

[SCG50-P11] **Electrical conductivity in a brine-saturated granite under uni-axial compression**

*Yui Aikawa[1], Tohru Watanabe[1] (1.University of Toyama)

[SCG50-P12] Lithologic and thermal controls of seismicity in the northwestern Kii Peninsula, southern Honshu, Japan

*Sumire Maeda[1], Shinji Toda[2], Toru Matsuzawa[3], Makoto Otsubo[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

[SCG50-P13] On approximations of EASY%R_o model to estimate maximum experienced temperature from vitrinite reflectance in rocks

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Seismic anisotropy of the dipping Pacific slab and adjacent mantle

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With the increasing number of seismic stations deployed and high-quality seismic data accumulated, body-wave anisotropic tomography has shown its power in revealing the 3-D anisotropic structure of subduction zones (e.g., *Wang & Zhao*, 2008, 2013; *Zhao*, 2015; *Liu & Zhao*, 2016, 2017; *Ishise et al.*, 2018). To simplify the calculation, the previous studies often assume an anisotropy with a hexagonal symmetry for materials in the modeling space. This assumption is a good approximation for typical mantle minerals such as olivine. For a further simplification, the previous studies assumed the symmetry axis to be either horizontal or vertical for investigating azimuthal anisotropy or radial anisotropy. However, the assumption of horizontal or vertical symmetry axis is not reasonable at least in two cases that are common in subduction zones: (1) complex mantle flow with a flow direction neither parallel nor perpendicular to any of the modeling axes, and (2) intra-slab anisotropy affected by the geometric inclining of a subducting slab. Therefore, the horizontal or vertical symmetry axis assumption should be released for better revealing the intra-slab fabric alignment and the 3-D mantle flow field in subduction zones. Under a general hexagonal symmetry anisotropy assumption, we developed a new tomographic method (*Wang & Zhao*, 2021) to determine a high-resolution 3-D P-wave anisotropic model of the Japan subduction zone by inverting a great number of travel-time data of local and teleseismic events. As a result, the 3-D anisotropic structure in and around the dipping Pacific slab is firstly revealed. Significant anisotropy with a dipping symmetry axis also occurs in the mantle wedge and the sub-slab mantle associated with the slab subduction. Our results show that slab deformation plays an important role in both mantle flow and intra-slab fabric, and the widely observed trench-parallel anisotropy in the forearc from shear-wave splitting measurements is related to the intra-slab deformation during the outer-rise yielding of the subducting plate.

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Keywords: subduction zones, seismic anisotropy, seismic tomography

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Magnitude of east-west contraction forces acting to Japanese Islands since 3Ma estimated from altitude changes

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Rapid east-west contraction accompanied by uplift of mountain ranges has been occurred on the Central and North-Eastern Japan since 3 Ma. Takahashi (2006, 2017) proposed a hypothesis that these are caused by the east-ward migration of the TTT-triple junction and the Japan Trench arising from the motion direction change of the Philippine Sea plate. This hypothesis is consistent with several geological observations, while no validation from a view point of mechanics has been done.

Therefore, this study attempts to estimate the magnitude and distribution of the east-west contraction forces acting to Japanese Island since 3 Ma. Based on the estimation, we validate the hypothesis from a view point of mechanics and discuss the origin of the forces.

Horizontal contraction forces that cause uplift of a mountain range and extensional forces arising from an increment of lithospheric body forces associated with the uplift are nearly equilibrium (e.g, Molnar and Lyon-Caen, 1988). Therefore, we can estimate a magnitude of an increment of contraction forces from altitude changes of mountain ranges. This study estimated the magnitude and distribution of the increment of the east-west contraction forces acting to Japanese Island since 3 Ma from the altitude change of the five mountain ranges: Kiso, Akaishi, Hida, Echigo, and Ou.

We obtain the following results. For Kiso, Akaishi, and Hida mountain ranges, ~2×10^{12} [N/m] of the contraction forces per unit length has been added along 200 km of the length of the mountain ranges. For Echigo and Ou mountain ranges, they are ~0.4×10^{12} [N/m] along 300 km. In total, 5.2×10^{17} [N] of the east-west contraction forces has been added to the Japanese Island since 3 Ma.

If the east-west contraction is caused by the east-ward migration of the triple junction and the Japan Trench arise from the motion direction change of the Philippine Sea plate, the magnitude of the contraction forces should be consistent with the magnitude of the force that caused the motion direction change of the Philippine Sea plate. The candidate of the force caused the motion direction change is the slab-pull arising from the west-ward subduction from the Philippine Trench initiated at 5-8 Ma. Seno (2000) estimated that the magnitude of the slab-pull force along the Philippine Trench is 3×10^{18} [N]. From the analysis of global plate motion, Forsyth and Uyeda [1975] estimated that around 90% of a slab-pull force balances to a slab viscous resistance force and the rest 10 % of it balances to the forces acting to the surface part of plates. Therefore, 5.2×10^{17} [N] of the east-west contraction forces estimated by this study are consistent with the slab-pull force although both of the magnitude of the forces are rough estimation. This result indicates that the east-west contraction of the Japanese Island can be explained by the motion direction change of the Philippine Sea plate from a view point of mechanics. In addition, the estimated east-west contraction forces take a maximum value for Central Japan. This implies that the largest east-west contraction force acting from around the TTT-triple junction. This is also consistent with the hypothesis.

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Keywords: Japanese Islands, East-west contraction, Quaternary, Tectonics, Lithospheric body force, Gravitational potential energy

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Earthquake simulation based on Coulomb stress change on inland faults during megathrust earthquake cycles in southwest Japan

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In the subduction zone, the stress changes due to megathrust earthquakes may modulate the shallow crustal seismicity in the overriding plate. Historical documents indicate the frequent occurrence of large shallow crustal earthquakes in the overriding continental plate 50 years before and 10 years after the megathrust earthquakes along the Nankai trough in southwest Japan (i.e., active period). We performed the earthquake simulation based on Coulomb failure stress (CFS) change assuming the strength of inland block boundary faults using the locking distribution of the megathrust fault and the relative motion rate of block boundary faults (hereafter "inland faults") estimated using geodetic data. The stress change is computed using numerical code by Fukahata and Matsu'ura (2006), assuming the medium composed of an elastic layer overlying a Maxwell viscoelastic half-space. The stress sources of inland faults are the slip (i.e., earthquake) and locking on the megathrust fault and inland faults. The stress change due to megathrust fault locking is calculated using geodetic backslip rates. On the other hand, the backslip rate of the inland faults is assumed by multiplying the geodetic rate of relative block motion by an arbitrary coupling ratio uniformly for all the inland faults. The megathrust earthquake releases backslip accumulated during the interseismic period every 120 years. The inland earthquake occurs when the CFS exceeds the assumed fault strength of an inland fault. As a result of the simulation, the "active period" of the past seismic activity in southwest Japan could be explained when the apparent friction coefficient and the coupling ratio of inland faults were about 0 and 0.1, respectively. The tendency of simulated long-term seismic activity is consistent with the past seismic activity at the low apparent friction coefficient. It suggests that the fault strength hardly changes over time. Furthermore, the small coupling ratio indicating low loading rates of the inland faults suggests that most part of geodetic observed deformations are inelastic deformations. Another interpretation is also possible that the low loading rates imply that the geodetic relative block motion is distributed among slips on not only major faults but also minor faults along the block boundary.

Keywords: Megathrust Earthquake Cycles, Southwest Japan, Inland Earthquake, Earthquake Simulation, Active Period

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GNSS observation around the shear zone in southern Kyushu, southwest Japan (5)

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GNSS observation (Ref.1; Ref.2) illustrates an active left-lateral shear zone with high shear strain rate (>10^{-7}/yr) in southern Kyushu (hereafter SKSZ), where M5-6 earthquakes have occurred frequently (Ref.3). However, the surface topography does not have the traces of obvious active faults. In order to explore the crustal deformation in more detail, we established 10 GNSS sites across the SKSZ and started observation from March 2016. From the observation up to November 17, 2019, the slip rate and locking depth were estimated to be 13 mm/yr and 22 km (Ref.4) using a vertical strike-slip fault model (Ref.5). On the other hand, block fault modeling using GNSS data (e.g., Ref.6) shows the slip rate of 7-8 mm/yr at the SKSZ and our estimated locking depth seems to be slightly deeper than the average thickness of the earth's crust. To solve the discrepancies, we added another year of GNSS data and examined other deformation factors such as after slip of the 2016 Kumamoto earthquake (hereafter KEQ2016) and re-estimated the slip rate and locking depth of the SKSZ.

Daily site coordinates at our sites from April 19, 2016 to November 30, 2020 were estimated using Bernese GNSS Software (ver.5.2). Subsequently, we corrected those by removing the following factors: 1) common mode bias, 2) viscoelastic deformation due to the KEQ2016, 3) volcanic deformation at Kirishima and Sakurajima volcanoes, 4) slow slip event in the Bungo Channel, 5) coseismic displacement of a M6.3 earthquake in the Hyuganada on May 10, 2019, 6) subduction of the Philippine Sea plate, 7) after slip of the KEQ2016, and 8) annual and semi-annual variations in coordinates time series. After the processes, site velocities relative to the Amur plate were estimated. Additionally, we also applied the Ref.5 fault model to the site velocities of a target area. The area was assumed to be a width of 25 km in the EW direction and a length of 90 km in the NS direction from the tentative center of the SKSZ (E130.5˚, N32.0˚), and its strike was assumed to be N104.8˚E (Ref.4). However, we obtain only the solutions that the locking depth exceeded average crustal thickness in the case of single strike-slip zone. Therefore, we introduced the case of double strike-slip zones. As a result, we found that the first and second deformations occur at 13.83±6.75 km north and 40.98±7.23 km south from the tentative center of the SKSZ with left-lateral slip rates of 10.06±4.13 mm/yr and 6.43±4.24 mm/yr and locking depths of 8.13±11.26 km and 5.23±13.36 km.

For the first deformation, our slip rate is consistent with that derived from block fault modeling and our locking depth is close to the hypocentral depths of the 1997 Northwestern Kagoshima earthquakes. For the second deformation, it is not known for the geodetic observation and our dense GNSS observation detects it for the first time. From the seismological study, the hypocenters with left-lateral strike-slip mechanisms lead from Kagoshima city to Koshikijima (Ref.7), and its strike and slip sense agree with our observation. This suggests that aseismic slip at a deep part of the earth's crust contributes to the strain accumulation and at least two deformation centers with left-lateral strike-slip are in the SKSZ.

This study was carried out by a contract with the Agency of Natural Resources and Energy, part of the 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.

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Keywords: shear zone in southern Kyushu, left-lateral strike slip fault, dense GNSS observation, the 2016 Kumamoto earthquake, post-seismic crustal deformation

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Classification of faults using vertical gravity gradient data by machine learning

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Changes in the density structure of the subsurface due to fault movement have been observed as gravity anomalies or gravity gradients. Gravity gradients are more sensitive to the change in the subsurface density structure compare to gravity anomalies, and are therefore widely used to estimate subsurface structures such as faults (e.g., Thompson, 1982; Copper and Cowan, 2006). Subsurface normal faults can be seen because the low-density layer is the upper plate. On the other hand, subsurface reverse faults are difficult to determine their structures such as their dips because the high-density layer is the upper plate.

Machine learning is one of the artificial intelligence (AI) techniques, which is used to filter out spam mail and automated driving technology, for example. It can classify data or pictures which are difficult to judge visually. In this study, we applied the machine learning method to classify faults, which have been done by researchers' visual judgements or roadside surveys, from vertical gravity gradients data obtained from fault models. For machine learning, we used Convolutional Neural Network (CNN), which is useful for image classification. The gravity gradient data was obtained by assuming fault models using the Talwani's method (Talwani, 1965), and the data were subjected to random noise with 0-50 Eötvös. The data was imaged and the image size was unified as 256×256 pixel for supervised learning. Here, we classified normal and reverse faults with different fault dips. At first, the normal faults were classified by fault dips of *45°*, *60°* and *75°*. 200 images with a fault dip of *60°* were classified. The value of the loss function was approximately 0.10, which yields the accuracy of 97%. Next, the reverse faults were classified by fault dips of *15°*, *30°*, *45°* and *60°*. 200 images with a fault dip of *30°* were classified. The value of the loss function was approximately 0.15, which yields the accuracy of 88.5%. The values of the loss functions were approximately 0.10 and 0.15, indicating that classifications of the fault dip were done with high accuracy. This indicates that the classification of normal and reverse fault using the machine learning method is possible. However, the accuracy of the reverse faults was 10% lower than that of the normal faults. This indicates that the classification of reverse faults is more difficult than that of normal faults. We will apply this method to actually observed data in the future study. However, since our method is based on linear fault model, we need to use actual data that can be approximated to be linear faults.

Keywords: machine learning, gravity gradient, fault

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Hierarchical clustering of reduced stress tensors based on angular stress distance

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To reveal the crustal stress state is essential to elucidate mechanism and driving force of tectonics. In the field of geology, mesoscale structures such as faults, mineral veins and dikes are used to detect paleostresses through stress tensor inversion techniques. The techniques usually determine so-called reduced stress tensors which carry three principal stress axes and a stress ratio. Since the crustal stress state changes temporally and spatially, plural different stresses can be recorded in a set of mesoscale structures. Sometimes we meet a difficulty in inferring the tectonic origins of stresses because of a large number of and a wide variety of stress tensors detected from a study area. In such case we need a statistical approach to find out the characteristics of a group of stress tensors. In order to meet such requirement, this study proposes to utilize the hierarchical clustering method.
The hierarchical clustering method needs to define the differences between elements. In this study, angular stress distance (Yamaji and Sato, 2006) is used as the measure of difference between two reduced stress tensors. Once the tensors are grouped to form a cluster, we also need to define the distances between clusters. There are several methods to define the distances between clusters. Among them the group average method was found to be optimal through a Monte Carlo calculation to compare the methods with evaluations of the cophenetic correlation coefficients (Sokal and Rohlf, 1962).
We applied the hierarchical clustering method to stresses detected from the mesoscale structures in the Tanabe Group, SW Japan. The Tanabe Group is the middle Miocene paleoforearc basin fill, exposed in the southwest of the Kii Peninsula. A total of 1148 clastic dikes and 303 calcite veins have been analyzed by the mixed Bingham distribution method (Yamaji and Sato, 2011), and 327 faults have been analyzed by the Hough transform method (Sato, 2006). As the result of analyses, 21 stresses have been detected. The hierarchical clustering with group average method gave five clusters of stresses. In this clustering analysis, two clusters were distinguished when their angular stress distance is larger than 59.26° (Yamaji and Sato, 2019). Two of the clusters consist solely of the stresses detected in the southern sites. Plural different clusters detected in the same area suggest a temporal stress change. Another cluster comprises the stresses detected in the northern and the central sites. These three clusters appear to reflect a spatial change of the paleostress. Another cluster is composed of the stresses detected from clastic dikes. Clastic dikes observed in the Tanabe Group are considered to have intruded at the time during or soon after deposition (Miyata et al., 2009; Nakaya and Hamada, 2009). This cluster, therefore, shows the stress at the time of middle Miocene. The other cluster include only two stresses, and angular stress distance between them is near 59.26° of the threshold value. This cluster may not reflect the tectonic stress. In this way, hierarchical clustering of the detected stresses has indicated a spatio-temporal change of paleostress.

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Keywords: paleostress analysis, hierarchical clustering, angular stress distance, Tanabe Group

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Characteristic of fault geometry and the subducting plate boundary in the focal area of the 2016 Mw7.8 Kaikoura earthquake, New Zealand inferred from high precision aftershock distribution

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On 14 November 2016, in the northeast region of South Island, New Zealand, the Kaikoura earthquake (Mw 7.8) occurred. One of the main characteristics of this event, which is pointed out by previous studies, is the complexity of the rupture process involved with several faults. Our temporary observation group had installed more than 70 sites surrounding the target area before the mainshock and it has successfully recorded the mainshock and the aftershocks. In this study, we applied a double-difference relocation algorithm (Waldhauser and Ellsworth, 2000) to the dense observations and we determined fault geometries based on the high precision hypocenter distribution.
In order to evaluate the fault structure quantitatively, we employed multivariate analysis and a statistical method used in Yukutake and Iio (2017). As a result, we identified 11 fault planes in total. In particular, one of them is the fault where the rupture of the Kaikoura earthquake initiated, which is consistent with the structure shown by other studies and the nodal plane of the mainshock focal mechanism.
Furthermore, the bottom of the aftershock distribution in the northern area reveals a curved surface deepening towards the northwest direction. The result is almost parallel to, but approximately 3 km above, the slab interface determined by Williams et al. (2013). We detected many aftershocks in reverse fault type above this interface, which showed similarity in dip angle of the events to the interface. We consider whether the curved surface could represent the top of the subducting slab, or another type of interface.

Keywords: Kaikoura Earthquake, New Zealand, high precision aftershock distribution, fault geometry, plate boundary

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Analysis of fault kinematics and internal structure of fracture zone at ISTL

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Purpose of this study is to elucidate the activity history of the Yokokawa fault in FMP, And we carried out geological reconnaissance, structure observation of fault rocks, X-ray diffraction measurement and Rf/ ϕ strain analysis.

From the above results and considerations, we estimated formation process of Yokokawa fault and displacement of fault gouge. We used numerical expressions of displacement (Scholz, 1987). As a result, the amount of displacement was 4.7-470m. This result was smaller than displacement of Nechi-Ono Belt which was estimated by Shiraishi (2003). For this reason, we estimated that Yokokawa fault is connected to Nechi-Ono Belt.

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Keywords: Itoigawa Shizuoka Tectonic Line, Fault rock, Yokokawa Fault

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Non-double-couple earthquake in the focal area of the 2000 Western Tottori earthquake by “0.1 manten” hyperdense seismic observation

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Non-double-couple (NDC) earthquakes are defined as a faulting of ordinary double-couple (DC) earthquake on a fault associated with additional rupture at the hypocenter. They have been mainly observed in volcanic zones and interpreted as faulting related to fluid effects in the hypocentral region. Study on NDC earthquakes is important for understanding the faulting process and provides an opportunity to obtain new information on stress and strength of the Earth’s crust.

In the focal area of the 2000 Western Tottori earthquake (M7.3), Yukutake et al. (2017) showed 8 best fit fault planes, suggesting the aftershock sequence was attributed to complex fault system. In order to investigate states of stress and strength in the large earthquake in detail, we have deployed 1,000 temporary seismic stations in and around the source region of the earthquake during the period from April 2017 to April 2018. This observation is called “0.1 manten” hyperdense seismic observation. We determined hypocenters and focal mechanisms using the data of the seismic network of both the “0.1 manten” and Hi-net by NIED. The data we analyze is both manually and automatically picked the arrival times and polarities of first P wave onset. Hayashida et al. (2020) found that the observational polarity distribution was slightly different from that expected by a DC source model at certain areas. In this study, we attempted to obtain spatial characteristic of the NDC events from the precise moment tensor solution. By following the processing in the previous study, we adopted the tensile-shear model and searched optimal model by performing a grid search and correlation analysis of S/P wave amplitude ratio. In addition, we introduced a weighting factor to homogenize the distribution of polarities on a focal sphere of an event in the NDC detection.
We found a trend that magnitude of NDC component become small as hypocenter was distant from the fault plan and located at edges of the faults plane. In addition, few earthquakes with large NDC components have large magnitude.

Keywords: inland earthquake, Non-double-couple earthquakes

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Transition from radial to parallel dike swarm in Amakusa, Japan and their paleostress analyses

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Dikes in the Amakusa Islands were believed to have NNE trends, suggesting their intrusion accompanied by the initial rifting of the Okinawa Trough (Yamamoto, 1991). The sheet intrusions intruded to the Cretaceous and Paleogene sedimentary rocks, and the timing of intrusion was constrained to be 14–19 Ma depending on the radiometric ages of the intrusive rocks (Shibata and Togashi, 1975; Nagao et al., 1992; Hamasaki, 1996; Ohira et al., 2012). We observed 243 sheet intrusions in the islands and found that the NNE trending dikes were parts of a radial dike swarm. We also found that the radial pattern transformed laterally to a parallel one.

We took two approaches to estimate the paleostress(es) during the intrusion. First, to estimate the direction of σ_{Hmax}-axis during intrusion, a two-dimensional elastic model which involved the transition (e.g., Odé, 1957) was fitted to the distribution and trends of the sheet intrusions. The model assumed an elastic body with an internally pressured circular hole subjected to a bi-axial far field stress. This analysis showed the regional E-W trending σ_{Hmax}-axis.

Second, orientation data from the sheet intrusions were analyzed by the method of Yamaji and Sato (2011), which fits a mixed Bingham distribution to the orientations. This method was applied to the data set that consisted of 26 data taken from an area at the distances from 30 to 40 km form the center of the radiating system. The area existed within the parallel system. As a result, we obtained Stresses A and B of normal and strike-slip faulting regimes. Their σ_3-axes had N-S and ENE trends, respectively. Since the latter was obtained from sills in steeply dipping, well stratified sedimentary rock, we interpreted that Stress B was an artifact resulted from the mechanical weakness of the bedding. On the other hand, the principal axes of Stress A were approximately parallel to those determined by the two-dimensional elastic model. Therefore, Stress A was probably the regional stress at the time of dike intrusion. Stress A had the stress ratio of 0.40.

Magma pressure may have had temporal and spatial variations. The stress analysis yielded the DPI of 0.09: DPI (driving pressure index) is the 95th percentile of driving pressure ratios of the magmas (Faye et al., 2018). The orientation data of intrusions in an area from 2 to 10 km from the radiating center had two clusters indicating DPIs of 0.38 and 0.60 (Ushimaru and Yamaji, 2020), a few times larger than the DPI determined from the dikes far from the center. This difference is consistent with the picture that magma pressure declines with the distance from the center of a radiating dike system.

Keywords: stress, dike, sill

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Electrical conductivity in a brine-saturated granite under uni-axial compression

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Measurements of elastic wave velocity and electrical conductivity have been made on a brine-saturated rock (Aji granite) under uni-axial compression (< 20 MPa) in order to understand the influence of differential stress on electrical conductivity in fluid-bearing rocks. Microcracks perpendicular to the compression axis were preferentially closed to show anisotropic change in elastic wave velocity. Velocity significantly increased in the direction parallel to the compression axis, while it showed little change in the direction perpendicular to the compression axis. On the contrary, electrical conductivity showed no anisotropic change: conductivity decreased similarly in directions parallel and perpendicular to the compression axis. Cracks perpendicular to the compression axis, which were closed under compression, must contribute to electrical conduction in directions parallel and perpendicular to the compression axis. In order to understand the observed change in conductivity, the orientation distribution of cracks must be evaluated.

The orientation distribution of cracks can be evaluated by the crack density tenor (e.g., Sayers and Kachanov., 1995), which is calculated from elastic compliance tenor. In order to determine full compliance tensor, velocity must be measured in a direction oblique to the sample surface. Velocity measurement at an oblique angle was successfully made by attaching small (~10 mm) Aji granite prisms on sample surfaces. In a preliminary experiment on the dry sample, crack density tensor showed the closure of cracks perpendicular to the compression axis. We will next determine crack density tensor and aspect ratio in the wet sample and construct a quantitative model of electrical conduction to reproduce the observed conductivity change in both directions.

Keywords: electrical conductivity, crack, fluid, stress

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Lithologic and thermal controls of seismicity in the northwestern Kii Peninsula, southern Honshu, Japan

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A spatial similarity of the distributions between inland earthquakes and the lithotectonic belts, which is considered to be controlled by the mechanical properties of the lithosphere such as rheology of minerals, has been reported by several papers (e.g., Huzita et al. 1973). Particularly, the relationship between the deeper limit of earthquakes (seismicity cut-off) and the depth to the brittle-ductile transitions in the crust has been extensively investigated (e.g., Albaric et al. 2009; Hauksson and Meier 2019). However, these studies have compared the vertical distribution of the seismicity only with the rocks consisting of the lithotectonic belts at the ground surface, but not with the subsurface geological structure. In order to understand the relationship between the earthquake occurrence and the rheological properties at depth in detail, we attempted to quantitatively interpret the horizontal variety in the vertical extent of the shallow inland seismicity related to the difference of the lithotectonic belts, based on the temperature-dependent rock friction.

The study area is the northwestern Kii Peninsula, southern Honshu, Japan. We first relocated the earthquake hypocenters in this area, based on the double-difference location method (Waldhauser and Ellsworth 2000). We then estimated the density distribution (Talwani et al. 1959) in the study area by analyzing gravity data (Geological Survey of Japan 2013) to clarify how deep the surficial lithotectonic belts vertically extend. We finally compared the horizontal and vertical relationship between the seismicity and the geological structure based on these results.

From the density analysis, we confirmed that the surface rock bodies in the tectonic belts are likely to extend from the surface to at least 7 km depth, although the lower limit of the subsurface tectonic structure can be deeper. Based on the results of the relocated hypocenters, we found that the earthquakes are concentrated mainly in the shallow part (approximately 4.5–6.0 km) within the pelitic rock belts. Within the mafic rock belts, on the other hand, the seismicity rate is low in the shallow part but high in the deep part (approximately 5.5–7.5 km).

In order to interpret the difference in the vertical extents of the seismicity depending on the lithology, we compare the frictional properties of pelitic and mafic rocks obtained by rock experiments with the earthquake depths within the lithotectonic belts composed of respective rocks in the study area. The rock experiments have shown that gouges of the pelitic and mafic (metabasalt) rocks exhibit the velocity-weakening at 250℃ to 400℃ (Den Hartog et al. 2012) and at 300℃ to 600℃ (Zhang et al. 2017), respectively. Based on the heat flow of 130 mW/m^2 in the Wakayama region estimated by Matsumoto (2007) and thermal conductivity of 2.5 $Wm^{-1}K^{-1}$ (Fowler 2005; Tanaka 2009), these temperature ranges in which the velocity-weakening occurs are converted to the depth ranges of approximately 4.7–7.7 km for the pelitic belt and 5.7–11.8 km for the mafic belt. The depth ranges of high-seismicity areas within representative pelitic and mafic rock belts are consistent with these vertical ranges of the velocity-weakening found from the experiments. These good consistencies strongly suggest that the occurrence of shallow intraplate earthquakes is controlled by the temperature-dependent and

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lithology-dependent friction.

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On approximations of EASY%R_o model to estimate maximum experienced temperature from vitrinite reflectance in rocks

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Vitrinite reflectance is one of the most popular thermal indices for rocks. Among various models to estimate paleothermal histories, EASY%R_o has been widely used since proposed by Sweeney & Burnham (1990). Approximations of EASY%R_o solutions employing specific paleothermal histories have been used in the field of structural geology to estimate maximum experienced temperatures from vitrinite reflectance. However, comparisons of those approximations with results obtained with EASY%Ro itself have not been reported in scientific literatures, and the errors of approximations and the limitations of their use to determine maximum temperature remain undocumented. In this study, we performed such comparisons and found that the use of some approximations proposed in the previous studies can lead to considerable deviations from the results obtained with EASY%R_o. We then derived new approximations of EASY%R_o solutions for four representative paleothermal histories that provided estimates of the maximum temperatures within 3 ˚C of those obtained with EASY%R_o. We also describe the Jacobian of EASY%Ro for each specific paleothermal history, which can be used to propagate errors from vitrinite reflectance to maximum temperatures. We expect that four approximations derived in this study will be useful because of their smaller approximation errors and wider application ranges compared to the previous approximations, although we recommend to calculate EASY%R_o itself if greater precision or particular paleothermal histories other than those assumed in this study are required.

Keywords: Vitrinite reflectance, Paleothermal history, EASY%Ro, Approximation

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.19 Zoom Room 19

[S-CG51] New perspectives of subduction zone earthquake dynamics through experiments across-scales

convener:Masataka Kinoshita(Earthquake Research Institute, University of Tokyo), Chairperson:Masataka Kinoshita(Earthquake Research Institute, University of Tokyo), Toshinori Kimura(Japan Agency for Marine-Earth Science and Technology)

Knowledge on subduction zone earthquake phenomena has considerably increased in the last decade. On the other hand, there are limits to seismological approach alone to comprehensively elucidate the earthquake mechanism in which phenomena that differ by 10 orders of magnitude in space and time, from earthquake nucleation/growth processes to its driving force. Steps to enable scientific earthquake forecasting should include; monitoring regional seismic/tectonic activity using networked observatories, sampling of and insitu measurement in seismogenic faults and plate materials through ultra-deep drilling, and reproduction/insitu-observation of fracture nucleation processes by high-pressure quantum-beam experiments. Through a close collaboration, we challenge a dynamic imaging of earthquake processes. Based on the proposal approved as a Large Research Master Plan 2020 of the Science Council of Japan, we will deepen the interdisciplinary discussion on subduction-zone earthquakes and the state & property of lithosphere. We welcome, but not limited to, presentations from fields of ocean and land networks observation, seismogenic zone drilling, rock mechanical & quantum beam experiments, fracture process
theory, etc.

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

[SCG51-01] Current status and future plan of deformation and fracture experiments at SPring-8/BL04B1

★Invited Papers

*Yuji Higo[1] (1.Japan Synchrotron Radiation Research Institute)

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

[SCG51-02] Ultrasonic elastic wave velocity measurement of antigorite at high pressures to 10 GPa

*Yoshio Kono[1], Riseno Nose[1], Nozomi Kondo[1], Ken-ichi Hirauchi[2] (1.Geodynamics Research Center, Ehime University, 2.Shizuoka University)

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

[SCG51-03] Depth-dependent frictional properties of mud gouge in the Nankai Trough accretionary prism

*Kyuichi Kanagawa[1], Tomohiro Ishii[2], Tomoya Funaki[2], Junya Fujimori[3], Michiyo Sawai[1] (1.Graduate School of Science, Chiba University, 2.Faculty of Science, Chiba University, 3.Graduate School of Science and Engineering, Chiba University)

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

[SCG51-04] Seafloor fiber optic strainmeter performance with different cable laying condition.

*Eiichiro Araki[1], Shuhei Nishida[1], Takashi Yokobiki[1], Matthew James Cook[1], Mark Zumberge[2], Toshinori Kimura[1], Yuya Machida[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.IGPP, Scripps Institution of Oceanography)

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

[SCG51-05] Real-time SSE monitoring by optical borehole tiltmeter in the Nankai Trough, Japan

*Toshinori Kimura[1], Eiichiro Araki[1], Takashi Yokobiki[1], Shuhei Nishida[1], Matthew J Cook[1], Mark Zumberge[2], Keisuke Takahashi[3], Takane Hori[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth

Science and Technology, 2.Scripps Institution of Oceanography, 3.UBE Industries, Ltd.)

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

[SCG51-06] Thermal maturity observations depend on the structural history of the wedge

*Utsav Mannu[1], David Fernández-Blanco[2], Ayumu Miyakawa[3], Taras Gerya[4], Masataka Kinoshita[5]
(1.Indian Institute of Science Education and Research Pune, 2.Barcelona Center of Subsurface Imaging, Institut de Ciències del Mar (ICM-CSIC), Barcelona, 3.Geological Survey of Japan, AIST, 4.Institute of Geophysics, ETHZ Zurich, 5.Earthquake and Volcano Information, Earthquake Research Institute, Tokyo-U)

Current status and future plan of deformation and fracture experiments at SPring-8/BL04B1

*Yuji Higo[1]

1. Japan Synchrotron Radiation Research Institute

In the past 20 years, the understanding of the crystal structure and chemical composition of minerals that make up the Earth's inner spherical shell structure has been dramatically improved by in situ observation experiments using synchrotron radiation under high pressure at SPring-8. On the other hand, high-resolution seismic tomography and other techniques have revealed the heterogeneity of the Earth's interior, and a unified understanding of global dynamics and geological phenomena such as earthquakes and volcanoes, which are closely related to human life, is now required. In the future, there is an urgent need to accumulate experimental data necessary for constructing a dynamic picture of the Earth, such as the fracture of mantle minerals, plastic flow, viscoelasticity, elemental diffusion, and viscosity, foaming, and partial melting of magma, which are necessary for interpreting seismic tomography from a material science perspective. In this presentation, we will introduce the past efforts of deformation and fracture experiments at SPring-8/BL04B1, and the future plans for the advancement of these experiments to capture the dynamic phenomena.

Keywords: Synchrotron Radiation Experiment, High pressure

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Ultrasonic elastic wave velocity measurement of antigorite at high pressures to 10 GPa

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1. Geodynamics Research Center, Ehime University, 2. Shizuoka University

Knowledge of P- (Vp) and S-wave (Vs) velocities of antigorite is important to understand low seismic wave velocity anomalies in subduction zones. Efforts have been made to understand Vp and Vs of antigorite at high pressure conditions of subduction zones, while there are serious discrepancies in the Vp and Vs results at high pressures (>1 GPa) in previous studies (Bezacier et al., 2013; Wang et al., 2019). Here we investigated elastic wave velocities of natural antigorite sample up to ~10 GPa. The natural serpentinite sample, collected from the Nagasaki metamorphic rocks, is mainly composed of antigorite with minor amounts (<3.5 %) of other minerals. The sample does not show any clear planar and/or linear structures. Four samples were cored from orthogonal directions to check possible inhomogeneity of the rock sample. Sample size is 4.5 mm in diameter and 1.5-1.9 mm in length. Ultrasonic Vp and Vs measurements were conducted up to 8.5-10.3 GPa under room temperature condition in 1000 ton multi-anvil high-pressure apparatus.

Vp of the antigorite increases with increasing pressure below 4-5 GPa, while it starts to decrease at higher pressures. Vs also increases with increasing pressure at low pressures of <2.5-3.5 GPa, while it decreases at higher pressures. Vp/Vs ratio shows increase with increasing pressure. There are some variations in the Vp, Vs, and Vp/Vs ratio of antigorite obtained in four experiments, which are interpreted as due to inhomogeneous proportion of other mineral constituents. Vp, Vs, and Vp/Vs ratio of pure antigorite is calculated by linear fitting of four experimental results as a function of proportion of other mineral constituents. Our obtained Vp, Vs, and Vp/Vs ratio of antigorite is consistent with the results of Bezacier et al. (2013). In contrast, Vp, Vs, and Vp/Vs ratio reported in Wang et al. (2019) shows markedly different values compared to those of this study and Bezacier et al. (2013).

Keywords: Serpentine, Elastic wave velocity, High pressure

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Depth-dependent frictional properties of mud gouge in the Nankai Trough accretionary prism

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1. Graduate School of Science, Chiba University, 2. Faculty of Science, Chiba University, 3. Graduate School of Science and Engineering, Chiba University

In order to investigate the depth-dependent frictional properties of mud gouge in the Nankai Trough accretionary prism, we conducted triaxial friction experiments on gouge of a mud sample cored from 2183.6 mbsf (meters below seafloor) at IODP Site C0002, at pressure, pore-water pressure and temperature conditions supposed at depths of 1000–6000 mbsf there, and axial displacement rates V_{axial} changed stepwise among 0.1, 1 and 10 μm/s.

The results show that the steady-state friction coefficient μ_{ss} decreases from 0.32–0.35 at the 1000 mbsf condition to 0.29–0.31 at the 3000 mbsf condition, while it increases from those values at that condition to 0.34–0.37 at the 6000 mbsf condition. Fitting the friction data for each step change in V_{axial} by the rate-and state-dependent friction constitutive law reveals that ($a-b$) value (rate dependence of μ_{ss}) monotonously decreases from positive values at the 1000 mbsf condition through ≈0 at the 5000 mbsf condition to negative values at the 6000 mbsf condition.

Dehydration of smectite at the 3000 mbsf condition where temperature was 100℃ possibly increased pore pressure in the impermeable gouge layer, which was likely responsible for the minimum μ_{ss} at this condition. This suggests the presence of a high pore-pressure zone at ≈3000 mbsf of IODP Site C0002 due to dehydration of smectite in impermeable mud sediments. Our experimental results also suggest a transition from aseismic faulting with $a-b>0$ to potentially seismic faulting with $a-b<0$ at ≈5000 mbsf of IODP Site C0002. In fact, stick-slip corresponding to seismic faulting was observed at the 6000 mbsf condition.

Keywords: mud gouge, frictional properties, Nankai Trough accretionary prism

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Seafloor fiber optic strainmeter performance with different cable laying condition.

*Eiichiro Araki[1], Shuhei Nishida[1], Takashi Yokobiki[1], Matthew James Cook[1], Mark Zumberge[2], Toshinori Kimura[1], Yuya Machida[1], Shuichi Kodaira[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. IGPP, Scripps Institution of Oceanography

Measuring seafloor strain in long baseline, can be powerful means to observe dynamics occurring at depth, because local interference at the seafloor may be reduced by averaging over the long baseline, while the effect of strain source at depth does not. Aiming at capturing slow crustal deformation which may episodically occur in the subducting plate interface, we installed a seafloor fiber strainmeter, which measures length of 200 m long optical fiber laid in the seafloor, in the Nankai Trough seafloor in June, 2019 (Araki et al., 2019). The instrument is linked to the DONET (Dense Ocean-floor Network for Earthquake and Tsunamis) and data is continuously obtained through the network. Since the initial installation, we have conducted a series of seafloor experiments by remotely operated vehicle (ROV) to investigate how we can make observation of seafloor strain with low-noise enough to capture expected slow slip event.

In the initial installation, we aimed to surficial bury the fiber cable in the seafloor by a few cm by ROV towed sled. This was partially successful, but we noticed the laid fiber was slightly meandered and suspected if the measured strain really represents distances between two end points of the fiber cable. Therefore, we pulled up and retention the fiber in October 2019 to lay the cable straight but not buried in the seafloor. The modified lay resulted in more reasonable response of the fiber length over long-term, which showed more rapid, but decaying drift. We consider the decaying drift characteristics reflected that the tension acting on the fiber was distributed along the whole length unlike the initial installation. The drawback of the retention fiber in the seafloor, on the other hand, is that a part of the fiber is not in friction to the seafloor sediment, but suspended in the water due to small undulation of the seafloor topography. Behavior of such suspended fiber is difficult to predict, because slight change in the contact surface of the fiber cable could result in the shift of the cable, leading to the total length change. We considered that reasonable friction between the laid fiber cable and the seafloor sediment was necessary to suppress such non-linear behavior. So, we revisited the seafloor strainmeter site again in August 2020, to visually check the condition of laid fiber by ROV camera, and placed metallic plates to secure the cable in contact with the sediment where was suspended in the water. After the seafloor operation, unexpected shift of observed strain data did not occur, and the strain data became quiet enough for low frequency seismic observation. Long-period stability of the measured fiber strain data is approximately 200 nano-strain after reduction of long-term trend and effect of ocean tide, stable enough to expect observation of slow slip event of moderate size, if occurred at the plate interface beneath the instrument.

We are currently planning to install more fiber strainmeters in the Nankai Trough. In the future installations, care need to be taken to completely bury the sensing fiber in the sediment while the whole length is laid straight so that measured fiber strain truly represents strain of the seafloor sediment.

Keywords: fiber optic strainmeter, seafloor observation, slow slip event, slow earthquakes

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Real-time SSE monitoring by optical borehole tiltmeter in the Nankai Trough, Japan

*Toshinori Kimura[1], Eiichiro Araki[1], Takashi Yokobiki[1], Shuhei Nishida[1], Matthew J Cook[1], Mark Zumberge[2], Keisuke Takahashi[3], Takane Hori[1], Shuichi Kodaira[1]

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In the Nankai Trough subduction zone, a submarine cable network observation system named DONET has been in operation. The DONET system was originally equipped with broadband seismometers and pressure gauges to observe broadband real-time seismic and tsunami activities and vertical displacement of the seafloor above the source region of the mega-thrust earthquake which occurs every 100 to 150 years. The DONET system has an ability to expand observation by connecting new sensors to the observation node. To monitor small and slow crustal deformation, three borehole observatories, each having a tiltmeter, a strainmeter and a pore-fluid pressure gauge installed in the bottom of boreholes with depths of 500 to 900 mbsf, have been connected to the DONET nodes since 2013. Long-term data observed by the borehole sensors revealed that a slow slip event (SSE) of several weeks period has occurred repeatedly and accommodated about half of the plate motion (Araki et al., 2017). SSE monitoring in a wide area along the plate subduction zone enables us to estimate spatio-temporal change of interplate coupling, which would be a key parameter for the assessment of the rupture region of the future mega-thrust earthquakes.

In recent efforts, we have developed and installed new sensors, including a fiber optic strainmeter on seafloor and a bubble type tiltmeter in the shallow borehole with diameter of 104 mm and depth of 8.6 mbsf drilled by BMS (Boring Machine System) in the DONET 2F and 1B areas since 2019. These pilot observatories have been installed and operated to observe SSE distributed along the DONET region. Initial data observed by these sensors suggested that they have the ability to capture weak signals related to SSE. However, the observed data suggested that the coupling condition of sensors on the seafloor and in the borehole is very important to measure weak signals. Also, new sensors which have higher stability and lower self-noise than conventional sensors are still needed.

Accordingly, we prepared a new sensor and installation scheme for high-quality real-time SSE monitoring. For the new sensor, we fabricated an optical tiltmeter, which was originally developed by Scripps Institution of Oceanography. The tiltmeter has two long pendulums that swing with length of ~40 cm around orthogonal horizontal axes while their weighted ends are tracked by Michelson interferometers (Zumberge et al., 2018). The power unit and data transmission scheme were modified for DONET protocol. The optical tiltmeter was tested in a shallow borehole drilled in the Kamioka mine for 6 weeks from Oct. to Dec. 2020, and was compared with a broadband seismometer, CMG3T, same as DONET seismometers. We performed power spectral density analysis and phase analysis using ambient noise records and teleseismic records. Results confirmed that the optical tiltmeter can observe broadband signals from approx. 0.001 Hz to several ten Hz with the same flat amplitude and phase responses as those of the broadband seismometer. In long-term data, the stability of the optical tiltmeter was almost the same level as the bubble type tiltmeter. These results suggest that the optical tiltmeter can observe broadband seismic signals and geodetic signals. We developed a new installation scheme for the tiltmeter in a high stability environment created by drilling a borehole and cementing in the sensor. BMS was modified for drilling a large diameter of Φ230 mm with 20 m depth for the optical tiltmeter.

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Cement-based mortar with special formulation for sensor installation was developed. A mortar deployment system by ROV (Remotely operated vehicle) was developed including the pumping system. A special winch unit was also developed for the tiltmeter installation by ROV.

The tiltmeter was successfully installed into a 19 m borehole on 26 Jan. 2021 by KM-ROV. Before the installation, the borehole was drilled by the BMS, and a greater than 2 m interval at the bottom of the borehole was filled with cement. The optical tiltmeter was then installed by the winch system. On 11 Feb. 2021, the tiltmeter was connected to the DONET network by ROV Hyper Dolphin. The optical tiltmeter is now on-line transmitting continuous tilt data. Preliminary results of timeseries and PSD analysis suggest that the optical borehole tiltmeter has lower noise level than that of horizontal component of the DONET broadband seismometer in long-period seismic band. We expect that the tiltmeter can measure weak horizontal signal related to teleseismic and very low frequency earthquakes, which cannot be captured by DONET seismometer. In this presentation we will show initial data observed by the tiltmeter including seismic signals and tidal response.

Keywords: Nankai Trough, Slow slop event, Optical tiltmeter

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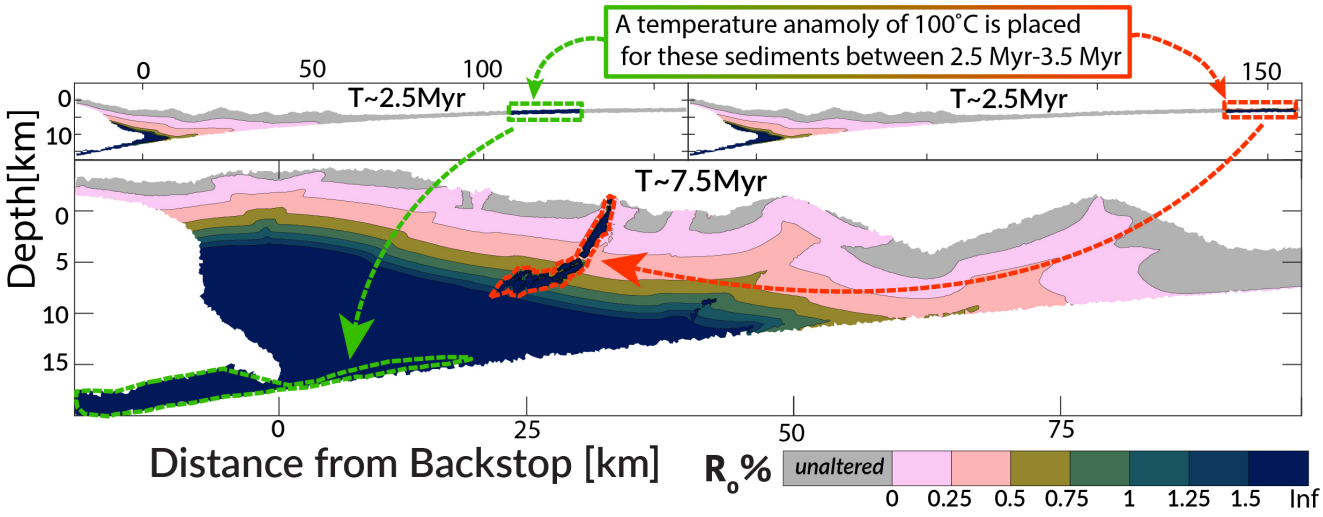
Thermal maturity observations depend on the structural history of the wedge

*Utsav Mannu[1], David Fernández-Blanco[2], Ayumu Miyakawa[3], Taras Gerya[4], Masataka Kinoshita[5]

1. Indian Institute of Science Education and Research Pune, 2. Barcelona Center of Subsurface Imaging, Institut de Ciències del Mar (ICM-CSIC), Barcelona, 3. Geological Survey of Japan, AIST, 4. Institute of Geophysics, ETHZ Zurich, 5. Earthquake and Volcano Information, Earthquake Research Institute, Tokyo-U

Estimations of the thermal evolution of sediments from thermal maturity proxies like vitrinite reflectance overlook the influence of fault patterns in wedge evolution. Our numerical study uses conservative 2D finite-difference thermomechanical models of subduction to show that the distribution of faults in the wedge, and particularly, the location of the frontal thrust, is critical to providing feasible inferences for thermal maturity observations. Given that the fault patterns that occur during wedge evolution are influenced by external factors, such as sedimentation, erosion, incoming sediment thickness, the topographic gradient in the slab, etc., these factors also control the thermal maturity of wedge sediments. Our observations support the existence of low and high maturity paths in the wedge, and more relevantly, constraint the conditions of preference of specific pathways. Our results also show that the thermal maturity distribution inside the wedge is most robust in the shallower part of the wedge for sediments at the highest structural locations and that thermal maturity inferences ought to account for the structural patterns of wedge evolution.

Keywords: Accretionary Wedge, Thermal maturity, Geodynamic modeling



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[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.12_3

[S-CG51] New perspectives of subduction zone earthquake dynamics through experiments across-scales

convener:Masataka Kinoshita(Earthquake Research Institute, University of Tokyo)

Knowledge on subduction zone earthquake phenomena has considerably increased in the last decade. On the other hand, there are limits to seismological approach alone to comprehensively elucidate the earthquake mechanism in which phenomena that differ by 10 orders of magnitude in space and time, from earthquake nucleation/growth processes to its driving force. Steps to enable scientific earthquake forecasting should include; monitoring regional seismic/tectonic activity using networked observatories, sampling of and insitu measurement in seismogenic faults and plate materials through ultra-deep drilling, and reproduction/insitu-observation of fracture nucleation processes by high-pressure quantum-beam experiments. Through a close collaboration, we challenge a dynamic imaging of earthquake processes. Based on the proposal approved as a Large Research Master Plan 2020 of the Science Council of Japan, we will deepen the interdisciplinary discussion on subduction-zone earthquakes and the state & property of lithosphere. We welcome, but not limited to, presentations from fields of ocean and land networks observation, seismogenic zone drilling, rock mechanical & quantum beam experiments, fracture process
theory, etc.

[SCG51-P01] For examining steady-state solution for pore pressure distribution in a plate-subduction zone incorporating fluid release by chemical reaction

*Shunya Kaneki[1], Hiroyuki Noda[1] (1.Disaster Prevention Research Institute, Kyoto University)

[SCG51-P02] A new method for large number of core sample CT scanning and preliminary results of Nankai Trough DSDP and ODP core samples

*Satoshi Tonai[1], Yusuke Kubo[2], Masataka Kinoshita[3], Keishi Okazaki[2] (1.Faculty of Science and Technology, Kochi University, 2.Kochi Institute for Core Sample Research, JAMSTEC, 3.Earthquake Research Institute, University of Tokyo)

For examining steady-state solution for pore pressure distribution in a plate-subduction zone incorporating fluid release by chemical reaction

*Shunya Kaneki[1], Hiroyuki Noda[1]

1. Disaster Prevention Research Institute, Kyoto University

Progressive compaction and dehydration of subducting sediments in a plate-subduction zone have been considered to affect its pore pressure condition. Representative dehydration reactions include smectite-illite-muscovite conversion and amorphous silica-Opal CT-quartz conversion reactions. Some previous studies modelled quantitative effects of compaction and these dehydration reactions on steady-state pore pressure and permeability. However, these studies ignore the volumetric change in solid phase by reaction, and thus the steady-state solutions incorporating the spatial heterogeneity of such volumetric change should be examined.

The ultimate goal of this study is to examine the steady-state solutions for pore pressure distribution incorporating progressive compaction and dehydration reactions based on a reasonable physical model. Because the permeability of fault rocks is generally much higher than that of surrounding intact rocks, we consider the very simple model in which fluid flows only along a fault zone. Dirichlet boundary conditions of pore pressure were postulated at a surface and a down-dip limit of seismogenic crust. We focus on Kumano Basin in Nankai Trough as an example of plate-subduction zones, and various physical properties were set according to the previous studies examined in this area. Amorphous silica content in the core samples is reported to be less than 1 wt%, so we focus only on the transformation reactions of smectite. As we could not find any literatures reporting kinetics of illite-muscovite conversion, only illitization of smectite is considered here.

The qualitative effect of fluid release due to chemical reaction on pore pressure depends on the balance between the rates of fluid release and pore volume created by reaction. On the basis of some reaction equations reported in previous studies, illitization of smectite can have both positive and negative effects on pore pressure. However, if we consider the constraints on the reaction equation such that the mole number of reacted smectite and generated illite must be equivalent, illitization of smectite may have positive effect on pore pressure. The preliminarily calculation shows that smectite dehydration can decrease pore pressure by up to ~10 MPa. In this presentation, we would like to discuss the calculation results obtained before the conference, in addition to these preliminarily results.

Keywords: Plate-subduction zone, Dehydration reaction, Smectite, Pore pressure, Steady-state solution

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A new method for large number of core sample CT scanning and preliminary results of Nankai Trough DSDP and ODP core samples

*Satoshi Tonai[1], Yusuke Kubo[2], Masataka Kinoshita[3], Keishi Okazaki[2]

1. Faculty of Science and Technology, Kochi University, 2. Kochi Institute for Core Sample Research, JAMSTEC, 3. Earthquake Research Institute, University of Tokyo

X-ray CT scan (hereafter referred to as CT) can obtain the three-dimensional internal structure of an object with non-destructive and high spatial resolution by using the difference in the degree of X-ray absorption depending on the density and/or element. Since it is highly valuable as basic information for geological core samples, geological core samples drilled by D/V *Chikyu* are taken CT data on board. However, other core samples are basically not collected CT data. One of the issues when collecting CT data for a large number of core samples is working time, and we report a new method for acquiring efficiently CT data at Kochi Core Center, Japan (hereafter referred to as KCC).
At KCC, core samples are usually scanned one by one using CT scanner. In the reporting method, 12 core samples were scanned at one time and divided into CT data for each core using an image processing program. With these improvements, work efficiency has increased about 10 times. For example, CT data can be acquired in about 1 or 2 days for core samples from one site of ODP or IODP (several hundred meters long). The spatial resolution of the CT image from the new method is about 0.5 mm/pixel, which is slightly inferior to the resolution of 0.2 mm/pixel when taken with a one by one image. Nevertheless, they can be fully utilized for analysis of geological structure, crack distribution, or downhole profiles of mean CT values of core samples.
As a preliminary study, the method of this study was applied to some DSDP and ODP core samples around the Nankai Trough. In the Nankai Trough, a hydrothermal mineralization was reported from the drilling core at Site C0023 of IODP Expedition 370 located at the toe of the Nankai accretionary complex (Tsang et al., 2020). In order to clarify the scale and origin of the hydrothermal mineralization, CT data of other sites excavated around the Nankai Trough are considered to be effective, and mainly the Nankai Trough off the coast of Ashizuri, Kochi Prefecture. CT data were obtained for the core samples from seven sites. As a result, sections showing high CT values were confirmed at multiple intervals. In particular, high CT value intervals were found in the lower part of the Shikoku Basin sediments at site 1177. At least in some of these high CT value intervals, no corresponding description or physical property data was confirmed by previous studies using the same samples. Thus, it is considered that there is a possibility that new geological information of core samples can be extracted by acquiring a large amount of CT data.

Keywords: Nankai Trough, Hydrothermal alternation, X-ray CT

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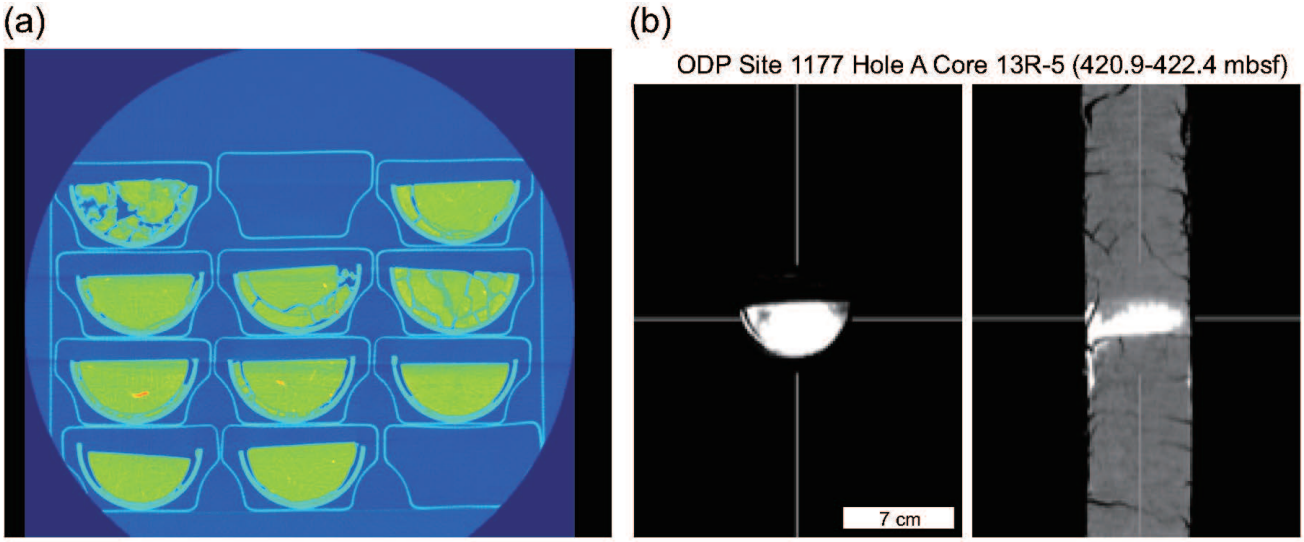


Fig.1. (a) 12 CT slice images scanning one time. (b) Typical high CT value interval of core sample (white area).

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.18 Zoom Room 18

[S-CG52] Driving Solid Earth Science through Machine Learning

convener:Hisahiko Kubo(National Research Institute for Earth Science and Disaster Resilience), Yuki Kodera(Meteorological Research Institute, Japan Meteorological Agency), Makoto Naoi(Kyoto University), Keisuke Yano(The Institute of Statistical Mathematics), Chairperson:Yuki Kodera(Meteorological Research Institute, Japan Meteorological Agency)

The development of machine learning techniques, such as deep learning, has led to innovations in various fields and is gaining ground in the solid earth sciences. This session provides an opportunity to inspire each other for future developments by bringing studies of machine learning applications in various fields including solid earth science. We especially welcome researches that have led to the discovery of phenomena and theories in solid earth science. We also look forward to studies on the black box problem of deep learning and efforts toward explainable AI.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG52-01] Crustal stress inferred from focal mechanism solutions based on P wave first-motion polarities picked using deep learning

*Takahiko Uchide[1], Takahiro Shiina[1], Kazutoshi Imanishi[1] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG52-02] Automatic seismic arrival-time picking of seismogram sampled at 250 Hz using Deep Learning

*Shinya Kato[1], Yoshihisa Iio[2], Hiroshi Katao[2], Masayo Sawada[2], Kazuhide Tomisaka[2], Rie Mizushima[2] (1.Graduate School of Science, Kyoto University., 2.Disater Prevention Research Institute, Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG52-03] Deep-neural-network-based arrival-time picking and earthquake location: application to S-net

*Rintaroh Suzuki[1], Naoki Uchida[1], Weiqiang Zhu[2], Takashi NAKAYAMA[1], Genti Toyokuni[1], Ryota Takagi[1], Ryosuke Azuma[1], Gregory C Beroza[2] (1.Graduate School of Science, Tohoku University, 2.Department of Geophysics, Stanford University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG52-04] Induced Earthquakes Before and After Cessation of Longterm Injections in Rongchang Gas Field, Sichuan, China

*Zhiwei Wang[1], Xinglin Lei[2], Jinrong Su[3], Shengli Ma[1], Yusuke Mukuhira[4] (1.Institute of Geology, China Earthquake Administration, 2.Geological Survey of Japan, AIST, 3.Earthquake Monitoring Centre, Sichuan Earthquake Administration, 4.Institute of Fluid Science, Tohoku University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG52-05] Site Generalization Performance of Ground Motion Models: Application of Monotonic Neural Networks

*Tomohisa Okazaki[1], Nobuyuki Morikawa[2], Hiroyuki Fujiwara[2], Naonori Ueda[1] (1.RIKEN Center for Advanced Intelligence Project, 2.National Research Institute for Earth Science and Disaster Resilience)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG52-06] Prediction of natural disasters based on a hybrid approach of physics-driven and data-driven method

★Invited Papers

*Takashi Miyamoto[1] (1.University of Yamanashi)

Crustal stress inferred from focal mechanism solutions based on P wave first-motion polarities picked using deep learning

*Takahiko Uchide[1], Takahiro Shiina[1], Kazutoshi Imanishi[1]

1. Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)

Understanding of crustal deformation and forecast of inland earthquakes need knowledge on the crustal stress orientation. Estimated stress orientations have been compiled as the World Stress Map (Heidbach et al., 2018). In the case of the Japan Islands, Terakawa et al. (2010) estimated the stress orientations using moment tensor solutions from the routine catalog of NIED F-net for typically M 3.5 or greater. Yukutake et al. (2015) used focal mechanism solutions that were determined using manual picks of P wave first-motion polarities. The resolution of the stress field estimation is limited by data. Moreover, there are many areas with no focal mechanism solutions and then the stress field cannot be estimated in this way. There is a case that stress orientations inferred from focal mechanism solutions of microearthquakes were clearly different from their surroundings (e.g., Imanishi et al. (2012)), which suggests that the interpolation of the stress estimation does not always work. Therefore, we desire the focal mechanisms of even more earthquakes. Thanks to the recent development of deep learning, Uchide (2020) studies focal mechanisms of ~ 110 thousand events with M 1.5 or larger beneath Japan Islands. Using this technique, we estimate focal mechanisms of even more earthquakes and the crustal stress orientation of the Japan Islands.

First, we determined focal mechanisms of small to microearthquakes around Japan Islands by the HASH method (Hardebeck and Shearer, 2002) using P-wave first-motion polarities. Seismic data were from NIED Hi-net, JMA, and GSJ/AIST. P-wave arrival times were from the JMA catalog and first-motion polarities were picked by the neural network model of Uchide (2020). We selected earthquakes with JMA magnitudes greater than 0.5, inside of or within 50 km from coastlines of Japan Islands, and at depths less than 20 km. As a result, we analyzed ~ 573 thousand events, which is approximately five times more than those studies by Uchide (2020). We obtained “A” to “C” rank solutions for more than 195 thousand events, which was used for the following stress inversion analysis.

The stress orientation was estimated using the SATSI code (Hardebeck and Michael, 2006). The grid interval was 0.2° for both latitude and longitude. Several small-scale stress anomalies were seen: normal faulting areas in northeast Japan and stress anomaly around Cape Shionomisaki of Kii peninsula, beneath which a high-density block was detected (Honda and Kono, 2005). The spatial changes in the stress orientation were often seen on tectonic lines and faults, such as the southern end of Itoigawa-Shizuoka Tectonic Line, the Median Tectonic Line in Shikoku island, Nagato-Hida marginal Tectonic Line in Chugoku region, and Hinagu and Futagawa faults in Kyushu island. This spatial correspondence can be a clue to investigate the cause of the stress orientation changes.

Acknowledgment
We used phase data from JMA Unified Earthquake Catalog, and seismic data from NIED Hi-net, JMA, and GSJ/AIST. We also used the HASH code (Hardebeck and Shearer, 2002) and the SATSI code (Hardebeck and Michael, 2006). This work was supported by the AIST EDGE Runners project.

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Keywords: Seismology, Crustal Stress, Focal Mechanisms, Stress Inversion, Deep Learning

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Automatic seismic arrival-time picking of seismogram sampled at 250 Hz using Deep Learning

*Shinya Kato[1], Yoshihisa Iio[2], Hiroshi Katao[2], Masayo Sawada[2], Kazuhide Tomisaka[2], Rie Mizushima[2]

1. Graduate School of Science, Kyoto University., 2. Disater Prevention Research Institute, Kyoto University

Accurate seismic arrival-times are required to detect accurate earthquake location and to estimate a velocity structure. In recent years, the number of observation data has been increasing. In particular, We have installed high dense seismic station networks (Manten network) with 250 Hz sampling in Kinki, San-in and Nagano (Miura et al., 2010; Iio., 2010; Iio et al., 2017). The amount of data used for analysis has been increasing as seismic stations have been increasing, but the workload has also been increasing since arrival-time picking is a very time-consuming task.

Automatic arrival-time picking algorithms that can detect arrival-time in a shorter time than humans have been proposed. Conventional automatic arrival-time picking algorithms (Allen., 1978; Sleemen & van Eck., 1999) has poor accuracy, but recently, automatic arrival-time picking algorithms using deep learning (Ross et al., 2018; Zhu and Beroza, 2018; Hara et al., 2020) has been proposed and reported that models made by automatic arrival-time picking algorithms using deep learning are comparable to human accuracy.

In this study, in order to reduce the workload, we made an automatic arrival-time picking model. An algorithm used to make the model is PhaseNet (Zhu and Beroza., 2018). It can output probability values of P-wave, S-wave, and Noise (The Noise probability is calculated by Prob.(Noise) = 1− Prob.(P-wave) −Prob.(S-wave)) for each sampling point of input waveform. Currently, the automatic arrival-time picking model made by PhaseNet is available (https://github.com/wayneweiqiang/PhaseNet), but that model used 100 Hz sampling waveforms for training. Therefore, it is necessary to make the model that is suitable for seismic waveforms obtained with 250 Hz sampling.

For the training of PhaseNet, we used waveforms of M-0.9 to 4.7 recorded by the Manten network in San-in during the period of March to October 2015, whose arrival-times were detected by experts. Although this data set and data set used in Hara et al.(2020) are partially the same, the accuracy of the arrival-time used in this study is better than data used in Hara et al.(2020) due to the redetection of experts. The inputs to PhaseNet are three-component waveforms, and the available model was trained with UD, NS, and EW as input. In this study, we trained PhaseNet for the following three cases, taking into account the fact that when we have detected S-wave arrival-times of seismic waveforms obtained by Manten network, we have usually used SH components.

Case 1 : Model trained by UD, EW and NS
Case 2 : Model trained by UD, SH wave and 0 as missing value
Case 3 : Model trained by UD, SH wave and SH wave (copy)

The accuracies of the three models were evaluated, and the automatic arrival-time picking model of the 250 Hz sampling waveform was made. In this presentation, the accuracy evaluation of the models and the results by the models will be presented.

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Keywords: deep learning, arrival-time picking, Manten network

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Deep-neural-network-based arrival-time picking and earthquake location: application to S-net

*Rintaroh Suzuki[1], Naoki Uchida[1], Weiqiang Zhu[2], Takashi NAKAYAMA[1], Genti Toyokuni[1], Ryota Takagi[1], Ryosuke Azuma[1], Gregory C Beroza[2]

1. Graduate School of Science, Tohoku University, 2. Department of Geophysics, Stanford University

1. Introduction

Off the Pacific coast of Tohoku Japan, the new cabled ocean bottom seismic network (S-net) gives us a large number of seismograms of offshore earthquakes. Automatic arrival time picking (hereafter, phase picking) and event location methods make an important contribution for fast earthquake detection and location from such a large dataset. In our previous study, we evaluated a phase picking method based on a deep neural network, PhaseNet (Zhu and Beroza, 2019) for application to S-net (Suzuki et al., 2020: JpGU-AGU Joint Meeting). Although we used the pre-trained model with the seismic data in northern California for the phase picking, PhaseNet showed comparable or better performance compared with two other automatic phase picking methods. In this study, we train PhaseNet using S-net data and estimate arrival times with the newly trained PhaseNet. We then, associate the phases to detect events and estimate their hypocenters.

2. Data and method

The S-net has been deployed since 2013 by the National Research Institute for Earth Science and Disaster Resilience, and the continuous records from 2016 are available. We focused on a M5.6 event on Aug. 8. 2018 (hereafter, the mainshock) that occurred near the Japan trench offshore Miyagi. Note that the S-net data has been used for JMA’ s hypocenter location since September 2020. We first trained the PhaseNet with data from 150 S-net and 492 other land stations by 727 events. We used 98,766 manual picks from onshore (39,858) and offshore (58,918) stations in the Tohoku region. The number of the P and S wave picks are the same. After training PhaseNet, we used continuous waveform data from 9 S-net stations near the mainshock for phase picking by the newly trained PhaseNet for the period from 1 week before to 2 weeks after the mainshock. We then performed earthquake detection by associating the picked phases to individual events using a phase association method (REAL; Zhang et al., 2019) to find new events offshore Tohoku. This method REAL associates P and S phases from multiple stations with a single event and locates its hypocenter with a grid search to minimize the travel time residuals. We searched potential hypocenters shallower than 50 km and within the area of 0.48 ×0.48 degrees area centered at the station that recorded the first-arriving phase for each events. Finally, we refined the hypocenter location by a nonlinear earthquake location method (hypomh; Hirata and Matsu’ ura, 1987).

3. Results

The newly trained PhaseNet using S-net and land stations data achieved good performance (F1 score: harmonic mean of precision and recall rate) for both P (0.745) and S (0.494) waves. This F1 score is better than that of the original model (0.409 for P waves and 0.283 for S waves) that was trained by the northern California data. This suggests despite the smaller number (1/10) of training data, the new model trained with S-net data has better performance for S-net data.

Using the newly trained model of PhaseNet and the phase association method (REAL), we detected 106 events in the region during the three-week period while JMA listed 43 events using land data only. This suggests the sequential application of PhaseNet and REAL is potentially effective to automatically detect new earthquakes. We expect that the phase picking method based on a deep neural network will

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contribute to revealing the detailed seismicity offshore Tohoku, Japan by using S-net waveform data.

Keywords: S-net, Neural networks, Computational seismology, Seismic monitoring

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Induced Earthquakes Before and After Cessation of Longterm Injections in Rongchang Gas Field, Sichuan, China

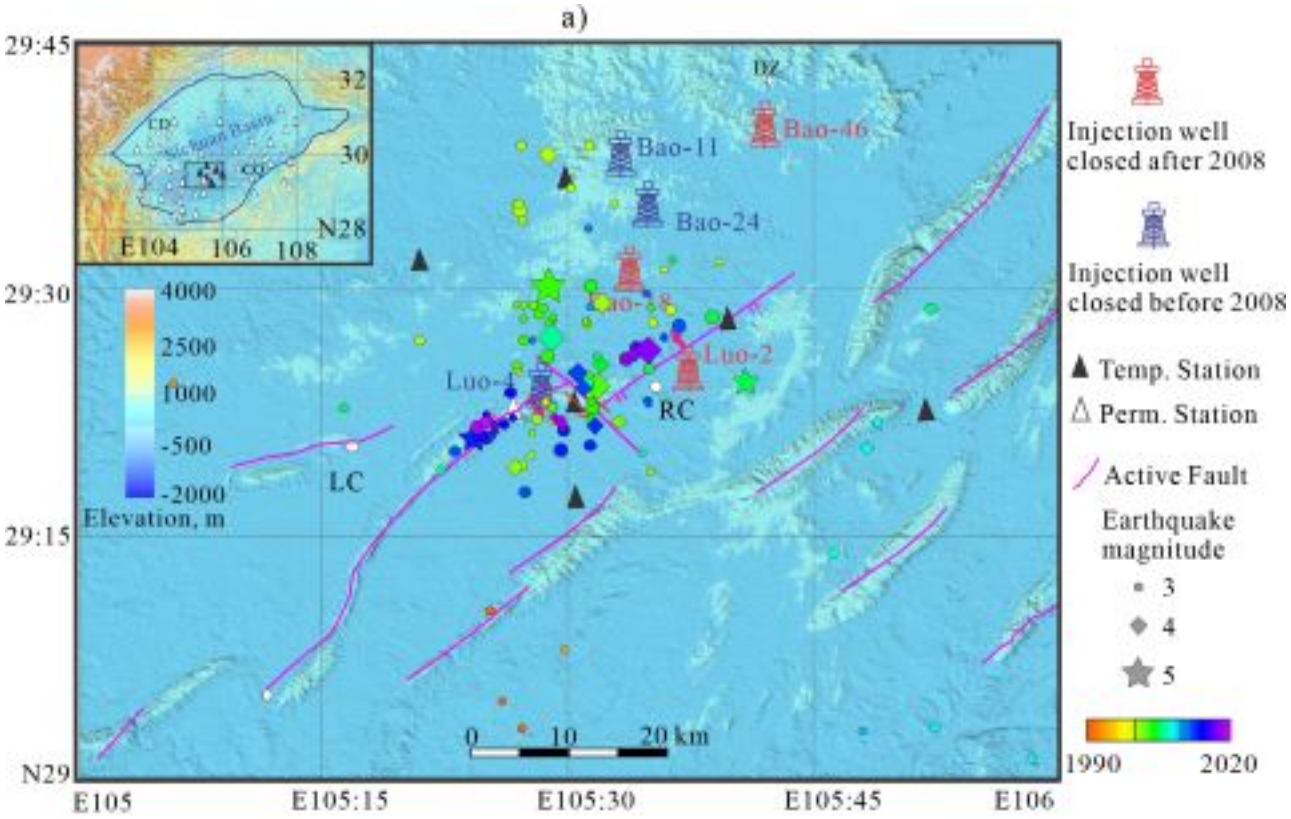
*Zhiwei Wang[1], Xinglin Lei[2], Jinrong Su[3], Shengli Ma[1], Yusuke Mukuhira[4]

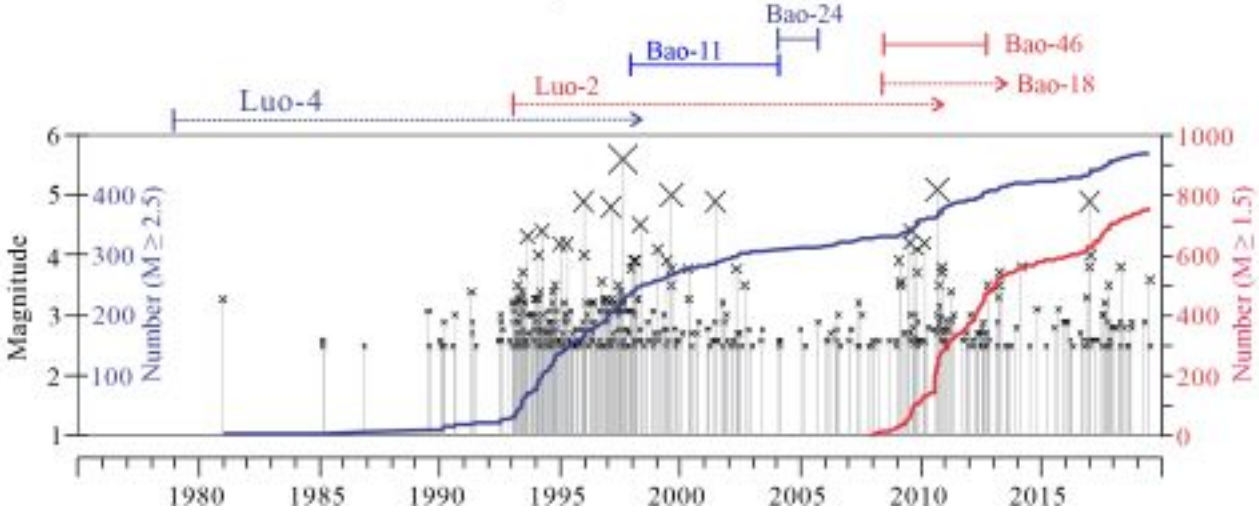
1. Institute of Geology, China Earthquake Administration, 2. Geological Survey of Japan, AIST, 3. Earthquake Monitoring Centre, Sichuan Earthquake Administration, 4. Institute of Fluid Science, Tohoku University

For more than three decades, the depleted Rongchang gas reservoir in China's Sichuan Basin was used for the disposal of unwanted water, which resulted in induced earthquakes, with magnitudes as high as 5.2. After all wells were closed, the frequency of seismic activity was observed to decay following a modified Omori law, and since April 2015, seismic activity again began to increase, and a M4.9 earthquake occurred on 27 December. The results of an Epidemic Type Aftershock Sequence (ETAS) model analysis show that forced seismicity accounted for more than 70% of the total events. For most Magnitude greater than 3.5 earthquakes, including two Magnitude greater than 4 events, the estimated overpressure was lower than the maximum injection pressure. These results, coupled with the fact that postinjection seismic activity has similar characteristics to seismicity during injection, indicate that the injected overpressure fluid was still the driving factor for postinjection seismic activity.

Keywords: Longterm Injection Induced Earthquakes, Postinjection Seismic Activity, Overpressure Fluid

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Site Generalization Performance of Ground Motion Models: Application of Monotonic Neural Networks

*Tomohisa Okazaki[1], Nobuyuki Morikawa[2], Hiroyuki Fujiwara[2], Naonori Ueda[1]

1. RIKEN Center for Advanced Intelligence Project, 2. National Research Institute for Earth Science and Disaster Resilience

Ground motion models (GMM) provide empirical relationships between earthquake parameters and ground-motion intensities. In addition to regression models developed over the past 50 years, machine learning (ML) methods recently came into use. ML models can obtain input-output relationships without assumptions, but are in danger of overfitting owing to their flexibility. To evaluate the predictive power (generalization performance) of ML GMMs, observational records are customary divided into training and test datasets based on records or earthquakes.

In this presentation, however, we demonstrate that the above division of dataset does not work for monitoring overfitting to recorded site when a model includes site-condition proxies (SCP) as input variables; complex deep neural network (DNN) models with many SCPs apparently exhibit good predictive power at trained sites but show serious overfitting at new sites. Therefore, it is crucial to divide dataset based on recorded site for correctly evaluating site generalization performance. As a possible solution to maintain generalization performance in DNN models, we propose to impose monotonic dependence on input variables. An experimental application supports the effectiveness of this simple approach.

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Prediction of natural disasters based on a hybrid approach of physics-driven and data-driven method

*Takashi Miyamoto[1]

1. University of Yamanashi

Data-driven science methods, which have made remarkable progress in recent years, are expected to be utilized in the field of disaster management, and their applications in hazard prediction, current situation assessment, and disaster response are being studied. On the other hand, because it is difficult to assure the quality and quantity of data under the inherent uncertainty of natural phenomena and the rarity of major events, the application of data-driven science methods is becoming increasingly difficult. In particular, predicting the temporal evolution of disaster events is necessary to predict future states, including situations that have never been experienced before, and improving the accuracy of such extrapolative predictions is a major challenge for data-driven science.

To solve this problem, an approach that combines physical methods where natural laws are modeled with data-driven science methods has recently gained popularity. Such an approach makes complementary use of the advantages of data-driven methods, which build models flexibly from data, and the advantages of physical methods, which enable extrapolative prediction by applying natural laws.

In this presentation, after an overview of the integration of physical and data-driven methods, a method for short-term rainfall prediction is presented as a concrete example of research by the presenter. In this method, the governing equation of rainfall is divided into two terms, i.e., the substantial change term and the advection term under the Lagrangian coordinates, then each term is modeled by different data-driven methods. The substantial change term is modeled using the Koopman mode analysis, a data-driven method for discovering the laws behind dynamic phenomena. The method's performance in representing the development and decay of rainfall is presented compared with conventional short-term forecasting methods.

Keywords: Prediction of phenomena, data-driven science, spatio-temporal data

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[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.14_3

[S-CG52] Driving Solid Earth Science through Machine Learning

convener:Hisahiko Kubo(National Research Institute for Earth Science and Disaster Resilience), Yuki Kodera(Meteorological Research Institute, Japan Meteorological Agency), Makoto Naoi(Kyoto University), Keisuke Yano(The Institute of Statistical Mathematics)

The development of machine learning techniques, such as deep learning, has led to innovations in various fields and is gaining ground in the solid earth sciences. This session provides an opportunity to inspire each other for future developments by bringing studies of machine learning applications in various fields including solid earth science. We especially welcome researches that have led to the discovery of phenomena and theories in solid earth science. We also look forward to studies on the black box problem of deep learning and efforts toward explainable AI.

[SCG52-P01] Automatic hypocenter determination by deep learning for microseismic networks in geothermal areas

*Kyosuke Okamoto[1], Yusuke Mukuhira[2], Hiroshi Asanuma[1], Markus Häring[3] (1.National Institute of Advanced Industrial Science and Technology, 2.Tohoku University, 3.Häring GeoProject)

[SCG52-P02] Toward development of dense low cost citizen seismic network: Performance comparison of different types of neural network architectures

*Ahyi KIM[1], Hiroki Uematsu[1], Yuji Nakamura[1], Yuta Takahashi[1], Momoko Nakamura[1] (1.Yokohama City University)

[SCG52-P03] Unsupervised automatic classification of seismic records based on a hierarchical clustering

*Yuki Kodera[1], Shin'ichi Sakai[2] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Earthquake Research Institute, the University of Tokyo)

[SCG52-P04] Hierarchical cluster analysis of F-net moment-tensor-solution catalogue in Japan

*Hisahiko Kubo[1], Takeshi Kimura[1], Katsuhiko Shiomi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

Automatic hypocenter determination by deep learning for microseismic networks in geothermal areas

*Kyosuke Okamoto[1], Yusuke Mukuhira[2], Hiroshi Asanuma[1], Markus Häring[3]

1. National Institute of Advanced Industrial Science and Technology, 2. Tohoku University, 3. Häring GeoProject

A dense seismic network including deep borehole sensors is ordinally employed in developing geothermal areas to detect a change in seismicity regarding the geothermal developments. It is possible that illuminating subsurface fluid flows in detail by tracking the microseismic clouds in high-resolution. However, hypocenter determinations based on manual phase picks are sometimes difficult due to lack of manpower as well as cost. Moreover, automatic event picks based on STA/LTA still need manual corrections of the picks for high-resolution hypocenter determinations,

In this study, we aimed to develop an automatic event pick method based on deep learning that could substitute for manual picks especially for microseismic networks in geothermal areas. We developed the method by using seismic data observed by a dense seismic network (five borehole sensors, four surface sensors) employed in Okuaizu Geothermal Field (Fukushima, Japan) since May 2015. We also examined applicability of this method to another geothermal field by using seismic data observed by a dense seismic network (six borehole sensors) in Basel geothermal field (Switzerland).

Deep learning was conducted by “teachers”: manual picks of 33,008 P-waves and 65,925 S-waves from microseismic events (local magnitude range: -1.5 –2.5) observed in the Okuaizu Geothermal Field. Then, the accuracy of the learning was evaluated by 3,344 P-waves and 3,310 S-waves. As the result, the accuracy for P-waves was average = ˜0.03 s and standard deviation = ˜0.46 s and that for S-waves average = ˜0.01 s and standard deviation = ˜0.30 s. We applied this deep learning phase picker to the seismic events detected from continuous seismic waves by STA/LTA in Okuaizu Geothermal Field, and found that the hypocenter distribution based on the deep learning pick showed a shape similar to that based on the manual pick. When applying to this deep learning phase picker to 3,069 seismic events in the Basel geothermal field (17,138 P-waves, 13,702 S-waves), the accuracy for P-waves was average = ˜0.15 s and standard deviation = ˜0.58 s and that for S-waves average = ˜0.16 s and standard deviation = ˜0.65 s.

For further applying this method to other seismic networks in geothermal areas, it is needed to consider transfer learning and optimization of the structure of hidden layers.

This study was performed as a part of the “Technology to evaluate and manage geothermal reservoirs” sponsored by Japan Oil, Gas and Metals National Corporation (JOGMEC).

Keywords: Deep learning, Phase pick, Microseismic monitoring, Geothermal development, Fluid flow

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Toward development of dense low cost citizen seismic network: Performance comparison of different types of neural network architectures

*Ahyi KIM[1], Hiroki Uematsu[1], Yuji Nakamura[1], Yuta Takahashi[1], Momoko Nakamura[1]

1. Yokohama City University

We have developed a community based low cost seismic network in Yokohama, Japan, called Citizen Seismic Network (CSN), to monitor local scale strong motion which is closely linked to community’ s life. Each sensor unit composed of 12 bit MEMS accelerometer and Raspberry Pi.
Since the units are supposed to be installed under high-noise condition such as inside of house where spiky noise made by human activities often misinterpreted as seismic signal, it is difficult to discriminate the seismic signals from other noises. In such condition, applying conventional detection method using amplitude ratio (e.g. STA/LTA) is problematic. To overcome the issue, we employed an artificial neural network that utilizes pattern recognition to retrieve seismic signals. In this study, we compared the 3 different types of neural networks, namely, 3 layered shallow network (ANN), convolutional neural network, and recurrent neural network. For the training and validation, we prepared numerical data set produced by seismic records obtained from K-net adding CSN sensor noise (~90000 for training and ~40000 for validation). Since it is possible the amount of the data is not enough for CNN and RNN, we also tested transfer learning using pre-trained model open to public. As preliminary results, we found that using pre-trained ANN on the Raspberry Pi in real time and making final decision using deep neural network pre-trained by transfer learning on server is the most effective.

Keywords: Neural network, Machine Learning, Seismic signal, Seismometer, Strong motion, CNN

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Unsupervised automatic classification of seismic records based on a hierarchical clustering

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1. Meteorological Research Institute, Japan Meteorological Agency, 2. Earthquake Research Institute, the University of Tokyo

Introduction

Continuous seismic waveforms recorded in a seismometer include various signals such as earthquakes, human activities, and instrumental noises. If the automatic classification of continuous records is possible, that enables us to understand geophysical phenomena around a target seismometer and to monitor the instrumental condition of a seismometer used in a real-time system such as earthquake early warning. We have been developing an unsupervised automatic classification algorithm for continuous records that is applicable to various seismometers deployed in different observation environments.
Kodera and Sakai (2020, SSJ Fall Meeting) proposed a classification algorithm that calculates running spectra as features and then clusters a dataset in the frequency and time domains using clustering methods based on the k-means and spectral clustering algorithms, respectively. However, the algorithm has a weak point in that the algorithm needs a hyperparameter that defines the number of clusters output by the spectral clustering algorithm, which is difficult to determine appropriately in advance. In this study, we propose a new algorithm based on a hierarchical clustering that does not require the hyperparameter for the number of output clusters and therefore can classify a dataset in a more flexible way.

Proposed algorithm

The proposed algorithm is divided into three parts as Kodera and Sakai (2020): (1) feature extraction, (2) clustering in the frequency domain, and (3) clustering in the time domain.
(1) Feature extraction: Running spectra are used as features, calculated with a 4-s time window every 0.1 s. Then, running spectra are converted into 10-dimensional vectors through a filter bank with 10 separated frequency bands.
(2) Clustering in the frequency domain: A dataset is clustered in the frequency domain by selecting 2000 representative points (RPs) and assigning each data point to the nearest RP. We determine the RPs by a random sampling, after dividing the dataset into several groups based on distances between data points to deal with the imbalanced data problem (i.e., the data amount of stationary noise signals is the largest).
(3) Clustering in the time domain: In the spectral clustering, the kernel principal component analysis (kPCA) is performed based on the adjacent matrix of a graph, and then the k-means algorithm is used to determine the clusters; in this study, the k-means algorithm is replaced with the Ward hierarchical clustering algorithm. The adjacent matrix is constructed from a transition matrix assuming the Markov chain. The dimension of the kPCA is set to 10.

Application to test data

We applied the proposed algorithm to continuous records from March 1 to 7, 2017, at station E.JDJM, a MeSO-net station located near a subway (Kawakita and Sakai, 2009). The figure shows a dendrogram obtained from the hierarchical clustering algorithm and classification results for a certain 30-minute record. At a high level in the dendrogram, there were two groups separated with small and large clusters; the former and latter may correspond to groups related to earthquake and noise signals, respectively. When the dendrogram was cut at 1/2 of the maximum height, frequent noise signals were classified into high- and low-level noise classes. With the dendrogram cut at 1/3, the high-level noise class was divided

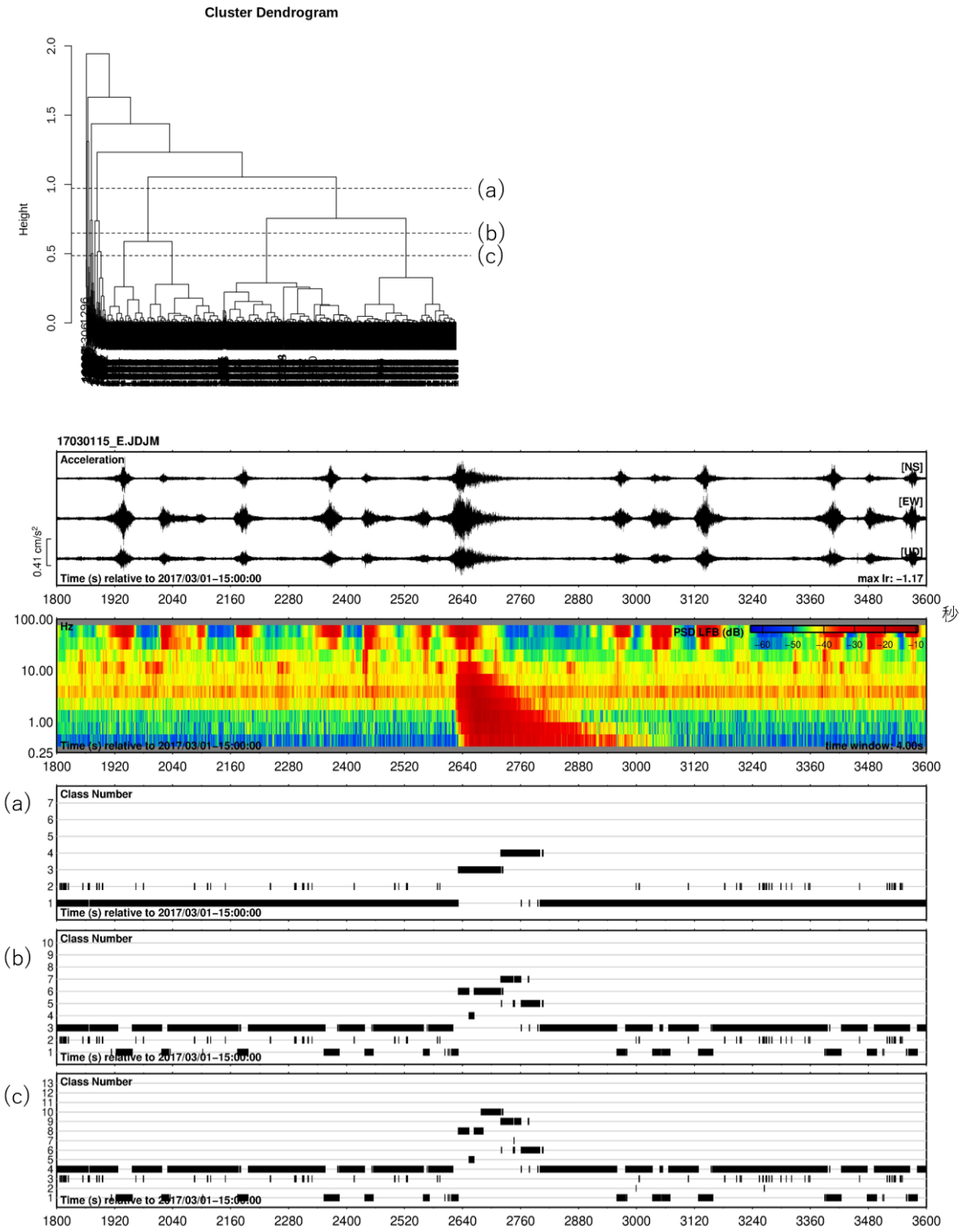
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into two sub-classes, one of which corresponded to train noises.
Those results indicate that, although there remains an issue of how to cut the dendrogram appropriately, signals on continuous records could be classified and extracted by the hierarchical clustering algorithm.

Acknowledgment: We used seismic records of MeSO-net maintained by the Earthquake Research Institute, the University of Tokyo.

Keywords: Machine learning, Unsupervised learning, Automatic classification, Seismic waveform record

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図：階層的クラスタリングにより得られたデンドログラムとクラス分類結果．(a), (b), (c)はデンドログラムをそれぞれ最大高さの1/2, 1/3, 1/4でカットしたときの分類結果に対応する．

Figure: A dendrogram obtained from the hierarchical clustering algorithm and classification results for a certain 30-minute record. (a), (b), and (c) correspond to classification results with the dendrogram cut at 1/2, 1/3, and 1/4 of the maximum height, respectively.

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Hierarchical cluster analysis of F-net moment-tensor-solution catalogue in Japan

*Hisahiko Kubo[1], Takeshi Kimura[1], Katsuhiko Shiomi[1]

1. National Research Institute for Earth Science and Disaster Resilience

The spatial distribution of earthquakes is heterogeneous in response to background stresses and underground structures. Therefore, finding regional characteristics of seismic activity from seismic catalogs leads to the understanding of background stresses and underground structures that affect the way earthquakes occur. Kubo et al. (2020, SSJ) applied a dimensionality reduction technique of unsupervised machine learning to the moment tensor solution catalog of F-net of NIED and demonstrated that earthquakes with similar properties are embedded in the same region in the dimensionality-reduced space. In this study, we apply hierarchical clustering, which is also a kind of unsupervised machine learning, to the F-net moment tensor solution catalog to obtain the hierarchical structure of earthquake clusters and investigate the regional characteristics of seismic activity in Japan.

We used the moment tensor solution dataset provided by Kubo et al. (2020, SSJ). This dataset is based on the F-net moment tensor solution catalog and includes additional information on double couple and CLVD. The target parameters in the clustering of this study are latitude, longitude, and depth of earthquakes, and x and y of the source-mechanism diagram (Kavernia et al. 1996; Kagan 2005). A large x means that the reverse fault component is dominant, and a small x means that the normal fault component is dominant. A large y means that the strike-slip fault component is dominant. As a preprocessing for the cluster analysis, an axis transformation using principal component analysis was applied to latitude and longitude, and then each parameter was normalized.

There are two types of clustering methods: hierarchical clustering and non-hierarchical clustering such as k-means. Although hierarchical clustering is more computationally expensive, it has the advantage of obtaining a hierarchical structure of data with information about the relationships among clusters. In this study, we used the agglomerative method of hierarchical clustering, and the Ward method was used to calculate the distance between clusters. Agglomerative Clustering of scikit-learn was used as the analysis code.

Here, as a preliminary analysis, we examined the top 10 clusters obtained by hierarchical clustering. We found that the top 10 clusters consisted of earthquake groups with different fault types (normal fault, reverse fault, and strike-slip fault), different regions (eastern and western Japan), and different source depths (less than 20 km, 20-100 km, and greater than 100 km). This result indicates that groups of earthquakes with similar properties can be extracted by the hierarchical clustering of the moment tensor solution catalog. Further investigation of the lower clusters is expected to extract more local earthquake groups.

Keywords: Hierarchical clustering, Moment tensor solution, Unsupervised machine learning, Regional characteristics of seismic activity

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[E] Oral | B (Biogeosciences)：B-CG Complex & General

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.26 Zoom Room 26

[B-CG03] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Shingo Kato(RIKEN), Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Yohey Suzuki(Graduate School of Science, The University of Tokyo)

Earth and planetary science is currently capable of sampling from three frontiers: space, deep ocean and deep underground for the study of the origin and evolution of life. The state-of-the-art technologies in multi-omics and high-resolution material analyses are very powerful to expand our understanding of many fields of earth and planetary sciences. It is also important for us to be aware of global warming and climate change that dramatically affect biodiversity, biological activities and elemental cycling. The aim of this session is to cross the border of science sections to explore the frontiers of earth and planetary science.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BCG03-01] Hunting mineral-centered life from deep rocky biosphere

*Yohey Suzuki[1] (1.Graduate School of Science, The University of Tokyo)

9:15 AM - 9:37 AM JST | 12:15 AM - 12:37 AM UTC

[BCG03-02] Investigation of “Martian nitrogen cycle” and its evolution: The case of a young meteorite, Tissint

★Invited Papers

*Mizuho Koike[1], Ryoichi Nakada[2], Iori Kajitani[3,4], Haruna Sugahara[3], Tomohiro Usui[3] (1.Hiroshima Univ., 2.JAMSTEC, 3.JAXA, 4.Univ. Tokyo)

9:37 AM - 10:00 AM JST | 12:37 AM - 1:00 AM UTC

[BCG03-03] Metabolite analysis and machine learning-assisted discrimination of archaea and bacteria using minimally invasive single-cell Raman microspectroscopy

★Invited Papers

*Shinsuke Shigeto[1], Nanako Kanno[1], Shingo Kato[2], Motomu Matsui[3] (1.Kwansei Gakuin Univ., 2.RIKEN, 3.Univ. of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BCG03-04] Ongoing archaeal methanogenesis in an organic- and iodine-rich deep aquifer: molecular evidence from coenzyme factor 430 and methane-specific radiocarbon measurements

*Atsushi Urai[1,2], Yoshinori Takano[1], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Shinshu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BCG03-05] Microbial community and its functions on methane metabolism in the wetland ecosystems

*Wipoo Prasitwuttisak[1], Katsunori Yanagawa[1] (1.The University of Kitakyushu)

Hunting mineral-centered life from deep rocky biosphere

*Yohey Suzuki[1]

1. Graduate School of Science, The University of Tokyo

The emergence of life is generally considered to be assisted by the power of minerals. Modern organisms are equipped with biochemical machineries that might have replaced the primitive mineral parts long time ago. Given high energetic costs to operate such sophisticated machineries, it is speculated that mineral-centered life might have been evolutionarily preserved on modern Earth where the primordial geochemistry prevails with extreme energy starvation. One of ideal places to hunt the primitive life is the deep subsurface restricted by the supply of energy-rich photosynthetic products. Granite and basalt are geologic giants that have been representative of continental and oceanic crusts since ~4.0 billion years ago. Energy-starved deep biospheres in granitic and basaltic crusts have been potentially hosting primitive life without outcompeting with biochemically sophisticated microbes.

To explore the granite biosphere, 69-million-year-old granite was investigated at a 300-m deep underground tunnel at the Mizunami Underground Laboratory. Metagenomic analysis in combination with geochemical and microbiological site characterizations revealed that anaerobic methane-oxidizing archaea are harvesting energy from magmatic methane under energy-starved conditions (Ino et al. 2018). In addition, a diverse and dominant phylum within Candidate Phyla Radiation (CPR) called Parcubacteria appears to be dominant in the deep granite biosphere. All members of CPR are represented by small genomes and cell sizes with restricted metabolic capacities, which might have been inherited from an early metabolic platform for life (Hug et al. 2016).

For the oceanic crust biosphere, the *JOIDES Resolution* (JR) was used to drill 13, 33.5 and 104 million-year-old basalt lava during Integrated Ocean Drilling Program (IODP) Expedition 329 that targeted life beneath the seafloor of the South Pacific Gyre (SPG). To understand the nature of rocky biosphere in oceanic crust, a new life-detection technique was successfully developed for drilled rock cores in combination with nanoscale mineralogical characterizations (see Yamashita et al. 2019 and Sueoka et al. 2019 for technical details). Basalt fractures filled with clay minerals and calcium carbonate were associated with the formation of Fe/Mg- smectite compositionally and structurally similar to saponite and/or nontronite, indicators of low-temperature basalt-water interactions. Unexpectedly, the dense colonization of microbial cells was directly imaged to exceed ~10^{10} cells/cm^3, a range of cell density typically found in human gut. More surprisingly, the dominance of heterotrophic bacteria was indicated by analyses of DNA sequences and lipids to conclude organic matter as carbon and energy sources in subseafloor basalt.

These findings change our view of the rocky biosphere where inorganic energy sources derived from rock-water interactions are generally regarded as primary ecological importance. Given the prominence of basaltic lava and/or magmatic methane on Earth and Mars, microbial life could be habitable where subsurface igneous rocks interact with liquid water. It is also important to note that microbial presence/absence and metabolic repertories will clarify poorly characterized physicochemical properties in deep igneous rocks such as permeability and fluid and energy fluxes. Finally, the technology is ready to hunt mineral-centered life in the deep subsurface for unveiling the life’s story from the very beginning.

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Keywords: Primitive life , Deep biosphere, rock-water interactions

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Investigation of “Martian nitrogen cycle” and its evolution: The case of a young meteorite, Tissint

*Mizuho Koike[1], Ryoichi Nakada[2], Iori Kajitani[3,4], Haruna Sugahara[3], Tomohiro Usui[3]

1. Hiroshima Univ., 2. JAMSTEC, 3. JAXA, 4. Univ. Tokyo

Geological and geochemical records on the surface of Mars indicate that, in ancient times, this Red Planet possibly had persistent liquid water and denser atmosphere [e.g., 1]. Question of “past (or present) life on Mars” has driven intensive studies based on the planetary explorations and the laboratory analyses of Martian meteorites. To date, we have a large collection of Martian meteorites, which sample various timings from ~4.4 billion years ago (Ga) to ~160 million years ago (Ma) and locations of Mars. Especially, a unique Martian meteorite named Allan Hills (ALH) 84001 is known to contain carbonate minerals that precipitated from aqueous fluid at the Martian near-surface system at ~4.0 Ga [2, 3]. Our recent study [4] investigated these carbonates with a new in-situ analytical technique for nitrogen (N) speciation and revealed that the 4-Ga Martian carbonates preserved nitrogen(N)-bearing organic matter, which plausibly originated from ancient Mars. Koike et al. [4] also reported the apparent absence of nitrate (or NO_x salts) in these carbonates. Such two findings strongly infer the importance of reduced forms of N at the Martian near-surface system during Noachian period. The past “Martian nitrogen cycle”, where N cycled between various reservoirs (i.e., atmosphere, hydrosphere, sediments and possible biosphere) with changing its chemical forms (i.e., N_2, NO_2, NH_3, organics…), probably affected the early-stage environments and the habitability of Mars. It is quite important to understand this “Martian nitrogen cycle” and its long-term evolution. Here, we investigate another Amazonian-aged Martian meteorite named Tissint (~600 Ma [5]), by applying the analytical technique developed in [4].

Shock-melted glassy phases in the polished chip of Tissint were carefully picked up using FIB-SEM at Extraterrestrial Sample Curation Center, JAXA. The N K-edge X-ray absorption near-edge structure (μ-XANES) analyses of this sample with various N-bearing reference compounds were conducted at BL27SU, SPring-8. Our N-XANES spectra of Tissint glass show the heterogenous presence of nitrate (NO_x) and atmospheric N_2, whereas contribution of the N-bearing organics is minor or ignorable in this young meteorite. Further analyses including N-isotopic ratio ($^{15}N/^{14}N$) will reveal the long-term evolutions of Martian nitrogen over 4 Ga.

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Keywords: Martian meteorites, nitrogen cycle, micro XANES analysis, Martian surface environment

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Metabolite analysis and machine learning-assisted discrimination of archaea and bacteria using minimally invasive single-cell Raman microspectroscopy

*Shinsuke Shigeto[1], Nanako Kanno[1], Shingo Kato[2], Motomu Matsui[3]

1. Kwansei Gakuin Univ., 2. RIKEN, 3. Univ. of Tokyo

The vast diversity of microorganisms inhabiting various earth environments is now rapidly being unveiled by virtue of microbiome analysis using next-generation sequencing. To understand the types and functions of specific microorganisms among them, nondestructive single-cell analysis is required that enables us to gain access to potential nonculturable microorganisms (microbial dark matter). Here we report that Raman microspectroscopy can be used for minimally invasive metabolic analysis and species discrimination of bacteria and archaea at the single-cell level. Raman spectra are recorded by irradiating laser-trapped, label-free single cells with laser light and encode the "fingerprints" of biomolecules such as proteins, DNAs, lipids, sugars, and metabolites.

We explore the capability of single-cell Raman microspectroscopy to detect characteristic metabolites in methanogenic archaea *Methanosarcina mazei* and *Methanopyrus kandleri*. In both archaea, we observe the Raman spectroscopic features of corrinoids such as vitamin B_{12} analogues. These features allow for investigating cell-to-cell variation in the corrinoid concentration in *M. kandleri* and for imaging the spatial distributions of the corrinoid in relatively larger *M. mazei* cells, both of which could provide useful insight into increased microbial corrinoid production.

In addition to the detection of particular metabolites, the molecular fingerprints encoded in Raman spectra can represent cell's phenotypic information. We develop an accurate discrimination method of bacterial and archaeal species based on machine learning of single-cell Raman data. As a proof-of-concept, we measure Raman spectra of six microorganisms (three bacterial and three archaeal species) and construct a discrimination model using random forest. The model distinguishes among the tested species with >99% accuracies. Owing to the minimally invasive nature of our approach, specific discriminated cells can easily be subjected to further analysis such as single-cell genomics and ecophysiological analysis.

Keywords: Raman spectroscopy, Single-cell analysis, Archaea, Machine learning

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Ongoing archaeal methanogenesis in an organic- and iodine-rich deep aquifer: molecular evidence from coenzyme factor 430 and methane-specific radiocarbon measurements

*Atsushi Urai[1,2], Yoshinori Takano[1], Naohiko Ohkouchi[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Shinshu University

Deep methanogenesis in a subsurface environment is an important process for understanding global biogeochemical cycles. Biogenic methane is produced by methanogenic archaea living under anaerobic conditions, including deeply marine sediments down to 2.5 km below the seafloor (Inagaki et al., 2015). However, the ecology of methanogenic archaea, such as in situ biomass and activity, is still unclear. To elucidate the deep prokaryotic community including methanogenic archaea in a forearc basin at Southern Kanto gas field (Ishii et al., 2019), we conducted three parallel approaches; i) the lipid-based analysis, ii) small-subunit (SSU) rRNA gene sequencing, and iii) coenzyme factor 430 analysis (Kaneko et al., 2014), which is a key molecular of all methanogenic archaea (Thauer et al., 2019). To assess the origin of deep carbon, we performed radiocarbon measurements of methane and dissolved inorganic carbon (DIC). The Southern Kanto gas field is located on the Boso Peninsula and known as the largest natural gas dissolved in the water field in Japan. The deep aquifer, which originated from ancient seawater, has many unique features; high-purity of methane (>99%), high concentrations of iodine (~2000 times of seawater) and dissolved organic matter (DOM).

The results of lipid-based analysis suggested that the biomass of domain archaea was less than 10% of the total prokaryote in deep aquifer, which was supported by the result of the SSU rRNA gene sequencing. The high concentration of native F430 (1.67×10^7 femto mol/L; Urai et al., 2021) with the absence of the F430 epimers was confirmed in the brine-rich water, suggesting activated ongoing methanogenesis in the deep aquifer. Radiocarbon measurements of methane and dissolved inorganic carbon (DIC) revealed ^{14}C-depleted ($\Delta^{14}C_{methane}$ and $\Delta^{14}C_{DIC}$, <−997.4‰; Urai et al., 2021), indicating the independent deep habitat and active state of archaeal methanogenesis.

This study was supported in part by the Japan Society for the Promotion of Science (JSPS) with the joint research between the Kanto Natural Gas Development Co., Ltd. and JAMSTEC.

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Keywords: deep aquifer, radiocarbon measurement, Iodine, methane, small sub-unit rRNA gene sequencing, methanogenic archaea

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Microbial community and its functions on methane metabolism in the wetland ecosystems

*Wipoo Prasitwuttisak[1], Katsunori Yanagawa[1]

1. The University of Kitakyushu

Wetland ecosystems have been certified as the main natural source of atmospheric methane, the potent greenhouse gas that influences global climate and carbon fluxes. The metabolism of methane in a wetland environment is carried out by a diverse group of methane-metabolizing archaea through the biological decomposition of organic matter under anaerobic conditions. Recently, cultivation-independent genomic approaches are allowing us to explore genomic diversity and expand our understanding of the unidentified microbial lineages on their ecological lifestyles. However, clear evidence for methane metabolism and the functional methanogenic community is yet to be much documented. In this work, we characterized the microbial community structures in peats collected from the Bogatsuru Wetland, Oita Prefecture, Japan. The phylogenetic analysis based on 16S rRNA gene sequences and functional genes were used for investigating the key microbial groups and activity potentially involved with the metabolic pathways for methane production. The members of Methanomicrobia (mainly Methanomicrobiales and Methanosarcinales) were detected in anoxic sub-surface peat corresponded to the existence of the *mcrA* gene, a key functional gene for methanogenic archaea, indicating the methane production potentials. Additionally, the phylogenetic analyses of functional genes revealed that the Methanomassiliicoccales lineages, classified H_2-dependent methylotrophic archaea, were also detected from deeper peat. Interestingly, uncultured methanogenic Bathyarchaeota, the proposed methylotrophic methanogens, and unrecognized terrestrial archaeon were highly observed in this study. These findings emphasize the importance of discovering members of the methanogenic archaea in order to understand the ecological diversity and metabolic functions that play a vital role in the global carbon cycle.

Keywords: Wetland, Microbial community, Methane metabolism, Methanogen, Carbon cycle

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[E] Oral | B (Biogeosciences)：B-CG Complex & General

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.26 Zoom Room 26

[B-CG03] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Shingo Kato(RIKEN), Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Shingo Kato(RIKEN)

Earth and planetary science is currently capable of sampling from three frontiers: space, deep ocean and deep underground for the study of the origin and evolution of life. The state-of-the-art technologies in multi-omics and high-resolution material analyses are very powerful to expand our understanding of many fields of earth and planetary sciences. It is also important for us to be aware of global warming and climate change that dramatically affect biodiversity, biological activities and elemental cycling. The aim of this session is to cross the border of science sections to explore the frontiers of earth and planetary science.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BCG03-06] Microbial protein synthetic activities in deep underground granites revealed by meta-proteomic analysis

*Nao Masuda[1], Akito Ishikawa[2], Yohey Suzuki[2], Kazuyoshi Endo[2] (1.Department of Biological Sciences, Graduate School of Science, The University of Tokyo, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:00 AM - 11:22 AM JST | 2:00 AM - 2:22 AM UTC

[BCG03-07] Mineral-catalyzed hydrothermal CO_2 reduction that generated primordial autotrophic metabolisms

★Invited Papers

*Kensuke Igarashi[1] (1.National Institute of Advanced Industrial Science & Technology)

11:22 AM - 11:45 AM JST | 2:22 AM - 2:45 AM UTC

[BCG03-08] The unique metabolism of hyperthermophilic archaea

★Invited Papers

*Haruyuki Atomi[1] (1.Department of Synthetic Chemistry and Biological Chemistry, Graduate School of Engineering, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[BCG03-09] Investigating Environmental Controls on Cyanobacterial Primary Productivity: Laboratory, Genomic, and Environmental Studies.

*Shawn E McGlynn[1], Lucia Gastoldi[2], Fatima Li Hau[1], Paula Prondzinsky[1], Lewis M Ward[1,3] (1.Tokyo Institute of Technology, 2.Università Politecnica delle Marche , 3.Harvard University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[BCG03-10] New clues on the Atlantic eels spawning behavior and area: The Mid-Atlantic Ridge Hypothesis

*Yu-Lin Eda Chang[1], Eric Feunteun[2], Yasumasa Miyazawa[1], Katsumi Tsukamoto[3] (1.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan, 2.Museum National d'Histoire Naturelle, BOREA, Center of research on coastal ecosystems (CRESCO), France, 3.Department of Aquatic Bioscience, The University of Tokyo, Japan)

Microbial protein synthetic activities in deep underground granites revealed by meta-proteomic analysis

*Nao Masuda[1], Akito Ishikawa[2], Yohey Suzuki[2], Kazuyoshi Endo[2]

1. Department of Biological Sciences, Graduate School of Science, The University of Tokyo, 2. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Deep underground environments represent one of the extreme environments with little molecular oxygen, high pressure, and few nutrient resources. Recent geochemical, microbiological, and molecular analyses made it clear that microorganisms do exist in such environments. In particular, granite, which is the most abundant rock type in the deep underground environment, with a maximum age of 4 billion years ago, may have been a stable habitat for microbial life throughout the history of the Earth. Thus, understanding the ecology of microorganisms in the deep granite environment would be important for understanding the history of life evolution. In addition to geochemical analysis, 16S rRNA and metagenomic analyses have been carried out to characterize microbial communities inhabiting deep granite environments. Metagenomic analysis is a method that can directly analyze the genomes of microorganisms in the environment without relying on cultivation, however, interpretation of the data is limited to discussion based on the existence of genes. It has been unclear whether the proteins they encode are actually expressed in the environment.

In the present study, aiming at clarifying the ecology of microorganisms in a deep underground granite environment, we performed metaproteomic analysis on the microorganisms collected by filtering the groundwater 300 m underground at the Mizunami Underground Research Laboratory located in Gifu prefecture, central Japan. Metaproteomic analysis is a method for directly identifying the proteins that exist in the samples, an approach which allows us to know the genes that are actually expressed in the environment. As a result, a total of 961 proteins (from 151 prokaryote species), and 995 proteins (from 153 prokaryote species) were identified from the 1st and the 2nd samples, respectively (179 species in total). For each protein, the function and its expression level were determined. By summarizing the expression levels of proteins expressed in each species, we were able to discriminate the species that are actively synthesizing proteins in this environment from those that are not. These results were not clear from the 16S rRNA analysis or other genomic analysis alone, indicating the importance of performing proteomic analysis.

Focusing on the function of proteins, those that are essential for survival are well expressed in most species, while only a limited number of proteins involved in metabolic pathways are expressed. This may suggest that microorganisms in the underground granite environment generally live with a reduced level of activity. The expression levels of the proteins are the highest in the species of Nitrospirae among all taxa, and in particular, genes involved in sulfur metabolism and ATP synthesis are well expressed. This suggests that Nitrospirae are very active in sulfur metabolism and sulfur respiration. In addition, proteins involved in methane metabolism are also well expressed in Euryarcheaota (including ANME-2d). This result is consistent with the previous genomic study (Ino et al., 2018) suggesting that ANME-2d mediates anaerobic oxidation of methane in a granite environment.

Keywords: Microorganisms, Metaproteomic analysis, Deep underground environment, Groundwater

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Mineral-catalyzed hydrothermal CO_2 reduction that generated primordial autotrophic metabolisms

*Kensuke Igarashi[1]

1. National Institute of Advanced Industrial Science & Technology

Minerals are thought to play a crucial role in chemical evolution by driving the production of biomolecules via their catalytic activity. Especially in autotrophic theories for the origin of life, mineral catalysts are believed to enhance the continuous generation of organic molecules from inorganics such as CO_2 under the relatively moderate geochemical settings in the Hadean Earth; such as hydrothermal vents. Biochemistry suggests that such primordial CO_2 fixation reactions are preserved as “metabolic fossils” within the extant reductive acetyl-CoA pathway, the most primitive CO_2 fixation pathway, of organisms utilizing CO_2 and H_2, because of the similarity of the key components and reaction flows. In these theories, the most fundamental step that provides the necessary building blocks for autotrophic chemical evolution is reduction of CO_2. Hydrogen is thought to be the primary electron donor for the reaction on the Hadean Earth. Generation of H_2 occurs by water-rock interaction, namely serpentinization, in the Earth’s crust, providing H_2-rich water to hydrothermal vents fueling the catalytic reduction of CO_2 by minerals. Over the past decades, many studies have attempted to find possible chemical routes analogous to the acetyl-CoA pathway assaying CO_2 reduction by H_2 using commonly observed metal sulfides in hydrothermal vents, such as FeS and NiS. However, no efficient reactions have been reported until recently. Recently, a series of new trials have been conducted using minerals formed by serpentinization and/or originated from meteorites rather than conventionally used metal sulfides. The presenter has reconsidered the geochemical settings of the serpentinization reaction and its relevant by-product minerals to assay their potential for CO_2 reduction by H_2 in hydrothermal systems. Greigite (Fe_3S_4), a mixed-valence iron sulfide, was found to catalyze CO_2 reduction by H_2, generating formate, acetate, and CH_4 as products under versatile hydrothermal conditions (pH~10, ~100 ˚C, and ~100 bar). Similar reaction route catalyzed by other minerals synthesized as serpentinization product, namely magnetite (Fe_3O_4) and awaruite (Ni_3Fe), has also been discovered independently in the different laboratories. Magnetite and awaruite have been shown to catalyze the synthesis of pyruvate and ethanol, in addition to formate and acetate, from CO_2. The product profile of these minerals was similar to those of the intermediates and the end products of the extant reductive acetyl-CoA pathway. These facts suggest the significant involvement of these minerals in the abiotic synthesis of organics from CO_2 with H_2, providing building blocks required for the ancient reductive acetyl-CoA pathway in the chemical evolution. These findings support the theory that the first life could have formed from the primordial catalytic network based on CO_2 fixation catalyzed by geochemical reactions, preceding the enzyme-catalyzed biochemistry. In this presentation, a series of notable progress in mineral-catalyzed CO_2 reduction studies, including the recently discovered reaction route described above, will be introduced. Afterwards, research for ancient metalloenzymes which the presenter is conducting now will also be introduced in the context of the mineral-catalyzed chemical evolution process. Finally, the limitations and future perspectives on the autotrophic origin of life research will be discussed.

Keywords: Origin of life, Chemical evolution, Hydrothermal vent, CO2 reduction, Autotrophs

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The unique metabolism of hyperthermophilic archaea

*Haruyuki Atomi[1]

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Archaea represent the third domain of life and are phylogenetically distinct to the Bacteria and Eucarya. Studies on their metabolism have clearly demonstrated that Archaea utilize enzymes and pathways that differ to those previously established in bacteria and eukaryotes. *Thermococcus kodakarensis* is a hyperthermophilic archaeon that exhibits an optimal growth temperature of 85°C. The organism is an obligate heterotroph, and utilizes polysaccharides, peptides, amino acids, and organic acids as a carbon source and their oxidation as an energy source. The *T. kodakarensis* genome sequence has been determined, and gene disruption methodology has been established, enabling us to carry out both biochemical and genetic analyses on the metabolism and physiology of this organism. Here I will introduce some of the unique aspects of metabolism in *T. kodakarensis* and archaea in general. The majority of archaea do not utilize a pentose phosphate pathway, and the mechanisms to synthesize and degrade the ribose moieties of nucleosides and nucleotides had not been understood in these organisms. Using genome information and comparative genomics along with classical biochemistry and genetics, we have shown that the reverse flux of the ribulose monophosphate pathway and the newly identified pentose bisphosphate pathway are responsible for these conversions. I will describe pathways unique to the archaea, and by comparing the metabolism among the three domains of life, evolutionary aspects will be discussed.

Keywords: Archaea, Metabolism, Hyperthermophile

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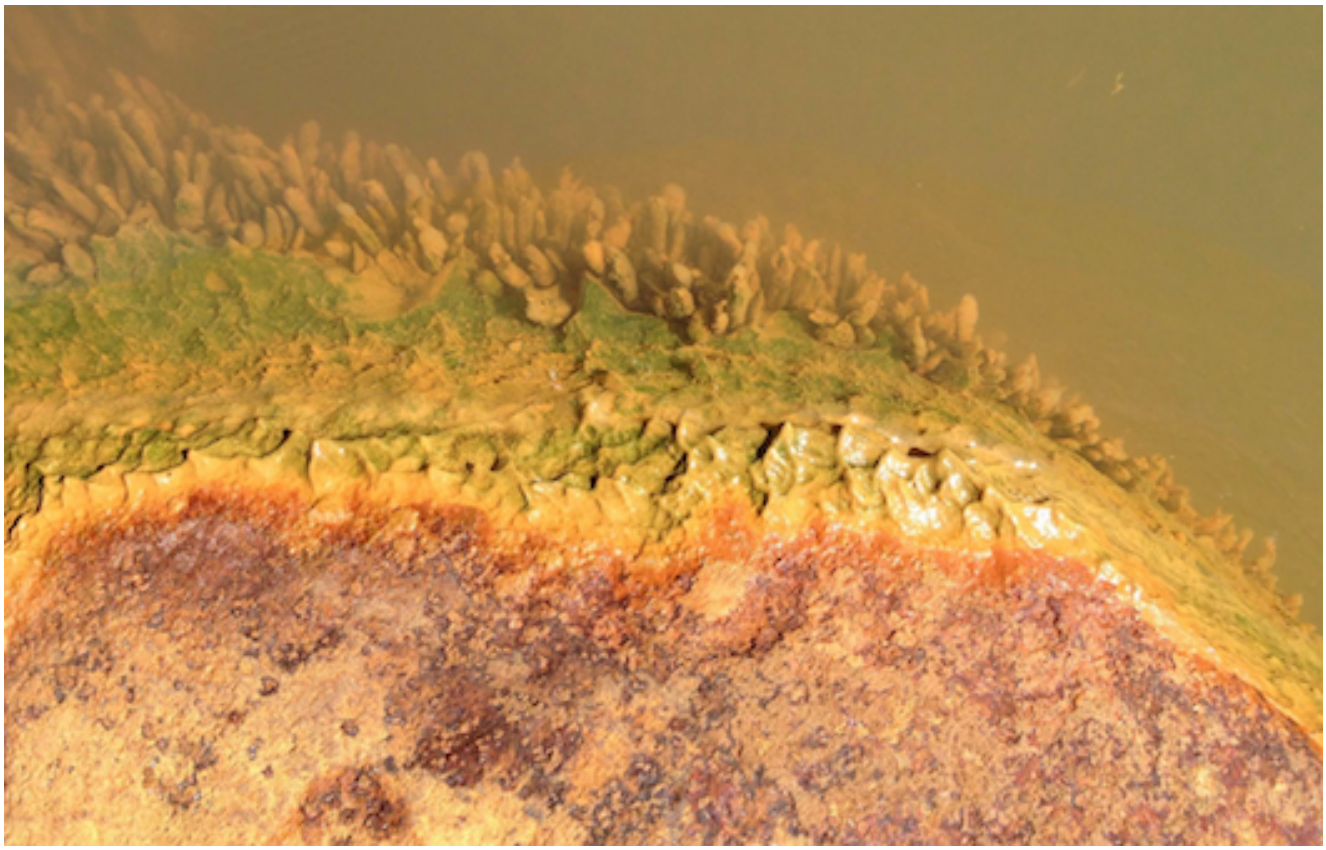
Investigating Environmental Controls on Cyanobacterial Primary Productivity: Laboratory, Genomic, and Environmental Studies.

*Shawn E McGlynn[1], Lucia Gastoldi[2], Fatima Li Hau[1], Paula Prondzinsky[1], Lewis M Ward[1,3]

1. Tokyo Institute of Technology, 2. Università Politecnica delle Marche , 3. Harvard University

Cyanobacteria are key players in Earth’ s biogeochemical cycles. In this talk, I will review hypotheses which aim to account for a potential delay in Earth’ s oxygenation due to cyanobacterial oxygenic photosynthesis, and provide new insights into the controls of cyanobacterial ecology and evolution. From laboratory studies, we find unique responses to nutrient and pCO_2 modulations with relevance to cyanobacterial proliferation in ancient environments. From genome analyses of the *Thermosynechococcus* genus, we find that extensive genomic adaptation is unnecessary for broad tolerance to diverse environmental conditions. From environmental studies of cyanobacteria in diverse iron carbonate hot springs in Japan, we gain insight into interspecific interactions and an expanded awareness of the distribution of cyanobacteria across natural environments.

Keywords: Cyanobacteria, Primary Productivity, Delayed Oxygenation, Hot Springs



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New clues on the Atlantic eels spawning behavior and area: The Mid-Atlantic Ridge Hypothesis

*Yu-Lin Eda Chang[1], Eric Feunteun[2], Yasumasa Miyazawa[1], Katsumi Tsukamoto[3]

1. Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan, 2. Museum National d'Histoire Naturelle, BOREA, Center of research on coastal ecosystems (CRESCO), France, 3. Department of Aquatic Bioscience, The University of Tokyo, Japan

The Sargasso Sea has long been considered as the only spawning area for Atlantic eels, despite the absence of direct observations. The present study raises a novel scenario deviating from Schmidt’ s dogma begins with a review of historical and recent observations that were combined to build up a global theory on spawning ecology and migration behavior of Atlantic eels. From this, it is argued that a favorable spawning area could be located eastward of Sargasso Sea at the intersection between the Mid-Atlantic Ridge and the oceanic fronts. Ocean circulation models combined with 3D particle-tracking method confirmed that spawning at this specific area would result in larval distribution fitting the field observation. This study explores the hypothesis that leptocephali are able to swim and orientate to reach their specific growth areas. It proposes a novel framework about spawning ecology, based on orientation, navigation and meeting cues of silver eels to the spawning area. Together this framework may serve as a stepping-stone for solving the long-lasting mystery of eel reproduction which first came out 2,400 years ago and promotes the understanding of oceanic migration and reproduction of marine organisms.

Keywords: eel, spawning , Sargasso Sea, Mid-Atlantic Ridge

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[E] Poster | B (Biogeosciences)：B-CG Complex & General

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.16_1

[B-CG03] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Shingo Kato(RIKEN), Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University)

Earth and planetary science is currently capable of sampling from three frontiers: space, deep ocean and deep underground for the study of the origin and evolution of life. The state-of-the-art technologies in multi-omics and high-resolution material analyses are very powerful to expand our understanding of many fields of earth and planetary sciences. It is also important for us to be aware of global warming and climate change that dramatically affect biodiversity, biological activities and elemental cycling. The aim of this session is to cross the border of science sections to explore the frontiers of earth and planetary science.

[BCG03-P01] Desorption behavior of heavy metals from contaminated soils:A surface complexation modeling

*Natsumi Takeda[1], Keisuke Fukushi[2], Baasansuren Gankhurel[1], Akihiro Okuyama[1] (1.Kanazawa University, 2.Institute of Nature and Environmental Technology Kanazawa University)

[BCG03-P02] Formation conditions of calcium carbonate hemihydrate

*Suyama Mai[1], Keisuke Fukushi[2] (1.kanazawa University, 2.Institute of Nature and Environmental Technology Kanazawa University)

[BCG03-P03] **Recent development of seamless procedures on wet chemistry, cation-exchange chromatography and ion-pair chromatography with high-precision mass spectrometry for short-chain peptide molecules.**

*Yoshinori Takano[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

[BCG03-P04] New procedures to inactivate microorganisms for Martian life detection

*Mariko Kouduka[1], Yuri Sueoka[1], Yohey Suzuki[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan.)

[BCG03-P05] Oxidation and reduction of iron by a single *Rhodoferax* isolate at circumneutral pH

*Shingo Kato[1], Takashi Itoh[1], Moriya Ohkuma[1] (1.RIKEN)

[BCG03-P06] Physiological Response to the Extraordinary Iron Stress in the Unicellular Red Alga *Galdieria sulphuraria*

*Yukihiro Fukuta[1], Yuu Hirose[3], Ayumi Minoda[2] (1.University of Tsukuba, School of Life and Environmental Science, College of Biological Sciences, 2.Faculty of Life and Environmental sciences, University of Tsukuba, 3.Toyohashi University of Technology, Department of Applied Chemistry and Life Science)

Desorption behavior of heavy metals from contaminated soils:A surface complexation modeling

*Natsumi Takeda[1], Keisuke Fukushi[2], Baasansuren Gankhurel[1], Akihiro Okuyama[1]

1. Kanazawa University, 2. Institute of Nature and Environmental Technology Kanazawa University

It is reported that soil at Kamegai mine in Toyama Prefecture contains heavy metals at a level that greatly affects human health. In this study, we conducted desorption experiments from the soils mainly composed of goethite collected at Kamegai mine under various environmental conditions to elucidate the desorption behavior of heavy metals. The results of the experiments showed that the desorption concentration of Pb, Cu, Cd and Zn decrease as the pH increased. When the pH increased further, these elements re-desorbed. Pb and Cu had the minimum desorption concentration at pH7, and Cd and Zn had the minimum concentration at pH8 and above. The behavior of this desorption concentration decrease can be explained by the mineral surface charge. However, the behavior of re-desorption at high pH can be explained by the chemical species. This mechanism could be explained thermodynamically by using surface complexation modeling. Finally, when modeling was performed under the experimental conditions based on the JIS standard conducted in the previous research, the results exceeded the environmental standard for a wide range of pH, and even for natural water condition. Therefore, proper treatment is required when using land in the Kamegai mine area.

Keywords: Surface complexation modeling, heavy metal, desorption

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Formation conditions of calcium carbonate hemihydrate

*Suyama Mai[1], Keisuke Fukushi[2]

1. kanazawa University, 2. Institute of Nature and Environmental Technology Kanazawa University

Calcium carbonates are classified into 6 mineral species: calcite, aragonite and vaterite of anhydrous calcium carbonate, monohydrocalcite (MHC, $CaCO_3 \cdot H_2O$) and ikaite ($CaCO_3 \cdot 6H_2O$) of hydrous calcium carbonate and amorphous calcium carbonate (ACC). In addition to these, calcium carbonate hemi hydrate (CCHH, $CaCO_3 \cdot 1/2H_2O$) was synthesized for the first time by Zou et al. (2019). They reported that when $CaCl_2$, $MgCl_2$, and Na_2CO_3 solutions are mixed, CCHH is produced after ACC formation as a precursor of MHC. Because Ca, Mg and CO_3 are abundant in nature, it is considered that CCHH formation is possible even in the natural environment. If a new type of calcium carbonate will be discovered, some geochemical processes which have been overlooked so far may be revealed. Therefore, the purpose of this study is to clarify the formation conditions for CCHH by attempting to synthesize calcium carbonates from the initial solution containing Ca, Mg, and CO_3 under various concentration conditions. In addition, we will compare the composition of the reacted solutions after the syntheses with the natural water to deduce the possible formation environment in nature.

Keywords: Calcium carbonate , Calcium carbonate hemihydrate, Formation conditions , solubility, alkaline lakes

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Recent development of seamless procedures on wet chemistry, cation-exchange chromatography and ion-pair chromatography with high-precision mass spectrometry for short-chain peptide molecules.

*Yoshinori Takano[1]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

We report seamless analytical procedures for characterization of underivatized short-chain peptides by wet chemical treatment and ion-pair liquid chromatography with electrospray ionization–mass spectrometry. The chromatographic separation via a porous graphitic carbon stationary column eluted using an acetonitrile solvent gradient revealed a positive correlation between the retention time and the degree of hydrophobicity reflected in a distinct relationship between methylene elongation of amino acids. We also validated the chromatographic separation utilizing other stationary column and high-resolution mass spectrometry, which supports the analytical accuracy for identification. By eliminating the inorganic and organic matrix effect via cation-exchange chromatography, we can avoid ion suppression and enhancementto demonstrate accurate analytical evaluations with robust mass spectroscopic responses. The developed method provides new insight into short-chain peptide chemistry that can be utilized for numerous interdisciplinary research applications.

Please see the recent publication for more in detail [1]. The preliminary reports in this paper were presented at the 29th International Meeting on Organic Geochemistry at Gothenburg, Sweden in September 2019. This work was supported by the Japan Society for the Promotion of Science (JSPS). This is a joint work with Y. Oba, S. Furota, H. Naraoka, N. O. Ogawa, T. M. Blattmann, and N. Ohkouchi.

[References]

[1] Takano et al. (2021) Analytical development of seamless procedures on cation-exchange chromatography and ion-pair chromatography with high-precision mass spectrometry for short-chain peptides. International Journal of Mass Spectrometry, doi: 10.1016/j.ijms.2021.116529.

Keywords: short-chain peptide, LC/ESI-MS analysis , target and non-target analysis

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New procedures to inactivate microorganisms for Martian life detection

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For sample return missions from Mars, the risk assessment of putative Martian life (backward planetary protection) represents technological and social challenges. It is aimed to develop procedures for the inactivation of microorganisms such bacteria and viruses without losing the capability of life detection by high-sensitivity analytical measurements. In the present study, near-saturated calcium chloride solution was evaluated for the short-term inactivation of model bacterial and viral organisms. The entrapment of cells in calcium carbonate was also evaluated. Based on cultivation-based assessments, it was revealed that the near-saturated calcium chloride solution inactivated *Escherichia coli* and Bacteriophage T4 within one minute regardless of subsequent calcium carbonate precipitation. *E. coli* cells inactivated with the near-saturated calcium chloride solution were found to be entrapped within calcium carbonate precipitates. The entrapped cells were embedded in hydrophilic resin, the *E. coli* cells were clearly visualized without cell destruction. As the entrapment of microbial cells with $CaCO_3$ particles has some advantages such as anti-scattering effect and minimizing the analytical inference for organic compounds. Thus, the method developed in this study has the potential to be applied to life detection procedures potentially conducted by rovers and astronauts on Mars. In additions, our procedures are feasible at confinement facilities in space stations and on Earth.

Keywords: backward planetary protection, rock-hosted microorganisms, viral and bacterial disinfection, anti-scattering agent

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Oxidation and reduction of iron by a single *Rhodoferax* isolate at circumneutral pH

*Shingo Kato[1], Takashi Itoh[1], Moriya Ohkuma[1]

1. RIKEN

Iron cycling (oxidation/reduction and dissolution/precipitation) is involved in geochemical cycling of various elements such as carbon, sulfur, and heavy metals. In natural environments, the iron cycling is mainly driven by iron-oxidizing/reducing microorganisms. Although recent culture-independent metagenomics has suggested the presence of phylogenetically diverse iron-oxidizing/reducing microorganisms, only small number of cultivated species have been reported so far. Here we report cultivation of four novel freshwater iron-oxidizing bacteria (FeOB) capable of growing at circumneutral pH under the microaerobic conditions. Iron-rich microbial mats were collected in a wetland, Tsukuba, Japan, and used as inoculum for soft-agarose-gradient cultivation with $FeCO_3$ plug. Eventually, three isolates (strains MIZ01, MIZ03, and MIZ09) and one co-culture (strain MIZ02 with MIZ09) were obtained. Typical iron-bands for known microaerophilic FeOB were observed in these gradient cultures. Whole-genome sequences of these strains were determined by Illumina and Nanopore sequencing. Phylogenomic analysis indicated that MIZ01 and MIZ02 were affiliated in the genus *Sideroxydans*, MIZ03 was affiliated in *Rhodoferax*, and MIZ09 was affiliated in *Thiomonas*, respectively. Remarkably, our cultivation experiments demonstrated that *Rhodoferax*sp. MIZ03 could grow not only by microaerobic iron oxidation, but also by anaerobic iron reduction, which was consistent with its genome content. Moreover, MIZ03 could grow by hydrogen and thiosulfate oxidation under the (micro)aerobic conditions. Thus, MIZ03 is the first *Rhodoferax* isolate growing chemolithoautotrophically, and, to our best knowledge, is the first organism capable of microaerobic iron oxidation and anaerobic iron reduction at circumneutral pH among the three domains of life. Considering the fact that DNA sequences related to *Rhodoferax* have been often detected in subsurface environments, *Rhodoferax* spp. may play a more significant role in biogeochemical cycling than previously recognized.

Keywords: Iron cycle, Bacteria, Cultivation, Genome, Chemolithoautotrophy

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Physiological Response to the Extraordinary Iron Stress in the Unicellular Red Alga *Galdieria sulphuraria*

*Yukihiro Fukuta[1], Yuu Hirose[3], Ayumi Minoda[2]

1. University of Tsukuba, School of Life and Environmental Science, College of Biological Sciences, 2. Faculty of Life and Environmental sciences, University of Tsukuba, 3. Toyohashi University of Technology, Department of Applied Chemistry and Life Science

Introduction

Cyanidiophyceae is a family of extremophiles adapted to high temperature and acidic conditions (pH 2, 42˚C), such as hot springs. *Galdieria sulphuraria* is the most stress tolerant member in Cyanidophyceae and the dominant species occupied over 90% of the biomass in their habitats (Schönknecht et al. 2013, Science 339:1207).

Cyanidiophyceae have been reported to live in volcanic areas and rivers around mining areas where contains iron over several hundred mM (Baker et al. 2004, AEM 70:6264) because high temperature and acidity in such areas promote the leaching of metals from the environment. In the laboratory, it has been reported to grow in the presence of 200 mM Al (Yoshimura et al. 1999, Soil Sci Plant Nutr 45:721). Thus, Cyanidiophyceae exhibits a highly metal tolerance that is several hundred to a thousand times higher than that of many organisms living in neutral regions.

Regarding the metal tolerance mechanism, the metal chelation of polyphosphate has been reported in Cyanidophyceae as known as in other organisms (Nagasaka et al. 2003, BioMetals 16:465). However, the behavior of metals under acidic environment is completely different from that in neutral pH in their chemical form and their adsorption kinetics, suggesting the existence of unknown metal tolerance mechanisms in addition to the known mechanisms. Whole-genome sequencing suggests that horizontal gene transfer from archaea and bacteria facilitates the adaptation to extreme environments (Schönknecht et al. 2013), but the functions of the genes acquired by horizontal gene transfer are mostly unknown. The mechanism which enable *G. sulphuraria* to survive under the extraordinary metal stress has not been elucidated. In this study, we focused on iron which is essential but toxic at high concentration and aimed to clarify the tolerance mechanism to excess iron in *G. sulphuraria*.

Results and Discussions

At first, the growth of *G. sulphuraria* were examined in the normal culture media (2x Allen’ s medium) containing 0.03, 0.3, 3, 30, 100, and 300 mM $FeSO_4$. The results showed that the growth rate and final OD of *G. sulphuraria* were similar to those of the normal culture conditions up to 100 mM, whereas *G. sulphuraria* did not grow at 300 mM. Since the addition of 300 mM H_2SO_4 does not affect the growth of *G. sulphuraria*, the growth inhibition observed under 300 mM $FeSO_4$ would be due to the excess amounts of Fe.

The Fe concentration of the culture supernatant dropped sharply to 0.3 ±0.1 mM between 1 and 2 days after the addition of 3 mM $FeSO_4$, while after the addition of 100 mM $FeSO_4$, the Fe concentration in the culture supernatant after 2 days was kept as 98 ±3 mM and decreased to 77 ±3 mM on the 6th day as

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increasing the number of the cells. These results suggest the two different mechanisms underlying the growth in the presence of 3 mM and 100 mM $FeSO_4$. After the addition of 3 mM $FeSO_4$, cells absorbed Fe in the culture medium within two days, lowering the extracellular Fe concentration and maintaining the growth similar to the normal growth conditions. In the presence of 100 mM $FeSO_4$, cells seemed to absorb Fe for 6 days, but the extracellular Fe concentration remained high even if they absorbed Fe in the medium. Therefore, cells will need a mechanism that allows them to maintain the growth in the addition of Fe absorbing mechanism in the presence of 100 mM Fe.

Microscopic observation showed the extracellular structure after the addition of more than 3 mM $FeSO_4$. This structure was stained with several lectins-FITC, including ConA, suggesting that they contain polysaccharides. The extracellular structures started to form within 6 hours after the addition of 100 mM $FeSO_4$. In order to understand the tolerance mechanism to excess amounts of Fe, including the formation of extracellular structures, we are currently conducting mRNA-seq analysis using RNA sampling at 0, 1, 3, 6, 24, and 48 hours after the addition of 100 mM $FeSO_4$.

Keywords: Cyanidiophyceae, Galdieria sulphuraria, Iron stress, mRNA-seq

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.26 Zoom Room 26

[M-IS02] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Misato Fukagawa(National Astronomical Observatory of Japan), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science)

Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Individual themes related to Astrobiology, such as chemical evolution in the early Solar System, formation of planetary system, prebiotic chemistry in the early Earth, evolution of life in the Earth's history, extremophile, and habitable planetary environments, has been studied by the knowledge and methods from the multiple fields, which has enabled us to explain "Where we came from" in some ways. However, despite an overwhelming number of investigations and discussions through gathering of the scientists from different fields, there has remained the long-standing unsolved question: How did abiotic materials gain biological function in the Earth and elsewhere in universe? There is still a large gap between prebiotic organic chemistry and biochemistry toward Origins of Life and planetary habitability. Therefore, the JpGU Astrobiology session focuses on pathfinding of "integration of astronomy, geoscience, and biochemistry", which will face an increasing need for the future Astrobiology. In order to enhance our understanding of "What is life", we propose to discuss the biochemical events linked with planetary systems, which is beyond the knowledge in a test tube, by an integration of exoplanets and molecular biology, etc. Through this approach, we will lead the discussions and developments of life-detection strategies for the future exploration of life in universe.

1:45 PM - 2:10 PM JST | 4:45 AM - 5:10 AM UTC

[MIS02-01] Organics in Extraterrestrial Samples

★Invited Papers

*Scott Alan Sandford[1] (1.NASA - Ames Research Center)

2:10 PM - 2:35 PM JST | 5:10 AM - 5:35 AM UTC

[MIS02-02] Astrochemistry and molecular composition in protoplanetary disks

★Invited Papers

*Shota Notsu[1] (1.Star and Planet Formation Laboratory, RIKEN Cluster for Pioneering Research)

2:35 PM - 3:00 PM JST | 5:35 AM - 6:00 AM UTC

[MIS02-03] Linking geochemistry to biochemistry: enzyme-mimetic catalysis

★Invited Papers

*LI Yamei[1] (1.Earth-Life science Institute, Tokyo Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS02-04] **Thioesters as primordial energy currency: kinetics, thermodynamics, their use by enzymes during evolution**

*Shawn E McGlynn[1,2], Liam M Longo[1,2], Sebastian A Sanden[1], Ruiqin Yi[1] (1.Tokyo Institute of Technology, 2.Blue Marble Space Institute of Science)

Organics in Extraterrestrial Samples

*Scott Alan Sandford[1]

1. NASA - Ames Research Center

Organic materials are now known to be present in a wide range of astrophysical environments, both within and outside the Solar System. Within our galaxy, organics are seen throughout the diffuse and dense interstellar media and are present in star formation regions. Pre-existing organics were undoubtedly incorporated into the protosolar nebula, which was itself a good environment for the creation of additional organic materials. Both pre-existing and newly formed organics were incorporated into the planetesimals that ultimately formed comets, asteroids, and the planets and their satellites. Extraterrestrial organics incorporated into planetary environments were ultimately altered or destroyed, but organics that ended up in small bodies like comets and asteroids have a chance survive largely untouched for the age of the Solar System. Organics in these objects can now be studied in extraterrestrial samples like cosmic dust, meteorites, and samples returned by sample return missions like Stardust, Hayabusa, Hayabusa2, and OSIRIS-REx. These organics are of considerable interest to the field of Astrobiology since their delivery to early planetary surfaces must have played a critical role in the generation of habitable surfaces and may have played key roles in the origin of life.

Keywords: Organics, extraterrestrial, Astrobiology, Sample Return Missions, meteorites, cosmic dust

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Astrochemistry and molecular composition in protoplanetary disks

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1. Star and Planet Formation Laboratory, RIKEN Cluster for Pioneering Research

Planets form and obtain their compositions in protoplanetary disks around young stars. The chemical compositions of gas and solid dust grains in these planet-forming disks will decide planetary compositions including water and organic molecules, which relate planet's habitability. Chemical structures in protoplanetary disks are determined by a combination of in situ chemical reactions and inheritance from molecular clouds and protostellar envelopes. In addition, positions of "snowlines" always influence planet formation, since they determine the elemental content of solids and gas at different locations in protoplanetary disks.
Recently, in addition to updates in theoretical studies, astronomical observations with ALMA (Atacama Large Millimeter/submillimeter Array) have investigated the spatial distributions of volatiles (C/N/O) and detected organic molecules in protoplanetary disks. In this review talk, we introduce some research topics (mainly ALMA observations) about astrochemistry and molecular composition in protoplanetary disks, and also discuss future prospects in this field and connections with planetary systems.

Keywords: astrochemistry, ALMA, protoplanetary disks, snowline, molecules, organic molecules

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Linking geochemistry to biochemistry: enzyme-mimetic catalysis

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1. Earth-Life science Institute, Tokyo Institute of Technology

A transition from geochemistry to biochemistry has been considered as a necessary step towards the emergence of primordial life. The chemistry underlying this transition involves many levels of creation and reconstruction, finally reaching the molecular, structural, and functional buildup of complexity. Among them, one apparent question is: how the biochemical catalytic system emerged from the mineral-based geochemical system? Michael Russell proposed that several transition metal sulfide minerals could have acted as structural analogs of metalloenzymes for catalyzing prebiotic redox conversions. This assumption has been tested and verified to some extent by several studies, which focused on using Earth-abundant transition metal sulfides as catalysts for catalyzing multi-electron C and N conversions. I will introduce the progress in this field and also the relevant study that I have been working on for the past four years.

Keywords: Bio-mimetic catalysis, Prebiotic chemistry

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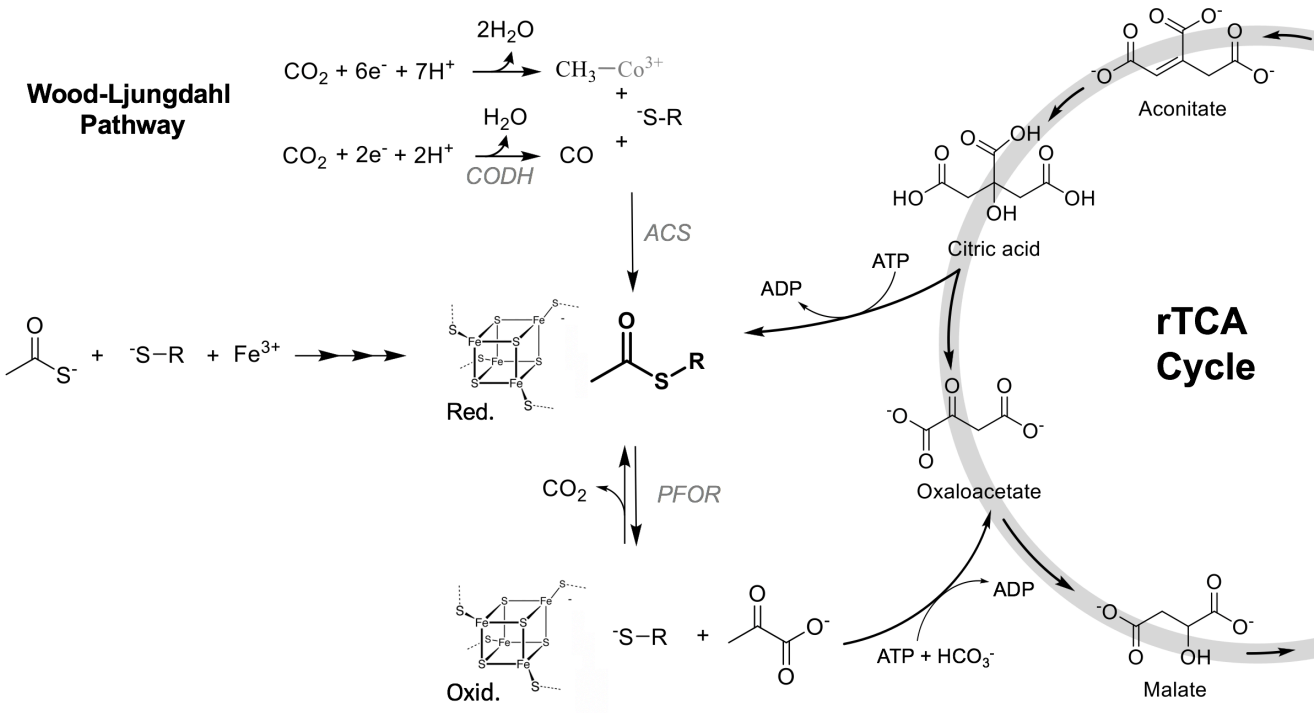
Thioesters as primordial energy currency: kinetics, thermodynamics, their use by enzymes during evolution

*Shawn E McGlynn[1,2], Liam M Longo[1,2], Sebastian A Sanden[1], Ruiqin Yi[1]

1. Tokyo Institute of Technology, 2. Blue Marble Space Institute of Science

A centerpiece of biological chemistry is the buildup of a hydrolysable disequilibrium that can be used to overcome kinetic and thermodynamic energy barriers. While nucleotide triphosphates are the primary hydrolysable agent in life today, other molecules may have been used in primordial metabolism. In this work, we present data from computational chemistry, laboratory chemistry, and protein evolution studies to shed light on the possibility that thioesters predate phosphoesters in metabolism. Differences in the kinetic and thermodynamic properties of these molecular types may have led to the early adoption or exclusion of one type. Following the emergence of a protein world, the metabolic placement and protein fold recruitment of thioesters and phosphoesters provides insight into the evolutionary select-ability of these molecules. Finally, we present laboratory results demonstrating a new synthetic route to thioesters, which connects to amino acid, peptide, and iron-sulfur cluster biosynthesis.

Keywords: Energy Exchange Reactions, Protein Evolution, Thioesters, Phosphoesters, Iron-sulfur redox



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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.26 Zoom Room 26

[M-IS02] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Misato Fukagawa(National Astronomical Observatory of Japan), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science)

Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Individual themes related to Astrobiology, such as chemical evolution in the early Solar System, formation of planetary system, prebiotic chemistry in the early Earth, evolution of life in the Earth's history, extremophile, and habitable planetary environments, has been studied by the knowledge and methods from the multiple fields, which has enabled us to explain "Where we came from" in some ways. However, despite an overwhelming number of investigations and discussions through gathering of the scientists from different fields, there has remained the long-standing unsolved question: How did abiotic materials gain biological function in the Earth and elsewhere in universe? There is still a large gap between prebiotic organic chemistry and biochemistry toward Origins of Life and planetary habitability. Therefore, the JpGU Astrobiology session focuses on pathfinding of "integration of astronomy, geoscience, and biochemistry", which will face an increasing need for the future Astrobiology. In order to enhance our understanding of "What is life", we propose to discuss the biochemical events linked with planetary systems, which is beyond the knowledge in a test tube, by an integration of exoplanets and molecular biology, etc. Through this approach, we will lead the discussions and developments of life-detection strategies for the future exploration of life in universe.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS02-05] Effects of borate on sugar phosphorylation in the evaporitic environment on early Earth.

*Yuta Hirakawa[1], Takeshi Kakegawa[1], Yoshihiro Furukawa[1] (1.Tohoku University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS02-06] Abiotic synthesis of metal-sulfur clusters containing iron and molybdenum and evaluation of their catalytic functions

*Shunjiro Sodei[1], Sebastian Adrian Sanden[1], Daisuke Ishikawa[1], Shawn E McGlynn[2], Masahiko Hara[1] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS02-07] The role of ferrous saponite in the formation of sulfur-bearing organic matter, carbon cycles, and climate on early Mars

*Natsumi Noda[1,2], Yasuhito Sekine[1], Yoshio Takahashi[2], Hiroshi Sakuma[3], Takahiro Kawai[2], Nakagawa Mayuko[1], Norio Kitadai[4], Kristin N Johnson-Finn[1], Shawn E McGlynn[1] (1.ELSI, Tokyo Tech., 2.Grad. School Sci., Univ. Tokyo, 3.National Institute for Materials Science, 4.Japan Agency for Marine-Earth Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS02-08] Relationship among evolutions of continental crust, marine ecosystem, and atmosphere

*Yasuto Watanabe[1], Eiichi Tajika[1] (1.The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS02-09] A mechanism for non-linear amplification of methane flux in the early Earth system with primitive biosphere

*Aika Akahori[1], Yasuto Watanabe[1], Eiichi Tajika[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS02-10] Space experiments on a terrestrial cyanobacterium, *Nostoc* sp.HK-01

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

Effects of borate on sugar phosphorylation in the evaporitic environment on early Earth.

*Yuta Hirakawa[1], Takeshi Kakegawa[1], Yoshihiro Furukawa[1]

1. Tohoku University

In the evolution from organic molecules to life, one of the most essential steps has been regarded as the emergence of RNAs, molecules that can act as biocatalysts and hold a part of gene information. RNAs are polymers of ribonucleotides which are consisted of ribose, nucleobase, and phosphate. Most of the previous research attempted to synthesize nucleotides by phosphorylation of nucleosides. Nucleoside synthesis by this approach is chemically possible, but might not have been possible geologically since this reaction’s source materials are substantially unstable in aqueous environments. Thus, it is not clear whether nucleotides were formed from nucleoside phosphorylation on the early Earth. Current life synthesizes nucleotides from ribose 5’-phosphate and nucleobase in their cell. This motivated us to investigate the phosphorylation of ribose as the similar pathway to the biosynthesis. This reaction was investigated previously and found that it does not happen, due to the selective formation of ribose 1’-phosphate. In this study, the phosphorylation of ribose was investigated in the presence of borate and urea because borate forms a complex with ribose and stabilize it and urea catalyzes the phosphorylation of hydroxyl. Since the phosphorylation of sugars is a dehydration reaction, the dry condition is thermodynamically advantageous. Sample drying was carried out in a furnace at 80℃ for 24 hours. Orthoboric acid was used as the borate source, and disodium phosphate was used as the phosphate source. As a result of liquid chromatography-mass spectrometry of the experimental products, ribose 5’-phosphate was detected with high intensities in the samples containing borate, whereas they were detected with very low intensities in the samples without borate. The extent of the phosphorylation was the most significant with ribose compared with other aldopentoses. These results suggest that ribose 5’-phosphate was preferentially formed in borate-rich evaporitic environments on the early Earth leading to further chemical evolution to RNA.

Keywords: borate, phosphate, nucleotide, ribose phosphate

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Abiotic synthesis of metal-sulfur clusters containing iron and molybdenum and evaluation of their catalytic functions

*Shunjiro Sodei[1], Sebastian Adrian Sanden[1], Daisuke Ishikawa[1], Shawn E McGlynn[2], Masahiko Hara[1]

1. Tokyo Institute of Technology, 2. Earth-Life Science Institute, Tokyo Institute of Technology

The chemical evolution is a widely accepted theory describing the origin of life on Earth. However, the specific reaction pathways and catalysts of the chemical evolution are still controversial. Extant life uses metalloproteins with clusters consisting of metal and sulfur atoms as their active centers, as catalysts for a variety of biochemical reactions in metabolic systems [1]. Metal-sulfur clusters ligated by small compounds are predicted to have played a catalytic role in chemical evolution [2]. There are however only few reports of chemical reactions catalyzed by metal-sulfur clusters in the context of chemical evolution (e.g., [3]) and among the reactions reported, iron-sulfur clusters are predominantly used. It is unclear how metal-sulfur clusters containing metals other than iron could contribute to chemical evolution as catalysts. Herein, this study aims to experimentally evaluate the role of metal-sulfur clusters in chemical evolution processes on the early Earth. This study is focused on the iron-sulfur clusters and iron-molybdenum-sulfur clusters, which are the active centers of ferredoxin [4] and nitrogenase [5], respectively. We examined whether metal-sulfur clusters containing iron and molybdenum could be synthesized abiotically and whether they also exhibit a catalytic function.

Ferric chloride, ferrous chloride, ammonium tetrathiomolybdate, and sodium sulfide were used as metal and sulfur sources, and glutathione and 2-mercaptoethanol were used as ligands. Reacting these compounds yielded UV-visible absorption spectra akin to 4Fe4S clusters. These preliminary results suggests that metal-sulfur clusters containing iron and molybdenum might have been synthesized abiotically. The addition of anthraquinone-2-sulfonate, used here as a redox indicator, suggests that some of the mixed metal-sulfur clusters could be involved in redox reactions. It is currently investigated whether these cluster species could facilitate the reduction of organic compounds.

Reference

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Keywords: Chemical evolution, Iron-sulfur cluster, Metalloprotein

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The role of ferrous saponite in the formation of sulfur-bearing organic matter, carbon cycles, and climate on early Mars

*Natsumi Noda[1,2], Yasuhito Sekine[1], Yoshio Takahashi[2], Hiroshi Sakuma[3], Takahiro Kawai[2], Nakagawa Mayuko[1], Norio Kitadai[4], Kristin N Johnson-Finn[1], Shawn E McGlynn[1]

1. ELSI, Tokyo Tech., 2. Grad. School Sci., Univ. Tokyo, 3. National Institute for Materials Science, 4. Japan Agency for Marine-Earth Science and Technology

In-situ CO_2 fixation is a key process governing the formation of organic matter, climate stability, and possibly the origin of life on Earth. Exploring the characteristics of organic matter resulting from these in-situ reactions in different planetary environments is essential to identify potential biomarkers for current space missions and to aid in the Astrobiology initiatives of missions in the future.

NASA’ s Curiosity rover has investigated the mineralogical and geochemical compositions of lacustrine sediments deposited within Gale Crater on Mars. These analyses tell us information about the geochemistry of early Mars. The SAM (The Sample Analysis at Mars) instrument onboard Curiosity enables detection of organic matter evolved through pyrolysis of drilled samples. Based on mass spectroscopic data acquired by SAM the existence of sulfur-bearing organic matter, including thiols and thiophenes was reported from drilled lacustrine mudstones (Eigenbrode et al., 2018). Terrestrial sulfur-bearing organic matter is known to originate biogenically from metabolism or abiotically through the sulfurization of organic matter in sediments during diagenesis (e.g., Canfield, 2001; Werne et al., 2008). However, few studies, e.g., Heinen & Lauwers, 1996, have investigated the formation of such sulfur-bearing organic matter through CO_2 fixation in sulfur-rich surface environments similar to the surface of early Mars. A main reservoir of inorganic carbon on early Mars would be the carbon dioxide atmosphere, suggesting that carbon dioxide fixation was required to form organic matter.

Here, we investigate the formation of sulfur-bearing organic matter through CO_2 fixation on sulfur-rich meant to simulate early Mars. Our experiments focus on water-rock interactions between ferrous iron-bearing minerals and an aqueous solution of carbon dioxide and hydrogen sulfide. We conducted systematic laboratory experiments using four types of ferrous iron-bearing minerals: troilite, iron-nickel alloy, magnetite, and ferrous saponite. Among them, ferrous saponite is suggested to be widespread on early Mars (Michalski et al., 2015; Chemtob et al., 2017). However, the effective reducing power of ferrous saponite is uninvestigated because of its instability under oxidizing terrestrial conditions. Each mineral powder was enclosed in glass vials with sodium bicarbonate solution, carbon dioxide gas, and hydrogen sulfide under anoxic conditions, followed by heating at 90˚C for 2–4 weeks. After heating, we analyzed the gas compounds using gas chromatography mass spectrometry. [SEM1] .

We found significant production of methanethiol and ethanethiol only in the experiments with iron-nickel alloy and ferrous saponite. The results of Scanning transmission X-ray microscopy analysis of ferrous saponite after the experiments show the presence of aliphatic and carboxyl compounds on the surface or within the interlayers of the saponites. The formation of hydrogen molecules occurs only in the experiments with ferrous saponite and troilite at an order of magnitude higher concentrations than the control experiments without hydrogen sulfide.

These results suggest the possibility that atmospheric carbon dioxide could have been reduced to sulfur-bearing organic matter with the presence of ferrous saponite in aqueous environments on early

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Mars. Given the widespread occurrence of ferrous saponite on early Mars, in-situ CO_2 fixation on ferrous saponite would have acted as a sink of atmospheric carbon dioxide. In addition, evolved H_2 could have helped to warm the surface due to the greenhouse effect of collision-induced absorption (CIA) (Wordsworth et al., 2017).

Keywords: Early Mars, Organic matter

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Relationship among evolutions of continental crust, marine ecosystem, and atmosphere

*Yasuto Watanabe[1], Eiichi Tajika[1]

1. The University of Tokyo

The atmospheric oxygen level (pO2) has substantially increased from low (< 10^{-5} PAL) to weakly oxidized condition (~10^{-2} PAL) at around 2.4–2.1 Ga, which is called the Great Oxidation Event (GOE) (e.g. Lyons et al., 2014). Preceding the GOE, it is suggested that mass of continental crusts has increased during the Archean (4.0–2.5 Ga) (e.g. Hawkesworth et al., 2019), which would have contributed to accumulation of oxygen in the atmospheric through the increased burial of organic carbon at continental shelves (Godderis and Veizer, 2000) and through a change in the composition of continental crusts (Lee et al., 2016). Continents are also important in regulating the Earth's climate through the carbonate-silicate geochemical cycle and in providing the phosphorus to the ocean through the surface weathering (e.g. Walker et al., 1981; Hao et al., 2020). However, the relationship among the evolutions of continents, marine microbial activity, and atmospheric oxygen has not been clearly understood. Here we conducted an equilibrium calculation using an ocean biogeochemical model with photochemical and climatic parameterization based on Harada et al. (2015) to demonstrate the relationship between crustal and atmospheric evolution with parameter sets assuming the early Earth and extrasolar Earth-like planets. We show that the continental phosphorus input increases according to the continental growth (Hao et al., 2020). This is because the relative contribution of continental weathering against seafloor weathering increases with the continental growth. Once the rate of the continental weathering increases through continental growth, the equilibrium surface temperature is decreased due to the increased consumption of atmospheric CO_2. The seafloor weathering rate, on the other hand, decreases because of the decreased atmospheric CO_2 level and surface temperature. Thus, the relationship between the continental growth and the riverine phosphorus input is unique to the Earth-like planets with effective seafloor weathering. We found that, as a result of this relationship, the atmosphere evolves differently in response to the continental growth in the early Earth, depending on the structures of the marine microbial ecosystem. In the case for which the riverine phosphorus is primarily utilized by oxygenic photoautotrophs, evolution of the continental crust alone could drive the GOE by increasing the riverine phosphorus input when the CO_2 outgassing rate is sufficient. On the other hand, in the case for which the phosphorus is also utilized by anoxygenic photoautotrophs as in the late Archean ocean (e.g. Ozaki et al., 2019), the atmospheric oxygen level could not rise even with high CO_2 outgassing rate. In this case, the continental growth could drive the formation of hydrocarbon haze in the atmosphere when CO_2 outgassing rate is comparable to the present condition. This is because the atmospheric CO_2 level decreases with the increased CO_2 consumption from the atmosphere. The evolution of the atmosphere in the early Earth before and after the GOE and implications for extrasolar Earth-like planets will be discussed.

Keywords: Atmospheric Evolution, Biogeochemistry

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A mechanism for non-linear amplification of methane flux in the early Earth system with primitive biosphere

*Aika Akahori[1], Yasuto Watanabe[1], Eiichi Tajika[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Geological records indicate that the climate of the Archean Earth was warm or even warmer than the modern Earth. On the other hand, the standard evolution model of the Sun suggests that early solar luminosity was 30~20% dimmer than the present value. The atmosphere containing high levels of greenhouse gases would be a key to explain the paradox. Methane (CH_4) produced by methanogens had probably played an important role in the Archean Earth, in addition to carbon dioxide (CO_2). Ozaki et al. (2018) developed a coupled atmosphere-ocean ecosystem model, and evaluated CH_4 concentrations in the Archean atmosphere for two cases; one assumed ecosystem based on hydrogen (H_2)-using anoxygenic photoautotrophs, and the other assumed ecosystem based on H_2-using and iron (Fe)-using anoxygenic photoautotrophs, with carbon monoxide (CO)-consuming acetogens and methanogens. They found that the CH_4 flux increases non-linearly in the latter case against volcanic H_2 outgassing flux, which can explain the high CH_4 levels in the atmosphere of the Archean Earth. The mechanism of non-linear amplification of CH_4 flux, however, remains unclear.
Here, we investigate the mechanism for non-linear amplification of CH_4 flux by detailed analysis with a coupled model of atmospheric photochemistry and marine ecosystem. We found that the difference between the two cases is derived from difference in redox balance at the same outgassing flux of H_2. A net flux of reducing power increases with activity of Fe-using anoxygenic photoautotrophs. Two positive feedbacks for the production of H_2 and CO, strongly impact on the CH_4 flux and concentrations. Biogenic CH_4 is converted back to H_2 and CO by photolysis in the atmosphere, which are recycled by marine microbial ecosystem, forming organic matters followed by decomposition to produce CH_4 again. That is, increase of H_2 and CO concentrations owing to photolysis of CH_4 in the atmosphere triggers positive feedback of CH_4 flux. Increase of H_2 concentration increases linearly, while CO concentration increases non-linearly with an increase in the CH_4 flux. This result indicates that positive feedback with CO should contribute to amplification for CH_4 flux more stronger than the positive feedback with H_2.
We will also discuss on application of this model to Earth-like exoplanets orbiting around stars with different masses and spectral types.

Keywords: Archean, Atmospheric photochemical model, Marine microbial ecosystem, Faint young Sun paradox, Earth-like exoplanet

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Space experiments on a terrestrial cyanobacterium, *Nostoc* sp.HK-01

*Kaori Tomita-Yokotani[1]

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The terrestrial cyanobacterium Nostoc sp. HK-01 has a high tolerance to various elements related to the space environment. This strain was selected as an experimental subject for the Tanpopo mission over three years ago. According to the results, this cyanobacterium might have the interplanetary ability to be transferred and arrive at Earth. Some of the detailed results will be presented at this time.

Keywords: terrestrial cyanobacteria, space experiment

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.17_1

[M-IS02] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute)

Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Individual themes related to Astrobiology, such as chemical evolution in the early Solar System, formation of planetary system, prebiotic chemistry in the early Earth, evolution of life in the Earth's history, extremophile, and habitable planetary environments, has been studied by the knowledge and methods from the multiple fields, which has enabled us to explain "Where we came from" in some ways. However, despite an overwhelming number of investigations and discussions through gathering of the scientists from different fields, there has remained the long-standing unsolved question: How did abiotic materials gain biological function in the Earth and elsewhere in universe? There is still a large gap between prebiotic organic chemistry and biochemistry toward Origins of Life and planetary habitability. Therefore, the JpGU Astrobiology session focuses on pathfinding of "integration of astronomy, geoscience, and biochemistry", which will face an increasing need for the future Astrobiology. In order to enhance our understanding of "What is life", we propose to discuss the biochemical events linked with planetary systems, which is beyond the knowledge in a test tube, by an integration of exoplanets and molecular biology, etc. Through this approach, we will lead the discussions and developments of life-detection strategies for the future exploration of life in universe.

[MIS02-P01] Deep genetic link between banded iron formation and non-photoautotrophic microbial community on the early Earth

*Takeshi Kakegawa[1] (1.Graduate School of Science, Tohoku University)

[MIS02-P02] Possible roles of solar energetic particles in the formation of amino acids and their enantiomeric excesses in early Earth atmosphere

*Kensei Kobayashi[1], Koki Naito[1], Toshiki Sakamoto[1], Yoko Kebukawa[1], Jun-ichi Takahashi[1], Hiromi Shibata[2], Kenya Kubo[3], Hitoshi Fukuda[4], Yoshiyuki Oguri[4], Vladimir Airapetian[5] (1.Yokohama National University, 2.Osaka University, 3.International Christian University, 4.Tokyo Institute of Technology, 5.NASA Goddard Flight Center)

[MIS02-P03] Circular polarization induced by aligned dust grains at UV wavelength

*Hajime Fukushima[1], Hidenobu Yajima[1], Masayuki Umemura[1] (1.University of Tsukuba)

[MIS02-P04] Evaluation of cosmic ray from nearby supernova

*shintaro taira[1] (1.The Open University of Japan)

[MIS02-P05] Amino acid production by heating and gamma-ray irradiation experiments simulating aqueous alteration in small bodies

*Akari Ishikawa[1], Yoko Kebukawa[1], Isao Yoda[2], Kensei Kobayashi[1] (1.Yokohama National University, 2.Tokyo Institute of Technology)

[MIS02-P06] Abiotic synthesis of sugars by heating or gamma irradiation simulating aqueous alteration in meteorite parent bodies

*Shunpei Abe[1], Yoko Kebukawa[1], Isao Yoda[2], Kensei Kobayashi[1] (1.Yokohama National University, 2.Tokyo Institute of Technology)

[MIS02-P07] Track Image Clustering for Tanpopo Mission

*Yunosuke Miyamoto[1], Hirohide Demura[1], Hajime Yano[2,3], Kyoko Okudaira[1], Akihiko Yamagishi[2,4]
(1.University of Aizu, 2.Japan Aerospace Exploration Agency, 3.Institute of Space and Astronautical Science, 4.Tokyo University of Pharmacy and Life Sciences)

Deep genetic link between banded iron formation and non-photoautotrophic microbial community on the early Earth

*Takeshi Kakegawa[1]

1. Graduate School of Science, Tohoku University

Archean banded iron formations (BIFs) are often used as a proxy to reveal surface environments of the early Earth. BIFs are often underlain by carbonaceous sedimentary rocks, which indicate high productivities of deep-sea microbial communities before major deposition of BIFs. It has been unknown if such carbonaceous sedimentary rocks, thus microbial activities, influenced the genesis of BIFs. In order to approach the above problem, BIFs from 2.7 Ga Abitibi Greenstone Belt in Canada were examined. Carbonaceous sedimentary rocks associated with BIFs contain abundant sulfides, and often described as sulfidic BIFs. New analytical data of 34S/32S and 33S/32S ratios of pyrite indicate that large amounts of seawater sulfates were accumulated into carbonaceous sediments at the diagenetic stage, allowing the high activities of sulfate reducers. Typical “high-temperature” sulfides also accumulated in the same sediments. Those findings suggest that carbonaceous sediments behaved as cap rocks of benthic hydrothermal systems, and such capping contributed further evolution of Fe2+ dominating hydrothermal fluids. Apatite crystals were often abundant in oxide layers of BIFs, suggesting the temporal enrichment of phosphorous in local ocean waters. Such enrichment was most likely caused by hydrothermal leaching of phosphates from host rocks, utilization and preservation of phosphates by vent communities and release of phosphate by degradation of organic matter at later stage. This step-by-step process lead enrichment of phosphate in local oceans. This further activated photoautotrophic microbial activities, following progressive deposition of Fe hydro-oxides on the sea floor. In other words, the genesis of BIFs was concealed with microbial activities from Fe2+ supply to Fe2+ oxidation stages, and without such microbial activities, giant BIFs could not be formed.

Keywords: early Earth, BIF, microbial community

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Possible roles of solar energetic particles in the formation of amino acids and their enantiomeric excesses in early Earth atmosphere

*Kensei Kobayashi[1], Koki Naito[1], Toshiki Sakamoto[1], Yoko Kebukawa[1], Jun-ichi Takahashi[1], Hiromi Shibata[2], Kenya Kubo[3], Hitoshi Fukuda[4], Yoshiyuki Oguri[4], Vladimir Airapetian[5]

1. Yokohama National University, 2. Osaka University, 3. International Christian University, 4. Tokyo Institute of Technology, 5. NASA Goddard Flight Center

Solar energetic particles (SEPs) are high energy particles ejected from the Sun during solar flares and corona mass ejection, and their major constituents are protons. It was suggested that high-flux SEPs were generated from the young Sun and entered into the Earth atmosphere. Recently superflares were observed in solar-type stars [1]. Thus, we can estimate that high-flux of SEPs were shot out by the young Sun, which could have been important energy sources for prebiotic synthesis. It was estimated that the solar luminosity at 4 Ga was about 70 % of the present value. If so, the Earth should be frozen at that time (the faint Sun paradox). Airapetian *et al.* reported theoretically that SEPs could form N_2O in the primitive Earth atmosphere, which could work as a greenhouse gas to keep the Earth warm [2]. We performed experiments simulating the action of SEPs and discussed possible roles of SEPs in habitability of the early Earth and in formation of amino acids and their enantiomeric excesses.

In these days, it was considered that the early Earth atmosphere was only slightly reducing (*e.g.*, N_2 + CO_2 + H_2O + trace of reducing gases) [3] rather than strongly reducing (*e.g.*, CH_4 + NH_3 + H_2O) [4]. It is difficult to produce amino acids or N-containing organics from non-reducing gas mixtures (N_2 + CO_2 + H_2O) [5]. We compared the yields of amino acids from slightly reducing gas mixtures (N_2 + CO_2 + H_2O + CH_4) by spark discharges (using a Tesla coil), UV irradiation (using a Xe lamp) and proton irradiation (using a Tandem accelerator, Tokyo Institute of Technology), where the molar ratio of CH_4 was 0 –50%. Amino acids were determined by HPLC after the products were acid-hydrolyzed. UV could not yield amino acids since it could not dissociate N_2. Proton irradiation could give amino acids even the molar ratio of CH_4 was as low as 0.5 %, while spark discharge gave them only when the molar ration of CH_4 was 15% or over. Thus, it was suggested that galactic cosmic rays (GCRs) and SEPs were most effective energies for prebiotic formation of amino acids from slightly reducing atmospheres. Since the energy flux of SEPs from the young Sun was expected to be much more than that of GCRs, it can be said that SEPs are most promising energy sources for prebiotic production of bioorganic compounds. In addition, the formation of N_2O was confirmed by GC/MS when a gas mixture of N_2, CO_2 and H_2O was irradiated by protons. Enhancement of amino acid yields by addition of N_2O to the gas mixtures were also observed.

SEPs could generate spin-polarized muons, which may have formed enantiomeric excesses of amino acids toward generation of their homochirality in the terrestrial biological system [6]. Such possibility is now being tested by spin-polarized muon (μ^+ and μ^-) irradiation of amino acids in Materials and Life Science Experimental Facility (MLF) of Japan Proton Accelerator Research Complex (J-PARC).

[1] H. Maehara *et al., Nature* **485**, 478-481 (2012).

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[3] D. C. Catling and J. F. Casting, Atmospheric Evolution on Inhabited and Lifeless Worlds, Cambridge University Press (2017).

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Keywords: Origins of life, The early Earth, Amino acids, Homochirality, Muon, Solar energetic particles

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Circular polarization induced by aligned dust grains at UV wavelength

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1. University of Tsukuba

The L-acid excesses have been discovered in meteorites, and it is the candidate of the origin of the bimolecular chirality. Circular polarization (CP) at the ultraviolet (UV) wavelength causes the enantiomeric excesses of amino acids. In the interstellar medium, UV photons are mainly emitted from massive stars. The star-forming regions around them are the production sites of the enantiomeric excesses if CP light at the UV wavelength exists. In observations, the high CP degree (>20%) at the near-infrared (NIR) wavelength is discovered, and it is caused by the light scattering on the aligned dust grains. However, it is unclear that UV light has a high CP degree. In this study, we develop the radiative transfer code with the Monte Carlo technic, including the Stokes parameters (Fukushima et al. 2020). We consider the light scattering in the dusty slab around a massive star. We find that the high degree of CP (>20%) is realized at UV wavelength with the dust size model of the MRN mixture. On the other hand, the high CP degree at the NIR wavelength is only realized if the micron-size dust grain is contained. In the case of the standard MRN mixture, the CP degree is less than 10%, and the observed high CP degree is not caused. We conclude that the high CP degree at UV wavelength is easily induced compared with that of the NIR wavelength.

Keywords: Circular polarization, Non-spherical dust grains, Enantiomeric excesses

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Evaluation of cosmic ray from nearby supernova

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It is suggested that strong cosmic ray from nearby supernova had influenced the past Earth environment including biota significantly. We used diffusion approximation model which was proposed by Mellot et al.(2017) and evaluated cosmic-ray flux spectrum from nearby supernova and atmospheric ionization rates which is number of ions produced at each altitude. It was confirmed that the similar results to the original paper ones were obtained. Additionally, we changed the distance between Earth and nearby supernova, which is a parameter r in the equation of cosmic-ray density at earth, and calculated the time that is neceaary for cosmic ray intensity at earth to return to the present one.
As the latest case of nearby supernova which influenced earth environment, Maiz-Apellaniz of Johns Hopkins University discovered that the supernovae belonging to Scorpius-Centaurus OB association in Gould's Belt approached solar system about 2.6Ma and suggested that it is thought to be a cause of mysterious die of marine creatures between Pliocene and pleistocene. Actually, decrease of number of whales, decrease of diversity of penguins, extinction of large sharkes(megalodon), etc. are reported as moderate extinction of marine megafaunas all over the world. In some study, it is suggested that there is a possibility that strong cosmic ray from nearby supenova caused strong irradiation of muon at Earth ground and many marine megafaunas died due to cancer.
We used the diffusion approximation model which was proposed by Mellot et al.(2017) to discuss the influence of nearby supernova. In the model, it is assumed that Earth and the nearby supernova existed in local bubble which is high temperature and low density interstellar area produced by past supernova explosion. In the local bubble, it can be thought that Galactic magnetic field(GMF) is expelled and cosmic ray diffuses isotropically from the supernova. We postulated that the distance between Earth and nearby supernova was 50pc following the past study. Matlab R2019b was used to run simulations on note PC easily.
In order to calculate the atmospheric ionization rates induced by cosmic-ray flux, we utilized the table data of atmospheric ionization values which is public on internet(http://kusmos:phsx:ku:edu/melott/Astrobiology:htm). We convolved the calculated cosmic-ray flux spectrum with the table of atmospheric ionization values and obtained atmospheric ionization rates. Atmospheric ionization rates are important to discuss the atmospheric chemical influence of cosmic ray because ion pairs in air produce NO and NO_2 which cause the destruction of ozone layer by catalytic reaction. It was confirmed that the similar results to the original paper ones were obtained.
Then we changed the distance between Earth and nearby supernova, which is a parameter r in the equation of cosmic-ray density at earth, and calculated the time that is necessary for cosmic-ray flux to return to the present one. The present cosmic-ray flux is assumed to be equal to the one that r is 50pc and time measued from the release of cosmic ray is 10ky. We confirmed the change of time associated with the change of distance for the isotropic diffusion model. If another approximation model is applied, the different results will be obtained.
In the future, we are going to discuss influences of cosmic ray including atmospheric chemical reactions which induce the destruction of ozone layer based on these results.

Reference: A.L.Mellot, B.C.Thomas, M.Kachelries, D.V.Semikoz and A.C.Overholt, "A Supernova at 50pc: Effects on the Earth's Atmosphere and Biota", The Astrophysical Journal,840:105,2017 May 10

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Keywords: cosmic ray, atmospheric ionization, diffusion approximation of comic ray

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Evaluation of cosmic ray from nearby supernova

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The Open University of Japan

Introduction

- It is suggested that the strong cosmic ray from nearby supernova had influenced the past earth environment including biota significantly.
- We used the diffusion approximation model which was proposed by Mellot et al. and evaluated cosmic-ray flux spectrum from nearby supernova and atmospheric ionization rates.
- We changed the distance between the Earth and nearby supernova, which is a parameter r in the equation of cosmic-ray density at earth , and calculated the time that is necessary for cosmic ray intensity at earth to return to the present one.

Calculation of cosmic-ray flux spectrum

The source： A.L.Melott,B.C.Thomas,M.Kachelries,D.V.Semikoz and A.C.Overholt ,"A Supernova at 50pc: Effects on the Earth's Atmosphere and Biota", The Astrophysical Journal,840:105,2017 May 10

Diffusion approximation

$$D(E) = D_0 \ (E/E_0)^{1/3},$$

$D_0 = 2 \times 10^{28}\ \mathrm{cm^2\ s^{-1}}$, and $E_0 = 1\ \mathrm{GeV}$.

Effective diffusion distance

$$r_{\mathrm{diff}}{}^2 = 4\,D\ t.$$

Cosmic-ray density at earth

$$n(E, r, t) = Q(E)/(\pi^{3/2}\ r_{\mathrm{diff}}{}^3)\exp(-r^2/r_{\mathrm{diff}}{}^2),$$

Injection energy of supernova

$2.5 \times 10^{50}\ \mathrm{erg}$

Source spectrum

$$Q(E) \sim E^{-2.2} \exp\ (-E/E_c)$$

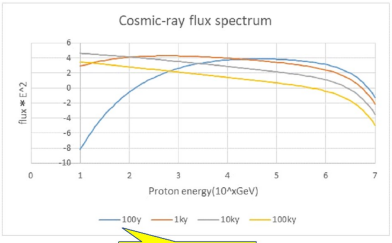
Cosmic-ray intensity at earth

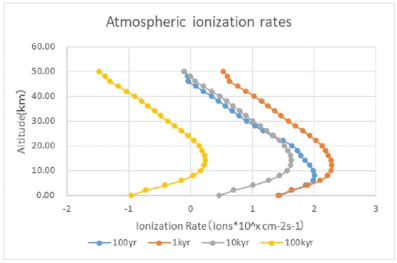
$$I = (c/4\pi)\ n.$$

Cutoff energy

$E_c = 1\ \mathrm{PeV}$.

Simulation results





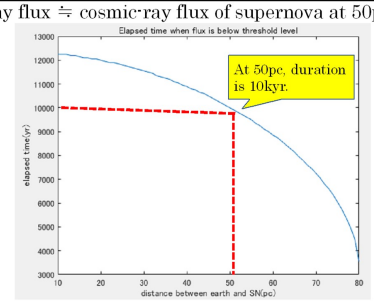
Times measured from the release of the CR

The distance between earth and nearby supernova =50pc

The similar results to the original paper were obtained.

Time that is necessary for cosmic ray intensity at earth to return to the present one

Present cosmic-ray flux ≒ cosmic-ray flux of supernova at 50pc and 10ky case



Necessary time decreases with the increase of the distance

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Amino acid production by heating and gamma-ray irradiation experiments simulating aqueous alteration in small bodies

*Akari Ishikawa[1], Yoko Kebukawa[1], Isao Yoda[2], Kensei Kobayashi[1]

1. Yokohama National University, 2. Tokyo Institute of Technology

Amino acid production by heating and gamma-ray irradiation experiments simulating aqueous alteration in small bodies

*Akari Ishikawa[1]、Yoko Kebukawa[1]、Isao Yoda[2]、Kensei Kobayashi[1]

1.Yokohama National University、2.Tokyo Institute of Technology

[Introduction]

Organic substances such as amino acids are indispensable for the origin of life, and they have been delivered from meteorites . The meteorites containing organic matter are known as carbonaceous chondrites, and their parent bodies have been subjected to aqueous alteration mostly due to the heat generated by the radioactive decay of short-lived radionuclides such as ^{26}Al. Macromolecular organic matter and amino acids in carbonaceous chondrites could be produced during such hydrothermal process [1] [2]. On the other hand, the gamma rays from the decay of ^{26}Al might directly contributes to the formation of amino acids. The previous studies shown that gamma rays contributed to form various amino acids from HCHO and NH_3 aqueous solutions[3]. In this study, we investigated the effects of gamma rays for the production of amino acids from various starting solutions containing simple molecules likely excited in the small bodies such as HCHO, NH_3, glycolaldehyde, hexamethylenetetramine (HMT), and compared with the effects of heating.

[Experiment]

The following mixed solutions were prepared as a starting materials.

(1) HCHO : Glycolaldehyde : NH_3 : $Ca(OH)_2$: H_2O = 3.60 : 1.80 : 0.72 : 0.36 : 100 (molar ratio)

(2) HMT : H_2O = 1 : 100

(3) HCHO : NH_3 : H_2O = 5 : 5 : 100

Each 200 μL solution was vacuum-sealed in a glass tube. The samples were heated (24, 48, 72 h at 150 ℃) or subjected to gamma-ray irradiation (0.5, 1.5 kGy/h for 5, 20 h) from a ^{60}Co source at Tokyo Institute of Technology. The experimental products were acid hydrolyzed with 6 M hydrochloric acid (24 h at 110 ℃), and then analyzed by cation exchange HPLC for amino acid concentrations.

[Results and Discussion]

The amino acids in the samples (1) to (3) were mainly glycine (Gly), alanine (Ala), and β-alanine (β-Ala). In addition, serine (Ser), leucine (Leu), β-aminoisobutyric acid (β-AiBA), etc. were detected. The total

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concentrations of amino acids as well as variations in the amino acids were highest in the sample (3) after both heating and gamma-ray irradiation. In the case of gamma-ray irradiation, the number of detected amino acids in the sample (2) was higher than (1), and in the case of heating, the number of detected amino acids in the sample (2) was lower than (1). In addition, the total concentration of amino acids in the sample (1) was higher than (2) for both gamma-ray irradiated samples and heated samples.

Comparing the heated samples and the gamma-ray irradiated samples, the gamma-ray irradiated sample had larger variations than the heated samples in the case of (1) and (3). The amino acids concentrations were larger in the samples after longer heating, but their concentrations did not show significant correlation with gamma-ray dose.

The lower concentrations of amino acids in the sample (2) was probably due to partial decomposition of HMT[4]. The amino acid concentrations in sample (1) was small likely because the initial concentration of NH_3 was small compared to HCHO and glycolaldehyde. In addition, macromolecular compounds other than amino acids could be produced in the sample (1).

[Conclusions]

The amino acids were detected from all of the heated samples and gamma-ray irradiated samples after acid hydrolysis. The largest amounts of amino acids were produced from the sample (3). The gamma-ray induced larger variations in the amino acids than heating, but the amino acid productions did not show significant correlation with gamma-ray dose.

[References]

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Keywords: Amino acid, Gamma-rays, aqueous alteration, carbonaceous chondrites

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Abiotic synthesis of sugars by heating or gamma irradiation simulating aqueous alteration in meteorite parent bodies

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1. Yokohama National University, 2. Tokyo Institute of Technology

1.Introduction

Sugars and sugar derivatives play important roles in biological processes on the Earth. Sugars such as ribose, a component of RNA, are essential compounds for the origin of life. Since some sugars have been found in meteorites [1, 2], there is a possibility that some extraterrestrial sugar brought to the early Earth by carbonaceous meteorites. As a prebiotic sugar formation reaction, the “formose reaction” have been attracted attention [1, 2]. The formose reaction is the reaction that makes various sugars from aldehydes by using base catalysts, and further reaction makes substances whose structure is like Insoluble Organic Matter (IOM) in meteorites [3]. It is also known that amino acids are made with IOM-like substances by adding ammonia to aldehydes [4].

Meteorite parent bodies are considered to be among the places where the formose reaction may have occurred, since (i) formaldehyde, which is the raw material of the formose reaction, was likely to be present in there, and (ii) hydrothermal alteration induced by the radioactive decay heat from ^{26}Al presented in meteorite parent bodies might have promoted the formose reaction.

The effects of heat have been mainly investigated of formation of organic matter by the formose reaction. However, since the heat source is radionuclides such as ^{26}Al, it is possible that radiation such as γ-ray affected the formation of bio-related substances [5]. In this research, we verified whether sugars were formed or not in products by the “formose-like reaction” using heat or γ-ray simulating aqueous alteration in meteorite parent bodies, and we compared the results by these two energies.

2.Experimental

In this research, we applied aldononitrile acetate ester derivatization method [6] to GC/MS analysis of sugars and their related compounds. In this method, the aldehyde group of the sugar was reduced to nitrile group with hydrochloride hydroxylamine, and then the hydroxy group was converted to acetate ester with acetic anhydride.

Standard reagents of aldose (C3 : glyceraldehyde, C4 : erythrose, threose, C5 : ribose, lyxose, arabinose, xylose, C6 : allose, talose, mannose, altrose, glucose, gulose, idose, galactose) were derivatized by the aldononitrile acetate ester derivatization.

In order to simulate reactions in the meteorite parent bodies, 6 kinds of the starting mixtures were prepared: (1) formaldehyde : H_2O = 10 : 100, (2) glycolaldehyde : glyceraldehyde = 10 : 100, (3) formaldehyde : glycolaldehyde : H_2O = 3.6 : 1.8 : 100 (figures show the molar ratio of compounds of each system) and (1)-(3) with calcium hydroxide as a catalyst were prepared. 200 μL of each mixture was heated at 150℃ for 3 days or irradiated by γ-ray (^{60}Co source at Tokyo Institute of Technology, 1.5 kGy/h) for 20 hours. An aliquot of each product was derivatized by the present method, and analyzed by GC/MS.

3.Results and Discussion

Retention time and major *m/z* of each aldose were obtained by using authentic standards: The retention times (major *m/z*’s) were as follows. Triose: 9.7 min (*m/z* 86, 103), tetroses: 17.7-18.0 min (*m/z* 103, 145), pentoses: 24.8-26.0 min (*m/z* 103, 115, 145) and hexoses: 31.0-33.0 min (*m/z* 103, 115, 145). There was a positive correlation between the carbon number and the retention time.

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By comparing the analysis results of aldose standard reagents and the products of the “formose-like reaction” simulating the interior of meteorite parent bodies, peaks similar to those of pentoses were detected in all the products, and peaks similar to those of tetroses and hexoses were detected in most of γ-ray irradiated products and some heated products. On the whole, hexoses tended to be harder to produce than tetroses and pentoses.
In the same system, varieties and amounts of aldose produced by γ-ray irradiation tended to be greater than those of heated samples. Therefore, the pathway of aldose formation by γ-ray irradiation might differ from the formose-like reaction caused by heating.
Referring to the effects of calcium hydroxide catalyst, some samples with the catalyst produced more aldoses than without it, but other products showed opposite result. It was suggested that the catalyst promote not only producing aldoses but also further reactions that converted aldose into larger molecules.

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Keywords: Sugars, Formose reaction

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Track Image Clustering for Tanpopo Mission

*Yunosuke Miyamoto[1], Hirohide Demura[1], Hajime Yano[2,3], Kyoko Okudaira[1], Akihiko Yamagishi[2,4]

1. University of Aizu, 2. Japan Aerospace Exploration Agency, 3. Institute of Space and Astronautical Science, 4. Tokyo University of Pharmacy and Life Sciences

Introduction

Tanpopo mission [1] is a series of astrobiological experiments conducted by JAXA on the International Space Station (ISS). The purpose of this series of experiments is to investigate the origin of life on Earth. One of the methods for this is collecting fine particles such as cosmic dust and space debris in the ISS orbit.
This capture experiment uses ultra-low density aerogel panels to capture particles [2]. The mission team analyzes the panels on the ground. In this study, we use the surface images of the penetration holes (in after referred to as "Tracks") on the aerogel panels taken in the initial analysis.

These tracks have different shapes depending on the penetrating material and velocity. The shape type is essential for sample cutting and estimating the penetrating material and serves as a label when stored in the sample database. However, since researchers classified them into shape types by qualitative judgment, the classification type may change as the analyses proceed. Also, they manage the data manually. This classification creates a gap between the new data and the past data, making data management labor. The classification must be realized based on the quantitative judgment through a machine rather than qualitative judgment to solve this problem. When adding new data, it will be possible to re-clustering all the previous data, saving time and effort in management.

Methods

The method used in this research is divided into the following steps.
1) Selection of the images
The camera takes the surface on the panel, and it captures from directly above with changing heights. So they have three-dimensional variable-length data. This step selects three images from the top, middle, and bottom for conversion to fixed-length.
2) Image processing
Since the images have low contrast in common, this step coordinates contrast. Moreover, since there is a difference in the number of tracks between classifications, augmentation and downsampling are performed.
3) Learning
This step use supervised and unsupervised learning for classification or clustering.

The results and discussion of these methods in this study are presented.

Reference

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Keywords: Clustering, TANPOPO Mission, Astrobiology

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.17 Zoom Room 17

[M-IS03] Developments and applications of XRF-core scanning techniques in natural archives

convener:Steven Jyh-Jaan Huang, Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), A Ludvig Lowemark(National Taiwan University), Chairperson:Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), Ludvig A Lowemark(National Taiwan University), Jyh-Jaan Steven Huang

X-ray fluorescence (XRF) core scanning techniques have revolutionized element proxy based paleo-research over the last decade and has now become an indispensable tool for many research areas. However, despite being fast, non-destructive and providing records of elemental variations at submillimeter resolution, science applications of XRF-core scanning results also encounter numerous challenges due to its intrinsically semi-quantitative and ultra-high resolution nature, such as the influences of down-core physical and organic variations, parameter optimizations of machinery, as well as quantitative calibrations and evaluations of the voluminous and complex scanning data. Therefore, the implications of shifts and trends in the elemental data remain difficult to interpret in many settings. It is therefore considered timely to bring together international specialists using high-resolution XRF-core scanners in all fields of science to present new research, to stimulate new collaborations and discussions, as well as to propose new technological developments.

3:30 PM - 3:31 PM JST | 6:30 AM - 6:31 AM UTC

[MIS03-01] Introduction

3:31 PM - 3:48 PM JST | 6:31 AM - 6:48 AM UTC

[MIS03-02] Paleoceanographic interpretation of environmental magnetic and XRF core scanning data from sediment cores in the Western Pacific Warm Pool

★Invited Papers

*Toshitsugu Yamazaki[1], Futoshi Nanayama[2], Kosuke Inoue[1], Kazuho Horiuchi[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Geological Survey of Japan, AIST, 3.Graduate School of Science and Technology, Hirosaki University)

3:48 PM - 4:05 PM JST | 6:48 AM - 7:05 AM UTC

[MIS03-03] Artificial intelligence for facies classification based on high-resolution data from sediments of the Wadden Sea,Germany

★Invited Papers

*An-Sheng Lee[1], Dirk Enters[2], Bernd Zolitschka[1], Sofia Ya Hsuan Liou[3] (1.University of Bremen, Institute of Geography, Bremen, Germany, 2.Lower Saxony Institute for Historical Coastal Research, Wilhelmshaven, Germany, 3.National Taiwan University, Department of Geosciences, Taipei, Taiwan)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MIS03-04] A new sample holder for XRF scanning of ion exchange resin samples

*Ludvig A Lowemark[1] (1.National Taiwan University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MIS03-05] Implication of a black fine thin layer in the sediment cores from Lake Tazawa, Akita Prefecture, Northeast Japan

*Yoko Ishiyama[1], Daizo Ishiyama[1], Takuya Ishiguro[1], Kazuyoshi Yamada[2], Masafumi MURAYAMA[3], Takeshi Hayashi[4], Yasumasa Ogawa[1] (1.Department of Earth Resource Engineering and Environmental Science, Graduate School of International Resource Sciences, Akita University, 2.Faculty of Human Sciences, School of Human Sciences, Waseda University, 3.Department of Marine Resource Sciences, Faculty of

Agriculture and Marine Science, Kochi University, 4.Department of Regional Studies and Humanities, Faculty of Education and Human Studies, Akita University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MIS03-06] Corascope: Software assisted XRF scan merging

*GEORGE KONTSEVICH[1] (1.National Taiwan University)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[MIS03-07] Discussion

[E] Oral | M (Multidisciplinary and Interdisciplinary) | M-IS Intersection

[M-IS03] Developments and applications of XRF-core scanning techniques in natural archives

convener:Steven Jyh-Jaan Huang, Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), A Ludvig Lowemark(National Taiwan University), Chairperson:Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), Ludvig A Lowemark(National Taiwan University), Jyh-Jaan Steven Huang

Thu. Jun 3, 2021 3:30 PM - 5:00 PM Ch.17 (Zoom Room 17)

X-ray fluorescence (XRF) core scanning techniques have revolutionized element proxy based paleo-research over the last decade and has now become an indispensable tool for many research areas. However, despite being fast, non-destructive and providing records of elemental variations at submillimeter resolution, science applications of XRF-core scanning results also encounter numerous challenges due to its intrinsically semi-quantitative and ultra-high resolution nature, such as the influences of down-core physical and organic variations, parameter optimizations of machinery, as well as quantitative calibrations and evaluations of the voluminous and complex scanning data. Therefore, the implications of shifts and trends in the elemental data remain difficult to interpret in many settings. It is therefore considered timely to bring together international specialists using high-resolution XRF-core scanners in all fields of science to present new research, to stimulate new collaborations and discussions, as well as to propose new technological developments.

3:30 PM - 3:31 PM

[MIS03-01]Introduction

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Paleoceanographic interpretation of environmental magnetic and XRF core scanning data from sediment cores in the Western Pacific Warm Pool

*Toshitsugu Yamazaki[1], Futoshi Nanayama[2], Kosuke Inoue[1], Kazuho Horiuchi[3]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Geological Survey of Japan, AIST, 3. Graduate School of Science and Technology, Hirosaki University

The Western Pacific Warm Pool plays a significant role in large-scale atmospheric circulation and global hydrology. In order to better constrain climatic and oceanographic variability, we conducted an environmental magnetic study of two late Pleistocene sediment cores (KR0515-PC2, PC4) from the western equatorial Pacific Ocean offshore of New Guinea, which was published as Yamazaki and Horiuchi (2016). Geochemical data obtained afterward using an XRF core scanner (ITRAX) in 2019 have urged us to reconsider the previous magnetic interpretation.

Magnetic property measurements and transmission electron microscopy revealed that the magnetic mineral assemblages in the studied sediments are a mixture of biogenic and terrigenous magnetite, and the terrigenous component carries about 70% of the magnetization. Variations of magnetic mineral concentration and the proportion of terrigenous to biogenic magnetite are in-phase with local summer insolation at New Guinea. Variations of Fe/Ca ratio, a proxy of terrigenous input, are in accord with the proportion of terrigenous magnetite. Increased precipitation on New Guinea is considered to be the cause of the increased terrigenous input. Precessional frequencies in magnetic mineral concentration variations are suppressed after correction for carbonate dilution, whereas cyclic changes with a ~100 kyr periodicity remain in carbonate-free magnetic concentration variations. Ba/Ti ratio variations contain a ~100 kyr periodicity component, which suggests higher biological productivity in interglacials. Glacial-interglacial changes in bottom water currents may have influenced transportation and deposition of magnetic minerals and also productivity of this region.

Keywords: XRF core scanner, rock magnetism, Western Pacific Warm Pool

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Artificial intelligence for facies classification based on high-resolution data from sediments of the Wadden Sea,Germany

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1. University of Bremen, Institute of Geography, Bremen, Germany, 2. Lower Saxony Institute for Historical Coastal Research, Wilhelmshaven, Germany, 3. National Taiwan University, Department of Geosciences, Taipei, Taiwan

Sediment facies classification is one of the first but crucial steps in the analysis of sediment records. It provides vital information, for example, for reconstructing past environmental variability and indicating locations of natural resources. The conventional way of facies classification is to macroscopically describe sediment structure and color and combine both with basic physical and chemical information - a time-consuming task heavily relying on the experience of the scientists in charge. Moreover, these sediment descriptions can not be re-evaluated quickly by further studies. In recent years, high-resolution and digitized elemental data are readily available from X-ray fluorescence core scanning techniques. Such data offer an opportunity for applying machine learning techniques to facilitate sediment facies classification. In 2016, an interdisciplinary research project, Wadden Sea Archive, was launched to investigate the Wadden Sea’ s palaeo-landscapes and environments. The project has recovered more than 130 up to 5 m long sediment cores from the tidal flats, channels and off-shore around the island of Norderney (East Frisian Wadden Sea, Germany). These sediments were classified by the conventional method into 12 terrestrial and marine facies (e.g. glacioflucial sands, moraine, peat, tidal deposits, shoreface sediments). Altogether 92 cores were also scanned by an Itrax μ-XRF core scanner to obtain high-resolution (2000 μm) records of elemental data. This study gathered these data to develop and evaluate automatic facies classification models.
The raw elemental dataset was Centred log-ratio transformed to reduce bias caused by matrix effects and physical properties throughout the cores. Consequently, it was statistically represented by moving mean and standard deviation along each element to depict composite characteristics of a facies. The moving mean and standard deviation wrap the element intensities’ values and variations from the neighboring data points to a local point, respectively. The preprocessing (Principal component analysis) and classifier algorithms (Logistic regression, Support vector machine, Random forest) were implemented in the workflow to find the optimal solution. Our study provides confusion matrice, commonly used to describe details of prediction accuracy, and conjunction matrices, developed by this study to investigate the conjunctions between facies and visualize the models’ prediction characteristics. After cross-validation and evaluation of the test set, the model with the best performance was built by the Support vector machine algorithm without preprocessing, having 61 % accuracy in prediction. This is so far promising in comparison to a random guess from the 12 facies, which has a probability of 8 % of a correct prediction. Our automated sediment facies classification based on the use of μ-XRF core scanning and machine learning techniques provides scientists with more resources to pursue additional research questions. The elemental data gives more possibilities for further research than the conventional method, usually qualitative description. We expect that our approach will contribute in developing a more comprehensive and time-efficient automatic sediment facies classification in the near future.

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A new sample holder for XRF scanning of ion exchange resin samples

*Ludvig A Lowemark[1]

1. National Taiwan University

X-ray fluorescence core scanners are primarily developed for the scanning of untreated soft sediment cores from marine of lacustrine settings. However, recently several innovative applications of this technique have been developed, including the scanning of frozen soupy sediment, powdered samples, and ion exchange resins. In particular, ion exchange resins have found application in forensic geoscience where they can be used for low-cost monitoring of clandestine pollution of natural waters. The principle is straight-forward: ion exchange resin is enclosed in small sachets that are deployed in the waters for a few days. During this time the resin takes up heavy metals from the polluted waters in direct relation to the concentrations in the water. After retrieval the sachets are dried and scanned in the XRF core scanner. This allows a rapid assessment of both spatial and temporal variations in the pollution level of heavy metals in the water. However, a major bottleneck in this otherwise rapid and cost effective analysis is the filling of the ion exchange resin into cuvettes, and mounting the cuvettes on a rack before they can be scanned. In this study we developed a new sample holder that allows the resin to be rapidly filled in to the sample holder through holes on the side using a funnel. The sample holder is then sealed and flipped 90 degrees to allow the scanning of an array of 15 resin samples. Several sample holder can be arranged to be scanned sequentially in the same scan. The new sample holders also considerably reduce the time needed for cleaning the holders in between scans, substantially improving this already efficient way of addressing wide spread contaminations in areasthat are otherwise hard to monitor.

Keywords: XRF core scanner, Forensic geoscience, Geochemistry, Pollution, Itrax

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Implication of a black fine thin layer in the sediment cores from Lake Tazawa, Akita Prefecture, Northeast Japan

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Lake Tazawa that is caldera lake formed by the activity of Tazawako volcano around 1.7 Ma (Kano et al., 2020) is located at eastern part of Akita Prefecture, Northeast Japan. Four sediment cores were obtained from Lake Tazawa in 2015. Based on the data determined by ^{14}C radiocarbon dating for 26 plant fragment samples from 3 cores, those cores record environmental information from 7,000 years ago to present (Matsuoka, 2016). Akita-Komagatake volcano is also located near Lake Tazawa (12.5 km east-northeast). Akita-Komagatake volcano is a volcano composed of basaltic volcanic rocks. The tephra delivered from Akita-Komagatake volcano was mainly observed eastern part of Akita-Komagatake volcano due to the wind from west to east (Wachi et al., 1997). The tephra has not been observed in the sediment from Lake Tazawa that is present west of Akita-Komagatake volcano as of now. However, a black thin layer in the sediment cores from Lake Tazawa was identified using XRF core scanner. This research examines the implication of presence of the thin black layer.

Sediments of TZW15-3 core (276 cm long, obtained at the center of the lake) and 15-4 core (336 cm long, obtained at the southwest part of the lake) consist mainly of dark grayish siltstone. The sediments also intercalate thin sandy silt layers, diatom layers and 2 tephra layers from Towada volcano (Matsuoka, 2016). Most sandy silt layers which are consist of quartz, plagioclase and volcanic grass can be identified easily by the observation with the naked eyes. However, identification of the thin layer consisting of black fine sand was difficult by the naked eyes. Based on the determination using XRF core scanner, a peak showing high Ca intensity was observed at the position of the black thin layer in the sediment cores of TZW15-3 and 15-4. The thickness of the thin layer is 0.8 to 1.0 mm. The grain size and roundness of the black fine sand are 0.05 to 0.3 mm in diameter (fine sand) and angular, respectively. Observation under microscope shows that grains of the black fine sand consist of euhedral plagioclase showing lath-like texture and groundmass. The texture is similar to the that of basaltic rock. Ratio of intensities of Ca/K which is obtained by XRF core scanner were examined on the black thin layer and other sand silt layers. The black thin layer shows significantly higher Ca/K ratio compared to typical sandy silt layers and tephra layers. Quantitative analysis determined by ordinary XRF also shows that the silt sample containing the black thin layer has higher Ca/K ratio compared to other samples (Ishiguro, 2020). Based on the results shown above, there is a possibility that the black thin layer consists of grains having basaltic composition.

Three different basaltic rocks which are located around Lake Tazawa are thought to be a source of the black thin layer. They are the basalt in Shiritaka Formation in Neogene strata, Takabachiyama basalt (1.7 Ma) (Suto, 1987) and basalt of Akita-Komagatake volcano. The ^{14}C radiocarbon dating data (Matsuoka, 2016) and the stratigraphy of sediment cores indicate that the black thin layer was deposited around 1870 cal BP to 1630 cal BP. The main eruption activity of Akita-Komagatake volcano was started 13,000 years ago and intermittently continue to 1971 based on the data determined by ^{14}C radiocarbon dating (Wachi et al., 1997, Fujinawa et al., 2004, Kudo and Hoshizumi, 2006). Regarding the source of the black

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thin layer in the sediment cores, the possibilities of the basalt in Shiritaka Formation and Takabachiyama basalt were excluded due to older age compared with the estimated age of the black thin layer. Based on the records of eruption of Akita-Komagatake volcano (Kudo and Hoshizumi, 2006), age of deposition of the black thin layer in the sediments of Lake Tazawa is similar to the eruption record of 2.2 to 1.9 ka (2200 BP to 1900 BP), named AK-2 of Akita-Komagatake volcano.

Keywords: Lake Tazawa, Akita-Komagatake, XRF core scanner, lake sediment, Holocene

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Corascope: Software assisted XRF scan merging

*GEORGE KONTSEVICH[1]

1. National Taiwan University

Due to the physical constraints of X-ray Florescence (XRF) scanners, all but the shortest sedimentary cores are typically scanned in a piecewise fashion. Pieces are either extracted in whole (ex: Russian peat corer) or are sectioned after extraction (ex: piston and gravity cores). The XRF core scanner will the generate an optical/RGB line-scan image, an X-ray radiograph and a table of downcore variations in the elemental composition. The subsequent processes of digitally joining the individual section scans and reconstructing the original core as it was found in the ground is typically done in an ad-hoc manner with little visual feedback. Manual manipulation of elemental-composition tables while maintaining proper alignment with the optical scans is error prone and slow and as a result the image data is typically discarded at this point or only used as a rough reference. This means a potentially valuable data source is typically lost. Corascope is a first-pass data reconstruction tool for the Itrax XRF scanner that aims to streamline data merging before doing any analysis. It does this by giving immediate visual feedback while cutting and merging sections while automatically preserving optical and elemental data alignment. It further provides a statistically-guided set of tools for adjusting overlapping core sections. These allow users to go from several overlapped cores to one merged virtual core. This virtual core then provides a reconstruction of the sedimentary layers as they would appear had the cores been extracted in one continuous piece. In line with the goal of being a first-pass tool, Corascope leaves all data values unperturbed and merged core data is output in the same format as generated by the Itrax XRF scanner. This ensures that preexisting analysis software and laboratory procedures can continue to work on preprocessed data just as before.

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[E] Oral | M (Multidisciplinary and Interdisciplinary) | M-IS Intersection

[M-IS03] Developments and applications of XRF-core scanning techniques in natural archives

convener:Steven Jyh-Jaan Huang, Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), A Ludvig Lowemark(National Taiwan University), Chairperson:Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), Ludvig A Lowemark(National Taiwan University), Jyh-Jaan Steven Huang
Thu. Jun 3, 2021 3:30 PM - 5:00 PM Ch.17 (Zoom Room 17)

X-ray fluorescence (XRF) core scanning techniques have revolutionized element proxy based paleo-research over the last decade and has now become an indispensable tool for many research areas. However, despite being fast, non-destructive and providing records of elemental variations at submillimeter resolution, science applications of XRF-core scanning results also encounter numerous challenges due to its intrinsically semi-quantitative and ultra-high resolution nature, such as the influences of down-core physical and organic variations, parameter optimizations of machinery, as well as quantitative calibrations and evaluations of the voluminous and complex scanning data. Therefore, the implications of shifts and trends in the elemental data remain difficult to interpret in many settings. It is therefore considered timely to bring together international specialists using high-resolution XRF-core scanners in all fields of science to present new research, to stimulate new collaborations and discussions, as well as to propose new technological developments.

4:50 PM - 5:00 PM

[MIS03-07]Discussion

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.20_1

[M-IS03] Developments and applications of XRF-core scanning techniques in natural archives

convener:Steven Jyh-Jaan Huang, Atsuko Amano(National institute of Advanced Industrial Science and Technology), Masafumi MURAYAMA(Faculty of Agriculture and Marine Science, Kochi University), A Ludvig Lowemark(National Taiwan University)

X-ray fluorescence (XRF) core scanning techniques have revolutionized element proxy based paleo-research over the last decade and has now become an indispensable tool for many research areas. However, despite being fast, non-destructive and providing records of elemental variations at submillimeter resolution, science applications of XRF-core scanning results also encounter numerous challenges due to its intrinsically semi-quantitative and ultra-high resolution nature, such as the influences of down-core physical and organic variations, parameter optimizations of machinery, as well as quantitative calibrations and evaluations of the voluminous and complex scanning data. Therefore, the implications of shifts and trends in the elemental data remain difficult to interpret in many settings. It is therefore considered timely to bring together international specialists using high-resolution XRF-core scanners in all fields of science to present new research, to stimulate new collaborations and discussions, as well as to propose new technological developments.

[MIS03-P01] Reconstruction of variations in South Pacific westerly jet path during the last glacial and calibration for the water content influence of ITRAX intensity

★Invited Papers

*Hitoshi Hasegawa[1], Fuyu Nagaya[1], Kana Nagashima[2], Nagayoshi Katsuta[3], Masafumi MURAYAMA[4], Naomi Harada[2] (1.Faculty of Science and Technology, Kochi University, 2.JAMSTEC, 3.Faculty of Education, Gifu University, 4.Faculty of Agriculture and Marine Science, Kochi University)

[MIS03-P02] Preliminary investigation on geochemical distribution of heavy metals in Uranouchi Inlet Bay sediments during the the Anthropocene Epoch

*Masafumi MURAYAMA[1], Wataru Tanikawa[2], Tatsuhiko Hoshino[2], Akira Ijiri[2], Takehiro Hirose[2], Kazuno Arai[3], Go-Ichiro Uramoto[3], Kondo Yasuo[4] (1.Faculty of Agriculture and Marine Science, Kochi University, 2. Institute for Extra-cutting-edge Science and Technology Avant-garde Research, Kochi Institute for Core Sample Research, JAMSTEC, 3.Center for Advanced Marine Core Research, Kochi University, 4.Faculty of Science and Technology, Kochi University)

[MIS03-P03] Marine environmental changes affected by anthropogenic impacts based on XRF core scanner results in Tokyo Bay

*Atsuko Amano[1], Naohisa Nishida[2], Seishiro Furuyama[3] (1.National institute of Advanced Industrial Science and Technology, 2.Tokyo Gakugei University, 3.Tokyo University of Marine Science and Technology)

[MIS03-P04] Late Holocene vegetation dynamics in the Yangmingshan National Park, northern Taiwan

*Liang-Chi Wang[1] (1.National Chung Cheng University)

[MIS03-P05] A comprehensive 3-steps workflow of evaluation, transformation, and recognition towards automatic XRF-core scanning data processing

*Jyh-Jaan Steven Huang[1], Arata Kioka[2], Christoph Daxer[1], Jasper Moernaut[1], Michael Strasser[1] (1.Institute of Geology, University of Innsbruck, Austria., 2.Department of Earth Resources Engineering, Kyushu University, Japan.)

Reconstruction of variations in South Pacific westerly jet path during the last glacial and calibration for the water content influence of ITRAX intensity

*Hitoshi Hasegawa[1], Fuyu Nagaya[1], Kana Nagashima[2], Nagayoshi Katsuta[3], Masafumi MURAYAMA[4], Naomi Harada[2]

1. Faculty of Science and Technology, Kochi University, 2. JAMSTEC, 3. Faculty of Education, Gifu University, 4. Faculty of Agriculture and Marine Science, Kochi University

We present results of XRF core scanner (ITRAX) analysis on a marine sediment core (MR16-09 PC02) obtained from coastal southern Chile (46S, 76W, 2793 m depth). The study site is located near the boundary of present-day South Pacific summer and winter westerly jet path. Thus, the compositional change of studied core thought to record latitudinal changes of Southern westerly that influence rainfall patterns and water discharges of southern Chile. ITRAX analysis was performed at Center for Advanced Marine Core Research, Kochi University. Using method of Katsuta et al. (2019), water content-corrected μ-XRF intensities of wet sediment cores were converted elemental concentrations (dry weight %). Based on the obtained elemental composition, we reconstructed multi-millennial-scale variations in terrestrial detrital inputs, which likely record variations in westerly jet path during the last glacial.

Katsuta N. et al. (2019) *Sedimentology 66,* 2490-2510.

Keywords: Westerly wind, Off-Chile, Last glacial, ITRAX, Calibration for the water content influence

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Preliminary investigation on geochemical distribution of heavy metals in Uranouchi Inlet Bay sediments during the the Anthropocene Epoch

*Masafumi MURAYAMA[1], Wataru Tanikawa[2], Tatsuhiko Hoshino[2], Akira Ijiri[2], Takehiro Hirose[2], Kazuno Arai[3], Go-Ichiro Uramoto[3], Kondo Yasuo[4]

1. Faculty of Agriculture and Marine Science, Kochi University, 2. Institute for Extra-cutting-edge Science and Technology Avant-garde Research, Kochi Institute for Core Sample Research, JAMSTEC, 3. Center for Advanced Marine Core Research, Kochi University, 4. Faculty of Science and Technology, Kochi University

Heavy metals in marine sediments have been determined in surface sediments collected in Uranouchi Inlet Bay, Kochi, Japan in order to evaluate their levels and spatial distribution. It is very important issues to evaluate the effects of anthropogenic activities, and redox conditions on heavy metal accumulation in this inlet bay area. XRF core scanner (ITRAX) analysis was performed to assess the influencing factors and potential sources of heavy metal enrichment in the sediments. Here we will introduce some examples and initial results.

Keywords: heavy metal, XRF Core Scanner, Anthropocene

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Marine environmental changes affected by anthropogenic impacts based on XRF core scanner results in Tokyo Bay

*Atsuko Amano[1], Naohisa Nishida[2], Seishiro Furuyama[3]

1. National institute of Advanced Industrial Science and Technology, 2. Tokyo Gakugei University, 3. Tokyo University of Marine Science and Technology

The Tokyo Bay is one coastal area has heavily populated area in the drainage and its environment varied to be affected by the anthropogenic impacts during the last century. Previous studies discussed the environmental changes and its factors in Tokyo Bay such as eutrophication and pollution. This study reconstructed marine environment changes in Tokyo Bay based on variations of element contain in core sediments measured by XRF core scanner.
We collected four sediment cores by the gravity corer which has maximum core length of 150 cm in the offshore Shinagawa (TB01) and mouth of Tama river (TB06, 09, 13-2) in October 2020. These cores were measured the major and rear elements by XRF core scanner, Itrax (Cox Analytical Systems), set up at National Institute of Advanced Industrial Science and Technology (AIST, CS-49). These samples were measured in 30kV, 55mA and 10 seconds of exposure times using Molybdenum X-ray tubes at 1.0 mm intervals, respectively. All the XRF spectra were reevaluated by the Q-Spec software (version 15.1) to obtain individual element peak area. In order to reduce bias by matrix and closed-sum effects, the peak areas were normalized by the method of centered log-ratio(clr, Weltje and Tjallingii, 2008).
The collected cores were mainly consisted by silt. The TB01 and 06 cores showed the upper layer were darker than the lower and its boundaries were distinct. The TB09 showed dark color similar with the upper layer of TB01 and 06 through the core. The TB13-2 showed a dark color expected 10 cm of the surface and had plant and shell fragments concentrated layer. The Itrax results show that the clr values of Cr, Ni, Cu, Zn, Br and Y increase in these upper dark layers from the lower and the Si, Ca, Ti and Fe decrease in TB01 and 06. The profiles of these element in TB09 showed constant and same ranges of peak area with the upper layer of TB01 and 06. These results indicate that the upper dark layers contained more organic matters and metals than the lower affected by the eutrophication and pollution. On the other hand, the results of TB13-2 show the different patterns in the other cores which were almost constant and had some peaks. The site of TB13-2 was located at the mouth of Tama River. Therefore, the sedimentary process in TB13-2 was strongly influenced by the river discharge and the variations of element profiles indicated event layer caused by flood.

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Late Holocene vegetation dynamics in the Yangmingshan National Park, northern Taiwan

*Liang-Chi Wang[1]

1. National Chung Cheng University

This study was presented multi-decadal pollen and Itrax-XRF element record from the 180-cm sediment core of the Dream Lake (DL) in the Yangmingshan National Park at 860 m altitudes in northern Taiwan. High percentages of Poaceae pollen suggested the grassland as the dominant vegetation during the last 4500 cal BP period. The expanded wetland landscape during 4500-3500 cal BP was inferred by the increase of Cyperaceae pollen. The expansion of grassland may have markedly reduced wetland cover between 3500-3100 cal BP. During this period, the decrease of aquatic fern spore, Isoetes, which dominated the habitat with a water depth >30 cm, reflected a transition to dryer climatic conditions. The peat deposits with high pollen concentration suggested the stable lacustrine conditions of the last 3000 cal BP. The poor preservation of aquatic fern spores revealed that DL was the seasonal/intermittent freshwater ponds during this period.

Keywords: Pollen, wetland development, water depth

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A comprehensive 3-steps workflow of evaluation, transformation, and recognition towards automatic XRF-core scanning data processing

*Jyh-Jaan Steven Huang[1], Arata Kioka[2], Christoph Daxer[1], Jasper Moernaut[1], Michael Strasser[1]

1. Institute of Geology, University of Innsbruck, Austria., 2. Department of Earth Resources Engineering, Kyushu University, Japan.

X-ray fluorescence core scanning (XRF-CS) technique provides fast, high resolution, and non-destructive analyses to assess down-core elemental variations as indicators for past environmental and process changes down to annual and even sub-annual resolution. Although it has revolutionized elemental proxy-based paleo-researches over the last decade, three long-standing challenges, including (1) reliable quality assurance and quality control (QA/QC); (2) calibration of the matrix and closed-sum effect; (3) dealing with big datasets as proxy-based interpretations, remain to be addressed towards harvesting the full potential of the XRF-CS technique. Here, an automatic workflow, including (1) reliable QA/QC by depth-dependence local similarity evaluation, (2) calibrating the matrix and closed-sum problem by centered-log ratio transformation, and (3) usages of robust multivariate statistical methods, is provided to efficiently process the XRF-CS data and to reduce human bias. Particular focus is devoted to annually-varved lake Millstättersee (Austria), which has 700 years historical records documenting floods, earthquakes, and human occupation, as well as fascinating sedimentary records. By testing and applying our approach, the geochemical fingerprints of event deposits can be revealed and calibrated with historically known events. The causes-and-consequences of environmental perturbations can therefore be discussed.

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.25 Zoom Room 25

[M-IS21] Chemosynthetic community and mud volcano: biology, geochemistry, and geophysics of fluid discharge

convener:Yusuke Miyajima(Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Kayama Hiromi WATANABE(Japan Agency for Marine-Earth Science and Technology), Akira Ijiri(Japan Agency for Marine-Earth Science and Technology), Tomohiro Toki(Faculty of Science, University of the Ryukyus), Chairperson:Yusuke Miyajima(Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Hiromi Kayama WATANABE(Japan Agency for Marine-Earth Science and Technology)

Fluid discharge at mud volcanoes, cold seeps, and hydrothermal vents brings subsurface materials to the Earth's surface. Unique chemosynthesis-based ecosystems are fueled by the substances provided by discharged fluids, and have played a role in the evolution and diversification of life. Knowing fluid geochemistry, driving forces, and geological background of fluid discharge provides key to understand the distribution and evolution of chemosynthetic ecosystems. Multidisciplinary studies from viewpoints of geology, biology, geochemistry, and geophysics are essential to reveal the relationship between fluid discharge and material cycling, environmental changes, and natural hazards, in addition to elucidate spatio-temporal variation of chemosynthesis-based ecosystems. This session welcomes talks and posters focusing on organisms and geological phenomena related to mud volcanoes, cold seeps, hydrothermal vents, and other similar environments. We aim to understand interactions between geosphere, biosphere, and human both on land and in ocean through Earth history.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS21-01] Characteristic and Origin of erupted sediments in submarine mud volcanoes, off Tanegashima Island

*Ryoma Setoguchi[1], Akira Ijiri[2], Takeyasu Yamagata[3], Hiroyuki Matsuzaki[3], Kyoko Hagino[1], Juichiro Ashi[4], Masafumi MURAYAMA[1] (1.Kochi University, 2.Japan Agency for Marine-Earth Science and Technology, 3.The University Museum, The University of Tokyo, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS21-02] Methanogenesis in deep subseafloor sediments −living methanogen diversity, distribution, physiology and activity−

★Invited Papers

*Taiki Katayama[1], Hideyoshi Yoshioka[1], Masanori Kaneko[1], Susumu Sakata[1], Miki Amo[2], Tetsuya Fujii[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Japan Oil, Gas and Metals National Corporation)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS21-03] Aerobic and anaerobic methanotrophs and their activity in methane-seep sediments of the northeastern Japan Sea offshore Sakata assessed by ^{13}C-labelling experiments

*Yusuke Miyajima[1], Hideyoshi Yoshioka[1], Tomo Aoyagi[2], Tomoyuki Hori[2], Hiroshi A Takahashi[3], Masahiro Suzumura[2] (1.Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Environmental Management Research Institute, National Institute of Advanced Industrial Science and

Technology (AIST), Japan, 3.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Japan)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS21-04] Could listening underwater sounds reveal the dynamics of chemosynthetic ecosystems?

★Invited Papers

*Tzu-Hao Lin[1], Chong Chen[2], Hiromi Kayama Watanabe[2], Shinsuke Kawagucci[2], Yung-Che Tseng[3] (1.Biodiversity Research Center, Academia Sinica, 2.X-STAR, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 3.Marine Research Station, Institute of Cellular and organismic Biology, Academia Sinica)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS21-05] The minor-yet-crucial roles of gut microbiomes in a deep-sea hydrothermal vent snail

*Yi YANG[1,2], Jin SUN[1,3], Chong CHEN[4], Yadong ZHOU[5], Cindy Lee Van Dover[6], Chunsheng WANG[5,7], Jian-Wen QIU[2,8], Pei-Yuan QIAN[1,2] (1.Department of Ocean Science and Hong Kong Branch of the Southern Marine Science and Engineering Guangdong Laboratory (Guangzhou), The Hong Kong University of Science and Technology, Hong Kong, China, 2.Southern Marine Science and Engineering Guangdong Laboratory (Guangzhou), Guangzhou, China, 3.Institute of Evolution & Marine Biodiversity, Ocean University of China, Qingdao 266003, China, 4.X-STAR, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2-15 Natsushima-cho, Yokosuka, Kanagawa 237-0061, Japan, 5.Laboratory of Marine Ecosystem and Biogeochemistry, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China, 6.Division of Marine Science and Conservation, Nicholas School of the Environment, Duke University, Beaufort, NC, United States, 7.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China, 8.Department of Biology, Hong Kong Baptist University, Hong Kong, China)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS21-06] Dual symbiosis in the deep-sea hydrothermal vent snail *Gigantopelta aegis* revealed by its hologenome

*Yi Lan[1], Jin Sun[1,2], Chong Chen[3], Jian-Wen Qiu[4], Pei-Yuan Qian[1] (1.Hong Kong University of Science and Technology, 2.Ocean University of China, 3.Japan Agency for Marine-Earth Science and Technology , 4.Hong Kong Baptist University)

Characteristic and Origin of erupted sediments in submarine mud volcanoes, off Tanegashima Island

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Mud volcanoes are remarkable geological features formed by the vertical intrusion of low density and deformable sediments from deep subsurface to the surface, and are distributed both on land and seafloor at the continental margins. The mud volcanoes are an important source of methane to the hydrosphere and the atmosphere. In the sea around Japan, it is widely distributed in the Kumano Basin off the Kii Peninsula and off Tanegashima Island. The mud volcanoes in the Kumano Basin are well studied compared to those off Tanegashima, and the mechanism of the eruption has been inferred from fluid and sediment analyses. So far, 15 mud volcanoes have been identified in topographic surveys off Tanegashima Island and numbered from MV#1 to #15. During the KH-15 and KH-19 cruises in 2015 and 2019 by R/V Hakuho-Maru, we retrieved piston cores from MV#1 (30°53´N, 131°46´E; water depth: 1540 m), #2 (30° 55´N, 131°50´E; water depth: 1430 m) , #3 (31°03´N, 131°41´E; water depth: 1200 m) , and #14 (30° 11´N, 131°23´E; water depth: 1700 m) . We investigated the origin of sediments and fluids based on the chemical analyses of them. For the sediment cores, the internal structure was observed by X-ray CT, and the sediment age was estimated by ^{10}Be and calcareous nannofossils. Bulk mineral composition and clay mineral compositions were estimated by XRD analysis, and then the temperature history of sediments was estimated from the clay mineral composition. The origin of methane were investigated by the methane to ethane concentration ratio (C_1/C_2), and the carbon isotopic composition ($\delta^{13}C$) of methane. The sediments of MVs # 1, # 2, and #3 contain a large amount of mud breccia, and the modern hemi-pelagic sediments covered on the erupted sediments were not observed, suggesting that those mud volcanoes are active. On the other hand, nannofossils observations suggest that MV # 14 is dormant mud volcano in which the hemi-pelagic Quaternary sediments have covered on the erupted sediments. The nannofossil ages and the ^{10}Be ages of MVs#2 and #3 consistently show the Middle to Late Miocene. These ages are younger than the Eocence Shimanto belt distributed around Tanegashima (Ujiie et al., 2000), suggesting that the mud-volcano sediments are provided from the sedimentary layers above the Shimanto belt. The mud-volcano sediments were generally dominated in quartz, illite, and plagioclase, and there is no particular mineralogical difference among the mud volcanoes. Clay minerals were mostly dominated in illite, suggesting the experience 60–160 °C where smectite to illite transformation occurs. There were some differences in clay mineral composition among the mud volcanoes. The illite/smectite mixed-layer (I/S) was detected in MV # 1, but not detected in MVs #2, #3, and #14. In MV #1, the illite content in the I/S mixed-layer, estimated from the diffraction pattern, is 42 to 45%. The content indicates the early stage of illitization, suggesting that the experienced temperature is 60 to 100 °C. On the other hand, the MVs#2, #3 and #14 sediments, in which the mixed-layer was not detected, might be experienced higher temperatures than MV#1, due to the progress of smectite to illite transformation. At the active MVs #1, # 2, and #3, generally low C_1/C_2 ratio (30–50) and $\delta^{13}C$ of methane (-57‰ –-42‰) indicate that the hydrocarbon gases are derived from thermal decompositions of organic matter in deep sediments where the in situ temperature is >80°C. At the inactive MV#14, the C_1/C_2 ratios were high as 700–4000, and $\delta^{13}C$ of methane were -75‰ and -77‰, respectively. The data indicate the biogenic origin. Considering the geothermal gradient (25–50 °C/km) observed in the area, the conditions for thermogenic gas production (> 80 °C), and the temperature history of the sediments, the sediments and hydrocarbon gas would be

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provided from deep sedimentary realm deeper than 1.5 km below seafloor.

Keywords: Mud Volcano, Submarine Mud Volcano, Methane Gas, Clay mineral

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Methanogenesis in deep subseafloor sediments –living methanogen diversity, distribution, physiology and activity–

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Gas hydrates deposited in subseafloor sediments are considered to be the Earth’ s largest natural gas reservoir of biogenic methane based on geochemical analyses. However, thus far, viable methanogens, microorganisms that are responsible for biogenic methane formation, have been poorly obtained and characterized. Characterization of living methanogens in subseafloor sediments at hydrate sites are fundamental for understanding biogenic gas hydrate formation and our estimations of gas hydrate reserves. We performed cultivation dependent and independent analyses of microorganisms in the hydrate-bearing sediments from the eastern Nankai Trough. In this presentation, I will show previously overlooked phylogenetic and metabolic diversity of viable methanogens and importance of methylotrophic methanogenesis and discuss their depth-related profiles. This study was part of the Research Consortium for Methane Hydrate Resources program in Japan (MH21 Research Consortium).

Keywords: gas hydrate, biogenic methane formation, cultivation, deep subseafloor sediment

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Aerobic and anaerobic methanotrophs and their activity in methane-seep sediments of the northeastern Japan Sea offshore Sakata assessed by ^{13}C-labelling experiments

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Microbial oxidation of methane plays a major role in regulating the release of subsurface methane into the ocean and atmosphere. Up to 80% of methane migrating to the seafloor is consumed by aerobic and/or anaerobic methane-oxidizing microorganisms (Reeburgh, 2007; Boetius and Wenzhöfer, 2013). Identifying microbes involved in methane oxidation and assessing their activity in sediments can provide insights into subsurface microbial diversity and methane dynamics of gas hydrate systems. However, activity of both aerobic and anaerobic methanotrophs in marine sediments has been poorly investigated. Although lipid biomarkers are utilized as strong tools to examine the community structure and distribution of microbes in sediments, they have not been clearly linked to their source organisms, especially aerobic methanotrophs (e.g., Rush et al., 2016).

By combining genetic analysis, lipid biomarker analysis, and incubation experiments with ^{13}C-labelled methane, this study investigated aerobic/anaerobic methanotrophs and their activity in methane-seep sediments of the northeastern Japan Sea offshore Sakata. Push core samples were taken from sediments with microbial-mats like surface and used for the analyses. The sediments from 0–10 cm below seafloor (bsf) were aerobically and anaerobically incubated with CH_4 (20% ^{13}C) for more than 100 days at 4˚C, both showing ^{13}C uptake into dissolved inorganic carbon due to oxidation of ^{13}C-methane. The detection of both aerobic and anaerobic methanotroph activity in the same sediments is distinct from the predominance of either aerobic or anaerobic methanotrophs in mud volcano sediments (Niemann et al., 2006), and has important implications for the methane flux at the study site. Anaerobic oxidation of ^{13}C-methane was also observed at a much lower rate for deeper sediments (10–14 cmbsf). High-throughput sequencing of archaeal and bacterial 16S rRNA genes showed that anaerobic methane-oxidizing archaeal group ANME-1 was highly abundant in the sediments. The relative abundance of the ANME-1 archaea increased from less than 5% at the surface to more than 50% of the whole microbial communities at 10–14 cmbsf. Lipid biomarkers specific for archaea including ANME groups, archaeol and hydroxyarchaeol, were detected in trace amounts in the surface sediments above 4 cmbsf. From the same sediments, bacteriohopanepolyols, which are characteristic biomarkers for aerobic methanotrophs and other bacteria, were detected as degradation products released by periodic acid treatment of another aliquot of the total lipid extracts. Ongoing analyses of archaeal and bacterial lipids in the deeper sediments and ^{13}C uptake into the lipids will specify which lipids were produced by the source methanotrophs deduced from the gene sequences. The results for the ^{13}C-labelling approach could improve the use of lipid biomarkers in studying the composition, distribution, and activity of methanotrophic communities in methane-rich sediments and sedimentary rocks.

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This study was conducted as a part of the methane hydrate research project funded by the Ministry of Economy, Trade and Industry (METI), Japan.

Keywords: Aerobic/anaerobic oxidation of methane, Archaea, Bacteria, 13C-labelling, Lipid biomarker

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Could listening underwater sounds reveal the dynamics of chemosynthetic ecosystems?

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Chemosynthesis-based ecosystems support unique communities fed by chemical energy generated from subsurface geological and microbial processes. Hydrothermal vents are the best-known of such ecosystems, often occurring along active ocean ridges, seamounts, and back-arc basins. Active geological activities produce low-frequency sounds, which can propagate a long distance underwater. Such signals likely serve as acoustic signposts for deep-sea larvae to remotely locate these isolated, island-like geological hotspots among the vast abyssal plain –as has been demonstrated in previous experiments associated with the settlement of coral, mollusk, and reef-associated fish larvae in shallow-water habitats. As such, habitat-specific soundscapes, a composite of sounds from geophysical and biological sources, may be key to maintaining the resilience of vent ecosystems, as they are threatened by fast-approaching deep-sea mining. Although the heterogeneity of underwater soundscapes has begun to gain attraction as a useful proxy of habitat quality and biodiversity, soundscapes of hot vents remain poorly studied. Here, we review modern techniques of soundscape-based ecosystem sensing and then discuss the applications in monitoring vents dynamics. We also investigate the uniqueness of vent soundscapes by using two new recordings, one from a deep-sea vent in Suiyo Seamount, Izu-Bonin Arc, and another from a shallow-water vent at Guishan Island, northeastern Taiwan. Both fields are dominated by low-frequency sounds generated from vent orifices. The observed spectral pattern is entirely different from soundscapes recorded at estuaries, coral reefs, continental shelves, and other deep-sea habitats. Our results support the hypothesis that hydrothermal vents are acoustically different from other habitats, but many questions remain open. For example, do different vents possess different acoustic characteristics? Can we predict the amount of fluid discharge and temperature by measuring the intensities of vent-associated sounds? How do these low-frequency sounds propagate across the surrounding three-dimensional terrain that varies from vent to vent? Do vent-associated organisms produce sounds, and how frequently do they vocalize? Answer these questions will require future, more detailed acoustic assessments of the dynamics of vents and their associated communities. Based on the experience in shallow-water marine ecosystems, soundscape-based ecosystem assessments can reveal the interactions between a biological community and its habitat, as well as the ecological impacts due to anthropogenic development. We believe the same approach will improve our knowledge of the ecological dynamics of hydrothermal vents. Beyond that, additional data from cold seeps and organic falls will also help evaluate the feasibility of using soundscapes in monitoring other chemosynthesis-based ecosystems.

Keywords: Ecoacoustics, Underwater acoustics, Hydrothermal vents

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The minor-yet-crucial roles of gut microbiomes in a deep-sea hydrothermal vent snail

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Eukaryotes often exhibit a complex symbiotic relationship with gut microbes to attain better use of the available resources. Many animals endemic to deep-sea chemosynthetic ecosystems host chemoautotrophic bacteria endocellularly, and are thought to rely entirely on these symbionts for energy and nutrition. The provannid snail *Alviniconcha marisindica* hosts a *Campylobacterial* endosymbiont in its gill, but unlike many other chemosymbiotic animals, its gut is reduced but still functional. Here, we show through metagenomic and metatranscriptomic analyses that the gut microbiome of *A. marisindica* plays key nutritional and metabolic roles. The diversity of *A. marisindica* gut microbiota is comparable to that of the snails without symbionts but its composition and relative abundance differed from these snails. The relative abundance of microbial composition remains similar among three *A. marisindica* and their microbial community shows significant multi-taxa associations, suggesting a long-term association. Functional profiling of the gut microbiome reveals thousands of additional genes for the holobiont to cope with the shortage of amino acids, vitamins, and lipids, as well as the accumulation of metabolic waste and the maintenance of homeostasis. These microbes have the potential to form the protective slime capsule to protect themselves from the host’ s immune system, thereby contributing to their survival and development. Our findings advance the understanding of how deep-sea chemosymbiotic animals obtain available resources through considering an additional contribution of gut microbiota. The widespread less-abundant gut microbiota is potential to help hosts survive and thrift in extreme environments.

Keywords: Deep-sea vent, Provannid snail, Gut, Microbiome, Metagenome, Metatranscriptome

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Dual symbiosis in the deep-sea hydrothermal vent snail *Gigantopelta aegis* revealed by its hologenome

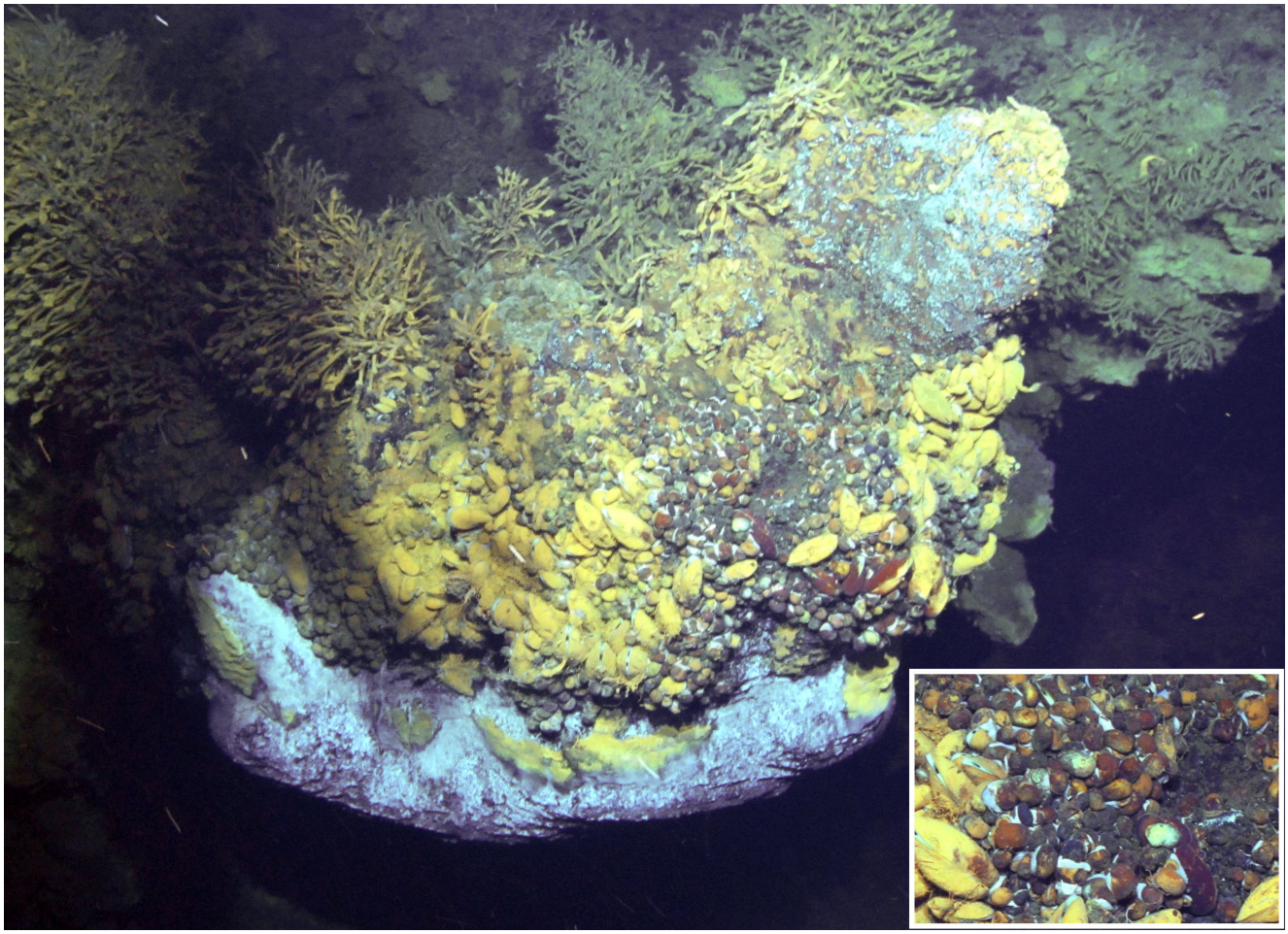
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Animals endemic to deep-sea hydrothermal vents often form obligatory relationships with bacterial symbionts, maintained by intricate host–symbiont interactions. Most genomic studies focusing on symbiotic systems failed to simultaneously investigate the host and symbionts to a similar depth. Here, we report novel dual symbiosis in the peltospirid snail *Gigantopelta aegis* with two gammaproteobacterial endosymbionts: one being a sulphur oxidiser and the other a methane oxidiser. We assembled high-quality genomes for all three parties of this holobiont, with a chromosome-level assembly for the snail host (1.15 Gb, 15 pseudo-chromosomes). In-depth analyses of these genomes revealed an intimate mutualistic relationship with complementarity in nutrition and metabolic co-dependency, resulting in a system that is highly versatile in transportation and utilisation of chemical energy. Moreover, *G. aegis* likely has remodelled its immune system to facilitate hosting more than one type of symbiont. Comparisons with *Chrysomallon squamiferum*, another chemosymbiotic snail in the same family but with only a sulphur-oxidising gammaproteobacterial endosymbiont, showed that the two snails' sulphur-oxidising endosymbionts are phylogenetically distant. This finding was consistent with previous results that the two snails have evolved endosymbiosis independently and convergently. Notably, same capabilities in the biosynthesis of specific nutrients lacking in the host genomes are shared by the two sulphur-oxidising endosymbionts of the two snail genera, which may be a key criterion in symbiont selection by the hosts.

Keywords: chemosynthesis, sulphur-oxidising, methane-oxidising, Mollusca

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.17_2

[M-IS21] Chemosynthetic community and mud volcano: biology, geochemistry, and geophysics of fluid discharge

convener:Yusuke Miyajima(Geomicrobiology Research Group, Research Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Kayama Hiromi WATANABE(Japan Agency for Marine-Earth Science and Technology), Akira Ijiri(Japan Agency for Marine-Earth Science and Technology), Tomohiro Toki(Faculty of Science, University of the Ryukyus)

Fluid discharge at mud volcanoes, cold seeps, and hydrothermal vents brings subsurface materials to the Earth's surface. Unique chemosynthesis-based ecosystems are fueled by the substances provided by discharged fluids, and have played a role in the evolution and diversification of life. Knowing fluid geochemistry, driving forces, and geological background of fluid discharge provides key to understand the distribution and evolution of chemosynthetic ecosystems. Multidisciplinary studies from viewpoints of geology, biology, geochemistry, and geophysics are essential to reveal the relationship between fluid discharge and material cycling, environmental changes, and natural hazards, in addition to elucidate spatio-temporal variation of chemosynthesis-based ecosystems. This session welcomes talks and posters focusing on organisms and geological phenomena related to mud volcanoes, cold seeps, hydrothermal vents, and other similar environments. We aim to understand interactions between geosphere, biosphere, and human both on land and in ocean through Earth history.

[MIS21-P01] Origin of noble gases in surface sediments from submarine mud volcanoes off Tanegashima

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[MIS21-P02] Subsurface structures and fluid transportation visualization by acoustic mapping in a shallow methane hydrate area off Sakata, eastern margin of the Sea of Japan

*Miho Asada[1], Mikio Satoh[1], Toshiyuki Yokota[1], Shusaku Goto[1] (1.NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST))

[MIS21-P03] Chemosynthesis, surface ruptures and possible methane eruption on the Kuroshima Knoll: a review from previous studies

*Takeshi Matsumoto[1] (1.Faculty of Science, University of the Ryukyus)

[MIS21-P04] Community composition and connectivity of hot vent endemic animals on the Izu-Bonin-Mariana Arc

*Hiromi Kayama WATANABE[1], Chong Chen[1], Shigeaki Kojima[2], Hiroyuki Yamamoto[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, the University of Tokyo)

[MIS21-P05] Population Genetic Structure and Gene Expression Plasticity of the Deep-Sea Vent and Seep Squat Lobster *Shinkaia crosnieri*

*Yao Xiao[1] (1.Hong Kong University of Science and Technology)

[MIS21-P06] A Decade to Study Deep-Sea Science

*Hiromi Kayama WATANABE[1], Kerry Howell[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.University of Plymouth)

Origin of noble gases in surface sediments from submarine mud volcanoes off Tanegashima

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A submarine mud volcano is a small hill where sediments with high pore pressure rise as a mud diapir and vent on the seafloor. In Japan, mud volcanoes have been found in the Kumano area of the Nankai Trough and off Tanegashima. In this study, we analyzed noble gases collected from the sediments of four mud volcanoes out of the 15 mud volcanoes discovered in the forearc region off Tanegashima. The purpose of this study is to analyze the measurement results of noble gases in the sediments of the mud volcanoes off Tanegashima, to discuss the origin of the gases, and to compare them with noble gas data from other marine areas.

The sampling was conducted during voyages using the *R/V Hakuho-Maru* from August 19 to September 1, 2015 and August 9 to 18, 2019. MV1 and MV14 sediment samples were collected during the 2015 voyage, and MV2 and MV3 samples were collected during the 2019 voyage. In MV1 and MV14, after collecting the piston corer, a hole was drilled in a PVC pipe and a copper tube was set in it, filled with surface sediment, and sealed with a metal clamp. For MV2 and MV3, copper tubes were set in pre-drilled holes in the pipes of the multiple corer and sediments were collected in the same way as for piston coring. The noble gases in the surface sediments in the copper tube were measured using a noble gas mass spectrometer at ETH Zurich and the Atmosphere and Ocean Research Institute of the University of Tokyo. As a result, the helium isotope ratio ($(^3He/^4He)_{raw}$) ranged from 0.23 to 0.96 R_A, all of which were lower than the value of 1 R_A in atmospheric equilibrium seawater (ASW). 0.23 R_A was the smallest value in MV1, and 0.96 R_A was the largest value in MV14. In MV3, we sampled at three depths, with the deeper depths showing higher values than the shallower ones. The $(^3He/^4He)_{raw}$ values of MV2 is 0.63 R_A. The results of $^4He/^{20}Ne$ values are as follows: MV3-1 shows the highest value of 18.4, followed by MV1, MV2, MV3-2, MV14, and MV3-3 shows the lowest value of 0.81. All the mud volcanoes are significantly higher than ASW, beyond the error range. The concentrations of heavy noble gases (Ar, Kr, and Xe) were obtained for MV1 and MV14, and it can be said that MV14 is slightly higher than MV1 for all noble gas concentrations. In both mud volcanoes, the concentrations are higher than those of ASW.

The $(^3He/^4He)_{corr}$ results corrected for the influence of ASW are about 0.2 R_A for MV1, 0.6 R_A for MV2, 0.3-0.6 R for MV3, and 0.9 R_A for MV14. The contribution of the mantle-derived helium was about 2% for MV1, 7% for MV2, 4-7% for MV3, and 12% for MV14. In the four mud volcanoes, the influence of crustal helium was about 88-98%, suggesting that most of the collected helium was of crustal origin. Plotting the helium isotope ratio data obtained in other forearc regions shows two major ranges. The first is in the range of 0.1-0.8 R_A, which is the data from the Oomine Ridge off Kumano and the mud volcanoes in the Gulf of Cadiz. The other is the data at depths of several kilometers below the seafloor with values of ~2.4 R_A, suggesting the presence of mantle-derived helium. The data off Tanegashima corresponds to the lower range of the helium isotope ratio. The NGTs inferred from the heavy noble gas concentrations of MV1 and MV14 were about 150℃ and 100℃, respectively. The NGT estimated from the heavy noble gas concentration is reasonable because the temperature at which the reaction occurs is estimated to be 60-160℃. If the geothermal gradient around Tanegashima is 25-50℃/km, the temperature of 100-150℃

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is estimated to be around 2-6 km below the seafloor. According to the velocity structure study, these depths are considered to be in the upper to middle crust around the Off Tanegashima, and the plate boundary is estimated to be located about 10 km below the seafloor, which is not a clear evidence for the origin of these noble gases near the plate boundary.
In the mud volcanoes off Tanegashima, the results of $^{3}He/^{4}He$ in the sediments suggest that about 90% of the helium is of crustal origin, although there are differences in MV1, MV3 and MV14. From the heavy noble gas concentration, the origin temperature of noble gas in MV1 and MV14 is estimated, and the helium corrected from sediments is considered to have come from about 2-6 km below the seafloor. Therefore, the helium isotope ratios and heavy noble gas concentrations in the sediments do not provide clear evidence that the noble gases originated near the plate boundary in either case.

Keywords: off Tanegashima, submarine mud volcano, noble gas

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Subsurface structures and fluid transportation visualization by acoustic mapping in a shallow methane hydrate area off Sakata, eastern margin of the Sea of Japan

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Shallow methane hydrates (MH) have been reported atop a knoll off Sakata (Sakata knoll, a tentative name), along a reverse fault located at the southwest foot of the knoll, along the eastern margin of the Sea of Japan (Temma and Goto, 2018). Fluid seepage not only helps in generating shallow MH, but also assists in the cultivation of chemosynthetic animal communities, and generates carbonate rocks from a mixture of gas-containing fluid and seawater. The distribution of chemosynthetic animal communities and rocks on and below the seafloor in this area is a slight indicator of fluid emission, including gas, in turn suggesting the distribution of buried shallow MH. However, the relationship between the distribution of the communities and rocks, and the route of gas emission is unclear.

Prior observation cruises in this area acquired data from: acoustic mapping using research vessels and autonomous underwater vehicles (AUVs), optical observations using remotely operated vehicles (ROVs), logging-while-drilling (LWD) measurements, and sediment sampling (Morita, 2015; Temma and Goto, 2018; Yokota, 2020). These results reveal a depression bordered by steep slopes atop the knoll (~1 km× ~300–400 m in diameter, ~12 m deep), two terraces on its northern and southern sides, a single hill near its center, and swells on the top around the depression (~15 km×~5–10 km in diameter, ~120 m of relative height from the southwestern foot of the knoll). The distribution of backscatter strength was the largest on the steep slopes, relatively large on the terraces within the depression and the surrounding swells, and continued southwestwards along the knoll. The shallow subseafloor structure showed an anticline along the topography of the knoll. Faults developed were more in number on the southwestern slope of the knoll, compared to a few found in the shallowest layer. A large acoustic blanking which developed directly beneath the depression prevented the visibility of shallow subsurface structures. Relatively common smaller acoustic blankings on the northeast side of the knoll, seemed to cut the layers.

To determine the detailed distribution of chemosynthetic communities and carbonate rocks on the seafloor, optical seafloor mapping was performed with a 1K20 cruise using Kaiyomaru no.1 (Kaiyo Engineering Co. Ltd.), and ROV-*Kaiyo3000* with *SeaXerocks 1* (high-resolution 3D mapping system, Kaiyo Engineering Co. Ltd.) in June 2020, in and around the depression. The seawater was turbid with increased biomass in the depression. Methane hydrates remained unconfirmed on the seafloor. The two terraces and swells were extensively covered with sediments, but rare rock outcrops and small biological mats were observed.

Since shallow subseafloor structures beneath the depression were unrecognizable because of acoustic blanking, it was difficult to extract information corresponding to the distribution of communities, rocks, and subseafloor structures. Nevertheless, we recognized larger visible faults just outside the depression, most of which stopped below the top layer of the sediment without reaching the seafloor. No communities or rocks were observed directly above these faults, suggesting the likelihood of less fluid and gas discharge through surface sediment. More communities and rocks on the steep slope surrounding depression than in the surrounding areas should be assisted by larger amount of fluid seepage through

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the exposure of the layers.

This study was conducted as part of the methane hydrate research project funded by the Ministry of Economy, Trade and Industry (METI).

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Keywords: shallow methane hydrate, acoustic mapping, 3D pictorial mapping system, different scale observation matchup

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Chemosynthesis, surface ruptures and possible methane eruption on the Kuroshima Knoll: a review from previous studies

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Kuroshima Knoll is located about 40km south of Ishigaki Island in the southwest Ryukyu arc. A Calyptogena colony was first discovered during the survey on seafloor fractures on the knoll by use of a deep-tow camera system in 1996. After this expedition, a reconnaissance survey on the eastern edge of the summit of the knoll was carried out at 24° 07-08' N, 124° 11-13' E by use of ROV Dolphin-3K and DSV Shinkai2000 in 1997 (Cruise ID: NT97-14). The purpose of the expedition was to detect the distribution pattern of the chemosynthetic communities and relationship between their situation and the basement rocks of the knoll. The survey revealed a living white Calyptogena colony (chemosynthetic communities) in the survey area (depth: 812-682m). Dense colonies of Calyptogena (both living and dead) were observed. A living tube worm is also found in this place. Doming structures and sedimentary mounds which were apparently formed recently together with brecciated rocks were also observed. These suggest that compressional stresses are predominant in the eastern part of the summit. Pipe-like calcareous sandstone "chimneys" (both standing and lying) were also observed near the mounds. It is estimated that the top of the Kuroshima Knoll is composed of the Miocene to Early Pleistocene Shimajiri Group overlain by the Pleistocene Ryukyu Group and that they are covered with recent calcareous sediments. The whole survey area seems to be suffered from fracture and brecciation. It is estimated that cold water seep and gas eruption have occurred since late Pleistocene era, accompanied with rock fracturing. Since then, calcareous sandstone chimneys might have been formed. (Matsumoto et al., 1998, JAMSTEC J. Deep Sea Res.).

Thus, a series of research cruises up to 2001 suggested the existence of methane hydrate under the seafloor of the knoll. After those expeditions, total 33 dives by ROV Dolphin-3K, ROV Hyper-Dolphin, DSV Shinkai2000 and DSV Shinkai6500 were operated from 2002 to 2004 for reconnaissance survey in the vicinity of 24° 07' 48" N 124° 11' 30" E (depth: 686-622m). Based on the video images from these dives, a seafloor mapping on the knoll was carried out in order to detect the area of the communities of chemosynthetic fauna and methane eruption. Calcareous sandstones, dead Calyptogena and living Bathymodiolus colonies spread over the wide area on the knoll. 35 methane bubble gushing were also observed. The area where methane may be existing beneath the seafloor of the knoll was estimated to be about 40,000 square meters in the survey area (Matsumoto and Aoki, JpGU2014, MIS22-P05).

It is necessary to examine if the sub-seafloor beneath the knoll is within the temperature and pressure conditions for methane hydrate stability. The temperature and depth records at 17 ARGO float stations around the knoll (there are no ARGO float stations just above the knoll) were examined to draw a temperature-depth profile. The result shows that the temperature at the summit (water depth : 640m) is too high (6 degrees Celsius in autumn, 9 degrees Celsius in spring) for methane hydrate to exist stably throughout the year (less than 7 degrees Celsius at pressure of 6MPa, according to the methane hydrate stability curve for bottom water with a salinity of 3.46%, Tishchenko et al., 2005). The water depth of the seafloor should be 750m or more if a possible sub-seafloor methane hydrate is stable. The observed bubbles are gushing directly from the methane that was formed sub-seafloor beneath the knoll.

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Keywords: Kuroshima Knoll, Calcareous chimney, Methane, Cheomosynthesis

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Community composition and connectivity of hot vent endemic animals on the Izu-Bonin-Mariana Arc

*Hiromi Kayama WATANABE[1], Chong Chen[1], Shigeaki Kojima[2], Hiroyuki Yamamoto[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Atmosphere and Ocean Research Institute, the University of Tokyo

Lush biological communities associated with deep-sea hydrothermal vents are sustained by high primary production through chemosynthesis. These communities are island-like, being discretely distributed on the normal deep-sea floor lacking in primary production. Nevertheless, planktonic larval dispersal among vents means the compositions of benthos inhabiting vent fields —even those hundreds of kilometres away —are often similar. The 2800 km long Izu-Bonin-Mariana (IBM) Arc is a submarine volcanic arc located off Japan to Guam, and host a number of vent communities. Here, we present the similarity of community composition of these vent communities, and the genetic connectivity among local populations of the vent crab *Gandulfus yunohana* on the IBM Arc as a case study to identify dispersal barriers and source-sink relationships of the deep-sea vent sites and animal populations.
Our similarity analyses using presence/absence data of 41 taxa in 10 deep-sea vent communities on the IBM Arc showed that the communities are subdivided into three major groups; Izu, Shallow (< 1000m) Bonin-Mariana, and Deep (> 1000m) Bonin-Mariana. This pattern of subdivision indicates that both water depth and tectonic discontinuity contribute to the realized distribution of deep-sea vent animals on the IBM Arc. Genetic analyses of *G. yunohana* in the vent communities on Myojin Knoll, Bayonaise Knoll (Izu Arc) and Nikko Seamount (Mariana Arc) suggest the populations on the Izu Arc are the source for those on the Mariana Arc. Although this vent crab is distributed continuously on the IBM Arc, its uneven dispersal is indicative of geographic restrictions to larval dispersal. Vents located on the northern part of the IBM Arc, within the Japanese EEZ, are known to produce ore-quality sulfide deposits and are being eyed as targets or deep-sea mining. Knowledge on the dispersal and settlement dynamics of vent endemic animals, like those presented herein, are required for an accurate evaluation of the ecosystems' resilience for the disturbance that is key to sustainable exploitation.

Keywords: Faunal composition, Gene flow, Mining impact

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Population Genetic Structure and Gene Expression Plasticity of the Deep-Sea Vent and Seep Squat Lobster *Shinkaia crosnieri*

*Yao Xiao[1]

1. Hong Kong University of Science and Technology

Shinkaia crosnieri (Decapoda: Munidopsidae) is a squat lobster that dominates both deep-sea hydrothermal vent and methane seep communities in the Western Pacific. Previous studies comparing *S. crosnieri* living in these two types of habitats have suffered from methodological and/or sample size limits. Here, using transcriptome-wide single nucleotide polymorphisms (SNPs) markers from 44 individuals of *S. crosnieri*, we reveal the extent of genetic connectivity between a methane seep population in the South China Sea and a hydrothermal vent population in the Okinawa Trough, as well as their signatures of local adaptation. Analysis of differentially expressed genes (DEGs) between these two populations and population-specific genes (PSGs) revealed that a large number of unigenes, such as cytochrome P450 (CYP), glutathione *S*-transferase (GST) and peroxiredoxin 6 (Prdx6) related to oxidoreductase, and sulfur dioxygenase (ETHE1) and chondroitin 4-sulfotransferase 11 (CHST11) related to sulfur metabolism, showed opposite expression patterns in these two populations. Data subsampling in this study revealed that at least five individuals of *S. crosnieri* per site are required to generate reliable results from the differential gene expression analysis. Population genetic analyses based on 32,452 SNPs revealed clear genetic differentiation between these two populations with an F_{ST} value of 0.07 ($p < 0.0005$), and physical oceanographic modeling of the ocean currents in middle and deep layers also suggests a weak connection between these two sites. Analysis of outlier SNPs revealed 345 unigenes potentially under positive selection, such as sarcosine oxidase/L-pipecolate oxidase (PIPOX), alanine-glyoxylate transaminase/serine-glyoxylate transaminase/serine-pyruvate transaminase (AGXT), and Cu-Zn superoxide dismutase (SOD1). Among the differentially expressed genes and genes with amino acid substitutions between the two sites are those related to oxidation resistance and xenobiotic detoxification, indicating local adaptation to the specific environmental conditions of each site. Overall, exploring the population structure of *S. crosnieri* using transcriptome-wide SNP markers resulted in an improved understanding of its molecular adaptation and expression plasticity in vent and seep ecosystems.

Keywords: Deep sea, Population genetics

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A Decade to Study Deep-Sea Science

*Hiromi Kayama WATANABE[1], Kerry Howell[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. University of Plymouth

Deep-sea occupied most parts of Earth’ s ecosystem, however, only a limited knowledge has been accumulated due to the physical and technical restriction of observation and sampling methods. Deep-sea is not a homogeneous environment, where various environments such as hydrothermal vent fields which are supported by chemosynthetic primary production, and hadal trench area which is occupied by specific microbes and faunas. Therefore, multi-disciplinary approaches, not only biological survey, but also physical and chemical observation that enable us to estimate how animals behave in invisible deep-sea, are required. Here I will introduce some projects including Challenger 150 program associating with the Decade of Ocean Science, and discuss how we can contribute to these projects.

Challenger 150 program is constituted with Decade working group in Deep-Ocean Stewardship Initiative (DOSI), SCOR WG-159, and Deep-Sea Special Interest Working Group in Challenger Society in UK. The program attempts to archive social outcomes related to SDGs, with scientific output about diversity, connectivity, functionality and resilience of deep-sea ecosystem. Local and topical committees will be organized and contribution of deep-sea researchers are anticipated.

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Keywords: The Decade of Ocean Science, Challenger 150 Program

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.09 Zoom Room 09

[M-GI29] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Chairperson:Shin ya Nakano(The Institute of Statistical Mathematics), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University)

Data assimilation is an inversion approach to estimate the evolution of a system by utilizing a constraint given by a dynamical simulation model. Data assimilation is now widely used not only in meteorology and oceanography but also other fields of geosciences such as hydrology, solid earth science, and space science. This session aims at providing an opportunity for discussion on data assimilation studies among researchers of various field of geosciences. We encourage contributions addressing novel methods and theoretical developments of data assimilation. Contributions dealing with useful applications of data assimilation are also welcome.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MGI29-01] A machine learning approach to the observation operator for satellite radiance data assimilation

*RIKEN Jianyu Liang[1], Koji Terasaki[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MGI29-02] Enhancement in Assimilation of Doppler Radar Radial Winds

★Invited Papers

*Tadashi Fujita[1], Hiromu Seko[1], Takuya Kawabata[1], Ken Sawada[1], Daisuke Hotta[1], Yasutaka Ikuta[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MGI29-03] Optimizing the localization scale for a convective-scale ensemble radar data assimilation system

★Invited Papers

*James David Taylor[1], Takumi Honda[1], Arata Amemiya[1], Takemasa Miyoshi[1] (1.RIKEN Research center for computational science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MGI29-04] Improving the Stability of the Local Particle Filter and Its Gaussian Mixture Extension: Experiments with an Intermediate AGCM

*Shunji Kotsuki[1,3], Ken Oishi[2], Takemasa Miyoshi[3] (1.Center for Environmental Remote Sensing, Chiba University, 2.Department of Information Engineering, Chiba University, 3.RIKEN Center for Computational Science)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MGI29-05] Non-Gaussian measure in Gaussian filtering problems

*Tianfeng Hou[1,2,3], Hideyuki Sakamoto[1], Toshiki Teramura[4], Takemasa Miyoshi[1,2,3] (1.Data Assimilation Research Team, RIKEN Center for Computational Science, Kobe, Japan, 2.RIKEN Prediction Science Laboratory, Kobe, Japan, 3.RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program, Kobe, Japan, 4.Research Institute for Computational Science Co. Ltd, Tokyo, Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MGI29-06] Development of a coupled atmosphere-ocean data assimilation system in the Japan Meteorological Agency: evaluation and future plan

*Yosuke Fujii[1,2], Chiaki Kobayashi[1], Ichiro Ishikawa[1], Yuhei Takaya[1], Toshiyuki Ishibashi[1], takuma yoshida[3] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.The Institute of Statistical Mathematics, 3.Japan Meteorological Agency)

A machine learning approach to the observation operator for satellite radiance data assimilation

*RIKEN Jianyu Liang[1], Koji Terasaki[1], Takemasa Miyoshi[1]

1. RIKEN Center for Computational Science

The ‘observation operator’ is essential in data assimilation (DA) to derive the model equivalent of the observations from the model variables. For satellite radiance observations, it is usually based on complex radiative transfer model (RTM) with a bias correction procedure. Therefore, it usually takes time to start using new satellite data after launching the satellites. Here we take advantage of the recent fast development of machine learning (ML) which is good at finding the complex relationships within data. ML can potentially be used as the ‘observation operator’ to reveal the relationships between the model variables and the observations without knowing their physical relationships. In this study, we test with the numerical weather prediction system composed of the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) and the Local Ensemble Transform Kalman Filter (LETKF). We focus on the satellite microwave brightness temperature (BT) from the Advanced Microwave Sounding Unit-A (AMSU-A). Conventional observations and AMSU-A data were assimilated every 6 hours. The reference DA system employed the observation operator based on the RTTOV and an online bias correction method.

We used this reference system to generate 1-month data to train the machine learning model. Since the reference system includes running a physically-based RTM, we implicitly used the information from RTM for training the ML model in this study, although in our future research we will explore methods without the use of RTM. The machine learning model is artificial neural networks with 5 fully connected layers. The input of the ML model includes the NICAM model variables and predictors for bias correction, and the output of the ML model is the corresponding satellite BT in 3 channels from 5 satellites. Next, we ran the DA cycle for the same month the following year to test the performance of the ML model. Two experiments were conducted. The control experiment (CTRL) was performed with the reference system. In the test experiment (TEST), the ML model was used as the observation operator and there is no separate bias correction procedure since the training includes biased differences between the model and observation. The results showed no significant bias of the simulated BT by the ML model. Using the ECMWF global atmospheric reanalysis (ERA-interim) as a benchmark to evaluate the analysis accuracy, the global-mean RMSE, bias, and ensemble spread for temperature in TEST are 2% higher, 4% higher, and 1% lower respectively than those in CTRL. The result is encouraging since our ML can emulate the RTM. The limitation of our study is that we rely on the physically-based RTM in the reference DA system, which is used for training the ML model. This is the first result and still preliminary. We are currently considering other methods to train the ML model without using the RTM at all.

Keywords: machine learning, data assimilation, satellite , observation operator, numerical weather prediction

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Enhancement in Assimilation of Doppler Radar Radial Winds

*Tadashi Fujita[1], Hiromu Seko[1], Takuya Kawabata[1], Ken Sawada[1], Daisuke Hotta[1], Yasutaka Ikuta[1]

1. Meteorological Research Institute, Japan Meteorological Agency

Radial wind from Doppler radar is one of the important sources of observational information on detailed atmospheric conditions, often related to severe weather events. This study is aimed to effectively utilize radial wind observations densely distributed in time and space in initializing a numerical weather forecast model. It is important to appropriately handle correlation of the observation error in data assimilation of these high-resolution data. Spatial and temporal correlations of the observation error are statistically diagnosed using the method by Desroziers et al. (2005). The statistical samples are generated running a 3-hourly 4D-Var data assimilation cycle using the experimental system based on the Meso-scale Analysis operated at Japan Meteorological Agency as of 2018 applying the JNoVA 4D-Var (Honda et al. 2005, JMA 2019). The correlation range is found to increase with the beam range and the forecast time, suggesting contributions from errors in the observation operator and the forecast model. An experiment using a simple variational assimilation shows that appropriate handling of the observation error correlation helps to consistently incorporate detailed structures of innovation pattern into the analysis. The correlated observation error of radial wind is applied in a real case experiment based on the Meso-scale Analysis. Spatial and temporal correlation of the observation error is incorporated into the 4D-Var to consistently assimilate radial wind data without applying a severe thinning. In order to extract more information from the dense observation data, the flow-dependent background error is also generated using the Ensemble of Data Assimilation method (EDA; Isaksen et al. 2010), and is introduced into the assimilation system by extending the 4D-Var into the hybrid 4D-Var. Verification of the forecast in the case study shows the flow-dependent background error contributes to effectively utilize the high-resolution and high-frequency radial wind observations. Investigations are also carried out on sensitivity of the performance to the EDA ensemble configuration, influence from the sampling of perturbations added to observations in EDA, and effect from an enhancement in configuration of the ensemble control variables.

Acknowledgements

This work was supported by JST AIP Grant Number JPMJCR19U2, JSPS KAKENHI Grant Number JP 19K23467, and “Program for Promoting Researches on the Supercomputer Fugaku” (Large Ensemble Atmospheric and Environmental Prediction for Disaster Prevention and Mitigation, ID:hp200128/hp120279) of MEXT. This work is based on the operational NWP system developed by Numerical Prediction Division, Japan Meteorological Agency.

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JMA, 2019: Outline of the operational numerical weather prediction at the JMA. JMA, Tokyo, Japan.

Keywords: data assimilation, observation error correlation, 4D-Var

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Optimizing the localization scale for a convective-scale ensemble radar data assimilation system

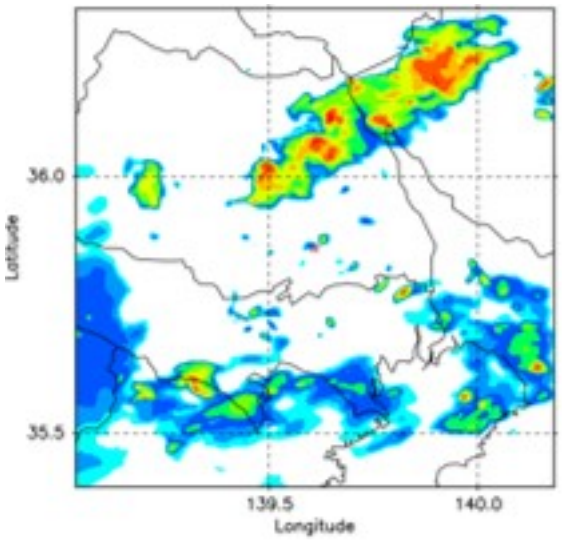
*James David Taylor[1], Takumi Honda[1], Arata Amemiya[1], Takemasa Miyoshi[1]

1. RIKEN Research center for computational science

For any ensemble-based data assimilation system sampling errors are introduced as a consequence of limited ensemble size, generating spurious backgound errors covariances and leading to erroneous adjustments to the analysis. As a way to reduce the impact of these systematic errors, as well as improve rank deficiency, covariance localization is applied, which artifically reduces the weighting of error covariances beyond a defined physical distance between the background and observations deemed to be false.

In this study we perform sensitivity tests to find the appropriate horizontal localization scale for the SCALE-LETKF, a numerical weather prediction model that combines the SCALE numerical model with the local ensemble transform Kalman filter. The system has been in development since 2013 to provide very high resolution modelling of convective weather systems and is unique in its ability to perform near real-time NWP operation at 500-m resolution refreshed every 30 seconds with observations from Phased Array Weather Radar (PAWR). Here, we perform sensitivity tests at 500-m resolution with 30-second update cycling of PAWR data for several testcases of heavy convective rainfall over Tokyo metropolitan area from August/September 2019. Test scores showed horizontal localization scale of 2-km generally provided optimal forecast skill for lead times up to 30 minutes, although there were variations on this dependent upon lead time and case study. We show that by reducing localization scale, systematic errors leading to over-intensification of convective activity in forecasts were reduced, resulting in improved consistency with observations. This was a conseqence of generating more convectively stable, less dynamically active environment with smaller localization scale.

Keywords: LETKF, localization, assimilation



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Improving the Stability of the Local Particle Filter and Its Gaussian Mixture Extension: Experiments with an Intermediate AGCM

*Shunji Kotsuki[1,3], Ken Oishi[2], Takemasa Miyoshi[3]

1. Center for Environmental Remote Sensing, Chiba University, 2. Department of Information Engineering, Chiba University, 3. RIKEN Center for Computational Science

The particle filter is an ensemble data assimilation method generally applicable to nonlinear and non-Gaussian problems. Penny and Miyoshi (2015) developed the local particle filter (LPF) in a form as the ensemble transform matrix of the Local Ensemble Transform Kalman Filter (LETKF). In this form, the resampling step of the LPF is formulated by multiplying the ensemble transform matrix to the prior perturbation matrix. Potthast et al. (2018) applied the LPF in the German weather service's operational LETKF system and reported a stable performance. Walter and Potthast (2021) improved their LPF as a Gaussian mixture filter (LPFGM), what they call the LMCPF (Local Mixture Coefficients Particle Filter). Kotsuki et al. (2021) implemented the LPF and LPFGM with an intermediate global circulation model known as the Simplified Parameterizations, Primitive Equation Dynamics (SPEEDY), and reported that the LPFGM outperformed the LETKF in sparsely observed regions. However, performances of the LPF and LPFGM were sensitive to tunable parameters such as inflation and resampling frequency. This study aims to explore methods for improving the stability of the LPF and LPFGM.

First, we revised the way to compute the posterior weights for the LPFGM. Walter and Potthast (2018) approximated the posterior weights of the LPFGM by those of the LPF. We introduced the exact posterior weights without approximation for the LPFGM, and showed that the exact weights improved the stability of the LPFGM in terms of the inflation parameter. Second, we implemented the optimal transport (OT) for constructing the resampling matrix from the posterior weights. Farchi and Bocquet (2018) reported that the OT was optimal for constructing the resampling matrix in the LPF through a series of experiments with the 40-variable Lorenz-96 model. However, our experiments revealed that the use of the OT in SPEEDY generally results in underdispersive posterior particles. This presentation will show the results of LPF and LPFGM experiments with SPEEDY, and discuss remaining problems for practical numerical weather prediction applications.

Keywords: Particle Filter, Data Assimilation, Gaussian Mixture, Atmospheric Global Circulation Model , non-Gaussianity

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Non-Gaussian measure in Gaussian filtering problems

*Tianfeng Hou[1,2,3], Hideyuki Sakamoto[1], Toshiki Teramura[4], Takemasa Miyoshi[1,2,3]

1. Data Assimilation Research Team, RIKEN Center for Computational Science, Kobe, Japan, 2. RIKEN Prediction Science Laboratory, Kobe, Japan, 3. RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program, Kobe, Japan, 4. Research Institute for Computational Science Co. Ltd, Tokyo, Japan

Data assimilation has been widely used in a multitude of disciplines, since it has the potential to provide a better prediction of chaotic systems by combining numerical simulation and observations. A wide variety of data assimilation approaches have been developed in many fields over the last few decades. Among these, the Ensemble Kalman Filter is found effective with high dimensional systems, because it can avoid at least partially the curse of dimensionality. However, in cases when a critical event happens such as the sudden downpour in the field of numerical weather prediction, the state probability density function may become highly non-Gaussian, and as a result, it can lead to an inaccurate estimation of the system. Therefore, the evaluation of the Gaussian assumption is very important in an Ensemble Kalman Filter. In this research, the Lorenz 63 model is used as a representative chaotic dynamic system, and the bias of the Ensemble Kalman Filter estimation is treated as a non-Gaussian measure. More specifically, a new replica-mean technique is introduced and both the mean-error (ME) and the mean of the root-mean-squared-error (RMSE) for each replica are calculated as the bias indicators. The results show that the RMSE-ME plot can reflect the qualitative change from the linear domain to the nonlinear domain and the attractor maximum of ME can represent this transition better than the RMSE. Therefore, we conclude that the temporal inhomogeneity of unpredictability occurs even on a minimal setting of data assimilation using the Lorenz three-variable model. In addition, it is also illustrated that when the non-Gaussianity is due to the finite covariance, there is a region where the maximum of ME should be scaled as ME $\propto$R^(γ / γ _0). Where, R and γ represent the observation interval and the observation error, respectively. Therefore, we conclude that both observation interval and observation error will affect the non-Gaussian measure in an EnKF, and we call this scaling “weak non-Gaussian scaling”.

Keywords: Data assimilation, non-Gaussian measure, Ensemble Kalman Filter, Lorenz 63 model, mean-error, replica-mean

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Development of a coupled atmosphere-ocean data assimilation system in the Japan Meteorological Agency: evaluation and future plan

*Yosuke Fujii[1,2], Chiaki Kobayashi[1], Ichiro Ishikawa[1], Yuhei Takaya[1], Toshiyuki Ishibashi[1], takuma yoshida[3]

1. Meteorological Research Institute, Japan Meteorological Agency, 2. The Institute of Statistical Mathematics, 3. Japan Meteorological Agency

The Meteorological Research Institute (MRI) of the Japan Meteorological Agency (JMA) has been developing a coupled atmosphere-ocean data assimilation system for more than 10 year. The current system, MRI-CDA1, is based on the coupled atmosphere-ocean general circulation model and separated atmosphere and ocean analysis routines adopted in JMA’ s operational weather and climate prediction systems. In this presentation, we evaluate the coupled reanalysis generated by MRI-CDA1, the sea surface air temperature field in the reanalysis. The atmosphere-ocean coupling generates realistic SST variations associated with tropical instability waves, and the SAT field responds to the SST variations in the subseasonal time scale. The SST-SAT relationships on the weather timescale were also recovered in the coupled reanalysis, although they are hardly seen in the uncoupled reanalysis generated by the same system. The coupled model physics generates weather timescale SST variations consistent with the atmospheric state, and the atmospheric parameters respond to the SST variations through the coupled model physics. As the result, correlations of SAT in the coupled reanalysis with buoy observations are increased. In this presentation, we will also introduce the future plan of the coupled data assimilation system development in JMA.

Keywords: Coupled Data Assimilation, Tropical Instability Wave, TAO array

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.09 Zoom Room 09

[M-GI29] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Chairperson:Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN)

Data assimilation is an inversion approach to estimate the evolution of a system by utilizing a constraint given by a dynamical simulation model. Data assimilation is now widely used not only in meteorology and oceanography but also other fields of geosciences such as hydrology, solid earth science, and space science. This session aims at providing an opportunity for discussion on data assimilation studies among researchers of various field of geosciences. We encourage contributions addressing novel methods and theoretical developments of data assimilation. Contributions dealing with useful applications of data assimilation are also welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MGI29-07] Inverse analysis of atmospheric CO_2 for elucidating seasonal and interannual variations of natural carbon fluxes

★Invited Papers

*Yosuke Niwa[1,2], Akihiko Ito[1], Yosuke Iida[3] (1.National Institute for Environmental Studies, 2.Meteorological Research Institute, 3.Japan Meteorological Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MGI29-08] Wave assimilation system of JMA and its improvement plan

★Invited Papers

*Nadao Kohno[1], Yosuke Fujii[1] (1.Meteorological Research Institute, JMA)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI29-09] Improving the salinity structure by AOEI in an EnKF-based ocean data assimilation system

*Shun Ohishi[1], Tsutomu Hihara[2], Hidenori AIKI[3], Joji Ishizaka[3], Yasumasa Miyazawa[4], Misako Kachi[5], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science, 2.JAFIC, 3.Nagoya Univ., 4.JAMSTEC, 5.JAXA)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI29-10] An iterative ensemble-based variational method with ensemble generation in random subspaces

*Shin ya Nakano[1,2] (1.The Institute of Statistical Mathematics, 2.Center for Data Assimilation Research and Applications, Joint-Support Center for Data Science Research)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI29-11] **Feasibility study of the global MHD simulation code toward reanalysis of the space weather phenomena**

*Shigeru Fujita[1], Shin ya Nakano[2], Akira Kadokura[3], Yoshimasa Tanaka[3], Ryuho Kataoka[3], Aoi Nakamizo[4], Yasubumi Kubota[4], Keisuke Hosokawa[5], Satoko Saita[6] (1.Meteorological College, Japan Meteorological Agency/ National Institute of Polar Research, 2.The Institute of Statistical Mathematics, 3.National Institute of Polar Research, 4.National Institute of Information and Communications Technology, 5.The University of Electro-Communications, 6.National Institute of Technology, Kitakyushu College)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI29-12] Data assimilation of electron radiation belts using the Arase high energy electron data

★Invited Papers

*Yoshizumi Miyoshi[1], Genta Ueno[2], Shinji Saito[3], Satoshi Kurita[4], Tomoaki Hori[1], Shun Imajo[1], Takefumi Mitani[5], Iku Shinohara[5], Takeshi Takashima[5], Nana Higashio[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.The Institute of Statistical Mathematics, 3.National Institute of Information and Communications Technology, 4.Research Institute for Sustainable Humanosphere, Kyoto University, 5.JAXA)

Inverse analysis of atmospheric CO_2 for elucidating seasonal and interannual variations of natural carbon fluxes

*Yosuke Niwa[1,2], Akihiko Ito[1], Yosuke Iida[3]

1. National Institute for Environmental Studies, 2. Meteorological Research Institute, 3. Japan Meteorological Agency

A number of ground-based stations and observational mobile platforms have conducted atmospheric measurements of carbon dioxide (CO_2) for several decades. Those long-term observations have revealed significant interannual variations of the growth rate of the atmospheric CO_2, which suggests that the natural CO_2 flux at the earth surface have been varying in conjunction with some climate key parameters (e.g., El Niño Southern Oscillation index). Furthermore, distinct seasonal variations of atmospheric CO_2 observed by those measurements give evidence of dynamic photosynthesis and respiration activities of terrestrial biospheres. An atmospheric inverse analysis, in which an atmospheric transport model is used to connect surface fluxes with atmospheric mole fractions, is useful in that it quantitatively gives spatiotemporal variations of surface fluxes. In order to obtain implications of surface flux mechanisms, we should conduct a long-term inverse analysis so that we could analyze flux variations in correspondence with interannual climate variations. Furthermore, those flux estimations had better be made with high spatial resolutions, because a spatially small scale but quantitatively significant source/sink event such as biomass burning often plays an important role on interannual variations of atmospheric CO_2. However, there are very few global inverse analyses that can estimate fluxes at high-resolution for a long-term; this is probably because of heavy computational burden required. Recently, we have developed a sophisticated and computationally efficient inverse analysis system, which is expected to contribute such a long-term carbon budget study. This inverse analysis system is based on Nonhydrostatic Icosahedral Atmospheric Model (NICAM) and the four-dimensional variational method (4DVar). Using this system, we performed a 12-year-long inverse analysis with synthetic observations to elucidate its capability for a long-term inverse analysis. By this experiment, we found that, though certain degree of biases remain, the system could reproduce better interannual variations of CO_2 fluxes than prior estimates.

Keywords: inverse analysis, carbon dioxide, carbon cycle

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Wave assimilation system of JMA and its improvement plan

*Nadao Kohno[1], Yosuke Fujii[1]

1. Meteorological Research Institute, JMA

JMA developed a wave analysis and assimilation system which is operationally used for years. The system consists of wave analysis and wave assimilation component. We will introduce the system and our future plans.

In recent decades, orbital satellites become a powerful tool for wave observation, and observed data, which is mainly significant wave heights, are used in assimilation systems in many National Meteorological Services (NMS). In JMA, an Objective Wave Analysis System (OWAS) was developed at first. The system analyzes wave heights with Optimal Interpolation (OI), by referring wave heights observed by satellites, buoys, coastal recorders, and ships reports. The analysis is carried out in global region except the polar regions with 0.5-degree resolution. The results are issued as wave analysis charts.

A wave assimilation system followed to be developed, by using the wave analysis results. In wave models, wave height is not sufficient information because wave spectrum is the basic physical value, and more detailed information on each spectrum are required. Therefore, some special treatment for modification is used in wave assimilation. In the JMA wave assimilation scheme, wave spectra are divided to wind-sea and swell by a partitioning method and both values are modified in different way. If swell is predominant, spectra are modified equally as the rate of energy of first guess (model original) and analysis. When wind-sea is predominant, the spectra are modified with Toba’ s power law, and residual swell spectra are modified so that the total wave energy will same as analysis.

In general, wave assimilation impact does not keep to later forecast, but our system shows some good impact till later time although it is not so much. The merit of wave assimilation would be rather in analysis and early forecasts, and it will be useful especially for reanalysis. Since current system use simple OI, we have a plan to improve assimilation scheme, such as introducing a three-dimensional variational method (3D-Var), which will give more reasonable wave fields. However, considering of assimilation impact and resource, more sophisticated scheme like a four-dimensional variational method (4D-Var) will not be necessary for operational use. Recently satellite wave spectrum observations become available, and assimilation of wave spectra is also introduced in some NMS. The development of a wave spectrum assimilation scheme is also our future plan.

Keywords: data assimilation, waves, analysis

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Improving the salinity structure by AOEI in an EnKF-based ocean data assimilation system

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1. RIKEN Center for Computational Science, 2. JAFIC, 3. Nagoya Univ., 4. JAMSTEC, 5. JAXA

With the enhanced satellite and in-situ observations such as Himawari-8 and Argo profiling float, the number and frequency of observations are dramatically increased since the 2000s. We have demonstrated that the combination of the incremental analysis updates (Bloom et al. 1996) and relaxation-to-prior methods (Zhang et al. 2004; Whitaker and Hamill 2012) significantly improved geostrophic balances and reproducibility in an Ensemble Kalman filter (EnKF)-based ocean data assimilation system assimilating observations as frequently as every day (Ohishi et al. in prep.). However, we have found that the low salinity structure in the ocean interior was degraded in the mid-latitude regions, and that the signals propagated toward subtropical regions. Therefore, the salinity field was not well reproduced in the subtropical and mid-latitude regions.

To investigate the cause of the salinity degradation, we perform salinity budget analyses using outputs from the ocean data assimilation system. Here, we conserve all terms in the temperature and salinity budget equations and analysis increments. Also, we estimate density increments from temperature and salinity increments. Cooler and warmer temperature increments near the surface and in the sub-surface, respectively, weakens density stratification in the mid-latitude region. These result in stronger vertical diffusions of salinity and eventually lead to the degradation.

Innovation statistics of Desroziers et al. (2005) estimated from observations and ensemble forecasts imply that representation errors exist in the mid-latitude region with an abundance of fronts and eddies. Minamide and Zhang (2017) developed the adaptive observation error inflation (AOEI) method for all-sky satellite radiance data assimilation in the atmosphere to account for large differences of satellite radiances between cloudy and clear-sky conditions. Here we apply the AOEI method to the ocean data assimilation system for the first time to consider the representation errors in the mid-latitude region. The results show that the AOEI successfully decreases the temperature increments and reduces strong vertical diffusion, so that the salinity structure is greatly improved.

Keywords: Ocean data assimilation, Ensemble Kalman filter, Adaptive observation error inflation, Salinity, Dynamical stability

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An iterative ensemble-based variational method with ensemble generation in random subspaces

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The ensemble-based method for variational data assimilation problems, referred to as the 4-dimensional ensemble variational method (4DEnVar), is a useful tool for data assimilation problems. Although the 4DEnVar is originally based on a linear approximation, highly uncertain problems, where system nonlinearity is significant, can be solved by an iterative algorithm which minimizes a quadratic function at each iteration. This iterative method can be regarded as an approximation of the Gauss-Newton method for solving 4-dimensional variational problems. Since ensemble-based methods basically seek the solution within a lower-dimensional subspace spanned by the ensemble members, it appears that the solution of this iterative method is confined within the subspace. However, the conditions for monotonic convergence to a local maximum of the objective function can be satisfied even if the ensemble is distributed in different subspace at each iteration. This study demonstrates that the iterative ensemble-based algorithm can solve high-dimensional problems if it is allowed that the ensemble can be generated in different subspace at each iteration.

Keywords: ensemble-based variational method, data assimilation

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Feasibility study of the global MHD simulation code toward reanalysis of the space weather phenomena

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We hardly obtain an accurate 3-D image of the magnetospheric phenomena only from the observations because the direct (in-situ) observations in the magnetosphere are sparse. Numerical simulations that accurately solve the physical first-principles are powerful tools for studying phenomena occurring in the magnetosphere. So, the magnetosphere-ionosphere global simulation is a useful tool for magnetospheric physics. For this purpose, we need to confirm the accuracy of the simulation results. Our final target is to present the reanalysis data in the magnetosphere-ionosphere system from the observation data and the simulation with the data assimilation technique.

There are a few global MHD simulation codes solving MHD equations in the magnetosphere-ionosphere coupled system in the world. Among them, the REPPU (REProduce Plasma universe) code developed by Tanaka [Tanaka, 2015] has a prominent property; it can reproduce the ionospheric features of the magnetospheric phenomena better than other MHD codes. Since the ionospheric and ground-based observations are far-more globally arranged compared with the in-situ magnetospheric observations, the REPPU code is suitable to reproduce the appropriate grid-point data of the magnetosphere-ionosphere region by confirming the simulation results in the ionosphere with the observations. However, the REPPU code uses free parameters to determine the ionospheric conductivities, which can be determined from assimilation between the simulation and the observation. Thus, we try to determine the free parameters from the data assimilation.

Before applying the assimilation technique to the REPPU code, we need to improve the present REPPU code. That is to say, the code uses limited information of the IMF (only By and Bz) and solar wind velocity (only Vx) because the original REPPU has been used primarily for investigating fundamental physical processes of the magnetospheric phenomena. The improved REPPU code is also made to include the effect of the magnetic axis’ s seasonal tilt on the ecliptic plane. The magnetic axis’ s rotation around the Earth's rotation axis is also considered in the improved REPPU. NICT first made this improvement for the operational space weather forecasts, and we made the improved REPPU code independently of NICT to obtain the code used for the assimilation study.

We started to compare the observed data with the simulation results based on the ionospheric conductivity distribution determined by the empirical parameters. The main results are as follows;

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The correlation coefficient between the calculated electric potential in the polar region and the superDARN potential is about 0.8. The simulation almost reproduces the field-aligned current pattern observed by the AMPERE. However, the field-aligned current intensity and location are not wholly the same between the simulation and the observation. Therefore, the correlation between the simulation and the observation becomes low.
These results suggest that the improved REPPU code product can be regarded as primitive reanalysis data.

We are now analyzing the superMAG data to investigate how the simulation reproduces the ground magnetic variations.

References

Tanaka, T. (2015), Substorm auroral dynamics reproduced by the advanced global M-I coupling simulation, In Auroral dynamics and space weather, Geophys. Monogr. Ser., vol. 215, edited by Y. Zhang and L. J. Paxton, p. 177, doi: 10.1002/9781118978719, AGU, Washington D. C.

Keywords: magnetosphere-ionosphere, global MHD simulation, data assimilation

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Data assimilation of electron radiation belts using the Arase high energy electron data

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Dynamical evolution of the outer belt electrons is determined by a delicate balance among several processes. To discriminate what physical processes are dominant for the large flux enhancement of the outer belt electrons, we have developed the data assimilation code on the outer belt electrons using the high energy electron data from Arase/XEP and HEP instruments. In this study, the particle filter and the particle smoother are used, which are effective for the non-linear/non-Gauss distribution problem. We include the radial diffusion coefficient, the lifetime due to the pitch angle scattering, and the internal source model as the state vector and estimate the dynamical variations of these parameters. From this assimilation, we derive the time variations of the diffusion coefficients and the wave amplitudes, which can be used for better modeling of the radiation belt electrons.

Keywords: radiation belts, Arase, Particle Filter

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.19_1

[M-GI29] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Takemasa Miyoshi(RIKEN), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University)

Data assimilation is an inversion approach to estimate the evolution of a system by utilizing a constraint given by a dynamical simulation model. Data assimilation is now widely used not only in meteorology and oceanography but also other fields of geosciences such as hydrology, solid earth science, and space science. This session aims at providing an opportunity for discussion on data assimilation studies among researchers of various field of geosciences. We encourage contributions addressing novel methods and theoretical developments of data assimilation. Contributions dealing with useful applications of data assimilation are also welcome.

[MGI29-P01] Local Particle Filter Experiments with Chaotic Cellular Automata

★Invited Papers

*Ken Furukawa[1], Hideyuki Sakamoto[1], Marimo Ohhigashi, Shin-ichiro Shima[2], Travis Sluka, Takemasa Miyoshi[1] (1.Institute of Physical and Chemical Research, 2.Graduate School of Simulation Studies, University of Hyogo)

[MGI29-P02] Improving Inflation and Resampling Methods To Stabilize Local Particle Filter

*Ken Oishi[1], Shunji Kotsuki[2,3] (1.Department of Information Engineering, Chiba University, Chiba, Japan, 2.Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3.RIKEN Center for Computational Science, Kobe, Japan)

[MGI29-P03] Local Ensemble Transform Kalman Filter Experiments with Hybrid Background Error Covariance

*Takaya Otaki[1], Shunji Kotsuki[2,3], Craig Bishop[4], Takemasa Miyoshi[3] (1.Department of Information Engineering, Chiba University, Chiba, Japan, 2.Center for Environmental Remote Sensing, Chiba University, Chiba, Japan, 3. RIKEN Center for Computational Science, Kobe, Japan, 4. School of Earth Sciences, University of Melbourne, Melbourne, Australia)

[MGI29-P04] Toward assimilation of high-precision 3-D lightning location data for severe thunderstorm forecast

*Yasumitsu Maejima[1], Futo Tomizawa[2,1], Tomoo Ushio[3], Takemasa Miyoshi[1,4,5] (1.RIKEN Center for Computational Science, 2.Graduate School of Engineering, the University of Tokyo, 3.Graduate School of Engineering, Osaka University, 4.University of Maryland, College Park, 5.Japan Agency for Marine-Earth Science and Technology)

Local Particle Filter Experiments with Chaotic Cellular Automata

*Ken Furukawa[1], Hideyuki Sakamoto[1], Marimo Ohhigashi, Shin-ichiro Shima[2], Travis Sluka, Takemasa Miyoshi[1]

1. Institute of Physical and Chemical Research, 2. Graduate School of Simulation Studies, University of Hyogo

Data assimilation (DA) has been developed extensively in meteorology. This study explores how DA can be applied to chaotic cellular automata. Cellular automata are useful to model many types of phenomena, including ecology. This study performs a series of local particle filter experiments for two-dimensional three-state chaotic cellular automata called the sheep model. The three states are Sheep, Grass, and Land and are arranged in two-dimensional square grid cells. The state of a cell is evolved by the condition of the adjacent eight cells. The sheep model consists of four processes simulating the ecological dynamics of sheep and grass: sheep eats grass, grass grows, sheep dies, and grass withers. No unique feature about sheep is included in the model. Due to the chaotic nature of the model, if we flip the states of only a few cells, the difference grows rapidly. Therefore, it is difficult to predict the evolution of the sheep model with imperfect initial data. With the local particle filter, we can estimate the true evolution very accurately with imperfect noisy observations. In this presentation, we introduce the sheep model's precise rule and its chaotic behavior. Next, we demonstrate that the local particle filter works well. Finally, we investigate sensitivities to the observation noise and densities in space and time.

Keywords: data assimilation, particle filter, cellular automata, localization, local particle filter

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Improving Inflation and Resampling Methods To Stabilize Local Particle Filter

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Ensemble data assimilation has been broadly applied in geoscience fields such as numerical weather prediction (NWP). While the ensemble Kalman filter (EnKF) has been intensively investigated in the past two decades, recent studies explore the local particle filter (LPF) to solve some issues in EnKF such as non-Gaussian likelihood functions. With limited particles, the LPF needs resampling that interpolates prior particles to yield posterior particles. Penny and Miyoshi (2016) developed an LPF in the form of the ensemble transform matrix of the Local Ensemble Transform Kalman Filter (LETKF). In this form, the resampling is performed by multiplying the ensemble transform matrix to the prior perturbation matrix. However, our preliminary experiments showed that the LPF was less stable than the LETKF.

This study aims at exploring better inflation and resampling methods for the LPFs that use the ensemble transform matrix for the resampling. Using the 40-variable Lorenz-96 model, we performed a series of LPF experiments with multiple inflation and resampling methods. With the simplest resampling method known as the stochastic uniform method (SU), the additive inflation was superior to relaxation to prior spread (RTPS) and additive noise to ensemble transform matrix in accuracy and stability. Following Reich (2013), we also implemented the optimal transport (OT) for generating resampling matrices. While the OT requires much more computations (*O(m^1.92)*) than SU (*O(m)*), the OT resulted in smaller root mean square errors than the SU. With the OT-based resampling, the RTPS resulted in a similar accuracy of the additive inflation. Since the incorporation of the additive inflation for the NWP system is not trivial, the combination of OT and RTPS would be a reasonable choice. This poster includes the most recent progress up to the presentation.

Keywords: Local Particle Filter, Data Assimilation, Resampling, Optimal Transport Problem, Ensemble Data Assimilation

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Local Ensemble Transform Kalman Filter Experiments with Hybrid Background Error Covariance

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Recent operational numerical weather prediction (NWP) systems have achieved significant forecast improvements by using hybrid background error covariance (HBEC) that linearly combines climatological and ensemble-based error covariance. Currently, the HBEC has been used mainly in variational data assimilation systems to use the flow-dependent error covariance in addition to static error covariance. This study explores using the HBEC within the ensemble Kalman filter (EnKF). EnKF approximates the error covariance matrix by sample estimates using the ensemble perturbations. EnKF potentially results in suboptimal analyses if the ensemble size is smaller than the number of assimilated observations. Kretchmer et al. (2015) proposed adding a collection of climatological perturbations to the forecast ensemble mean to boost the rank of the background error covariance. This study followed the Kretchmer et al. (2015)' s approach and implemented the HBEC coupled with the local ensemble transform Kalman filter (LETKF). In addition, this study investigates relationship between the rank deficiency and the degrees of freedom for signal (DFS). With the 40-variable Lorenz-96 model, we found that HBEC outperformed the standard LETKF especially when the ensemble size is smaller than the number of assimilated observations. With the HBEC, the optimal localization radius and DFS increased. These suggest that the HBEC mitigate the rank deficiency and assimilate more observations effectively than the standard LETKF. We also test the HBEC with an intermediate atmospheric model known as the SPEEDY (Simplified Parameterizations, Primitive Equation Dynamics). This presentation will include the most recent progress up to the time of the conference.

Keywords: data assimilation, ensemble data assimilation, DFS, hybrid data assimilation, rank deficiency, LETKF

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Toward assimilation of high-precision 3-D lightning location data for severe thunderstorm forecast

*Yasumitsu Maejima[1], Futo Tomizawa[2,1], Tomoo Ushio[3], Takemasa Miyoshi[1,4,5]

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In recent years, a high-precision lightning observation system named “BOLT” was developed (e.g. Yoshida et al. 2014), observing every 10^{-6} seconds 3-dimensional lightning locations at 100-m resolution. The original data have a 70-km range in the horizontal and a 20-km range in the vertical. To assimilate the lightning location data with a regional numerical weather prediction model “SCALE” (Nishizawa et al. 2015), an observation operator to convert the model variables to lightning data is needed. In general, lightning is triggered by large electric charge originated from graupel collisions with strong updraft. Therefore, we investigated a relationship between the lightning observation data and the model graupel data. First, we performed a 30-seceond-update, 100-m-mesh SCALE-LETKF (Miyoshi et al. 2016, Lien et al. 2017) experiment with every 30-second Phased Array Weather Radar at Osaka University (Ushio et al. 2014), and created every 30-second model data. For the lightning observation data, we calculated every 30-second lightning frequency given by counts per second per model grid. We investigated a scatter plot of the lightning frequency and the model graupel mixing ratio.

Using all lightning and graupel data, we could not find a clear relationship. However, we found a high correlation between the lightning frequency and the graupel mixing ratio by applying the following criterions on lightning generation described in Takahashi (1978): $w > 1$, $10 > qc > 0.01$ and $-3 > T > -30$, where w, qc and T represent vertical motion [m s^{-1}], cloud water content [g m^{-3}] and temperature [℃], respectively. The result may help develop an observation operator to improve severe thunderstorm forecast.

Keywords: Data assimilation, Numerical weather prediction

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.03 Zoom Room 03

[M-GI31] Open and FAIR Science: Data Sharing, e-Infrastructure, Data Citation and Reproducibility

convener:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), 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), Chairperson:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Yasuhisa Kondo(Research Institute for Humanity and Nature)

Open Science is widely accepted as a new research paradigm to accelerate scientific innovation. Deployed by ISC-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 making results of publicly-funded research freely available and accessible. Open Science also refers to community-supported bottom-up approaches such as citizen science, crowdfunding, and interdisciplinary research (Kitamoto 2016). Other stakeholders (research institutions, funding agencies, scientific editors, etc) are also fostering open science using tools like data management plans, data citation and the use of persistent identifiers. All these approaches envision the transformation of research process to meet to the FAIR (Findable, Accessible, Interoperable, and Reusable) principles (Wilkinson et al. 2016).
Following the past sessions at the JpGU and AGU Fall Meetings since 2018, this session reviews the current broad spectrum of Open Science in international contexts. 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, e-infrastructures and platforms for sharing data, scientific cloud infrastructures, FAIR principles, Persistent Identifiers (PID), data management, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI31-01] Open Science and Open Data: Definitive Steps Institutions and Researchers Can Take to Make Research Output More Discoverable, Accessible, and Transparent.

*Shelley Stall[1] (1.American Geophysical Union)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI31-02] Landscape of Community Development for Open Science and Data Sharing in Japan

*Yasuhiro Murayama[1], Takashi Watanabe[2], Toshihiko Iyemori[3], Yasuhisa Kondo[4] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology, 2.World Data System International Programme Office, 3.Kyoto University, 4.Research Institute for Humanity and Nature)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI31-03] Data and metadata sharing among Antarctic science community

*Masaki Kanao[1] (1.National Institute of Polar Research)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI31-04] **The connected sample - IGSN's contribution to making samples FAIR**

★Invited Papers

*Jens F Klump[1], Kerstin Lehnert[2], Lesley Wyborn[3], Sarah Ramdeen[2] (1.CSIRO Mineral Resources, 2.Lamont-Doherty Earth Observatory, Columbia University, 3.Australian National University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI31-05] Japanese efforts of archiving the primary samples for the promotion of the open science.

*Gaku Kimura[1] (1.Tokyo University of Marine Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MGI31-06] A big data system in Deep-time Digital Earth Science Program

★Invited Papers

*Juanle Wang[1] (1.Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences)

Open Science and Open Data: Definitive Steps Institutions and Researchers Can Take to Make Research Output More Discoverable, Accessible, and Transparent.

*Shelley Stall[1]

1. American Geophysical Union

Research is a critial element to addressing emerging global issues. At AGU our new Strategic Plan includes a goal to move our science from "usable" to "used". We see this as positioning our science outcomes to be more discoverable by those who need them, accessible to decision makers both globally and locally, and transparent such that it is clear how the research was conducted with all the relevent data, software, workflows, and methods available for evaluation. Global issues require our researchers to have access to all possible information, broader collaborations, and more community involvment by those impacted. Science that is "used" helps to solve problems both in our community and across the globe. This talk will recommend actions our institutions can take to support and encourage researchers to be more open.

Keywords: Open Data, Open Science, FAIR

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Landscape of Community Development for Open Science and Data Sharing in Japan

*Yasuhiro Murayama[1], Takashi Watanabe[2], Toshihiko Iyemori[3], Yasuhisa Kondo[4]

1. Strategic Program Produce Office, National Institute of Information and Communications Technology, 2. World Data System International Programme Office, 3. Kyoto University, 4. Research Institute for Humanity and Nature

Major discussion on Open Science in Japan has virtually started in 2013 triggered by G8 Science Ministers's statement including Open Research Data. Since then, the Japanese government and part of the scientific community including experts in funding agencies, research libraries, and publishing and journal editorial bodies etc. has been continuously working on policies, pilots, and practices practically applicable to the Japanese community. The Cabinet Office of Japan published a couple of related guidelines in past years, and other organizations including funders like Japan Science and Technology Agency and National Diet Library (only one unique national library in Japan) have been discussing and trying against this new challenge.
ISC (International Science Council; formerly ICSU)-WDS and ISC-CODATA national committees and experts in them have been the important international channels via Science Council of Japan (SCJ) to international open science and FAIR data sharing discussions. Recently SCJ, research institutions (including universities and national institutes), public funders and government agencies tend to be keen to join the discussion and eager to work on,e.g., data sharing policies and challenges on data infrastructures as well as licensing and data repositories/publications. It is still not on the way but the recent changes and challenges in Japan will be overviewed from the viewpoint of the authors.

Keywords: Open Science, Data Sharing, Community Engagement

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Data and metadata sharing among Antarctic science community

*Masaki Kanao[1]

1. National Institute of Polar Research

The Polar Environmental Data Science Center (PEDSC) of the Joint Support-Center for Data Science Research (DS), the Research Organization of Information and Systems (ROIS) has a responsibility to manage and publish the data involving Japanese research activities as one of a National Antarctic Data Center (NADC). At the International Polar Year (IPY2007-2008), a significant number of multi-disciplinary data have been compiled. These collected data/metadata have a tight collaboration with the Global Change Master Directory (GCMD), the Polar Information Commons (PIC), as well as several data centers belonging to the World Data System (WDS). In terms of data activities in polar communities of the Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC), tighter linkages of data/metadata sharing within the Asian Forum for Polar Sciences (AFoPS) countries has been discussed and should be further promoted by the involved Asian countries, in particular China, India, South Korea, Malaysia and Japan.

Keywords: Polar Environmental Data Science Center, Data and metadata sharing, Antarctic science community

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The connected sample - IGSN's contribution to making samples FAIR

*Jens F Klump[1], Kerstin Lehnert[2], Lesley Wyborn[3], Sarah Ramdeen[2]

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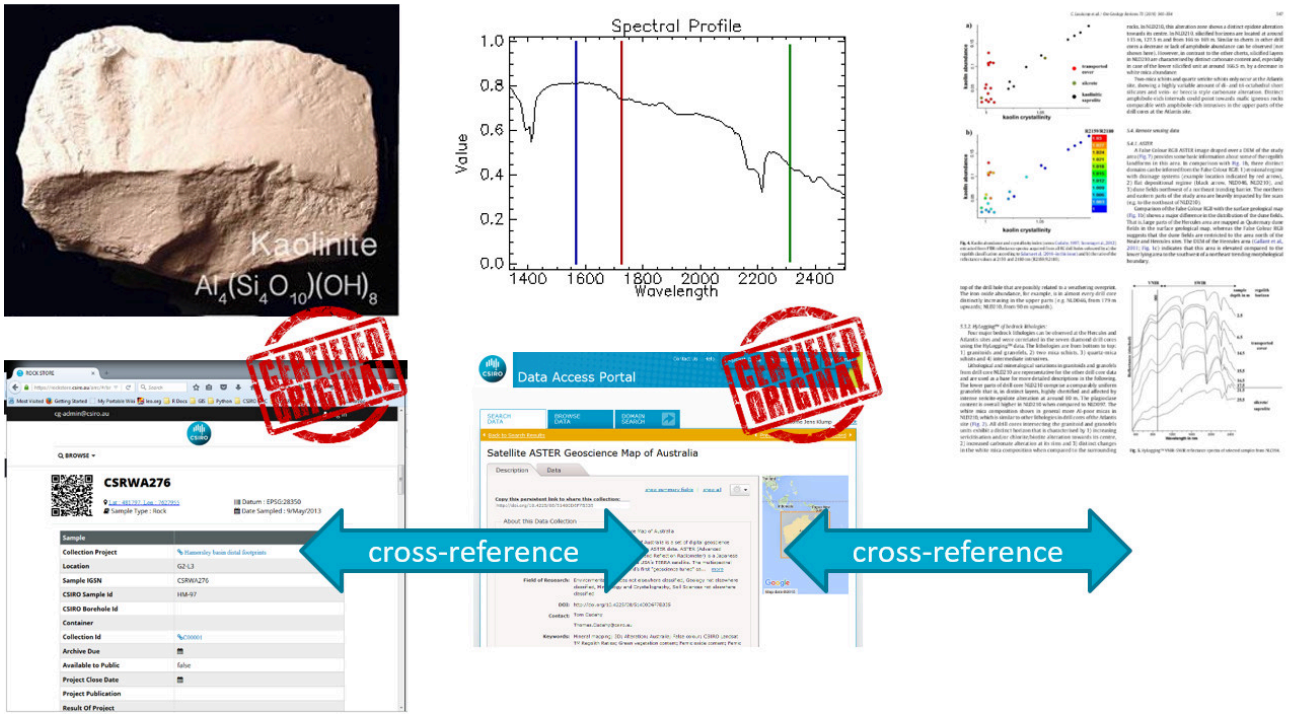
Persistent unique identifiers (PID) are a critical element of the research ecosystem and are used to unambiguously identify and cite digital representations of many entities including specimens, publications, data, instruments, researchers, organizations, funding awards, field programs, and others. IGSN was initially developed in 2004 to provide a persistent, globally unique, web resolvable identifier for physical specimens and now has over 10 million specimens registered. Apart from the number of uses now growing, increasingly over time, the application of identifiers to specimens has been at finer and finer granularity. There is now a need to not only enable the scaling to the billions of identifiers, but also to be able to link IGSNs to these other related entities and enable a ‘knowledge graph’ to be created that provides a complete picture of who collected the specimen, who funded it, who curated it, what data has been collected on that specimen, where have those data been published, where the specimen is curated, etc. As part of the IGSN 2040 project, the IGSN e.V. has been modernizing its technical infrastructure, adopting a web-based architecture with encoding of metadata using JavaScript Object Notation for Linked Data (JSON-LD). The new architecture can be leveraged by knowledge graph systems pulling data and metadata from various other sources that use semantic web standards.

IGSN’s new architecture is fundamentally driven by the need to facilitate collaboration and management of samples and data about samples, as a means to enable new research as part of a research ecosystem where IGSN provides registration service as well as the infrastructure and guidelines to support aggregation and value-added services such as knowledge graphs that enable each uniquely identified specimen to be related to many other components of the research data ecosystem.

Keywords: Persistent Identifier, Sample specimen, Knowledge Graph

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Specimen (IGSN) Spectrum (DOI) Publication (DOI)



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Japanese efforts of archiving the primary samples for the promotion of the open science.

*Gaku Kimura[1]

1. Tokyo University of Marine Science and Technology

The Science Council of Japan (SCJ) recommended to the government and society in June 2020 for the promotion and development of open science.
Three points have been proposed:

1. Arrangement of systematic rules for the open science promotion of data science period.
2. Construction of systematic platform for the open science promotion.
3. Construction of archiving system of primary samples for the open science promotion.

The third recommendation is quite important for the geological, geochemical, and geo-bio interdisciplinary fields in geosciences.
To promote the third recommendation, we have started to discuss in the Earth and planetary science committee of SCJ. The Japanese geoscience sample repositories consist mainly of three different components: those of university and research institutions, of museums, and of the geological survey and private companies. They have no systematic interactive archiving system at this moment.
In addition to the difficulty above, there is another difficulty for the open science promotion. Most of the sample curation systems are managed in the Japanese language system, because Japan has unique history without the western colonial occupation since the mid 19’ s century. The central government has promoted that all of education and research system from the primary school to the university in Japanese language soon after the domestic revolution in mid 19th century. Such a domestic system has kept even after the world war II in late 20th century.
We are urgently discussing to evolve the archiving system for the global promotion of open science.

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A big data system in Deep-time Digital Earth Science Program

*Juanle Wang[1]

1. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

The Deep-time Digital Earth (DDE) is an innovative and international Big Science Program that will provide new opportunities and directions for the Earth Sciences. DDE was formally initiated as the first IUGS Big Science Program at an International Union of Geological Sciences (IUGS) event in early 2019 in Beijing, China. Big data system is the core of DDE. The vision of DDE big data system is to harmonize and Share Earth Evolution Science Data Everywhere. Its mission is to establish the fusion mechanism of multi-source heterogeneous distribution geoscience data, and integrate multi-source deep time earth science data. The main tasks of the Big Data System include: to formulate an open and shared global scientific evolution data aggregation and sharing mechanism, to manufacture standards and norms for data integration and sharing of the Earth evolution science, and to build a DDE big data system and its corresponding software platform, to research and tackle key data science and technology such as data-driven geoscience discovery oriented to domestic and international application requirements of disciplines and regions, to establish global geoscience databases via 4 kinds of data nodes, i.e., regional node, discipline node, industry node, and interest node. Focusing on the major scientific issues of earth evolution and centering on all disciplines of solid earth science, the earth science knowledge map established based on the large knowledge system provides powerful data support for the establishment of the world's leading one-stop processing and analysis collaborative research platform. A initially progress has been made in 2020 and it has a research and cooperation plan in 2021 under the open science background.

Keywords: Big data, earth science, deep time, data sharing, data integration

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.03 Zoom Room 03

[M-GI31] Open and FAIR Science: Data Sharing, e-Infrastructure, Data Citation and Reproducibility

convener:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), 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), Chairperson:Shelley Stall(American Geophysical Union), Yasuhiro Murayama(NICT Knowldge Hub, National Institute of Information and Communications Technology)

Open Science is widely accepted as a new research paradigm to accelerate scientific innovation. Deployed by ISC-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 making results of publicly-funded research freely available and accessible. Open Science also refers to community-supported bottom-up approaches such as citizen science, crowdfunding, and interdisciplinary research (Kitamoto 2016). Other stakeholders (research institutions, funding agencies, scientific editors, etc) are also fostering open science using tools like data management plans, data citation and the use of persistent identifiers. All these approaches envision the transformation of research process to meet to the FAIR (Findable, Accessible, Interoperable, and Reusable) principles (Wilkinson et al. 2016).
Following the past sessions at the JpGU and AGU Fall Meetings since 2018, this session reviews the current broad spectrum of Open Science in international contexts. 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, e-infrastructures and platforms for sharing data, scientific cloud infrastructures, FAIR principles, Persistent Identifiers (PID), data management, 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

[MGI31-07] A Rubric for Research Data Management in Earth and Space Science

*Toshihiko Iyemori[1], Janice Smith[2,1], Shoji Kajita[1], Masahito Nose[3] (1.Kyoto University, 2.Karuta Project, 3.Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI31-08] **Improve data discovery and metadata interoperability via publishing structured data on the Web**

★Invited Papers

*Mingfang Wu[1], Leyla Jael Castro[2], Adam Shepherd[3] (1.Australian Research Data Commons, Australia, 2.ZB MED Information Centre for Life Sciences, Germany, 3.Woods Hole Oceanographic Institution, US)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI31-09] Publishing FAIR Data for Solar System Radio Astronomy

*Baptiste Cecconi[1], Cyril Chauvin[1] (1.Observatoire de Paris, CNRS, PSL Research University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI31-10] NASA Planetary Data System and Data Object Identifiers (DOIs).

*Jordan Padams[1], Ann Raugh[2], Dan Crichton[1], Emily Law[1], Steve Hughes[1], R Joyner[1] (1.Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 2.University of Maryland)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI31-11] Involving Citizen Scientists in Open-Science oriented Activity

*Takashi Watanabe[1] (1.National Institute of Information and Communications Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI31-12] **Lessons learned from interdisciplinary research between social and natural sciences**

*Yasuhisa Kondo[1] (1.Research Institute for Humanity and Nature)

A Rubric for Research Data Management in Earth and Space Science

*Toshihiko Iyemori[1], Janice Smith[2,1], Shoji Kajita[1], Masahito Nose[3]

1. Kyoto University, 2. Karuta Project, 3. Nagoya University

There is almost no systematic way for students and new researchers at Japanese universities to acquire the skills of research data management (RDM). Instead, they learn to manage data by themselves through trial and error or by emulating the RDM practices of their supervisors. While neither approach to acquiring skill with RDM is particularly effective, there is broad agreement that well-managed data improves the quality and efficiency of research. In fact, many research journals now require open access to data as part of the review process and increasingly, journal readers want to view the evidence that actual data can provide. However, without proper RDM skills, it is difficult for authors to prepare datasets for uploading to appropriate data repositories. To promote RDM education, we are developing a series of rubrics with discipline-specific strategies for effective RDM, beginning with Earth and Space Science. These rubrics allow new researchers to improve their RDM skills through a step-by-step approach. Our Earth and Space Science rubric organizes RDM criteria into four general areas: "Planning for Data", "Organizing Data", "Analyzing Data" and "Sharing and Publishing Data". Each area features six or seven criteria that describe four possible levels of measurable achievement in one or more RDM skills. The rubric will be housed within an ePortfolio that invites new researchers to develop RDM skills individually and in collaboration with peers, document their efforts with multimedia evidence, self-assess using the rubric criteria at appropriate intervals, and share their progress with others. An initial version of the Earth and Space Science rubric will be presented.

Keywords: research data management, Rubric, Earth and Space science

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Improve data discovery and metadata interoperability via publishing structured data on the Web

*Mingfang Wu[1], Leyla Jael Castro[2], Adam Shepherd[3]

1. Australian Research Data Commons, Australia, 2. ZB MED Information Centre for Life Sciences, Germany, 3. Woods Hole Oceanographic Institution, US

Over the past decade, it is becoming a common scientific practice of sharing data through increasing number of public and domain specific data repositories, for improving research reproducibility as well as aligning to Open Science initiatives. For example, the Registry of Research Data Repositories, had 23 data repositories in 2012; the number quickly increased to over 1,200 from across the globe in 2015, and the registry had more than 2450 repositories[1] by 2020. While data sharing via data repositories is highly welcomed by the scientific community, it becomes ever more challenging to discover relevant data, especially when required data comes from several repositories. In addition, data aggregators are required to deal with harmonising metadata from a number of sources using a variety of metadata schemas.

The Web provides a global platform for discovering data. One of the current uses of the Web as a data discovery platform relies on web-based data repositories publishing and presenting of metadata as part of websites landing pages. Such a presentation is friendly for human users to read, but not be easily understood by search engines and, in general, by machines. For machines to correctly interpret and process the meaning of metadata beyond a bag of words, we need to mark up metadata with a common vocabulary as well as in a machine-processable encoding. This structured markup makes possible both semantic and syntactic interoperability on the Web.

In the past years, Schema.org has become a vocabulary commonly used by websites to describe their content and expose the corresponding structured metadata so search engines can better interpret the meaning and data searchers can benefit from more accurate results. Schema.org was originally intended for use in e-commerce applications, but nowadays is also used by libraries around the world to publish bibliography information supporting Linked Data (Godby et al. 2015). Some data repositories, for example NASA and NOAA, have already adopted this approach. There are also communities (e.g. the Schema.org Cluster of the Earth Science Information Partners[2]) provide guidelines to their communities for supporting the consistent implementation of the Schema.org markups. When more repositories adopt this approach, the research data community can take advantage of such enhanced metadata interoperability; for instance, data aggregators can explore new methods for metadata syndication via the web architecture. If implemented consistently, structured data can lead to linked metadata, which will enable smart web data discovery applications to perform to their potential.

The Research Data Alliance Research Metadata Schema Working Group[3] was formed with the purpose to exchange experience and lessons learned from publishing structured metadata and to have consistent implementation of the publishing process across repositories. In this talk, we will present the guidelines with ten recommendations for publishing the structured data on the Web. The recommendations cover high level strategy and community engagement, semantical level interoperability, to consistent syntactic serialisation.

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[2] The ESIP Schema.org Cluster: https://wiki.esipfed.org/Schema.org_Cluster

[3] Research Data Alliance Research Metadata Schemas Working Group: https://www.rd-alliance.org/groups/research-metadata-schemas-wg

Keywords: Data discovery, Publising structured data , Metadata interoperability, Schema.org vocabulary, FAIR data, Linked data

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Publishing FAIR Data for Solar System Radio Astronomy

*Baptiste Cecconi[1], Cyril Chauvin[1]

1. Observatoire de Paris, CNRS, PSL Research University

Solar System Radio Astronomy is a scientific topic spanning across several communities: Heliophysics (Solar physics, Solar Wind, Earth and planetary magnetospheres), Planetary sciences, Astronomy. Making such data collections FAIR implies they are Findable, Accessible, Interoperable and Reusable through the tools and frameworks of those communities. The MASER project (Measurement, Analysis, Simulation of Emissions in the Radio range) focusses on low frequency radio astronomy, covering solar and planetary radio observations and models. The data collections are all registered with a DOI (through datacite). Their landing page include semantic annotations (following the schema.org model). They also have to be registered in the SPASE (Space Physics Archive Search and Extract) registry, as well as in the VESPA (Virtual European Solar and planetary Access) network. In this paper, we describe how we build (and map) the metadata between metadata systems, ensuring their consistency across topical domains.

Keywords: Radio Astronomy, Interoperability, FAIR

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NASA Planetary Data System and Data Object Identifiers (DOIs).

*Jordan Padams[1], Ann Raugh[2], Dan Crichton[1], Emily Law[1], Steve Hughes[1], R Joyner[1]

1. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 2. University of Maryland

The NASA Planetary Data System (PDS) captures, archives, and distributes data from robotic exploration of the solar system. In supporting this mission, it has developed an innovative architectural approach called “PDS4” to support the highly diverse set of heteroge-neous data from over 600 instruments. The PDS is implemented as a set of distributed archives with dif-ferent “nodes” managing repositories for this federated system [1]. To enable this federated approach, the PDS uses an information model to drive configuration of its archive and services, enabling it to evolve as data from the mission evolves, as well as the structure of the PDS. This approach has also enabled the PDS to work with and share its standards and architectures with the international community though the International Planetary Data Alliance (IPDA) [2].
The development of PDS4 has not only focused on the construction of compatible archives, but also on becoming a more FAIR system through improving access, (re)use, and interoperability of the data in the big data era. One primary method for enabling this has been the minting of Data Object Identifiers (DOIs) [3] for all PDS archival data as a standard mechanism:
•To credit data creators: PDS archived data sets are refereed publications.
•To support reproducibility of published re-search: This will sometimes involve citing subsets of a data set, or selected products from multiple data sets.

PDS DOI Policy: The PDS began investigating the use of Digital Object Identifiers (DOIs) in 2017 with the objective of assigning DOIs to various PDS data objects. To address the challenge of adopting and developing a consistent DOI solution applicable across the entire PDS and its international partners, the PDS Management Council (MC) approved a pilot project for creating and registering PDS4 data using DOIs. A working group, with members from each Discipline Node (DN) and international partners from the IPDA, was later formed in 2020 to establish the PDS DOI Policy [4], best practices for assigning DOIs to data sets, and improvements in the user documentation for citing PDS data [5].
NASA PDS has implemented an operational DOI system - where DOIs are assigned to PDS3 data sets, PDS4 data bundles, PDS4 data collections, and asso-ciated documents that are produced, archived, and distributed by the PDS Discipline Nodes (DNs). Each Discipline Node (DN) serves a different planetary sci-ence discipline user community and, accordingly, has a unique approach and process for generating and archiv-ing a variety of data products. Such variation has brought about the need to establish DOI policies and processes, while still permitting enough flexibility to accommodate each DN’s individual needs.
Future: NASA PDS will look to collaborate with the IPDA to adapt these policies and documents to provide a consistent approach for assigning and citing DOIs across all internationally-sponsored planetary science archives.

Acknowledgements: This research is being per-formed at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.

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Keywords: Planetary Data, Persistent Identifier, Archive

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Involving Citizen Scientists in Open-Science oriented Activity

*Takashi Watanabe[1]

1. National Institute of Information and Communications Technology

In the Open Science era, promotion of collaborations between domain scientists and citizens is one of the most important action items. In some research fields of the earth-planetary sciences, e.g. the meteoric astronomy, observational and data-analysis activities are conducted mainly by citizen scientists. It will be important that researchers collaborate with them to help not only in scientific aspects but in long-term sharing of quality-assessed data.

Keywords: Open Science, Earth-Planetary Sciences, Meteoric Astronomy

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Lessons learned from interdisciplinary research between social and natural sciences

*Yasuhisa Kondo[1]

1. Research Institute for Humanity and Nature

The field of geoscience presents numerous opportunities to conduct interdisciplinary research collaborations with the humanities and social sciences, particularly to address socio-environmental issues. However, gaps in research mindsets may disturb the effective sharing of data and knowledge among collaborators. In-project action research was conducted to understand how perceptual gaps occur and find solutions. It consisted of participatory observations, questionnaire surveys, and semi-structured interviews in several interdisciplinary projects, including the Historical Climate Adaptation Project of the Research Institute for Humanity and Nature and the KAKENHI PaleoAsia project, comprising social sciences (such as archaeology, history, and cultural anthropology) and geosciences (e.g., paleoclimatology and geochronology). This paper presents lessons learned from this action research from the perspective of open scientific knowledge production systems and discusses the resolution of gaps between different research mindsets and values.

Keywords: Interdisciplinary research, perceptual gaps, open scientific knowledge production system

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.18_1

[M-GI31] Open and FAIR Science: Data Sharing, e-Infrastructure, Data Citation and Reproducibility

convener:Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), 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)

Open Science is widely accepted as a new research paradigm to accelerate scientific innovation. Deployed by ISC-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 making results of publicly-funded research freely available and accessible. Open Science also refers to community-supported bottom-up approaches such as citizen science, crowdfunding, and interdisciplinary research (Kitamoto 2016). Other stakeholders (research institutions, funding agencies, scientific editors, etc) are also fostering open science using tools like data management plans, data citation and the use of persistent identifiers. All these approaches envision the transformation of research process to meet to the FAIR (Findable, Accessible, Interoperable, and Reusable) principles (Wilkinson et al. 2016).
Following the past sessions at the JpGU and AGU Fall Meetings since 2018, this session reviews the current broad spectrum of Open Science in international contexts. 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, e-infrastructures and platforms for sharing data, scientific cloud infrastructures, FAIR principles, Persistent Identifiers (PID), data management, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

[MGI31-P01] Update of the Global Heat Flow Database led by International Heat Flow Commission

*Akiko Tanaka[1], Sven Fuchs[2], Graeme Beardsmore[3], Paolo Chiozzi[4], Orlando Miguel Espinoza-Ojeda[5], Gianluca Gola[6], Will Gosnold[7], Robert Harris[8], Sam Jennings[9], Shaowen Liu[10], Raquel Negrete-Aranda[11], Florian Neumann[11], Ben Norden[2], Jeffrey Poort[12], Dušan Rajver[13], Labani Ray[14], Maria Richards[15], Jared Smith[16], Massimo Verdoya[17] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.GFZ German Research Centre for Geosciences, 3.School of Earth Sciences, University of Melbourne, 4.Department of Earth, Environment and Life Sciences, Università di Genova, 5.Instituto de Investigaciones en Ciencias de la Tierra, Universidad Michoacana de San Nicolás de Hidalgo, 6.Institute of Geosciences and Earth Resources, National Research Council of Italy, 7.Harold Hamm School of Geology and Geological Engineering, University of North Dakota, 8.College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 9.Mawson Geocenter, University of Adelaide, 10.School of Geography and Ocean Science, Nanjing University, 11.Laboratory of Tectono-physics and Heat Flow, Department of Geology, CICESE, 12.Institut des Sciences de la Terre de Paris (ISTeP), Sorbonne Université, 13.Geological Survey of Slovenia, 14.CSIR-National Geophysical Research Institute, 15.SMU Geothermal Laboratory, Huffington Department of Earth Sciences, 16.Department of Engineering Systems and Environment, University of Virginia, 17.Department of Earth, Environment and Life Sciences, University of Genoa)

Update of the Global Heat Flow Database led by International Heat Flow Commission

*Akiko Tanaka[1], Sven Fuchs[2], Graeme Beardsmore[3], Paolo Chiozzi[4], Orlando Miguel Espinoza-Ojeda[5], Gianluca Gola[6], Will Gosnold[7], Robert Harris[8], Sam Jennings[9], Shaowen Liu[10], Raquel Negrete-Aranda[11], Florian Neumann[11], Ben Norden[2], Jeffrey Poort[12], Dušan Rajver[13], Labani Ray[14], Maria Richards[15], Jared Smith[16], Massimo Verdoya[17]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. GFZ German Research Centre for Geosciences, 3. School of Earth Sciences, University of Melbourne, 4. Department of Earth, Environment and Life Sciences, Università di Genova, 5. Instituto de Investigaciones en Ciencias de la Tierra, Universidad Michoacana de San Nicolás de Hidalgo, 6. Institute of Geosciences and Earth Resources, National Research Council of Italy, 7. Harold Hamm School of Geology and Geological Engineering, University of North Dakota, 8. College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 9. Mawson Geocenter, University of Adelaide, 10. School of Geography and Ocean Science, Nanjing University, 11. Laboratory of Tectono-physics and Heat Flow, Department of Geology, CICESE, 12. Institut des Sciences de la Terre de Paris (ISTeP), Sorbonne Université, 13. Geological Survey of Slovenia, 14. CSIR-National Geophysical Research Institute, 15. SMU Geothermal Laboratory, Huffington Department of Earth Sciences, 16. Department of Engineering Systems and Environment, University of Virginia, 17. Department of Earth, Environment and Life Sciences, University of Genoa

Knowledge of heat flow is fundamental for understanding the lithospheric structure and heat-transfer processes. The International Heat Flow Commission (IHFC; www.ihfc-iugg.org) of the International Association of Seismology and Physics of the Earth's Interior (IASPEI) has been fostering the compilation of the Global Heat Flow Database (GHFDB) since 1963. Periodic revisions of the GHFDB have been carried out to update heat-flow data and the scientific methods. Since the last significant development of the GHFDB structure took place in 1976, with limitations of 80-character maximum length for each data, digitization, the evolution of database concepts and technologies and new ways of digital work and research demands for a reconstruction of the GHFDB. A new database structure was just launched in 2021 (Fuchs et al., 2021), including 56 individual fields, grouped in four main thematic groups, heat-flow density, metadata and flags, temperature, and thermal conductivity. The significant improvement over the former heat-flow database structure is the implementation of a parent-child system for heat-flow data determined at each location and an extended set of meta data fields, relevant to enable quality control, and supporting interoperability following FAIR and open data principles. Based on the presented new structure, a reconstructed database will be published as a data publication (Fuchs and Global Heat Flow Compilation Group, 2021) providing the ground for a global reassessment of historical heat-flow data.

Keywords: heat flow, database

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.18 Zoom Room 18

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Shin-ichi Ito(The University of Tokyo), Chairperson:Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology)

It is important to extract essential processes and structures from observed data sets in order to understand and predict the dynamic behavior of the earth and planetary systems. Recently, many powerful methodologies have been proposed to extract useful information from high-dimensional data sets in mathematical and information sciences. This session aims to provide an opportunity to gather various geoscientists to have a productive discussion for interdisciplinary collaborations.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[MGI33-01] Data-driven low-dimensional model/sparse sensing of fluid dynamics and its application to seismic waves

★Invited Papers

*Taku Nonomura[1], Yuji Saito[1], Takayuki Nagata[1], Kumi Nakai[1], Keigo Yamada[1], Sayumi Kaneko[1] (1.Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI33-02] Reclassification of oceanic intraplate basalts using trace element compositions of hotspots and petit-spots

*Yosuke Shimbo[1], Taku Yutani[1], Naoto Hirano[1] (1.Tohoku University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI33-03] Spatial distributions of source components for REY-rich mud based on independent component analysis on major- and trace-element composition

*Masahiro Hirako[1], Kazutaka Yasukawa[1,2], Erika Tanaka[1], Koichiro Fujinaga[2,1], Kentaro Nakamura[1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI33-04] Independent Component Analysis of bulk chemical compositions of submarine hydrothermal deposits in the Okinawa Trough

*Akito Aichi[1], Kazutaka Yasukawa[1,2], Tatsuo Nozaki[3,1,4,2], Yutaro Takaya[5,3,2], Mizuki Ishida[1], Erika Tanaka[1], Kentaro Nakamura[1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC, 4.Kobe University, 5.Waseda University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MGI33-05] Spatial resolution of Bayesian sensing

*Tatsu Kuwatani[1], Hideitsu Hino[2], Nagata Kenji[3], Takahiro Kawashima[4], mitsuhiro toriumi[1], Masato Okada[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.The Institute of Statistical Mathematics, 3.National Institute for Materials Science, 4.Graduate University for Advanced Studies, 5.The University of Tokyo)

Data-driven low-dimensional model/sparse sensing of fluid dynamics and its application to seismic waves

*Taku Nonomura[1], Yuji Saito[1], Takayuki Nagata[1], Kumi Nakai[1], Keigo Yamada[1], Sayumi Kaneko[1]

1. Tohoku University

In this presentation, the low-dimensional model/sparse sensing techniques developed in the fields of fluid dynimacs will be rewiewed with presenting the recent results of the research group of the authors. The real-time/cost-efficient fluid dynimic experiments will be explained to be realized using those techniques. In addition to that, the application of the low-dimensinoal model/sparse sensing to seismic waves will be addressed.

Keywords: Data-driven science, Low-dimensional model, Sparse sensing

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Reclassification of oceanic intraplate basalts using trace element compositions of hotspots and petit-spots

*Yosuke Shimbo[1], Taku Yutani[1], Naoto Hirano[1]

1. Tohoku University

Oceanic hotspot and petit-spot basalts are generally categorized as oceanic island basalts (OIBs) in their geochemical characteristics of enriched incompatible element compositions. The basalts derived from hotspot volcanoes show systematic evolution in magmatic compositions for several volcanic stages. The petit-spot basalts showing similar composition to OIB, on the other hand, must have different processes in their petrogenesis from hotspot magmas. Here, we adopt the principal component analysis (PCA) for selected trace elements in order to explain their geochemical features along the eruptive settings and magmatic evolution. The compositional variations of OIBs from selected intraplate volcanism in the Pacific Ocean and their structure of high-dimensional geochemical data are recognized using PCA for 26 incompatible elements in this study. The first principal component simply demonstrates their concentrations of all incompatible elements. The second principal component expresses depletions of HREE and fertilizations of LREE designating residual garnet in source mantle. The third principal component enhances HFSE anomaly, particularly in negative Nb, Ta, Zr, Hf and Ti, and positive Ba, Pb and Sr anomalies. This component evidently discriminates between the petit-spot basalts together with some rejuvenated stage lavas and other OIBs. The data suggest the similar mechanism in the petrogenesis of both petit-spots and lavas on the rejuvenated stage.

Keywords: OIB, petit-spot, principal component analysis

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Spatial distributions of source components for REY-rich mud based on independent component analysis on major- and trace-element composition

*Masahiro Hirako[1], Kazutaka Yasukawa[1,2], Erika Tanaka[1], Koichiro Fujinaga[2,1], Kentaro Nakamura[1], Yasuhiro Kato[1,2]

1. School of Engineering, The University of Tokyo, 2. Ocean Resources Research Center for Next Generation, Chiba Institute of Technology

Deep-sea sediments highly enriched in rare-earth elements and yttrium (termed REY-rich mud) are widely distributed in the Pacific and Indian Oceans [1, 2]. Because of the huge resource potential [3], REY-rich mud is expected as a new source for the industrially critical elements (i.e., REY). Toward future exploration and development, it is important to precisely understand the origin of REY-rich mud.

Independent Component Analysis (ICA), a method of multivariate analysis, was successfully applied to a chemical composition dataset of deep-sea sediments in the Pacific and Indian Oceans to elucidate the genesis of REY-rich mud [4]. However, in the previous study, only major-elements and REY were considered. In this study, ICA was performed on a higher-dimensional dataset consisting of major- and trace-elements to characterize source components of deep-sea sediments including REY-rich mud more comprehensively. Although the overall result was generally consistent with the previous work [4], some components were newly extracted and characterized mainly by trace elements. We also visualized the spatiotemporal distributions of the independent components containing information on 44 elements. In the presentation, we will present the results of the new and comprehensive analysis.

[1] Kato et al. (2011) *Nat. Geosci.* **4**, 535-539.

[2] Yasukawa et al. (2014) *J. Asian Earth Sci.* **93**, 25-36.

[3] Takaya et al. (2018) *Sci. Rep.* **8**, 5763.

[4] Yasukawa et al. (2016) *Sci. Rep.* **6**, 29603.

Keywords: deep-sea sediment, REY-rich mud, Independent Component Analysis, chemical composition, multivariate analysis

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Independent Component Analysis of bulk chemical compositions of submarine hydrothermal deposits in the Okinawa Trough

*Akito Aichi[1], Kazutaka Yasukawa[1,2], Tatsuo Nozaki[3,1,4,2], Yutaro Takaya[5,3,2], Mizuki Ishida[1], Erika Tanaka[1], Kentaro Nakamura[1], Yasuhiro Kato[1,2]

1. School of Engineering, The University of Tokyo, 2. ORCeNG, Chiba Institute of Technology, 3. JAMSTEC, 4. Kobe University, 5. Waseda University

Submarine hydrothermal activity is one of the key processes controlling the transfer of energy and materials from the Earth’s interior to surface systems including hydrosphere and biosphere. It is also an important process that produces mineral deposits of economic interest. In recent years, multiple scientific drilling cruises were conducted in the Okinawa Trough, a back-arc basin with a number of active hydrothermal vents [1-3], using the drilling vessel CHIKYU. The core samples contain various altered/unaltered volcaniclastic and hemipelagic sediments, as well as sulfide minerals. By ICP-QMS analysis, a comprehensive dataset of bulk chemical composition (>1,300 samples x 47 element contents) of the drilling core samples has been constructed.

In this study, we statistically analyzed the huge dataset using independent component analysis (ICA). ICA is a powerful method to recover mutually independent signals from an observed mixture of the source signals and it has been successfully applied to geochemical data [4-6]. We implemented ICA to identify multi-elemental features and their distributions involving geochemical heterogeneities in the (sub)seafloor hydrothermal deposits. In the presentation, through consideration of information of the extracted components, we will discuss the geochemical characteristics of the hydrothermal activities in the study area.

[1] Glasby et al. (2003) *Ore. Geol. Rev.* **23,** 299-339.
[2] Nakajima et al. (2015) *PLoS One.* **10**, e0123095.
[3] Nozaki et al. (2016) *Sci. Rep.* **6**, 22163.
[4] Iwamori & Albarède (2008) *Geochem. Geophys. Geosyst.* **9**, Q04033.
[5] Yasukawa et al. (2016) *Sci. Rep.* **6**, 29603.
[6] Yasukawa et al. (2019) *Geochem. Geophys. Geosyst.* **20**, 3402-3430.

Keywords: hydrothermal deposits, Okinawa Trough, hydrothermal mineralization, multivariate analysis, independent component analysis

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Spatial resolution of Bayesian sensing

*Tatsu Kuwatani[1], Hideitsu Hino[2], Nagata Kenji[3], Takahiro Kawashima[4], mitsuhiro toriumi[1], Masato Okada[5]

1. Japan Agency for Marine-Earth Science and Technology, 2. The Institute of Statistical Mathematics, 3. National Institute for Materials Science, 4. Graduate University for Advanced Studies, 5. The University of Tokyo

Bayesian sensing is a general framework that uses Bayesian estimation to advance measurement and observation in order to understand the essential physics of a target system. It utilizes prior knowledge and forward models through Bayes' theorem, to enable the accurate estimation of not only the model parameters that indicate the target physical quantities, but also the hyperparameters that indicate the hidden physical parameters governing the process and structure of the target and sensing systems. This paper discusses the physical meaning and mechanism of the Bayesian sensing using the concept of resolution in spatial inversion problem. It describes that the spatial resolution of the model parameters can be spatially mapped using a resolution matrix, dened as a linear mapping from the true model parameter to the recovered model parameter. We also show that the optimal hyperparameters are obtained by internally-consistent equations between the estimated optimal and the actual hyperparameters calculated from the estimated model parameters, in terms of resolution. The obtained equations contribute toward understanding the hidden physical process and the structure of the target and sensing system in various problems, as well as the potential to reduce the computational cost.

Keywords: Bayesian estimation, Inversion, Measurement informatics

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 3:30 PM - 5:00 PM JST | Thu. Jun 3, 2021 6:30 AM - 8:00 AM UTC | Ch.18 Zoom Room 18

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Shin-ichi Ito(The University of Tokyo), Chairperson:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology)

It is important to extract essential processes and structures from observed data sets in order to understand and predict the dynamic behavior of the earth and planetary systems. Recently, many powerful methodologies have been proposed to extract useful information from high-dimensional data sets in mathematical and information sciences. This session aims to provide an opportunity to gather various geoscientists to have a productive discussion for interdisciplinary collaborations.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MGI33-06] Sedimentology as a science of reconstruction

★Invited Papers

*Hajime Naruse[1], Rimali Mitra[1], Zhirong Cai[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI33-07] Data-driven Analysis of Nonlinear Heterogeneous Reactions through Sparse Modeling and Bayesian Statistical Approaches

*Masaki Ito[1], Tatsu Kuwatani[2], Ryosuke Oyanagi[2], Toshiaki Omori[1] (1.Kobe University, 2.Japan Agency for Marine-Earth Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI33-08] Development of a deep learning approach to estimate numerical simulation parameters of a hydrothermal system: Evaluation using a two-dimensional model

*Akihiro Shima[1], Kazuya Ishitsuka[1], Elvar Karl Bjarkason[2], Anna Suzuki[2], Weiren Lin[1] (1.Kyoto University, 2.Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI33-09] Testing on Earthquake Prediction by Deep CNN-Labeling Model

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI33-10] Discussion

*Tatsu Kuwatani[1] (1.Japan Agency for Marine-Earth Science and Technology)

Sedimentology as a science of reconstruction

*Hajime Naruse[1], Rimali Mitra[1], Zhirong Cai[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

Sedimentology is a geological science that aims to understand the mechanisms of sedimentation and erosion that form landforms, and to reconstruct the past environment of the Earth's surface from information recorded in strata. Strata are accumulations of sedimentary rocks formed by buried landforms that once existed on the Earth's surface. Landforms change their shape in response to variation in sediment supply and water discharge caused by orogenic activity and climatic changes, and these topographic changes are preserved in the strata. Sedimentology solves the inverse problem of the environmental changes that resulted in the landform changes from the strata. In the field of sedimentology, however, quantitative inverse analyses have rarely been performed.

This situation is changing drastically with the recent development of morphodynamics. Morphodynamics is a research field that combines fluid dynamics and sediment transport models to understand the dynamics of landform development due to sedimentation and erosion. Morphodynamics has been developed in the fields of river and coastal engineering, and has been mainly applied to river and coastal management and disaster prevention. Recently, however, it has been recognized that morphodynamics is an effective research method for understanding longer-term, large-scale geomorphic development, and has been widely accepted as a research method in the field of sedimentology. In this talk, we will discuss the recent advances in the field of geomorphology and sedimentology, including the use of morphodynamics-based forward models and inverse analysis. We will show the recent trend of research using inverse analysis in the field of sedimentology, and introduce the efforts of our research group.

In sedimentology, inverse analysis is particularly popular in (1) reconstruction of uplift rates of mountainous regions from longitudinal profiles of rivers and (2) estimation of hydraulic conditions from tsunami deposits. In addition to the above, our research group is working on (3) estimation of hydraulic conditions of turbidity currents from turbidites. (1) The inverse analysis of mountain uplift rate can reconstruct the uplift rate of the continental crust over a wide area and a long period of time (more than several hundred thousand years). (2) The inverse analysis of tsunami sediments is an important research topic for social application of sedimentology because it can estimate the magnitude of tsunamis in the past and the disaster risk of the region. (3) The inverse analysis of turbidite is an attempt to estimate the conditions of turbidity currents that occur in deep sea environments, which are difficult to observe directly. Turbidity currents that deposit turbidites build huge topographic features called submarine fans on the deep seafloor, and the deposits often become large-scale oil and gas reservoirs, making them an economically important subject of research. The ability to read the hydraulic conditions of turbidity currents is expected to shed light on the shape and properties of deep-sea reservoir rocks from limited geological information.
In order to solve these research problems, we are working on the development of inverse models using artificial neural networks. A serious problem in inverse analysis in sedimentology is the high computational loads of forward models. Common inverse modeling methods such as the Markov Chain Monte Carlo (MCMC) method often require tens of thousands of iterations of the forward model calculation, which cannot be parallelized and therefore cannot be used for inverse analysis of sedimentological subjects. Therefore, we attempted to generate an inverse model by performing several thousand iterations of the forward model with randomly generated initial conditions, and training the

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neural network with the resulting combination of sedimentary data and initial conditions as teacher data. The advantage of this method is that the generation of the teacher data can be completely parallelized, so that the computational load of the forward model becomes less of a problem. This method is particularly useful for the inverse analysis of tsunamis and turbidity currents in (2) and (3), and it has been confirmed that it can reproduce the hydraulic conditions of modern tsunamis and recover the hydraulic conditions of experimental turbidity currents from turbidites in experiments. In the future, it is expected that the analysis of past tsunami sediments and submarine fan deposits will be carried out.

Keywords: inverse analysis, turbidite, tsunami deposit

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Data-driven Analysis of Nonlinear Heterogeneous Reactions through Sparse Modeling and Bayesian Statistical Approaches

*Masaki Ito[1], Tatsu Kuwatani[2], Ryosuke Oyanagi[2], Toshiaki Omori[1]

1. Kobe University, 2. Japan Agency for Marine-Earth Science and Technology

Heterogeneous reactions are chemical reactions with conjugation of multiple phases, and they have the intrinsic nonlinearity of their dynamics caused by the effect of surface area between different phases. It is important not only in earth science, but also in engineering to understand heterogeneous reactions in order to figure out the dynamics of rock formation near surface of the earth. Since demand for the geosphere environment is increasing, such as the development of deposits and geothermal fields, the geological disposal of radioactive waste, and the underground storage of carbon dioxide. However, such dynamics is generally nonlinear and there are a lot of candidate nonlinear terms. Furthermore, observed time series data is generally partial and noisy. Therefore, it is necessary to establish a data driven approach for estimating the dynamics of heterogeneous reactions.

In this study, we propose a data-driven method for simultaneously extracting substantial reaction terms and surface models from a number of candidates based on sequential Monte Carlo algorithm and sparse modeling algorithm by using noisy partial observation data. We focus on surface area reactions between the solid phase and the liquid phase, and assume a model of the dissolution-precipitation reaction in which the reactant (solid phase) => intermediate product (liquid phase) => product (solid phase). Based on the state space model, we introduce sequential Monte Carlo method in order to estimate hidden variables of solid reactant, liquid intermediate product and solid product from a noisy observed data. Moreover, we employ sparse modeling algorithm to extract rate constants and determine a surface area reaction from many candidates. In addition to uniform sparsity, we introduce sparse modeling approach with non-uniform sparsity and make sparse modeling algorithm more robust in order to improve the estimation accuracy of rate constants. Therefore, we propose an effective method to simultaneously estimate rate constants and concentrations from nonlinear dynamics of heterogeneous reaction by using sparse modeling and sequential Monte Carlo method.

Using our proposed method, we show that the rate constants of dissolution and precipitation reactions, which are typical examples of surface heterogeneous reactions, necessary surface models and reaction terms underlying observable data were successfully estimated only from the observable temporal changes in the concentration of the dissolved intermediate product.

Keywords: Sparse Modeling, Bayesian Statistical Approaches, Heterogeneous Reactions

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Development of a deep learning approach to estimate numerical simulation parameters of a hydrothermal system: Evaluation using a two-dimensional model

*Akihiro Shima[1], Kazuya Ishitsuka[1], Elvar Karl Bjarkason[2], Anna Suzuki[2], Weiren Lin[1]

1. Kyoto University, 2. Tohoku University

For the development of a hydrothermal energy resource, it is important to understand its subsurface temperature distribution. In this study, we proposed a new method for estimating subsurface temperature distributions using deep learning, and investigated the accuracy and characteristics of this proposed method using two-dimensional simulation data. The proposed method first learns the relationship between the simulation parameters (e.g., permeability) and simulated temperatures at well locations (training step), and then estimates the parameters from observed temperature logs (estimation step). The data used in the training step is called training data. In general, the distribution of training data needs to be consistent with the observations; however, a procedure to ensure that this requirement is met has not been established. Therefore, we developed a procedure for visualizing and selecting training data based on multidimensional scaling (MDS), and examined whether the procedure can reduce estimation errors.

In this study, we used multiple sets of two-dimensional training and test data generated using the AUTOUGH2 hydrothermal simulator. For generating the simulation data, formation permeabilities and bottom boundary conditions provided to the simulator were varied. Subsequently, we trained a deep neural network to learn the relationship between the variable parameters and temperatures at pseudo-well locations. In addition, we used MDS analysis to check whether (pseudo) observed temperature logs were included in the range of temperature profiles covered by the training data, and we examined whether parameter estimation errors can be reduced by selecting training data that are most consistent with the pseudo temperature logs.

We found that estimation errors were smallest when using training data generated based on small parameter variabilities. This demonstrates the effectiveness of narrowing down the parameter ranges used to generate the training data in order to improve estimation accuracy. Then, based the MDS analysis results, we compared the estimation reliability between cases where the pseudo temperature logs were consistent and inconsistent with the training data. The error rate for the consistent case was 1.4%, while the error rate for the inconsistent case was 29.5%. Thus, we concluded that the data to be estimated must be included in the range covered by the training data, and the consistency can be assessed based on MDS analysis. Further, the error rate was reduced when selecting the training data based on the MDS analysis. These results demonstrate the effectiveness of using MDS analysis to improve the estimation accuracy of deep learning.

Keywords: Deep learning, Neural network, MDS, Hydrothermal system, Permeability, Geothermal

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Testing on Earthquake Prediction by Deep CNN-Labeling Model

*mitsuhiro toriumi[1]

1. Japan agency of marine science and technology

The global and regional correlated seismicity time series calculated from micro to small earthquakes seismicity data matrix by means of singular value decomposition method are characteristic in earth mechanics and seismicity. The correlated seismicity time series, then potential macroscopic features showing the mechanical behavior of plate boundary zones in the global and regional scales. In this consequence, the relative large earthquakes occurred in the plate subduction zones are possibly corresponded to the multivariate correlated seismicity time series by means of deep neural network type transformation techniques such as RNN, LSTM, CNN, state-space modeling and VAE modeling. This study is the first attempt for prediction testing by these methods with multiple labeling on large earthquake event and shows the available results on global and Japanese island region. The available methods of 1dCNN of various timestep and time-shift are suggested from the viewpoint of accuracy scores and small number of incorrect prediction result. The variational autoencoder (VAE) is also applied for investigation of possible pre-seismic signals appeared in the correlated seismicity time series.

Keywords: prediction testing of earthquake, deep convolutional neural network, variational timestep and time-shift method

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Discussion

*Tatsu Kuwatani[1]

1. Japan Agency for Marine-Earth Science and Technology

Discussion

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.20_2

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Shin-ichi Ito(The University of Tokyo)

It is important to extract essential processes and structures from observed data sets in order to understand and predict the dynamic behavior of the earth and planetary systems. Recently, many powerful methodologies have been proposed to extract useful information from high-dimensional data sets in mathematical and information sciences. This session aims to provide an opportunity to gather various geoscientists to have a productive discussion for interdisciplinary collaborations.

[MGI33-P01] Numerical modeling of mantle melting degree based on major element composition of melt

*Kenta Ueki[1], Satoru Haraguchi[2,1], Hikaru Iwamori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo)

[MGI33-P02] Bayesian modeling of the equation-of-state by integration of various data sets for liquid iron in Earth's outer core

*Taroujirou Matumura[1], Yasuhiro Kuwayama[2], Kenta Ueki[3], Tatsu Kuwatani[3], Ando Yasunobu[1], Kenji Nagata[4], Shin-ichi Ito[5], Hiromichi Nagao[5] (1.Research center for computational design of advanced functional materials, AIST, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology, 4.Research Center for Advanced Measurement and Characterization, National Institute for Materials Science (NIMS), 5.Earthquake Research Institute, The University of Tokyo)

[MGI33-P03] Superresolution of X-ray CT images of rock core samples and applications to serpentinite in the Oman ophiolite

*Shoui Suzuki[1], Atsushi Okamoto[2], Katsuyoshi Michibayashi[3], Toshiaki Omori[1] (1.Kobe University, 2.Tohoku University, 3.Nagoya University)

Numerical modeling of mantle melting degree based on major element composition of melt

*Kenta Ueki[1], Satoru Haraguchi[2,1], Hikaru Iwamori[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, The University of Tokyo

Determining the mantle melting degree is essential to understand the physical and chemical conditions of the mantle, the process of melt generation, and for estimating the chemical composition of the source mantle based on the chemical composition of volcanic rocks. Due to the low thermodynamic degrees of freedom during partial melting of mantle peridotite, the composition of the partial melt is controlled by the phase relation, including phase assemblage of residual minerals and the melt fraction. Therefore, it is expected that the melt fraction can be expressed only as a function of melt composition, although it is generally expressed as a function of temperature with a fixed bulk composition of the source rock and a fixed pressure. Based on this background, we conduct numerical modeling of mantle melting degree based on the major element composition of the melt.
We compiled the previously reported experimental results of mantle peridotites at pressures corresponding to the upper mantle. Both hydrous and anhydrous experiments are included in the compiled database. We use melting experiments in which the melting degree at a given bulk composition was reported. We conduct a regression analysis based on the data-driven method in Ueki et al. (2018 and 2020). Based on the method, a small number of essential variables are automatically selected to obtain a model of robustness and high predictive capacity. A model that calculates the degree of melt based on the melt composition without temperature and pressure information is constructed based on our analysis. This model will allow us to estimate the physical and chemical conditions of the source region of various natural primitive magmas.

Keywords: mantle, melting, data driven

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Bayesian modeling of the equation-of-state by integration of various data sets for liquid iron in Earth’s outer core

*Taroujirou Matumura[1], Yasuhiro Kuwayama[2], Kenta Ueki[3], Tatsu Kuwatani[3], Ando Yasunobu[1], Kenji Nagata[4], Shin-ichi Ito[5], Hiromichi Nagao[5]

1. Research center for computational design of advanced functional materials, AIST, 2. Department of Earth and Planetary Science, The University of Tokyo, 3. Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology, 4. Research Center for Advanced Measurement and Characterization, National Institute for Materials Science (NIMS), 5. Earthquake Research Institute, The University of Tokyo

Bayesian modeling of the equation-of-state (EoS) was demonstrated to constrain P-wave velocity (V_P) and density (ρ) of liquid iron under Earth’s outer-core conditions. We collected six data sets obtained by high-pressure (P) and high-temperature (T) experiments and *ab initio* molecular dynamics simulations in previous works. These data sets were integrated into one to estimate the parameters of EoS. However, as the type of observed data depends on the approach, integrated data set includes some unobserved data. To analyze such data set, we performed an analysis based on Bayesian inference. Our analysis successfully estimated the posterior probability distribution of the parameters and unobserved data by using the Hamiltonian Monte Carlo method. These posterior probability distributions enable us to calculate P– V_P and P– ρ profiles of liquid iron along the adiabatic P–T profile together with the associated credible intervals. Bayesian modeling of the EoS enables estimation of EoS’s parameters, integration of data sets that include unobserved data and evaluation of uncertainty ranges of physical properties, such as V_P and ρ, which are important for comparison with seismological properties of the core.

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Superresolution of X-ray CT images of rock core samples and applications to serpentinite in the Oman ophiolite

*Shoui Suzuki[1], Atsushi Okamoto[2], Katsuyoshi Michibayashi[3], Toshiaki Omori[1]

1. Kobe University, 2. Tohoku University, 3. Nagoya University

Recently, the X-ray computed tomography (CT) scanner has been commonly used for the onboard analyses of cores of scientific drilling, which provides us the 100 to 1000 m scale continuous data of various structures (lithological or sedimental layering, fractures, pores etc) of rocks. However, the resolution of such X-ray CT for the cores (for example, ~0.17 mm by the X-ray CT of Drilling Chikyu) is slightly low compare to reveal the shape and geometry of mineral grains and thin fractures. In contrast, the resolution of X-ray CT in usual laboratories is high (~0.01 mm or less). Therefore, if we can link the high resolution X-ray CT in the lab of the limited samples to the low resolution drilling core CT data, we can obtain the valuable big data for the analyses of multi-scale structures.

For this purpose, we have tried to apply sparse superresolution techniques to the rock samples with veins. The sample is a serpentinezed dunite in the Moho transition zone taken by the Oman Drilling project (CM1A). We took the X-ray CT images of the samples with the voxel size of 10, 20, 40 and 80 micrometers. The X-ray CT image reveals that distribution of magnetite and spinel grains and fractures filled with serpentine. We consider that each image is expressed by sparse representation; an image consists of a small number of basis images. The algorithm consists of two processes: dictionary learning and superresolution processes. In dictionary learning process, basis images are obtained by feature extraction from multiple X-ray CT images. In super-resolution process, a reconstructed high resolution image is obtained from a low resolution X-ray CT image by using common sparse representations. By using the sparse superresolution algorithm, we obtained results that sparse superresolutions provide fine structure from low resolution X-ray CT image.

Keywords: Oman Drilling Project, Image Superresolution, Sparse Representation

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.03 Zoom Room 03

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Chairperson:Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Ken T. 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".

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MGI34-01] Development of snow detection techniques by using visual IoT

*Yuki MURAKAMI[1], Ken T. Murata[1], Shigeto Watanabe[2] (1.National Institute of Information and Communications Technology, 2.Hokkaido Information University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MGI34-02] Environment Monitoring Using a Technology of Visual Internet of Things

*Tsutomu Nagatsuma[1], Ken T. Murata[1], Junji Tokairin[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1], Takamichi Mizuhara[2] (1.National Institute of Information and Communications Technology, 2.CLEALINK TECHNOLOGY Co. Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MGI34-03] Release of three-dimensional geological map of central Tokyo

*Susumu Nonogaki[1], Tsutomu Nakazawa[1], Tomonori Naya[1], Junko Komatsubara[1], Yoshinori Miyachi[1], Masanori Ozaki[1], Toshio Nakayama[2] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Civil Engineering Support and Training Center, Tokyo Metropolitan Government)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MGI34-04] Introduction of Ultra-large-scale Visualization Method for 3D Geographical Information Using a Web Browser-based Scalable Display System

Tomohiro Kawanabe[1], Kenji Ono[2], *Ken T. Murata[3], Atsushi Higuchi[4] (1.Institute of Physical and Chemical Research, 2.Kyushu University, 3.National Institute of Information and Communications Technology, 4.Chiba University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MGI34-05] Environmental Monitoring Experiment with the Sensor Network in Chikuma City

*Kohei Mizuani[1], Ken T. Murata[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1], Kazuya Muranaga[2], Takamichi Mizuhara[3] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants Co., LTD., 3.CLEALINKTECHNOLOGY Co.,Ltd.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MGI34-06] Data Quality Control and Data Disclosure of Phased Array Weather Radar

*Shinsuke Satoh[1], Fusako Isoda[1], Hiroshi HANADO[1], Katsuhiro Nakagawa[1], Susumu Uchino[2], Kohei Yamashita[2], Kazuya Muranaga[2] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants (SEC))

Development of snow detection techniques by using visual IoT

*Yuki MURAKAMI[1], Ken T. Murata[1], Shigeto Watanabe[2]

1. National Institute of Information and Communications Technology, 2. Hokkaido Information University

There is low-cost single board computer such as Raspberry Pi, Arduino, etc., and it can connect the cloud service through the Internet. The single board computer is expected as architecture for Internet of Things (IoT), and many users connect sensors and actuators to the computer. Visual IoT is a kind of IoT, and it is remote sensing method to extract information from image and/or video data in real time. Video transmission is not easy in low-band network like mobile environment, it is practical method to transmit extracted information in real time to cloud server through mobile network. In other words, remote camera is used as remote visual sensor instead of video transmitter. We selected snow detection as one of visual IoT applications. We developed and tested basis algorithm for snow detection. In test, we used field camera set up in Ebetsu city (Hokkaido prefecture) and Chikuma city (Nagano prefecture), and we focused on detection of trigger when snow fall begin or end. Now, we report abstract of the algorithm and test results.

Keywords: Visual IoT

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Environment Monitoring Using a Technology of Visual Internet of Things

*Tsutomu Nagatsuma[1], Ken T. Murata[1], Junji Tokairin[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1], Takamichi Mizuhara[2]

1. National Institute of Information and Communications Technology, 2. CLEALINK TECHNOLOGY Co. Ltd.

Visual Internet of Things (Visual IoT) is a technology which realizes high quality and intelligent visual data transfer via every IP network including mobile network using low-cost and programable visual data transfer system. High-performance video transmission protocol (HpVT) which was developed by CLEALINK TECHNOLOGY Co., Ltd. is a foundation of visual IoT measurement and data transfer system (visual IoT system) developed by NICT. To monitor the current traffic condition on route 398 along Mangoku-ura, we are collecting visual and meteorological data by a visual IoT system which was installed at clean center in Onagawa since Dec. 2020 under the cooperation with Onagawa town office. The main objectives of our visual IoT system in Onagawa is to monitor the traffic condition on route 398 along Mangoku-ura, and to estimate number of vehicles and its velocities using image analysis technology for quantitative understanding of traffic condition, and to study the quantitative relationship between traffic and weather condition. In addition, a PTZ camera in our system is capable to measure any image with any direction. We can extract and analyze many kinds of information, such as conditions of ships in the bay and the condition of snow falling by advanced image analysis technology. We will report current efforts and future perspectives in our activity.

Keywords: Visual IoT, Environment Monitorng, Advanced Image Analysis Technology

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Release of three-dimensional geological map of central Tokyo

*Susumu Nonogaki[1], Tsutomu Nakazawa[1], Tomonori Naya[1], Junko Komatsubara[1], Yoshinori Miyachi[1], Masanori Ozaki[1], Toshio Nakayama[2]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. Civil Engineering Support and Training Center, Tokyo Metropolitan Government

For promoting utilization of geo-information in urban areas, Geological survey of Japan (GSJ) has carried out the three-dimensional (3D) urban geological mapping project. In this project, we create a 3D geological map to a depth of several tens of meters using borehole logs obtained from drilling surveys for scientific research and public construction work. Additionally, we develop a web system for sharing 3D geo-information. In the spring of 2021, the 3D geological map covering the 23 special wards of Tokyo will be released as a cooperative work with the Civil Engineering Support and Training Center, Tokyo Metropolitan Government (CETC) on the Internet.

The 3D geological map of central Tokyo is the integrated map of topographical information and geological information. With regard to topographical information, we have created a landform classification map, which comprised with 11 categories, using geospatial data, such as digital elevation models (DEMs), aerial photos, and geological maps. With regard to geological information, we have performed stratal correlation of about 50 thousand borehole logs created for public construction work, which are provided by CETC, using a standard stratigraphic framework beneath central Tokyo established based on high-quality stratigraphic data obtained from drilling surveys and laboratory works by GSJ. The GSJ stratigraphic data includes detailed core descriptions (sedimentary facies, marker tephra layers, and fossils); age measurement; and PS velocity and density logging. Further, based on the result of stratal correlation, we have generated DEMs of basal surfaces of geological layers beneath central Tokyo and constructed a surface-based 3D geological model, which has 10 geological layers.

The 3D geological map of central Tokyo will be open to the public on the website “Urban Geological Map” (https://gbank.gsj.jp/urbangeol/). On the website, users can browse the GSJ stratigraphic data, visualize the borehole log images used for mapping and the geological map in 3D, and generate a vertical cross-section image of subsurface geological structure along arbitrary line.

In this presentation, we will talk about an outline of the 3D mapping project and the result of central Tokyo.

Keywords: three-dimensional geological map, borehole logs, DEM, urban area

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Introduction of Ultra-large-scale Visualization Method for 3D Geographical Information Using a Web Browser-based Scalable Display System

Tomohiro Kawanabe[1], Kenji Ono[2], *Ken T. Murata[3], Atsushi Higuchi[4]

1. Institute of Physical and Chemical Research, 2. Kyushu University, 3. National Institute of Information and Communications Technology, 4. Chiba University

In recent years, the drawing and expression capabilities of Web browsers have evolved remarkably, making it possible to replace many desktop applications. This is largely due to advances in web technologies such as HTML5 and JavaScript. Especially in 3D graphics, with the advent of WebGL, it has become possible to bring out the same performance as native applications. ChOWDER [1] is open-source software that is being jointly researched and developed by RIKEN and Kyushu University. It is a web-based scalable display system that builds an ultra-high-resolution display environment by arranging multiple displays (full-screen Web browsers) in tiles that cannot be realized with a single PC. As an advanced and practical function of this system, we have published last year the ability to perform distributed rendering of 3D Web GIS applications on multiple display devices. [2] Using iTowns [3], a WebGL-based open source GIS, as a base software, it displays ultra-high-resolution 3D geographic information on ChOWDER's distributed display. The overlay display function of user-defined data (polygons, point clouds, etc.) provided by iTowns can also be used as it is. Fig.1 shows a 3D point cloud of the cloud observation data of the meteorological satellite HIMAWARI and the map data published by The Geospatial Information Authority of Japan overlayed on a ChOWDER display which consists of 15 4K resolution displays (total resolution: 19200x6430 pixels). Operations such as changing the viewpoint can be performed interactively on the user's PC. In this presentation, we will introduce an overview of the basic technologies that make up this function and examples of some visualization results.

[1] https://github.com/SIPupstreamDesign/ChOWDER

[2] Kawanabe, T., Hatta, K., & Ono, K. (2020, September). ChOWDER: A New Approach for Viewing 3D Web GIS on Ultra-High-Resolution Scalable Display. In 2020 IEEE International Conference on Cluster Computing (CLUSTER) (pp. 412-413). IEEE.

[3] http://www.itowns-project.org/

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Environmental Monitoring Experiment with the Sensor Network in Chikuma City

*Kohei Mizuani[1], Ken T. Murata[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1], Kazuya Muranaga[2], Takamichi Mizuhara[3]

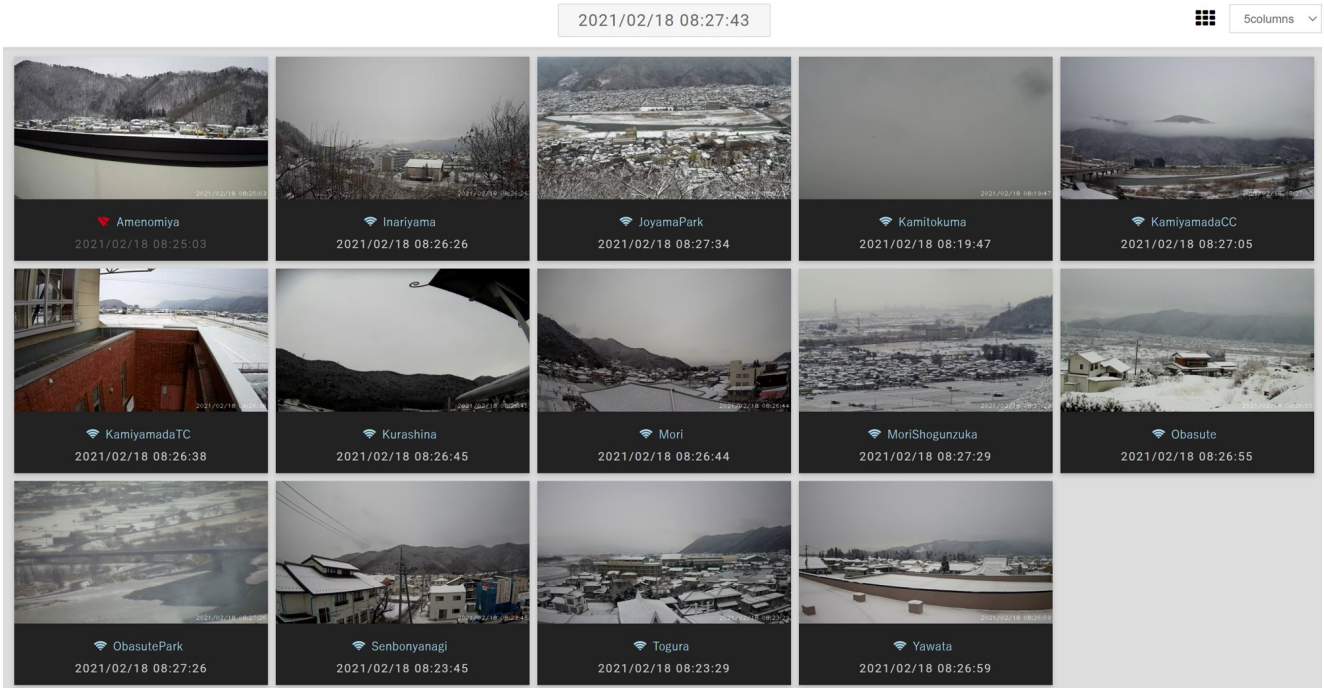
1. National Institute of Information and Communications Technology, 2. Systems Engineering Consultants Co., LTD., 3. CLEALINKTECHNOLOGY Co.,Ltd.

Internet of Things (IoT), where physical objects are connected and data of many kinds of sensors are collected over the Internet, becomes one of important social infrastructure technologies. Various sorts of data collection experiments through many kinds of network technologies in many areas have been implemented to improve services and solve problems in the community through uses and applications of the collected data. We are conducting environmental data monitoring experiments using private LoRa, which is one of the low-power wide area (LPWA) communication technologies, BLE and LTE over Chikuma city, Nagano prefecture, Japan. We recently abolished the LoRa relay station on the Koshoku governmental building which was one site of 10 LoRa relay stations and set up 5 new LoRa relay stations, resulting to 14 LoRa relay stations. The LoRa relay stations have Cameras, and high-quality images including short-time movies are transferred (Fig.1). Vaisala Weather stations are set near the all relay stations and weather data are transferred by LoRa. A few tenths of small environmental sensors are set in Togurakamiyamada Junior High School. The environmental data from these sensors are connected to the Data Cloud by BLE to LTE relay stations. Data are monitored in quasi-real time over the Internet and the various sensors are controlled over the Internet. Many kinds of sensors could be connected through this sensor network and some sensors of private companies are used in the network. A LoRa relay station has been set at Shinshu University Faculty of Engineering in Nagano city. We expect that this sensor network will be expanded and used for more applications.

Fig.1 Images from Cameras set in Chikuma city

Keywords: IoT, Sensor network, LoRa

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Data Quality Control and Data Disclosure of Phased Array Weather Radar

*Shinsuke Satoh[1], Fusako Isoda[1], Hiroshi HANADO[1], Katsuhiro Nakagawa[1], Susumu Uchino[2], Kohei Yamashita[2], Kazuya Muranaga[2]

1. National Institute of Information and Communications Technology, 2. Systems Engineering Consultants (SEC)

The Phased Array Weather Radar (PAWR), which was developed for early detection and prediction of torrential rain, performs detailed 3D observation in 30 seconds, and generate observation big data at 100 times the data rate of conventional parabolic antenna type weather radar. NICT is engaged in observation operation and data storage / distribution of four PAWRs installed in Suita (Osaka University), Kobe, Okinawa, and Saitama University. In general, the weather radar observation data is used in real-time to grasp and predict rainfall distribution. The PAWR real-time observation data every 30 seconds is also used in the smartphone apps "3D Amagumo Weather" and "RIKEN Weather Forecast." On the other hand, past observation data is also important for studying various rainfall events. Long-term data archiving is needed to investigate various heavy rainfall mechanisms, improved precipitation forecasting, and recent record heavy rainfall increases. On the PAWR web page (https://pawr.nict.go.jp/), a quick look (QL) image showing the rainfall distribution at an altitude of 2 km is created and published within 1 minute after observation. All QL images and rainfall summaries (graphs) are posted on the "Past Data" page. The rainfall summary includes the average rainfall, maximum rainfall, and rainfall area at an altitude of 2 km as daily and weekly graphs, and text data every 30 seconds. This QL image and rainfall summary are created for searching past data, but they are also used as useful data in themselves. Millions of QL images can be used for machine learning, and the rainfall summary can be used not only for grasping long-term rainfall conditions but also for investigating fluctuations in data quality.

Data quality control is important for the use of real-time and past data. The PAWR observation data includes unnecessary data such as surface clutter, noise, and pseudo-echo, so a data quality control (QC) flag is created within 10 seconds. However, because there are the issues of the QC accuracy due to various rainfalls, we are developing a clutter identification method using semantic segmentation. We are proceeding with the policy of disclosing past observation data as open data, but there are many issues. First, there is the problem of data capacity. The past data is saved in multiple storage servers as hourly tgz files in consideration of capacity reduction and handling, but it has already exceeded 3 PB. Since it is not realistic to publish all the data, only the requested data is copied to the data public server. Another problem is that the data is saved in polar coordinates in the original binary format, which makes it difficult for general users to use. In order to be widely used by many users as open data, it is necessary to perform data quality control and process it into an easy-to-use data format.

Keywords: Phased Array Weather Radar, Data Quality Control, Data Disclosure, Observation Big Data

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.03 Zoom Room 03

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Chairperson:Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi 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".

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[MGI34-07] Efforts of Aizu Research Center for Space Informatics, Univ. of Aizu as a Joint Usage / Research Center

★Invited Papers

*Hirohide Demura[1] (1.The University of Aizu)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[MGI34-08] Development of a Data Analysis Environment for Small Irregular-Shaped Bodies Centered on a 3D-GIS

*Naru Hirata[1,2], Takuma Furudate[1], Hiroshi Kikuchi[3], Hirohide Demura[1,2], Hiroyuki Sato[3], Koji Matsumoto[4], Naoto Nakasato[1], Fumiya Kono[1] (1.Dep. of Computer Science and Engineering, Univ. of Aizu, 2.ARC-Space, Univ. of Aizu, 3.Japan Aerospace Exploration Agency, 4.RISE Project, National Astronomical Observatory of Japan)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[MGI34-09] Practice, Application and Future Potential of High-Capacity Space Data Processing

*Junya Terazono[1], Ken T. Murata[1], Tomohiro Sato[1], YASUKO KASAI[1] (1.National Institute of Information and Communication Technology)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[MGI34-10] **Construction of hot spring database over Japan for clarifying thermal and fluid flow structures in the upper crust**

*Jacek Scibek[1], Katsuaki Koike[1], Koki Kashiwaya[1] (1.Kyoto University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[MGI34-11] Detection of geothermal fluids paths in highly vegetated area through a vegetation stress index using hyperspectral satellite imagery

*Taiki Kubo[1], Hiroaki Gonnokami[1], Mohamad Nur Heriawan[2], Katsuaki Koike[1] (1.Graduate School of Engineering, Kyoto University, 2.Institut Teknologi Bandung)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

[MGI34-12] Discussion

Efforts of Aizu Research Center for Space Informatics, Univ. of Aizu as a Joint Usage / Research Center

*Hirohide Demura[1]

1. The University of Aizu

Efforts of Aizu Research Center for Space Informatics, Univ. of Aizu as a Joint Usage / Research Center

Keywords: Archive Science, Lunar and Planetary Explorations, Data Informatics

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Development of a Data Analysis Environment for Small Irregular-Shaped Bodies Centered on a 3D-GIS

*Naru Hirata[1,2], Takuma Furudate[1], Hiroshi Kikuchi[3], Hirohide Demura[1,2], Hiroyuki Sato[3], Koji Matsumoto[4], Naoto Nakasato[1], Fumiya Kono[1]

1. Dep. of Computer Science and Engineering, Univ. of Aizu, 2. ARC-Space, Univ. of Aizu, 3. Japan Aerospace Exploration Agency, 4. RISE Project, National Astronomical Observatory of Japan

The geographical information system (GIS) is a powerful tool integrate map data in which observed values are associated with particular locations on the surface of a target body. The GIS and GIS-oriented tools are now widely used in various research fields that study the Earth and other large bodies such as the Moon and Mars. However, datasets of irregular-shaped bodies are hard to handle with usual GIS software. They support only spherical bodies with geographical coordinate system (by longitude and latitude), which is not the unique identifier on the irregular-shaped bodies.
We proposed a concept of 3D-GIS that uses 3D representation of the body shapes to solve this problem. The shapes of an irregular-shaped bodies is represented by a 3D polygon model and the 3D model is visualized as 3D-CG.
AiGIS is a implementation of this 3D-GIS concept. can display a polygon-based 3D shape model of the target body, and users can manipulate viewing conditions and a lighting condition by mouse operations. Map data and graph map data on AiGIS are a set of data that are associated with polygons consisting of the shape model. Polygons of the shape model are displayed with a color that is assigned according to a value in the selected map data with the look-up table.
We attempt to construct an data visualization and analysis environment based on AiGIS for small body exploration data. The pixel DB, developed as a piece of the environment, can store individual pixel values of images with observational conditions such as incidence angle, emission angle, and phase angle. This DB enable us to make analysis using pixel values throughout all available images. Estimation of the parameters of phase function on the surface at each local regions is an example of application of the DB. Results of such analysis can also be visualize on the 3D-GIS. We also develop a GPGPU-based code to compute the gravitation field on and around an irregular-shaped body. Computation of the gravitation field of an irregular-shaped object requires much time or CPU resource. The GPGPU-based code will greatly reduce computation time by parallel processing by GPU.
We will present not current status of AiGIS, pixel DB, and GPGPU-based gravitation field calculation code, but also future prospects of the analysis environment or small body exploration data.

Keywords: asteroid, GIS, image DB, gravitation field, GPGPU

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Practice, Application and Future Potential of High-Capacity Space Data Processing

*Junya Terazono[1], Ken T. Murata[1], Tomohiro Sato[1], YASUKO KASAI[1]

1. National Institute of Information and Communication Technology

The author continued his research on integrated visualization of scientific data, particularly image data, obtained by lunar and planetary exploration. The method consists primarily of constructing an image-based map on the Web-GIS system and overlaying visualized scientific data. The author constructed a prototype system called "WISE-CAPS" (Web-based Integrated Secure Environment for Collaborative Analysis of Planetary Science) which displays scientific data acquired in lunar explorations overlapping image data on a web browser window. Such a system will assist scientists in making new discoveries more easily by easily comparing various types of scientific data.
The amount of scientific information obtained from an exploration program increases rapidly over these years. Moreover, the total amount of data gathering all explorations made so far is also increasing. This means that the quantity of data that scientists should be processed is increasing. This leads to a growing demand for the development of data processing systems that scientists can operate intuitively and comprehensively.
Also, such system can be used, not by scientists, but by general citizens. The "Citizen Science" movement, which is led by citizens themselves to carry out scientific activities, is broadening its pace. Also, the publication and public outreach are currently generally regarded as an essential element of the scientific activity to deliver importance and progress of scientific research. The author should point out that the system useful for scientists may also be useful for citizens in general.
In this presentation, in addition to the lunar and planetary data processing system that the author has been working on for many years, authors address the outline of the ground data processing system for the GOSAT-GW, Global Observing Satellite for Greenhous Gases and Water Cycle, and outreach-oriented games using data obtained by Himawari 8, Geostationary Meteorological Satellite of Japan. These systems and applications demonstrate the essence of what the high-capacity space data handling system should have. Also, we address the future potential and ideal form of high-capacity space data processing system.

Keywords: lunar and plaentary exploration, data processing, earth observation, GIS, outreach

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Construction of hot spring database over Japan for clarifying thermal and fluid flow structures in the upper crust

*Jacek Scibek[1], Katsuaki Koike[1], Koki Kashiwaya[1]

1. Kyoto University

At Kyoto University, there is an on-going project that involves a review of various sources of geothermal data in Japan. The databases are updated using GIS, 3D models, and deep-learning algorithms to extract and correlated useful data. In the case of geothermal water use, the data exist in several categories that we must review and merge. One type of data are historical and modern records, maps, and statistics about the "hot spring" (thermal spring from warm to hot) development and management. Another important source of geothermal data are technical studies related to the geothermal energy exploration and development projects, but also in many of the managed hot spring areas, and natural volcanic areas. Finally, all data from deep drilling and studies are put together in a 3D hydro-structural-geothermal models and maps of heat flow and hydrothermal circulation and tectonic structure in Japan. This presentation is focused on the extraction of useful geothermal data for the national model from the observations of "hot springs" and thermally-heated groundwater anomalies in general. We are interested in the situation at the top of crystalline bedrock below surficial sediments and basins, although the hot and other springs usually emerge, or are pumped, within those shallow sediments because of the shallow depth (good access), and of high permeability and porosity (thermal water aquifers). These sediments usually obscure the true source of the thermal water up-flow location, but many fault zones are suspected to be sources in volcanic areas, and in some case, from deeper bedrock. There is some difficulty with understanding of some available data for many reasons: 1) commercial development (drilling, capturing, redistribution, etc.) of spring waters in Japan, 2) different definitions and labels used in geoscientific, local government statistics of "hot spring" use, and historical documents, 3) existing databases created for different purposes (e.g. whole hot spring areas vs. individual wells), 4) significant changes over the years of "hot spring" production and natural state. In our review in 2020, we noted that in many areas of Japan, almost the whole thermal plume in groundwater is captured and quantified, but in other areas only a small part of the thermal up-flow is used. Much of the thermal groundwater is lost to the hydrologic system or the ocean coast without counting the heat and mass flow. The improvement in these databases, and joining with other heat flow models (e.g. deep geothermal wells) can help to model the hydrothermal systems under Japan, and perhaps to also estimate the permeability of fault zone conduits and other conduits. Although the heat flow through rocks has been mapped regionally so far, the focus is also now on particular more permeable hot water conducting structures and the rates of heat flow through rocks and convectively by hot water circulation. The "hot spring" information is very abundant and is one of the best expressions of the underlying hydrothermal flow system and hydraulic structures under Japan. Therefore, these data and mappingresults can contribute to comprehensive understandings of the thermal fluid flow patters, geochemical water properties, and its relation with heat flow and geology within the upper Earth's Crust under Japan.

Keywords: hot spring, database, geothermal, structures, heat flow

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Detection of geothermal fluids paths in highly vegetated area through a vegetation stress index using hyperspectral satellite imagery

*Taiki Kubo[1], Hiroaki Gonnokami[1], Mohamad Nur Heriawan[2], Katsuaki Koike[1]

1. Graduate School of Engineering, Kyoto University, 2. Institut Teknologi Bandung

Detection of geothermal fluids paths including steam and gas from a geothermal reservoir is a major target of geothermal prospecting. Remote sensing analysis is one of the low-cost and effective methods to detect fractures distribution that have a function as fluid flow paths. However, vegetation cover is an obstacle for prospecting when the geothermal potential field are located in tropical mountainous areas. In this study, we extracted geothermal manifestations from highly vegetated areas using the linear spectral unmixing (LSU) method and a vegetation stress index. Hede et al. (2015) applied a vegetation stress index calculated from multispectral data, and we improved the index, termed as Vegetation Index considering Blue shift and Shortwave infrared (VIBS), using hyperspectral data which has a higher wavelength resolution. The Wayang Windu Geothermal Field (WWGF) situated in West Java, Indonesia was selected as a study site. Vegetation-covered zones were extracted from a hyperspectral image, obtained by Hyperion using the application of LSU. The spatial distribution of VIBS was clarified over the whole vegetation-covered area. The high-stress zones by VIBS were mainly overlapped with the location of geothermal manifestations in WWGF. In addition, lineament distribution was estimated from DEMNAS, the digital elevation model provided by the geospatial information agency of Indonesia. The high permeable zones were estimated from the lineament distribution and the result of the radon gas survey (Heriawan et al., 2020). The corresponding high-stress with the estimated high permeable zones suggested the presence of permeable fractures that act as the ascent paths of geothermal fluid flows.

Keywords: geothermal resource exploration, Hyperion, Indonesia, remote sensing, spectral unmixing

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[J] Oral | M (Multidisciplinary and Interdisciplinary) | M-GI General Geosciences, Information Geosciences & Simulations

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto University), Chairperson:Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University)

Thu. Jun 3, 2021 10:45 AM - 12:15 PM Ch.03 (Zoom Room 03)

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".

12:05 PM - 12:15 PM

[MGI34-12]Discussion

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.18_2

[M-GI34] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Keiichiro Fukazawa(Academic Center for Computing and Media Studies, Kyoto 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".

[MGI34-P01] An attempt of local government disaster prevention WebGIS

*Ken T. Murata[1], Asanobu Kitamoto[2], Tomohiro Kawanabe[3], Keiichiro Fukazawa[4], Kazuya Muranaga[1], Kazunori Yamamoto[1], Yuki MURAKAMI[1] (1.National Institute of Information and Communications Technology, 2.National Institute of Informatics, 3.Institute of Physical and Chemical Research, 4.Kyoto University)

[MGI34-P02] Development of interface for PTZ Camera to use image processing technique

*Yuki MURAKAMI[1], Ken T. Murata[1], Michiharu Niimi[2], Yoshihide Kagatani[3], Minehito Ageno[3], Kazunori Yamamoto[1], Tomohiro Kawanabe[4] (1.National Institute of Information and Communications Technology, 2.Kyushu Institute of Technology, 3.GEO Solutions Co.Ltd., 4.Institute of Physical and Chemical Research)

[MGI34-P03] Development of LPWA and visual IoT techniques (2)

Mehdad Shirazi[1], *Takamichi Mizuhara[1], Toshiki Aoki[1], Yuua Kagebayashi[1], Takeshi Murata[2], Kazunori Yamamoto[2], Kazuya Muranaga[3] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Systems Engineering Consultants Co.,LTD.)

[MGI34-P04] HpFP: development of high-speed data transfer applications (2)

Yasunori Kakizawa[1], Ayahiro Takaki[1], *Takamichi Mizuhara[1], Kazuya Muranaga[3], Kazunori Yamamoto[2], Takeshi Murata[2] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Systems Engineering Consultants Co.,LTD.)

[MGI34-P05] Programming Techniques for visual IoT on Raspberry Pi (4)

Toshiki Aoki[1], *Takamichi Mizuhara[1], Takeshi Murata[2], Kazunori Yamamoto[2], Kazuya Muranaga[3] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Systems Engineering Consultants Co.,LTD.)

[MGI34-P06] A large-scale distributed cloud system for research works on Earth and Planetary sciences

Kazunori Yamamoto[1], Kazuya Muranaga[2], *Ken T. Murata[1], Keiichiro Fukazawa[3], Atsushi Higuchi[4], Takeshi Nanri[5], Tomohiro Kawanabe[6], Yoshitaka Ohyoshi[7] (1.National Institute of Information and Communications Technology, 2.SEC, 3.Kyoto University, 4.Chiba University, 5.Kyushu University, 6.Institute of Physical and Chemical Research, 7.Virtual)

[MGI34-P07] Activity of preparing training data for study of space plasma with collaboration of observation, MHD simulation and machine leaning

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[MGI34-P08] Development of a multi-station airglow imaging system using commercial cameras

*Shin Suzuki[1] (1.Faculty of Regional Policy, Aichi University)

[MGI34-P09] Super-resolution and colorization of small body images by Generative Adversarial Network

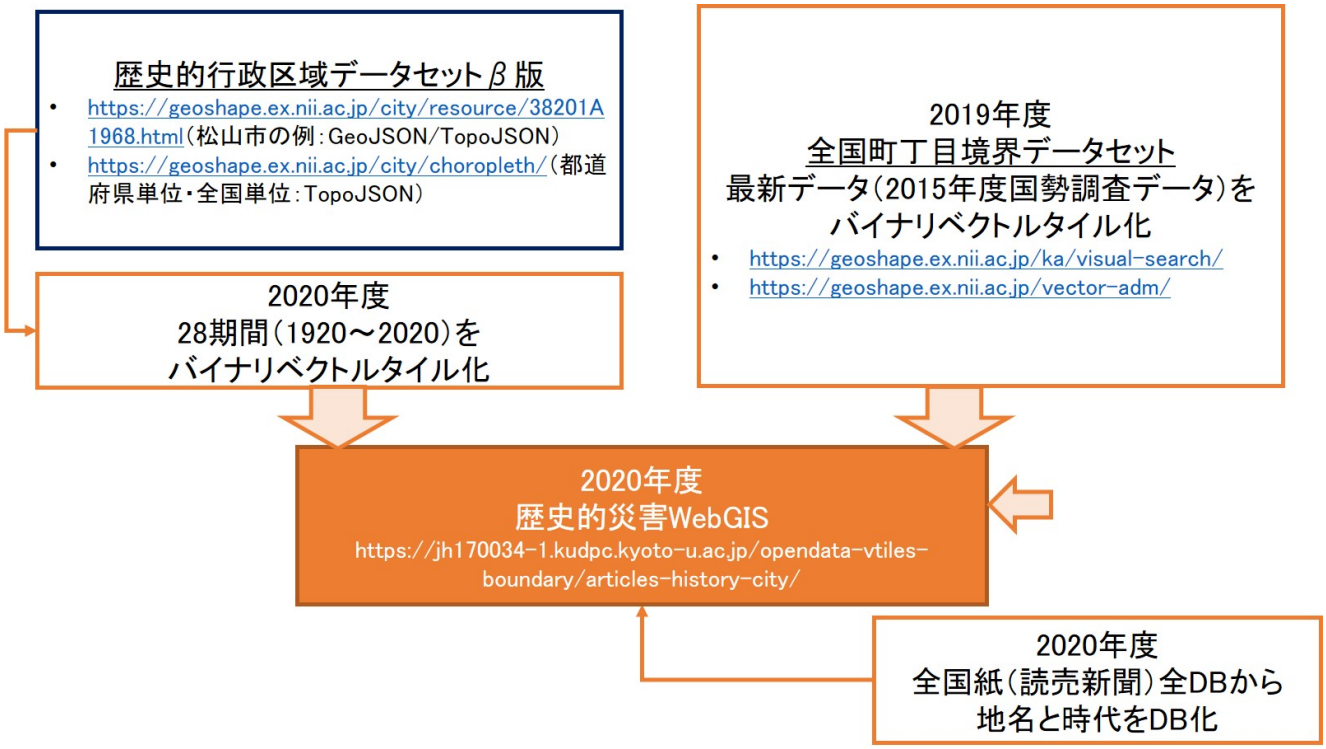
Rintaro Kishi[1], Ren Hashimoto[1], *Rie Honda[1], Kimikazu Tanase[1], Yasuhiro Yokota[2], Seiji Sugita[3], Tomokatsu Morota[3], Shingo Kameda[4], Naoya Sakatani[4], Eri Tatsumi[5], Yuichiro Cho[3], Toru Kouyama[6], Manabu Yamada[7], Masahiko Hayakawa[2], Hidehiko Suzuki[8], Kazuo Yoshioka[3], Chikatoshi Honda[9], Kazunori Ogawa[2], Hirotaka Sawada[2] (1.Kochi University, 2.ISAS/JAXA, 3.Univ. of Tokyo, 4.Rikkyo Univ., 5.Instituto de Astrofisica de Canarias, Univ. of La Laguna, 6.AIST, 7.Chiba Inst. Tech, 8.Meiji Univ., 9.Univ. of Aizu)

An attempt of local government disaster prevention WebGIS

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In this study, we build up a local government disaster prevention WebGIS by linking historical administrative area dataset with newspaper article dataset. Specifically, for Chikuma City, Nagano Prefecture, we visualize local information on various natural disasters occurred in the past in this era. Binary vector tiles that can speed up rendering make it possible to visualize past natural disaster occurrence locations extracted from newspaper articles on the current WebGIS map. This database and Web application will be provided to various user organizations for research and development, regardless of whether they are academia or private companies.



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Development of interface for PTZ Camera to use image processing technique

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In recent years, the government and companies aim at realization of smart society. Smart city is an element of smart society, and it produces safe and reliable life with feedback results of data aggregation and processing from sensors installed in a city. A Pan, Tilt and Zoom controllable camera (PTZ camera) is a kind of visual sensor. PTZ cameras set up in elevated spots of a city can help realization of automatic city monitoring system. The system monitors a situation of city in a normal period automatically. If the system detects anomaly points in a city, it focuses on the point. The system needs two core techniques: PTZ control and image processing. We developed an interface between PTZ control and image processing, and report results of PTZ control. The interface decides PTZ values from a pixel of an image. The PTZ values depend on not only position of the pixel but also target camera and zoom level, so a user must calibrate the target camera. However, it is difficult for the user to calibrate every camera in a city. We also developed self-calibration program, and packaged PTZ control and self-calibration program to use easily.

Keywords: Visual IoT, PTZ Control

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Development of LPWA and visual IoT techniques (2)

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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. We introduce an original carrier board for LoRa communication system development. Basic examinations in outdoor environments and our application to visual IoT syste are discussed.

Keywords: IoT, LPWA, Image

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HpFP: development of high-speed data transfer applications (2)

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For LFNs (Long-Fat Networks) with 10 Gbps or more and satellite networks with large latency, a variety of TCP-based protocols have been proposed which show high performance on large latency network conditions. However, such TCP protocols are essentially unable to archive large bandwidth on high latency networks accompanied with packet-losses that are inevitable on practical LFNs or satellite networks. To overcome this issue, we designed a new data transfer protocol on TCP/IP transport layer built on top of UDP: High-performance and Flexible Protocol (HpFP). It constantly monitors latency (RTT) and packet losses, and conducts rate control and retransmission control based on them to enable higher bandwidth data transfer than 10 Gbps even on packet-loss conditions over LFNs. The basic concepts are addressed and protocol design of the HpFP are discussed. An applications to transfer many data files in small size (e.g., 1MB x 10000 files) with almost wire-rate bandwidth (10 Gbps) is also addressed. In this study we develop a tool to bind multiple connection of HpFP aiming at higher throughput on a broadband network faster than 100Gbps. In the near future, big data transfer with high speed is expected on LFNs such as SINET5.

Keywords: HCP, LFN, BigData

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Programming Techniques for visual IoT on Raspberry Pi (4)

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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. Our presentation this year focuses on a remote operation function of PTZ-type IP camera (https://www.youtube.com/watch?v=cNCGVany0BQ).

Keywords: IoT, Camera, Image

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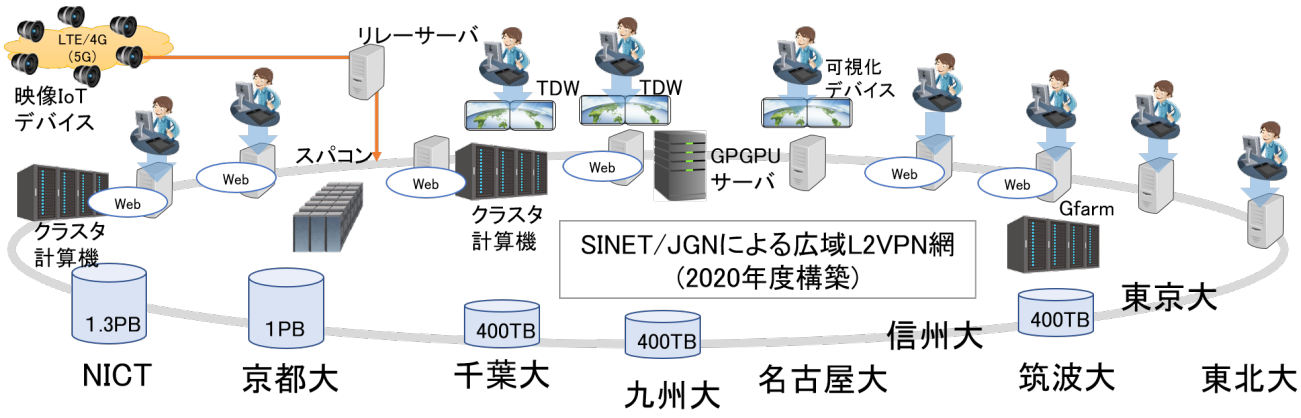
A large-scale distributed cloud system for research works on Earth and Planetary sciences

Kazunori Yamamoto[1], Kazuya Muranaga[2], *Ken T. Murata[1], Keiichiro Fukazawa[3], Atsushi Higuchi[4], Takeshi Nanri[5], Tomohiro Kawanabe[6], Yoshitaka Ohyoshi[7]

1. National Institute of Information and Communications Technology, 2. SEC, 3. Kyoto University, 4. Chiba University, 5. Kyushu University, 6. Institute of Physical and Chemical Research, 7. Virtual

NICT, National Institute of Information and Communications Technology, has been developing large-scale data transfer technology (HpFP) and high-speed communication technology (HpVT) in association with Clearlink Technology Co., Ltd. Since 2018, we have been conducting a wide-area system to verify out techniques using actual data in the Joint Usage/Research Center for Interdisciplinary Large-scale Information Infrastructures. Each base university (Tohoku University, Tokyo University, Nagoya University, Kyoto University, Kyushu University) and research bases (Tohoku University, Tokyo University, Nagoya University, Kyoto University, Kyushu University) is connected via JGN and SINET, high-speed backbone networks, using the highly functional communication protocol HpFP. By 2020, we have built an L2VPN network service (named as “JHPCN wide area distributed cloud”) that transfers and shares data at high speed between the information infrastructure centers of Chiba University, Kyoto0 University, Kyushu University, and NICT. Furthermore, we verified the performance of this environment and confirmed that the data transmission speed between bases can be achieved at or occasionally higher than that of a general LAN environment. As a result, researchers can freely utilize the huge computer resources provided by each research base; it has become possible to realize unprecedented big data science.

Keywords: JHPCN, Cloud system



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Activity of preparing training data for study of space plasma with collaboration of observation, MHD simulation and machine leaning

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The machine learning (ML) has become a powerful tool to find the relation between variables thanks to the deep learning technique. This performs greatly in the classification, regression and recently generative modeling in the engineering and commercial areas. However, due to the satisfaction of physical laws in the scientific research area, the application of ML has some difficulties. In particular, the generative modeling is very sensitive to scientific data since the generated data is not guaranteed by the physical laws.

To overcome these problems, we have tried to apply ML to space plasma physics for several years and then reconfirmed the importance of preparing the training data. For example, when we classify the aurora in the observation results with ML, we have to prepare the huge amount of aurora observational image to learn the feature with high accuracy. It takes a lot of time to prepare the aurora image if considering the augmentation. Thus, we are developing the web site to classify the image including the aurora or not with the expectation of citizen science cooperation. In this study we show the web site for preparing the classification image and the initial results of it. In addition, our database of global simulation data of magnetosphere using real solar wind data and formatted aurora image by All-Sky-Imager will be shown.

Keywords: machine learning, space plasma, database

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Development of a multi-station airglow imaging system using commercial cameras

*Shin Suzuki[1]

1. Faculty of Regional Policy, Aichi University

Atmospheric gravity waves significantly contribute to the wind/thermal balances in the mesosphere and lower thermosphere (MLT) through their vertical transport of horizontal momentum originated from meteorological disturbances in the lower atmosphere. Airglow imaging is a useful technique to observe two-dimensional structure of small-scale (<100 km) gravity waves in the MLT region and has been widely used to investigate behaviours of the waves. Recent studies with simultaneous/multiple airglow cameras have derived spatial extent of the MLT waves. Such network imaging observations are advantageous to ever better understanding of coupling between the lower and upper atmosphere via gravity waves and will become increasingly important. In this study, we newly developed low-cost airglow cameras to enlarge the airglow imaging network. Each of the cameras has a fish-eye lens with a 185-deg field-of-view and equipped with a CCD video camera (WATEC WAT-910HX) ; the camera is small (W35.5 x H36.0 x D63.5 mm) and inexpensive, much more than widely-used airglow camera, and has a CCD sensor with 768 x 494 pixels that is highly sensitive enough to detect the mesospheric OH airglow emission perturbations. For multipoint network observations using the system, however it is necessary to improve on data flow to make vast amounts of image data available to the public.

In this presentation, we will share some results of performance evaluation of the new camera and development of data flow. Outreach and educational activities based on this research will be also reported.

Keywords: camera network, airglow, mesosphere

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Super-resolution and colorization of small body images by Generative Adversarial Network

Rintaro Kishi[1], Ren Hashimoto[1], *Rie Honda[1], Kimikazu Tanase[1], Yasuhiro Yokota[2], Seiji Sugita[3], Tomokatsu Morota[3], Shingo Kameda[4], Naoya Sakatani[4], Eri Tatsumi[5], Yuichiro Cho[3], Toru Kouyama[6], Manabu Yamada[7], Masahiko Hayakawa[2], Hidehiko Suzuki[8], Kazuo Yoshioka[3], Chikatoshi Honda[9], Kazunori Ogawa[2], Hirotaka Sawada[2]

1. Kochi University, 2. ISAS/JAXA, 3. Univ. of Tokyo, 4. Rikkyo Univ., 5. Instituto de Astrofisica de Canarias, Univ. of La Laguna, 6. AIST, 7. Chiba Inst. Tech, 8. Meiji Univ., 9. Univ. of Aizu

Super-resolution plays a big role in the choice of the landing site in the small body exploration. Conventionally, analytical techniques such as the reconstruction of higher resolution images using slightly shifted multiple images. In this study, we examined the method named SRGAN, based on Generative Adversarial Network, for estimation of a high-resolution image from the low-resolution image via learning and applied it to the images of asteroid Ryugu obtained by the ONC - T camera onboard Hayabusa2. The experimental result shows the improvement of images is confirmed visually and its calculation time is about 1sec for a 1024 x 1024 pixel image, which is fast compared with the conventional method.

In addition, we also examined the colorization of the single-band image by the method named pix2pix, which is also one of the methods of GAN. Multi-band images are utilized to speculate the type of surface material on the small bodies. However, obtaining multi-band images at the lowest altitude is difficult because the FOV of the cameras moves very fast relative to the surface. We also examined to generate pseudo color images from single-band images based on the learning of the pairs of single band images and pseudo color images. We will report the result of these experiments for asteroid Ryugu images obtained by Hayabusa2’s ONC-T.

Both methods are expected to help to make the decision-making process during the active small body exploration smooth by reducing the time required for analysis and improving the limited information at the maximum.

Keywords: GAN, small body expoloration, super resolution, colorization

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Thu. Jun 3, 2021 9:00 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:00 AM - 1:30 AM UTC | Ch.17 Zoom Room 17

[M-TT42] Frontiers in Geochemistry

convener:Tsuyoshi Iizuka(University of Tokyo), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Chairperson:Tsuyoshi Iizuka(University of Tokyo), Aya Sakaguchi(Faculty of Pure and Applied Science)

The Earth and planetary sciences have been advanced through utilizing chemical approaches and state-of-the-art analytical techniques. Recent analytical developments allow us to obtain highly precise and accurate data, but at the same time require deepen knowledge on the methodology to use the data correctly and effectively. This session aims at providing an opportunity for various researchers to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. In particular, researchers who would like to apply innovative analytical 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 developments, which have a potential for breakthrough of the Earth and planetary sciences. Any presentations related to the direction of future geochemistry and cosmochemistry are also welcome. We expect wide-ranged and future-oriented discussion to further develop geochemistry and cosmochemistry. Note that presentation language in this session can be either English or Japanese.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MTT42-01] High energy resolution fluorescence XAFS for the speciation of trace elements in environment

Yamaguchi Akiko[1,4], Hikaru Miura[3], Makoto Nagasawa[1], *Yoshio Takahashi[1,2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Photon Factory, 3.CRIEPI, 4.JAEA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MTT42-02] Quantifying denitrification rate across water-sediment interface in aquatic areas by using triple oxygen isotopes as tracers

*FEI CUIXIA[1], Fumiko Nakagawa[1], Urumu Tsunogai[1], Masanori Ito[1], Hiroka Mizuno (1.Nagoya University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MTT42-03] High-precision measurement of ^{17}O-excess in phosphate in hydrosphere

*Takashi Sambuichi[1], Urumu Tsunogai[1], Fumiko Nakagawa[1], Masanori Ito[1] (1.Graduate School of Environmental Studies, Nagoya university)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MTT42-04] Development of iron stable isotope measurement for biological tissue and its application to the marine organisms

*Nanako Hasegawa[1], TAKAAKI ITAI[1], Yoshio Takahashi[1], Tatsuya Kunisue[2], Shinsuke Tanabe[2] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.CMES, Ehime Univ.)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[MTT42-05] Interaction between Cerium and H_2O in Hydrous Rhyolitic Melts

★Invited Papers

*Nozomi Kondo[1], Yoshio Kono[1], Koji Ohara[2], Ryoichi Nakada[3], Toshiaki Ina[2], Etienne Skrzypek[4,7], Akihiro Yamada[5], Satoshi SAITO[6] (1.Geodynamics Research Center, Ehime University, 2.Center for Synchrotron Radiation Research, Japan Synchrotron Radiation Institute, 3.Kochi Institute for Core Sample Research, Japan Agency for Marin-Earth Science and Technology, 4.Graduate School of Science, Kyoto University, 5.Center of Glass Science and Technology, The University of Shiga Prefecture, 6.Department of Earth

Science, Graduate School of Science and Engineering, Ehime University, 7.Institute of Earth Science, University of Graz)

High energy resolution fluorescence XAFS for the speciation of trace elements in environment

Yamaguchi Akiko[1,4], Hikaru Miura[3], Makoto Nagasawa[1], *Yoshio Takahashi[1,2]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. Photon Factory, 3. CRIEPI, 4. JAEA

Speciation of trace elements in environment is essential for better understanding of their behaviors in environment. For this purpose, X-ray absorption fine structure spectroscopy (XAFS) in fluorescence mode is one of most effective methods, but interference on the signal of each trace element by those from background elements is a severe problem to selectively obtain the signal from trace elements. To overcome the difficulties, we have employed two methods, which are using (i) high energy resolution energy dispersive detector and (ii) wavelength dispersive detection system. In this presentation, various applications of the two methods were shown for chemical state analysis of trace elements in geochemical samples. For example, oxidation state of Eu in feldspar, oxidation state of Ce in weathered granite, and radiocesium (RCs) species in cesium-bearing silica microparticles (CsMP) using X-ray absorption near-edge structure (XANES) analysis in fluorescence mode. It is also evident that to measure extended X-ray absorption fine structure (EXAFS) spectroscopy is not possible due to the lower signal to noise ratio. On the other hand, XANES, which can be obtained for trace elements, is not very informative in terms of chemical state analysis of various elements in the samples. However, higher energy resolution detection of fluorescence X-ray than the degree of lifetime broadening enables us to measure XANES itself by better energy resolution, which is known as high energy resolution fluorescence detection (HERFD) XANES. The HERFD-XANES has more information on electronic state of each element given by the method, by which we can extract chemical information to the maximum degree possible. As an example of HERFD-XANES, speciation of cesium and barium adsorbed within the interlayer of phyllosilicates will be presented.

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Quantifying denitrification rate across water-sediment interface in aquatic areas by using triple oxygen isotopes as tracers

*FEI CUIXIA[1], Fumiko Nakagawa[1], Urumu Tsunogai[1], Masanori Ito[1], Hiroka Mizuno

1. Nagoya University

Nitrate is one of the most important nutrients in aquatic systems, however, increasing nutrients result in eutrophication. Denitrification, the microbial reduction of nitrate (NO_3^-) to gaseous products (N_2 and/or N_2O), is an important process removing excess loaded nitrate from aquatic systems. Denitrification primarily occurs in the sediment (Seitzinger, 1988). Methods to quantifying denitrification rates at water-sediment interface has been established, such as acetylene inhibition method (Sorensen, 1978). However, the rates quantified by using the method is not accurate, sediment slurries for assay of denitrification rates probably overestimate in situ rates because denitrification is severely limited by nitrate, and shaking forces nitrate into zones where it would not normally be present (Oremland et al., 1984).

Recently, triple oxygen isotopic composition has been used to quantify nitrogen dynamics in various ecosystems. While atmospheric nitrate shows anomalous ^{17}O-enrichment with mean ^{17}O-excess ($\Delta^{17}O$) of +26‰, remineralized nitrate shows $\Delta^{17}O$ of 0‰ (Tsunogai et al., 2016). Besides, $\Delta^{17}O$ of nitrate is constant during bacterial processes of denitrification and assimilation on nitrate. As a result, changes in $\Delta^{17}O$ of nitrate occur only through addition of remineralized nitrate newly produced through nitrification. Therefore, both denitrification and nitrification rates can be independently quantified by using $\Delta^{17}O$ nitrate as tracer.

The object of this study is to apply the $\Delta^{17}O$ method to quantify both denitrification and nitrification rates at water-sediment interface in aquatic systems. Sediment samples were collected from Lake Biwa, in summer (31st, Aug) and winter (1st, Dec) of 2020. The cores contained 2 L ~ 3 L of sediment with 1.2 L ~ 2.5 L of overlying water, and were incubated in the dark at 7 ℃ for 48 hours, after the $\Delta^{17}O$ nitrate tracer ($\Delta^{17}O \fallingdotseq +19.2‰$) was added to the overlying water. Water samples were collected at 12-hour interval with originally made sampler. Nitrate $\Delta^{17}O$ measurements were determined by converting the nitrate in each sample to N_2O using the chemical method (Nakagawa et al., 2013). Purified N_2O was introduced into our original gold tube unit (Komatsu et al., 2008), which was held at 780℃ for the thermal decomposition of N_2O to N_2 and O_2. The produced O_2 purified from N_2 was then subjected to a continuous-flow isotope ratio mass-spectrometry system to determine the $\delta 33$ and $\delta 34$ by simultaneous monitoring of O_2^+ isotopologues at m/z ratios of 32, 33 and 34.

Results showed that denitrification rates were about 20.0 μmol m^2 h^{-1} and 3.0 μmol m^2 h^{-1} in summer and winter respectively while the removal constant was stable at around 0.01h^{-1} between two seasons. Denitrification rate from the entire lake sediments was determined and compared with that from the entire water column of Lake Biwa in summer, at around 77.1 μmol m^2 h^{-1}. Denitrification rates in the water-sediment interface was about a quarter of that from the water column in summer.

Keywords: denitrification rate, sediment, triple oxygen isotopic compositions

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High-precision measurement of ^{17}O-excess in phosphate in hydrosphere

*Takashi Sambuichi[1], Urumu Tsunogai[1], Fumiko Nakagawa[1], Masanori Ito[1]

1. Graduate School of Environmental Studies, Nagoya university

Since the pioneer work by Tudge (1960), the oxygen isotope ratio ($\delta^{18}O$) of inorganic phosphate (PO_4^{3-}) has been widely used as a proxy for the sources of dissolved inorganic phosphate (DIP), an essential nutrient in hydrosphere. While phosphate assimilated into biosphere rapidly exchange oxygen atoms with those in H_2O through enzymatic reactions, the P–O bonds in phosphate are always stable during the inorganic processes in hydrosphere. Therefore, DIP preserves isotopic signals that primary reflect the environment in which DIP had interacted with biosphere.

The $\delta^{18}O$ value of DIP remineralized from organic phosphorus (Org-P), however, is a function of temperature and $\delta^{18}O$ of H_2O when DIP had been assimilated into biosphere and converted to Org-P. Besides, it also varies depending on the type of Org-P and enzymes which hydrolyzes Org-P into DIP. As a result, it was often difficult to fix $\delta^{18}O$ values of remineralized DIP in general and to clarify the sources of DIP in hydrosphere only by using $\delta^{18}O$ as a tracer.

Our aim in this study is to quantify the ^{17}O-excess of DIP in hydrosphere ($\Delta'^{17}O \approx \delta^{17}O - 0.528 \times \delta^{18}O$) as an additional tracer to overcome the problems in using $\delta^{18}O$ of DIP. Influences of the isotope fractionation process on ^{17}O-excess should be negligible owing to mass-dependent fractionation between the corresponding $\delta^{17}O$ and $\delta^{18}O$ values during the progress of the enzymatic reactions. As a result, the ^{17}O-excess in DIP remineralized from Org-P corresponds with that of ambient H_2O when DIP had been assimilated into biosphere and converted to Org-P. Therefore, the ^{17}O-excess in DIP can be a robust tracer to clarify the sources of DIP, such as biosphere or the other sources such as igneous rocks, which should be depleted in ^{17}O relative to hydrosphere. This is the first study to report accurate and precise ^{17}O-excess in DIP.

Firstly, we extracted phosphate from the samples of river water (Tempaku river, Aichi prefecture), igneous apatite, and chemical fertilizers and precipitate phosphate as Ag_3PO_4. The decomposition of Ag_3PO_4 to extract oxygen atoms as O_2 was performed with a fluorination technique using BrF_5 at 250℃. Extracted and purified O_2 was analyzed using the dual inlet mode of a mass spectrometer with a cup configuration of m/z = 32, 33, and 34. The SD during multiple measurements of in-house Ag_3PO_4 standards showed 0.3 ‰for $\delta^{17}O$, 0.6 ‰for $\delta^{18}O$, and 0.02 ‰for $\Delta'^{17}O$. The O_2 yield relative to the ideal oxygen quantity in the decomposed Ag_3PO_4 was 119 % ±7 %, implying that all oxygen in a sample was extracted quantitatively. Additionally, during the measurements on all samples including in-house Ag_3PO_4 standards, we could not find any significant correlations between the oxygen isotope ratios and the reciprocal of the O_2 quantity, which implies that contribution of blank O_2 was minimum. Thus, the $\delta^{17}O$ and $\delta^{18}O$ values were obtained as the mean of multiple measurements in this study.

While the $\Delta'^{17}O$ value of DIP under the oxygen isotope exchange equilibrium with ambient river H_2O was estimated to be $+27 \times 10^{-6}$, those of the riverine DIP determined in this study ranged from -71 to $+3 \times 10^{-6}$. It is difficult to explain this ^{17}O-depleted DIP through remineralization of Org-P in hydrosphere. Besides to DIP remineralized from biosphere, we should assume some additional sources for the ^{17}O-depleted DIP in this river. Because the $\Delta'^{17}O$ value of the ^{17}O-depleted DIP endmember coincided with that of chemical

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fertilizer ($\Delta'^{17}O = -94 \times 10^{-6}$) determined in this study, we concluded that direct input of chemical fertilizer into the DIP pool of this river might be highly responsible for the source of the ^{17}O-depleted DIP. Based on the isotopic mass balance of the $\Delta'^{17}O$ values, we estimated that 20–80 % of DIP in this river was derived from the chemical fertilizer.

Keywords: Triple oxygen isotope, Dissolved inorganic phosphate, Hydrosphere, Biosphere

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Development of iron stable isotope measurement for biological tissue and its application to the marine organisms

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Iron (Fe) is one of the essential elements in the biota and its biogeochemical cycle strongly controls the primary productivity in the ocean. Despite complexity of Fe cycle in surface ocean, application of Fe stable isotope through marine ecosystem has been limited. Here we show the variation of δ^{56}Fe of marine organisms collected from Northwest Pacific Ocean. The samples (n=32) include fishes (4 species), cephalopod (1 species), cetaceans (3 species), and zooplankton (mainly copepods) inhabiting around Japan. The process of Fe stable isotope fluctuation was discussed by focusing on (1) trophic level, (2) habitat, and (3) metabolic process.

The δ^{56}Fe was analyzed using multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS, Thermo Fisher Scientific, Germany). The pretreatment was established by improving the anion-exchange column separation for removing matrixes. The accuracy of the analytical method was evaluated using 4 types of biological certified reference materials (CRM; DORM-4, DOLT-5, BCR-414, and ERM-CE464). The difference between measured and certified values was <0.06 ‰which is smaller than the precision of duplicate measurements (0.09‰). We obtained new δ^{56}Fe value for BCR-414 and DOLT-5 which showed -0.09 ±0.07 ‰and -2.32 ±0.07 ‰, respectively.

The measured δ^{56}Fe of marine organisms were as following, zooplankton: -0.03 ±0.08 ‰(n = 1), fish muscle: -2.64 ‰to -0.71 ‰(n = 19, average: -1.65 ‰), cetacean muscle: −2.37 ‰to −1.74 ‰(n = 9, average: −2.15 ‰). Most biological samples had lower δ^{56}Fe than the reported value of surface seawater (+0.3 to +0.7‰, Conway and John, 2014). The δ^{56}Fe values increased in order of cetacean < fish < zooplankton, suggesting that light isotopes tend to enrich with increase of trophic level. This is consistent with the sequential change of isotope value through the food chain as observed by other elements such as nitrogen and calcium although directions of isotope shift are variable. Despite general decreasing trend of δ^{56}Fe with trophic level, Japanese sardines (*Sardinops melanostictus*), an important prey for migratory fish, showed significantly lower values than the higher predator fishes. This indicated that sequential depletion of heavy isotope is not only the predominant fractionation process, thereby species specific fractionation process controlled by physiological characteristics should be examined.

Regional differences were assessed by comparing δ^{56}Fe of Japanese sardines (off Kochi and off Miyagi) and skipjack tuna (*Katsuwonus pelamis*, offshore Kamchatka, off Sanriku, off Guam, and East China Sea) of which data of multiple regions were available. No significant regional difference was observed, although the number of samples from each region was limited. The range of δ^{56}Fe of all skipjack tuna (-1.46 ‰to -0.71 ‰) had clearly higher than that of sardines (-2.64 ‰to -1.73 ‰), suggesting that the difference of species control δ^{56}Fe greater than that of region.
According to the pharmacokinetic property of Fe, potential isotope fractionation processes are classified into absorption, metabolism (change in chemical form), and excretion. The higher δ^{56}Fe in the liver than in muscle was plausibly derived from large isotope fractionation between heme Fe (predominat Fe form in red blood cell and muscle) and non-heme Fe (mainly stored in liver) in the body. Hence, the ratio of Fe burden between heme Fe and non-hem Fe pools possibly control tissue specific isotope value. Intestinal absorption is another important fractionation process. Rate of absorption can be a controlling factor of δ

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^{56}Fe of whole body due to the preferential absorption of light isotope. Although precise estimation of absorption efficiency of each species is difficult, mass balance calculation using fisheries ecological data suggested absorption efficiency can be a most important controlling factor. Our data provided here can be useful benchmark of Fe isotope systematics through marine ecosystem.

Keywords: iron stable isotope, metabolism, marine food web

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Interaction between Cerium and H_2O in Hydrous Rhyolitic Melts

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Cerium (Ce) in silicate melt is considered to provide important information about the nature of silicate magmas in the Earth’ s and planetary interiors, especially about their oxidation state. However, the behavior of Ce in a silicate melt may not be simple, particularly in hydrous silicate melt, where a strong depression of the Ce^{4+}/Ce^{3+} ratio occurs. Here we investigate the interaction between cerium and H_2O in the structure of hydrous rhyolitic melts. Hydrous rhyolitic glasses quenched from melts at 1 GPa and 1300 ˚C show a significant decrease of H_2O solubility by the incorporation of Ce. Pair distribution function analyses show no distinct change in the local structures of hydrous rhyolitic glasses with the incorporation of Ce, while we found a distinct change in the intensity of the T-OH (where T is Si or Al) Raman peak. The incorporation of Ce decreases the proportion of T-OH species and increases those of Q^4 and Q^3 species. These results suggest the occurrence of a direct charge transfer reaction between OH^- in the melt and incorporated Ce as $Ce^{4+}_{melt} + 2(OH)^-_{melt} \rightarrow Ce^{3+}_{melt} + H_2O + O^-_{melt}$. This reaction causes a charge transfer from Ce^{4+} to Ce^{3+} in the hydrous rhyolitic melt, and it inevitably produces Ce^{3+}. X-ray absorption near-edge structure (XANES) measurements show almost completely trivalent Ce (Ce^{3+}) in the Ce-incorporated hydrous rhyolitic glasses, which supports the production of Ce^{3+} through the charge transfer reaction between Ce and OH^-. The decrease of Ce^{4+}/Ce^{3+} ratio reported in hydrous silicate melts would be due to the charge transfer reaction between Ce and OH^-, which implies that the Ce^{4+}/Ce^{3+} ratio in hydrous silicate melts may bear a complex relationship to the oxidation state of magmas.

Keywords: Cerium, Rhyolitic melt, Water

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Thu. Jun 3, 2021 10:45 AM - 12:15 PM JST | Thu. Jun 3, 2021 1:45 AM - 3:15 AM UTC | Ch.17 Zoom Room 17

[M-TT42] Frontiers in Geochemistry

convener:Tsuyoshi Iizuka(University of Tokyo), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Chairperson:Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

The Earth and planetary sciences have been advanced through utilizing chemical approaches and state-of-the-art analytical techniques. Recent analytical developments allow us to obtain highly precise and accurate data, but at the same time require deepen knowledge on the methodology to use the data correctly and effectively. This session aims at providing an opportunity for various researchers to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. In particular, researchers who would like to apply innovative analytical 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 developments, which have a potential for breakthrough of the Earth and planetary sciences. Any presentations related to the direction of future geochemistry and cosmochemistry are also welcome. We expect wide-ranged and future-oriented discussion to further develop geochemistry and cosmochemistry. Note that presentation language in this session can be either English or Japanese.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MTT42-06] High resolution mass spectrometry analysis of alkaline copper oxide degradation products from insoluble organic matter in carbonaceous chondrite

*Miho Shigenaka[1], Tomoko Amimoto[1], Hikaru Yabuta[1] (1.Hiroshima University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MTT42-07] Analysis of single platinum nanoparticles using high-time resolution multiple collector ICP-MS (HTR-MC-ICP-MS) and application to cosmochemical samples

*Norika Numa[1], Shuji Yamashita[1], Takafumi Hirata[1] (1.School of science, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MTT42-08] On-site Magnetic Separation of Heterogeneous Geological Particles

*Chiaki Uyeda[1] (1.Institute of earth and Space Science Graduate School of Science Osaka University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MTT42-09] Towards quantitative evaluation of the chondritic Earth model: A combined geo-neutrino, -physics, and -chemistry study

*Tsuyoshi Iizuka[1], Nozomu Takeuchi[1], Kenta Ueki[2], Akiko Tanaka[3], Sanshiro Enomoto[4], Hiroko Watanabe[5], Satoru Haraguchi[1] (1.University of Tokyo, 2.JAMSTEC, 3.AIST, 4.University of Washington, 5.Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MTT42-10] Element abundance modeling method with the gamma distribution for quantitative balance calculations

*Sanshiro Enomoto[1,2], Kenta Ueki[3], Tsuyoshi Iizuka[4], Nozomu Takeuchi[5], Akiko Tanaka[6], Hiroko Watanabe[7], Satoru Haraguchi[5] (1.Kavli Institute for the Physics and Mathematics of the Universe, University of Tokyo, 2.University of Washington, 3.Japan Agency for Marine-Earth Science and Technology, 4.University of Tokyo, 5.Earthquake Research Institute, University of Tokyo, 6.National Institute of Advanced Industrial Science and Technology, 7.Research Center for Neutrino Science, Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MTT42-11] Prospects of Ocean Bottom Geoneutrino Detector for direct observation of mantle radioactive element distribution

*Kenta Ueki[1], Natsue Abe[1], Hiroko Watanabe[2], Kunio Inoue[2], Taichi Sakai[2], William F McDonough[2,3,4], Eiichiro Araki[1], Takafumi Kasaya[1], Kyo Masanori[1], Noriaki Sakurai[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Tohoku University Research Center for Neutrino Science, 3.Graduate School of Science, Tohoku University, 4.University of Maryland)

High resolution mass spectrometry analysis of alkaline copper oxide degradation products from insoluble organic matter in carbonaceous chondrite

*Miho Shigenaka[1], Tomoko Amimoto[1], Hikaru Yabuta[1]

1. Hiroshima University

Introduction

It has been thought that asteroids, comets, and cosmic dusts delivered prebiotic organic molecules to the early Earth (Ehrenfreund et al. 2000). Carbonaceous chondrite, which are probably derived from carbonaceous asteroids, contains acid-insoluble organic matter (IOM) that accounts for a major part of the total organic carbon of the meteorite (Pizzarello et al. 2006). According to the previous studies, IOM is composed of aromatic molecular network crosslinking with short-branched aliphatic chains and various oxygen functional groups (Cody et al. 2002). However, because of its complex structure, the intact structure of IOM is still unknown. For better understanding of the chemical structure of IOM at a molecular level, we chemically degraded IOM by an alkaline CuO oxidation, which selectively cleaves ether bonds of macromolecules, and analyzed the decomposition products by using a high resolution mass spectrometry.

Sample and Methods

Insoluble organic matter was purified from the powdered sample (676 mg) of Murchison carbonaceous CM2 chondrite by an acid treatment with HCl/HF. The obtained IOM was heated with CuO (10 mg), 2N NaOH aq (2.5 ml), and ammonium iron (II) sulfate hexahydrate (1.2mg) at 170℃, 3 hours. After heating, the sample were extracted with ethyl acetate. The extracts were concentrated into 100 μl and were analyzed by a high-resolution mass spectrometry (LTQ Orbitrap XL, Thermo Fisher Scientific) negative ion mode.

Results and Discussion

In this study, 222 ion peaks were identified as the alkaline CuO oxidation products of IOM from Murchison meteorite. Based on the exact masses of the ion peaks, possible composition formula were individually estimated. The main ion peaks, such as m/z 165.01946 ($C_8H_6O_4$), m/z 121.02982 ($C_7H_6O_2$), m/z 181.01428 ($C_8H_6O_5$), m/z 137.02463 ($C_7H_6O_3$), m/z 209.00905 ($C_9H_6O_6$), are probably corresponded to benzendicarboxylic acid, benzoic acid, hydroxybenzendicarboxylic acid, hydroxybenzoic acid, and benzenetricarboxylic acid, respectively, which were previously identified by a gas chromatography coupled with mass spectrometry (GCMS) measurement of the alkaline CuO oxidation products of Murchison IOM (Hayatsu et al. 1980). In addition, the ion peaks corresponded to the other twenty-two compounds identified by Hayatsu et al. (1980), were also detected in this study. As a result, 195 ion peaks were newly identified in this study. According to an unsaturation degree of the possible

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composition formula, the peaks can be classified into 95 kinds of aliphatic carboxylic acids, 98 kinds of 1-3 ring-aromatic carboxylic acids and/or phenols, 9 kinds of nitrogen-containing compounds, 15 kinds of sulfur-containing compounds. Furthermore, the composition formula corresponded to dicarboxylic acids ranging from C_2 to C_{15} were identified in this study, implying that longer aliphatic chains are ether-linked between aromatic moieties in IOM than reported by the previous studies. There results demonstrate that a structure of IOM in carbonaceous chondrite is more complex than previously thought, and they constrain the origin and evolution of organic compounds in the early Solar System.

Keywords: Carbonaceous chondrite, Insoluble organic matter(IOM), Alkaline copper oxide degradation, High resolution mass spectrometry analysis, Asteroid

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Analysis of single platinum nanoparticles using high-time resolution multiple collector ICP-MS (HTR-MC-ICP-MS) and application to cosmochemical samples

*Norika Numa[1], Shuji Yamashita[1], Takafumi Hirata[1]

1. School of science, The University of Tokyo

Introduction

Heavy elements, which played an important role to define the physicochemical evolution of both the Earth and life, are mainly produced by a neutron capture reaction, including s- and r-processes (Burbidge et al., 1957). The r-process is an explosive reaction process, and thus, the estimating of amount and isotopic composition of the elements produced have been retarded. To overcome this, we are trying to derive the material evidence or constraints from presolar grains in meteorites.

The presolar grains are the small grains of sizes varying from nm to μm (Lewis and Anderson, 1983). Isotopic signatures of the light elements, such as C, N, O, or Si, have been widely used to identify the presolar grains, and very few approaches were made to identify the presolar grains based on heavy elements. To understand both the origin and transport mechanism of the heavy elements, new identification protocol using the heavy elements is highly desired. In this study, the element Pt, which enriched in r-process isotopes is used as a test element to establish the new identification protocol for the presolar grains in meteorites. To do this, we have developed a new analytical technique for both the sensitive and fast Pt isotopic ratio measurements from small particles (i.e., nanoparticles).

With the isotopic analysis of nanoparticles using the ICP-MS technique, great care must be placed on the systematical error in the measured isotopic ratio caused by counting loss due to very high-count rates of the analytes (Obayashi et al., 2017). Faced with this, careful correction for the counting loss due to detector dead time was made to obtain reliable isotopic ratio measurements from the transient signals emanating from nanoparticles.

Another important development is that the sampling technique of the cosmic nanoparticles from meteorites. In this study, a laser ablation in liquid (LAL) technique was applied to extract the cosmic nanoparticles in meteorites. With the LAL technique, sample grains can be collected into the small volume of water without nearly no chemical invasions, and also the particles could be physically dispersed in the liquid by the laser-induced shock wave (Okabayashi et al., 2011). Moreover, since the size of laser pit is about 10 μm, and thus, the sampling from specific area can be made with the LAL technique. In this study, development of both the analytical technique for the Pt isotopes and sampling procedures were conducted.

Experiments and results

In this study, dead time was carefully measured for reliable correction of the counting loss. The MC-ICP-MS instrument is the Nu Plasma 2 equipped with in-house high-time resolution ion counter (e.g.,

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maximum time resolution 10 μs). Dead time of the ion counter was calibrated using the W and Ba mixed solutions of various concentrations (0.24, 0.48, 1.2, 2.4, 4.8, 12, 24 μg/L). To evaluate the reliability of dead time obtained here, the isotope ratios for Pt nanoparticles of various sizes (30 nm, 50 nm, and 70 nm) were measured, and the resulting $^{196}Pt/^{194}Pt$ was 0.77143±0.02905 (2SE) for 30 nm Pt NPs, 0.76856±0.01597 (2SE) for 50 nm Pt NPs and 0.76889±0.00309 (2SE) for 70 nm Pt NPs. Relative deviations from the natural isotopic ratios ($^{196}Pt/^{194}Pt$ = 0.76566) were 0.74% for 30 nm Pt NPs, 0.38% for 50 nm Pt NPs, and 0.42% for 70 nm Pt NPs, suggesting that the relative deviation of the measured $^{196}Pt/^{194}Pt$ ratio agreed with the natural value within analytical uncertainties.

This is followed by the optimization of the sample extraction procedures using the LAL. Hence, Nd:YAG laser (wavelength 266 nm and pulse width 1 ns) was used. Laser ablation was carried out with a repetition rate of 1 kHz, laser fluence of 0.7 J cm^{-2}, and laser scanning speed of 20 μm/s.

The resulting nanoparticle-dispersed solutions obtained through LAL sampling on the matrix phase of the carbonaceous chondrite were subsidized to the Pt isotopic analysis using the HTR-MC-ICP-MS technique. From the resulting sample solution, Pt NPs being sizes of 20 –200 nm were detected, suggesting the effectiveness of both the analytical protocol and sampling procedure using the LAL technique. In this presentation, we will demonstrate the $^{196}Pt/^{194}Pt$ and $^{196}Pt/^{194}Pt$ ratios for individual small grains collected from the meteorites, and also discuss the possible sources of these grains.

Keywords: ICP-MS, Nanoparticles, Isotopic ratio, meteorites

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On-site Magnetic Separation of Heterogeneous Geological Particles

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A principle to perform chemical analysis of a solid sample in a non-descrutive manner was proposed based on its translation caused by a magnetic force. The field was generated by a permenent magnetic circuit;note that most solids, whihc are diamagnetic or weakly paramagnetic materials, were not considered to cause dynamic motions at a low field intensity.Here the practicability of the aforementioned technique was examined on single mg-size particles with various diamagnetic susceptibility (χ_{dia}), whihc was reproduced from its velocity v, assuming a classical energy conservation law, and practicability of identifying its material was confirmed; identification is performed by collating the *meausred* χ_{dia} with a list of published values. Th origin of χ_{dia} of a material is mainly attributed to its configuration of electron orbitals; hence, by using these parameters, a reliable material identification is possible which derive from its intrinsic structure. The experimental v did not depennd on particle mass m ; unlike the conventional magnetization measurements, χ_{dia} was obtained without measuring m. Similar m-independent property, as seen in the translations, was previously observed in the period of magnetic oscillation of mg-size silica-chips, and was obtained without measuring m. The m-independent properties appeared in the two motions because they were driven by body forces which were proportional to m, and in principle, magnetization of a very small sample is detected even if m of particle is difficult to obtain. Reliability of chemical analysis based on field-induced motions increases by parallelly consulting χ_{dia}. By realizing the proposed measurements in nm-size particles, extent of structural reconstruction in the surface layers, which generally proceed with reduction of particle diameter, are estimated from the anomalies observed in χ_{dia} values.[1]Uyeda et al., (2010) J. Phys. Soc. Jpn. 79, 064709, [2] Hisayoshi, et al, (2016) Sci. Rep 6, 38431. [3]Uyeda et al, (2019) Sci. Rep 9, 3931.

Keywords: magnetic separation, material analysis, on-site analysis

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Towards quantitative evaluation of the chondritic Earth model: A combined geo-neutrino, -physics, and -chemistry study

*Tsuyoshi Iizuka[1], Nozomu Takeuchi[1], Kenta Ueki[2], Akiko Tanaka[3], Sanshiro Enomoto[4], Hiroko Watanabe[5], Satoru Haraguchi[1]

1. University of Tokyo, 2. JAMSTEC, 3. AIST, 4. University of Washington, 5. Tohoku University

It is commonly assumed that the bulk Earth has chondritic relative abundances of refractory elements. Evaluating the validity of this long-standing paradigm is crucial for a wide range of issues in Earth science, such as the timing of Earth’ s formation and differentiation and the structure of the mantle. Electron antineutrinos produced by natural radioactivity within the Earth, the so-called geoneutrinos, offer a unique opportunity to quantify the abundances of refractory-lithophile elements U and Th in the entire mantle, which in turn allows us to evaluate the chondritic Earth model. The geoneutrinos have been measured with a liquid scintillator detector at KamLAND in Japan since 2005. The uncertainty of the geoneutrino flux measurement is now reduced to a level small enough to set useful constraints on the mantle U and Th abundances, provided that the crustal contribution to the measured total geoneutrino flux is well established by determining U and Th distributions around the detector. Yet, the U and Th distributions in the Japan Arc crust, in particular deep crust, remains to be constrained quantitatively. Towards quantitative evaluation of the chondritic Earth model, we have conducted a combined geo-neutrino, -physics, and -chemistry study. We first developed a methodological framework to construct a 3-D crustal composition model by combining geological, seismic, and geochemical data (Takeuchi et al., 2019 PEPI). In this method, we utilized the Bayesian inference technique to model the 3-D lithology map by combining seismic data as “observation” with a prior model based on a geologic map of local deep crustal exposure. Besides, we constructed U and Th abundance distribution models for different rock types based on published geochemical data for rock samples. We adopted the gamma distribution for the elemental abundance modeling, whereas previous studies adopted normal and log-normal distributions. Importantly, the gamma distribution modeling allows to estimate the unbiased mean from rock sample data that could be distorted due to detection limit and outliers. This point is crucial but often overlooked in mass balance calculations of geochemistry and geophysics, as detailed in a companion presentation by Enomoto et al. By convolving the 3-D lithology model with the rock U and Th distribution models, we constructed 3-D probability density function (PDF) models of U and Th abundances in the Japan Arc crust, and then calculated crustal geoneutrino flux. This new methodology enables constructing a fully probabilistic flux model, but the uncertainties are large at ~70%. This is due to the difficulty in handling of correlations among all the PDFs at different locations in the flux integration: We conservatively assumed maximum correlations, leading to the large uncertainties. An investigation into the correlations is in progress. In this presentation, we report the current status and prospects of our interdisciplinary study.

Keywords: geoneutrino, chondritic Earth, crustal modeling

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Element abundance modeling method with the gamma distribution for quantitative balance calculations

*Sanshiro Enomoto[1,2], Kenta Ueki[3], Tsuyoshi Iizuka[4], Nozomu Takeuchi[5], Akiko Tanaka[6], Hiroko Watanabe[7], Satoru Haraguchi[5]

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Rocks display highly variable trace element abundances, even those with similar major element compositions. To estimate the trace element compositions of geochemical reservoirs containing various rocks, such as the continental crust, trace element distributions must be modeled. Normal and log-normal distributions have been widely adopted to model trace element data of rocks and the median has been widely used as a representative value of trace element abundance. However, such modeling or treatment does not preserve the mean value of the distribution, leading to biased results of mass balance calculations. On the other hand, it is often impossible to directly use the mean of the samples because of sample imperfections due to analytical detection limits, outliers, and other reasons. Here we present a method to model unknown true distributions without causing a bias on the means, combined with proper treatment of sample cutoffs. We show that the new method preserves the mean values of ideal samples of any distributions and is robust against actual sample imperfections. Although the method was primarily developed for geoneutrino analysis in Japan, for which mass and energy balance calculations among the crust, mantle, and the whole Earth are essential, it is applicable to many balance calculations that require the conservation of mean values.

Keywords: geochemical modeling, continental crust, geoneutrino

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Prospects of Ocean Bottom Geoneutrino Detector for direct observation of mantle radioactive element distribution

*Kenta Ueki[1], Natsue Abe[1], Hiroko Watanabe[2], Kunio Inoue[2], Taichi Sakai[2], William F McDonough[2,3,4], Eiichiro Araki[1], Takafumi Kasaya[1], Kyo Masanori[1], Noriaki Sakurai[1]

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Geoneutrino is an anti-neutrino emitted in the beta decay of radioactive isotopes in the earth. Geoneutrinos derived from uranium and thorium can be observed with the current observation. It means that the total amount of uranium and thorium in the whole solid earth can be directly estimated by geoneutrino observation. The information from geoneutrino, the amount of uranium and thorium in the earth, is key for understanding the amount of radiogenic heat in the earth that drives geodynamics and understand the origin of the solid earth.

Current geoneutrino observations are being carried out by the neutrino detector "KamLAND" in Kamioka, Gifu Prefecture. Since uranium and thorium are enriched in the crustal rocks, we have to estimate the neutrino flux from the nearby Japanese crust and subtract the crustal neutrino from the observations of KamLAND to obtain mantle geoneutrino. As such, the mantle information obtained from the current observations has a large error due to uncertainties related to crustal geoneutrino.

Ocean Bottom Geoneutrino Detector (OBD) has been proposed as a possible innovation of geoneutrino science. Since the oceanic crust is thinner and contains less uranium and thorium than the continental crust, OBD will allow us to observe mantle-derived geoneutrino with higher accuracy than the current on-land observation. Furthermore, OBD will be movable and will allow us to conduct global multipoint geoneutrino observations. Consequently, ocean bottom neutrino observation will enable us to obtain direct information of the high accuracy three-dimensional distribution of radioactive elements inside the earth. We will introduce the results of geoneutrino observations so far. Also, we will present the future prospects for ocean floor geoneutrino observations.

Keywords: Geoneutrino, Radioactive elements

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

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[M-TT42] Frontiers in Geochemistry

convener:Tsuyoshi Iizuka(University of Tokyo), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University)

The Earth and planetary sciences have been advanced through utilizing chemical approaches and state-of-the-art analytical techniques. Recent analytical developments allow us to obtain highly precise and accurate data, but at the same time require deepen knowledge on the methodology to use the data correctly and effectively. This session aims at providing an opportunity for various researchers to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. In particular, researchers who would like to apply innovative analytical 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 developments, which have a potential for breakthrough of the Earth and planetary sciences. Any presentations related to the direction of future geochemistry and cosmochemistry are also welcome. We expect wide-ranged and future-oriented discussion to further develop geochemistry and cosmochemistry. Note that presentation language in this session can be either English or Japanese.

[MTT42-P01] High-precision La isotope measurements to apply early Solar System chronology and nuclear cosmochronology

*Mitsuru Suzuki[1], Tsuyoshi Iizuka[1], Kota Yamamoto[1], Takafumi Hirata[1] (1.The University of Tokyo)

[MTT42-P02] **Factors limiting the accuracy and precision of peak positions and intensity ratios in Raman spectra: Optimisation of optics and measurement environment for carbon isotope ratio measurements of CO_2**

*Yuuki Hagiwara[1], Junji Yamamoto[1] (1.Hokkaido University)

[MTT42-P03] Development and evaluation of wet-flow type isotope analyses for fluid-inclusions in speleothems

*Ryu Uemura[1] (1.Nagoya University)

[MTT42-P04] Sub-microgram sulfur isotope analysis for the biological, geological, and extraterrestrial samples by sensitivity-improved EA/IRMS

*Nanako O. Ogawa[1], Toshihiro Yoshimura[1], Takeru Kochi[2,1], Junichiro Kuroda[2,1], Yoshinori Takano[1], Naohiko Ohkouchi[1] (1.JAMSTEC, 2.AORI, Univ. Tokyo)

High-precision La isotope measurements to apply early Solar System chronology and nuclear cosmochronology

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In the nature, La consists of two isotopes, ^{138}La and ^{139}La. ^{138}La is expected to be synthesized only by supernovae likewise short-lived radionuclides ^{92}Nb and ^{98}Tc. ^{92}Nb, which decays to ^{92}Zr with a half-life of 37 Myr, is one of the important chronometers for planetary differentiation in the early Solar System. It has been recently shown that ^{92}Nb was heterogeneously distributed in the early Solar System (Hibiya et al., in review). Thus, the use of ^{92}Nb as a chronometer requires the calibration of the heterogeneous distribution. The long-lived nuclide ^{138}La ($T_{1/2}$=105 Gyr) can be used as an index of the ^{92}Nb heterogeneity because of having the same origin as ^{92}Nb. Moreover, combining ^{138}La with ^{98}Tc, which decays to ^{98}Ru with a half-life of 4.2 Myr, potentially allows us to precisely constrain the timing and location of the supernova explosion which introduced these nuclides into the parental molecular cloud of the Solar System. Thus, ^{138}La analysis can be a strong tool for both the early Solar System chronology and nuclear cosmochronology.

So far, La isotope analysis has been conducted for limited samples such as Ca-Al-rich inclusions (CAIs) and several chondritic bulk samples. The results revealed that CAIs have ^{138}La excesses of up to 60±16 ε (2SD) (Shen and Lee, 2003), whereas for bulk meteorite sample ^{138}La anomalies are marginally resolvable only for carbonaceous chondrites (12±8 ε (2SD)) (Shen et al., 1994). To apply ^{138}La anomaly for the early Solar System chronology and nuclear cosmochronology, it is necessary to improve the precision of La isotope analysis.

In this study, we tested the precision of La isotope measurements by multiple collector ICP mass spectrometry (MC-ICP-MS). With this instrument, we can adopt the external calibration technique for instrumental mass bias effect for La having only two isotopes. Meanwhile, MC-ICP-MS analysis requires the correction of isobaric interferences on ^{138}La from ^{138}Ba and ^{138}Ce. The very low abundance of ^{138}La (0.1%) also makes it difficult to carry out a high-precision analysis. While 10^{11} Ωamplifiers are often used in mass spectrometries, we adopted 10^{13} Ωamplifier on 138 amu and 10^{10} Ωamplifier on 139 amu to improve the precision.

We measured a La standard solution NIST 3127a. Adopting the external calibration technique has improved the precision 10–20 times better than La standard bracketing method. Moreover, the isobaric interferences of ^{138}Ba and ^{138}Ce were corrected for by monitoring ^{137}Ba and ^{140}Ce, increasing the precision about 2 times compared to when no interference corrections made. As a result, we achieved an internal precision of ±1.4 ε (2SE) for a 80 ppb La standard solution.

Keywords: La, supernova, early Solar System, MC-ICP-MS

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Factors limiting the accuracy and precision of peak positions and intensity ratios in Raman spectra: Optimisation of optics and measurement environment for carbon isotope ratio measurements of CO_2

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Raman spectroscopy has been established as one of the most versatile quantitative analytical methods in materials science research due to its non-destructive analysis and high spatial resolution. Experimental calibration is performed to relate Raman spectral characteristics to the state of materials to quantify density, pressure, temperature, concentration, strain, etc. In recent years, Raman spectroscopy has been used to improve and develop non-destructive local isotope analysis methods for H_2O, CO_2, CH_4, HCO_3^-, CO_3^{2-}, N_2, humic acid, calcite, etc. However, the accuracy of these methods is still far from being applied to the measurement of isotope ratios in natural samples. For example, Arakawa et al. (2007)[1] and Yokokura et al. (2020)[2] reported 1 σ = 20‰ and 8.7‰, respectively, for the accuracy of carbon isotope ratio measurements of CO_2. In Yokokura et al. (2020)[2], the reason for the improvement in measurement accuracy is that the focal length of the monochromator is longer, the pixel resolution is higher, and the measurement time is longer, but it is not clear which factors contribute most to the improvement. Other parameters such as excitation wavelength, grating engraving number and size, slit width, detector noise characteristics, reciprocal line dispersion, and pixel size can also have a significant effect on measurement accuracy, but the relationship between these parameters and measurement accuracy is not well understood. Once we know which optics can be upgraded most efficiently to improve the accuracy of our measurements, we will be able to overcome the 1 σ = 8.7‰ barrier reported by Yokokura et al. (2020)[2] while reducing cost and time. In this study, we use simulated CO_2 Raman spectra to evaluate how the above parameters affect the accuracy of intensity ratio measurements.

The factors limiting the accuracy of Raman spectroscopy can be divided into three main categories: (1) noise, (2) spectral resolution, and (3) thermal and mechanical stability of the instrument.

To obtain the shot noise, the efficiency of Raman scattering (count/sec) is used as an input parameter, and the average number of photons (e-) arriving at the detector in a certain time interval is estimated from the quantum efficiency of CCD (%) and A/D count (e-/count). The square root of this value was then randomly generated as shot noise according to Poisson statistics. Dark noise and readout noise were randomly generated as Poisson and Gaussian distributed noise, respectively, using the measured values of 1.00×10^{-5} (e-/pix/sec) and 3.36 (e-/times$^{0.5}$). The effect of the instrumental spectral resolution on the peak bandwidth was introduced following the model of Liu et al. The projection of the slit on the CCD and the spectrum of the sample were assumed to be Gaussian distributed, and the resulting bandwidth was calculated to be the square root of (spectral resolution)^2+(natural bandwidth)^2.

Based on the above model, it is possible to generate spectra taking into account the effects of noise and spectral resolution by assuming the analysis time (sec), the number of vertical pixels (pix) (i.e. binning width), the shape of the Raman spectrum, the peak position (cm^{-1}), the natural bandwidth (cm^{-1}) and the amplitude (count/sec). It is possible to generate spectra taking into account the effects of noise and spectral resolution. In this study, the Raman spectra of CO_2 generated by the above method with varying the parameters were fitted with the spectrum analysis software (GRAMS/AI) to investigate which parameters affect the measurement accuracy such as peak position and intensity ratio. Finally, we estimate under what conditions the carbon isotope ratio of CO_2 can be measured with an accuracy of ‰.

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Keywords: Raman spectroscopy, Carbon isotope ratio, Quantification, Spectral resolution, Noise

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Development and evaluation of wet-flow type isotope analyses for fluid-inclusions in speleothems

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Cavity-ringdown spectrometers (CRDS) are used for hydrogen/oxygen stable isotope ratio analyses of fluid inclusions in speleothems. Several methods for analyzing fluid inclusions in stalagmites have been developed [(e.g., 1-3)]. However, stable isotope ratio analysis of water in fluid inclusions has a problem of memory effect [(3)]. In this study, we develop and evaluate a method for measuring isotope ratios in fluid inclusions to improve the sample throughput by reducing the memory effect.

The measurement line consists of a water extraction unit and a detector (CRDS, Picarro 2140-i) that measures the water isotope ratio. Stalagmite sample was crushed under a vapor stream (i.e., moisturized carrier gas) in which the isotope ratio and concentration are constant. This wet flow type method has been improved due to various developments [(1-2)].

We succeeded in producing a stable water vapor concentration (± 6 ppm, standard deviation for 10 minutes). The repeated measurement precision(1 σ) of working standard water (in the range of 0.1-0.4 μL) was ±0.1-0.2 ‰, ±0.1-0.2 ‰and ±0.2-0.6 ‰for $\delta^{17}O$, $\delta^{18}O$ and δD, respectively. As reported in previously, the precision became worse as the sample volume was 0.1 μL or less. By adjusting the introduction rate of water vapor, the accuracy could be maintained even at 0.05 μL.

References: (1) Affolter et al., Clim. Past, 2014; (2) De Graaf et al., Rapid Commun Mass Spectrom., 2020; (3) Uemura et al., Geochim. Cosmochimi. Acta, 2016

Keywords: speleothem, stable isotope, fluid inclusion, CRDS

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Sub-microgram sulfur isotope analysis for the biological, geological, and extraterrestrial samples by sensitivity-improved EA/IRMS

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The natural isotopic composition of sulfur ($\delta^{34}S$) is a useful, strong tool in geochemistry, ecology, environmental and planetary sciences. However, the scope of application is often limited by analytical capability. In the case of a sulfur isotope as well, it was often limited by analytical requirements for a large sample size (>60 μgS), and complicated preparatory procedures. To achieve precise measurement of $\delta^{34}S$ within small and limited quantities of samples, and to expand the scientific applicational range of the tool, we have developed a robust, sensitivity-improved sulfur isotopic analysis system by optimizing a commercial continuous-flow elemental analyzer/isotope-ratio mass spectrometer (EA/IRMS). Our EA/IRMS system successfully reduced the quantity of the required sample to 0.4 μgS or less to obtain reliable data of the sulfur abundances and isotopic compositions. In this presentation, we introduce the overview of the sensitivity-improved EA/IRMS for $\delta^{34}S$ with some application results from natural samples, such as gypsum, meteorites, and sulfur-containing organic compound such as methionine from biological samples.

Geological Samples: We established the conventional method to obtain $\delta^{34}S$ from gypsums and foraminiferal carbonates, with precisions of ±0.2‰ from samples of 0.5-2 μgS. The method was applied to study the sulfur cycle and evaporite formation during the Messinian Salinity Crisis. We will introduce the method details and the partial results of the project, as the main results will be presented and discussed by Kochi *et al.* at Session M-IS16 in this meeting.

Extraterrestrial Samples: We will also present the preliminary results of δ34S for carbonaceous chondrites (Murray, Murchison, Yamato 793321). The isotopic composition of bulk sulfur was obtained by analyzing the original (pre-treated) powders and the SOM extracted residues for these samples. The analytical techniques are going to be applied to investigate sample material recovered from the C-type asteroid Ryugu, as part of the Hayabusa2 SOM analysis team objectives [1,2].

Compound-Specific Samples: When combined with the compound-isolation/purification benefits of high-performance liquid chromatography (HPLC), the improved sulfur EA/IRMS can be applied to organic molecules, spanning a wide range of polarities and molecular weights, as well as investigate compound-specific isotope analysis. We will present the obtained $\delta^{34}S$ of Methionine separated from natural samples.

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Keywords: Sulfur isotope, Compound specific isotope analysis, Messinian Salinity Crisis, C-type asteroid Ryugu, Hayabusa2

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-ZZ Others

Thu. Jun 3, 2021 5:15 PM - 6:30 PM JST | Thu. Jun 3, 2021 8:15 AM - 9:30 AM UTC | Ch.19_2

[M-ZZ46] Marine Manganese Deposits: Origin, Exploration, and Development

convener:Akira Usui(Marine Core Research Center, Kochi University), Katsuhiko Suzuki(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Takashi Ito(Faculty of Education, Ibaraki University)

Marine manganese deposits occur in all world oceans, as nodules, crusts, and massive oxide aggregates. The deposits are known as potential resources of Co, Cu, Ni, REE as well as geological archives of surface environments. However, the controlling parameters on the regional and temporal variations in chemical and mineralogical composition have not been well understood yet. In the session, various factors in growth, enrichment and circulation of metals, paleoenvironment, formation age are discussed with the results of exploration and environmental impact studies from viewpoints of geosciences, engineering, and environments.

[MZZ46-P01] Detrital minerals in hydrogenetic ferromanganese crusts as an alternative tool for archiving marine geological environments

*Akira Usui[1], Takashi Ito[2], Hirokuni Oda[3], Hitoshi Hasegawa[4] (1.Marine Core Research Center, Kochi University, 2.Ibaraki University, 3.AIST, 4.Kochi University)

[MZZ46-P02] Fluxes of sinking particles in the exploration area for cobalt-rich ferromanganese crusts in the Northwest Pacific

*Kyoko Yamaoka[1], Atsushi Suzuki[1], Yuichiro Tanaka[1], Masahiro Suzumura[2], Ayumi Tsukasaki[2], Tatsuo Fukuhara[3], Takeshi Fujii[3], Junpei Minatoya[4], Nobuyuki Okamoto[4], Yoshiaki Igarashi[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Environmental Management Research Institute, National Institute of Advanced Industrial Science and Technology, 3.KANSO Co., Ltd., 4.Japan Oil, Gas and Metals National Corporation)

[MZZ46-P03] Submarine erosion of basement sedimentary rocks around ferro-manganese crust fields

*Takashi Ito[1], Masaki Saito[1], Eri Shimizu[2], Takashi Miyazaki[3], Bogdan S. Vaglarov[3], Katsuhiko Suzuki[3], Akira Usui[4] (1.Faculty of Education, Ibaraki University, 2.JOGMEC, 3.JAMSTEC, 4.Center for Advanced Marine Core Research, Kochi University)

[MZZ46-P04] Local structure of rare earth elements in marine ferromanganese oxides by extended X-ray absorption fine structure analysis

*Makoto Nagasawa[1], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

[MZZ46-P05] Reconstruction of rotation by paleomagnetic analysis of manganese nodules collected in the South Pacific

*Wataru Katanoda[1,2], Hirokuni Oda[2], Masafumi MURAYAMA[3], Akira Usui[3] (1. Kochi university Graduate school of Integrated Arts and Science, 2.National Institute of Advanced Industrial Science and Technology, 3.Kochi university)

[MZZ46-P06] Lamina-scale analysis of chemical composition of the mid-Cretaceous northern Shimanto belt, Kochi, Japan: implications for formative processes of bedded ferromanganese deposits

*Go-Ichiro Uramoto[1], Takaumi Nagata[1], Yoshiro Nishio[1] (1.Kochi University)

[MZZ46-P07] Biodiversity and connectivity of deep-sea amphipods at seamounts with cobalt-rich ferromanganese crusts in the Northwest Pacific

*Akira Iguchi[1], Eri Ikeuchi[1], Hiroyuki Yokooka[2], Hideki Sugishima[2], Kazumasa Ikeda[3], Ryuichi Miwa[4], Miyuki Nishijima[1], Nozomu Iwasaki[5], Yuichiro Tanaka[1], Taiga Kunishima[6], Shogo Kato[7], Junpei Minatoya[7], Yoshiaki Igarashi[7], Nobuyuki Okamoto[7], Atsushi Suzuki[1] (1.National Institute of Advanced Industrial Science and Technology, 2.IDEA Consultants, Inc., 3.Okamoto Glass Co., Ltd., 4.Kaiyo Engineering Co., Ltd., 5.Faculty of Geo-Environmental Science, Rissho University, 6.Wakayama Prefectural Museum of Natural History, 7. Japan Oil, Gas and Metals National Corporation)

Detrital minerals in hydrogenetic ferromanganese crusts as an alternative tool for archiving marine geological environments

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Since iron and manganese oxides have been precipitated in the world oceans since 20Ma or older, most of the deep-sea floors are covered with ferromanganese crusts and nodules. The hydrogenetic ferromanganese crusts are in particular noted as potential paleoceanographic archives as well as future metal resources. They can be used as a tape recorder for deciphering the historical changes in marine geological environments, as indicators of environmental changes. We have reported laminated structure or compositional changes of major chemical composition on various scales and their regional changes. However, most of the data that read the variations are growth structure of major iron-manganese oxide only, which is the principal hydrogenetic components. In this study, we paid special attention to other minor components useful to read the history. The goal is to utilize better techniques for further research and development for more reliable criteria for identification of mineral particles similarly to marine sediment cores. The target materials are the substrate rocks on the seafloor, terrigenous mineral particles (river output, eolian dust), remains and traces of organisms, extraterrestrial materials, volcanic ash, hydrothermal precipitates, and authigenic precipitates. We tried to identify the materials using high-resolution optical/electron microscopes, microscale analysis, X-ray CT, analysis software, acid leach, gravity separation, etc. As a result, together with the earlier reports on magnetic minerals, we found that microfossil assemblage, cosmic spherules, weathering products, chemical precipitates. We have several issues in the processes of separation, age models, and identification of the factors of the spatiotemporal fluctuations, but expect better future in archiving the paleoenvironmental information from the detrital components in marine manganese deposits.

Keywords: paleoceanography, manganese crusts, ocean sediments

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Fluxes of sinking particles in the exploration area for cobalt-rich ferromanganese crusts in the Northwest Pacific

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To assess the environmental impact of deep-sea mining, it is important to understand natural spatial/temporal variations and their mechanisms. As part of the environmental baseline survey in the exploration area for cobalt-rich ferromanganese crusts in the Northwest Pacific, we have conducted sediment trap observations around five seamounts (JA02, JA03, JA04, JA06, JA17). The sinking particles mainly consisted of biogenic carbonate, and total mass fluxes were low (~5 mg m^{-2} d^{-1}), which are consistent with the characteristics of the oligotrophic open ocean. The JA17 Seamount, which is located in the northernmost portion of the area (~24Nº), showed relatively elevated total mass fluxes and a seasonal peak corresponding to the spring bloom. The sinking particles also contained higher biogenic opal, suggesting contribution of diatoms. On the other hand, the total mass fluxes at other seamounts showed seasonality with a sharp peak in late summer (August–September), although satellite data indicated the lowest primary production in summer. This discrepancy could be explained by short-lived or subsurface blooms induced by passing typhoons (Yamaoka et al., 2020).

We also measured elemental composition of the sinking particles collected around JA06 Seamount located in the south of the area. The results demonstrated that elemental fluxes in the area are controlled by four major processes: lithogenic (Al, Ti, Fe), carbonate (Mg, Ca, Sr), biogenic (+scavenging) (Ni, Zn, Cd, Pb), and scavenging (V, Mn, Co, Cu, REE). The estimation of excess flux based on the composition of upper continental crust demonstrated that >85% of total Mn, Co, Ni, Cu, Zn, Cd, and Pb fluxes were attributable to scavenging (+biogenic uptake). Scavenging-dominant metal fluxes are likely ubiquitous in the oligotrophic open ocean. Interestingly, the excess fluxes of Mn (1.3–7.0 μg m^{-2} d^{-1}) and Co (0.04–0.1 μg m^{-2} d^{-1}) for sinking particles in this study roughly corresponded to the metal fluxes into ferromanganese crusts (1.9–3.0 μg m^{-2} d^{-1} for Mn and 0.03–0.11 μg m^{-2} d^{-1} for Co) estimated by Sato and Usui (2018). Recently, Usui et al. (2020) presented evidence of ongoing precipitation of Fe-Mn oxide particles (a few micrometers in diameter) from normal seawater at 900–4500 m depth based on *in situ* 15-year exposure tests. Such particulate precipitates could be a common source of Mn for both cobalt-rich crusts and sinking particles.

Keywords: seamount, sinking particle, ferromanganese crust

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Submarine erosion of basement sedimentary rocks around ferro-manganese crust fields

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The ferromanganese crust Sample HPD#958R12 collected from the depth of 1424 m at Takuyo-Daigo Seamount in the western Pacific Ocean was used as a research target to investigate the seamount erosion around the crust formation site. The number of fish tooth fossil samples separated from the 7-layers within the surficial 4 cm of this crust is 25 to 54, and the mass is about 0.1 mg to 0.2 mg. The fish tooth fossils for each of these strata were chemically treated and yield the $^{87}Sr/^{86}Sr$ ratio ranging from 0.70809 to 0.70880. The Sr isotopic composition of each fish tooth group in all layers is significantly lower than the coeval seawater Sr isotope ratio estimated from the ^{10}Be age of each layer of the crust. No specific pattern is observed in the growth direction. Based on these results, it was clarified that the teeth of fish contained in the crust include not only the fish that lived during the crust growth but also the older tooth fossils with lower Sr isotope ratio. The field observation by JAMSTEC ROV and the examination of the collected samples reveal that the exposed sedimentary rocks near the summit of Takuyo-Daigo Seamount are hard, phosphatized Cretaceous reef deposits. The results of this study clearly suggest that the following mechanism are very common, i.e. these phosphatized basement rocks are physically eroded and the washed-out fish teeth are contained in the growing layer of the crust. It was shown that the phenomena of physical erosion of hard sedimentary rocks and chemical precipitation of manganese oxide coexist in the seamounts.

Keywords: ferromanganese crust, fish tooth fossil, Strontium isotope

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Local structure of rare earth elements in marine ferromanganese oxides by extended X-ray absorption fine structure analysis

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Introduction
Marine ferromanganese oxides (MFMO), which is a mixture of nanoparticles of iron oxides and manganese oxides, formed as nodules or crusts at seafloor has been also of great interest as promising materials as metal resources. Among various elements enriched to MFMO, total abundance of rare earth elements (REE) enriched to MFMO reachs 2000 mg/kg. However, the extraction of REE other than by acidic solutions has not been reported for MFMO. In particular, high extraction rate of the target ions by aqueous solution at circumneutral pH is preferred, considering its possible influence on environment and ease to handle it for the refining processes.
In this study, speciation of REE, or yttrium (Y), in MFMO was conducted by extended X-ray absorption fine structure (EXAFS) analysis to reveal REE species adsorbed at the surface of MFMO or incorporated into MFMO. The species is highly important to understand their enrichment to the materials and also their extraction rate under various conditions. More specifically, formation of inner- and outer-sphere complexes at the solid-water interface is a most important factor controlling the extraction rate.

Sample and experimental
Typical marine ferromanganese nodules (D535) at the seafloor (water depth: 5222 m) employed in this study was collected in the Central Pacific, which is most likely formed by precipitation directly from seawater. This hydrogenetic process was also supported by iron and manganese ratio and other geochemical and mineralogical characteristics reported previously (Takahashi et al., 2007). Total REE abundances in D535 were 1920 mg/kg (Y: 130 mg/kg). EXAFS for Y at K-edge was employed to clarify the local structure of Y, or REE, in D535 at beamline BL01B1 in SPring-8.

Results and discussion
EXAFS spectra in k space for hydrated Y^{3+}, Y adsorbed on MnO_2 and goethite, and Y in D535 showed that the spectrum of Y in D535 is very similar to that of Y adsorbed on MnO_2. More quantitative analysis was conducted by the fitting of each shell in the spectra in R space for Y on MnO_2 and Y in D535 using backscattering and phase shift parameters given by FEFF. The fitting results quantitatively revealed that Y forms inner-sphere complex on MnO_2. It is suggested thta inner-sphere complexation of Y^{3+} in MnO_2 is essential as the host phase of trace elements under seawater condition with high salinity, because high ionic strength inhibits formation of outer-sphere complex as adsorbed species due to the ion-exchange reaction with other abundant cations in seawater.

Keywords: Rare earth element, Extended X-ray absorption fine structure, Speciation

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Reconstruction of rotation by paleomagnetic analysis of manganese nodules collected in the South Pacific

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Marine manganese nodules are believed to grow at or within the deep-sea sediments, and assumed uplifting and overturn during the growth without burial. We try to reconstruct the rotation and overturn during the growth process based on a paleomagnetic perspective using the manganese nodules collected with deep sea clay sediments.The Earth's magnetic field averaged over thousands of years can be approximated by a geocentric axial dipole, and the remanent magnetization direction recorded on the surface of a manganese nodule growing in a magnetic field is expected to correspond to the magnetic field direction at that time. If the manganese nodule has not been rotated during the growth process, the paleolatitude can be determined by determining inclination from the remanent magnetization direction. On the other hand, if the manganese nodule has rotated, the paleolatitude calculated from inclination will be different from the actual latitude, and the amount of rotation can be detected from this discrepancy.

The nodules were collected by a box corer (158˚30'64" W, 12˚00'03" S) from a depth of 5248 m in the GH83-3 Hakurei-maru cruise conducted by the Geological Survey in 1983 in the Penrhyn Basin. This is a spherical sample (B92-1-1; 74 mm long, 60 mm wide, and 66 mm high). The nodules were marked at the apex (center) with a white dot on board as a reference for the vertical direction.

The sample was split in half lengthwise on the plane including the white dot and the center of the nodule, and the vertical slice sample A was taken from the section as well as another vertical slice. Both slices were divided into five rows of strips, and then further divided in the growth direction into five subsamples. The samples were further divided into five or ten subsamples in the direction of growth to allow confirmation of changes in paleomagnetic and rock magnetic parameters with growth. The natural remanent magnetization of the subsamples was measured using a pass-through superconducting rock magnetometer (2G Enterprises Model 760R) at the National Institute of Advanced Industrial Science and Technology (AIST), and the primary remanent magnetization component was determined by stepwise alternating current demagnetization experiments and analysis of the demagnetization curve. Furthermore, rock magnetic properties such as magnetic hysteresis, isothermal remanent magnetization acquisition curve, and First Order Reversal Curve (FORC) were measured using a vibrating sample magnetometer (Lakeshore VSM 8604).

The paleomagnetic data confirmed that the paleomagnetic inclination of the samples near the surface near the white marker for both samples A and B are in good agreement with the expected geomagnetic inclination value (-23 degrees) at the sample collection point. This confirms that the surface layer of the sample records the current geomagnetic field. In addition, the paleomagnetic inclination tends to become deeper as we go back in time, indicating the sample was rotating. We discuss the possibility of rotation of manganese nodule during growth on the sediments, and the types and origin of magnetic minerals based on rock magnetic data.

Keywords: manganese nodule, paleomagnetism, geomagnetic inclination, growth process

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Lamina-scale analysis of chemical composition of the mid-Cretaceous northern Shimanto belt, Kochi, Japan: implications for formative processes of bedded ferromanganese deposits

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The mid-Cretaceous has been identified as a super-greenhouse world with tropical sea surface temperatures in excess of 35˚C. In addition to the mid-Cretaceous climate being characterized by extreme warmth, it was also associated with significant tectonic, geochemical, and biotic perturbations[1]. Subsequently, it has been considered that the formation of the ferromanganese deposits occurred in the limited area in the marine environments[2]. However, available studies have mainly focused on the shallow marine sequences in North America and Africa. Data from the Pacific region are still limited despite the fact that the paleo-Pacific constituted the largest open ocean in the mid-Cretaceous, thus the Pacific region is critical for gaining a better understanding of the formation of metallic minerals in marine environments during the climatic evolution of the greenhouse Earth.

The mid-Cretaceous sequence of pelagic chert and ferromanganese deposits of the northern Shimanto-belt is widely distributed in the Aki area, Kochi, Japan. Bulk sample analysis of the northern Shimanto belt in the previous study[3] suggested that the mineral component including metallic elements was of hydrothermal origin. To examine the more detailed formative processes of the ferromanganese deposits, we conducted observations of microstructures in the pelagic sequence and identified the tens-to-hundreds micrometer-scale lamina in the ferromanganese deposits. The elemental analysis by EPMA and laser ablation ICP-MS analyses indicated that the lamination is consists of (1) a high abundance of metallic elements such as iron and manganese and (2) metallic elements with silicate. Besides, we could identify the variations of the metallic element abundance in the chert sequence. Based on these results, we will discuss the formative processes of the ferromanganese minerals in the pelagic environment of the northwestern Pacific in the mid-Cretaceous.
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Keywords: northern Shimanto belt, mid-Cretaceous, ferromanganese deposit

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Biodiversity and connectivity of deep-sea amphipods at seamounts with cobalt-rich ferromanganese crusts in the Northwest Pacific

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To compare biodiversity and connectivity between seamounts with cobalt-rich ferromanganese crusts in the Northwest Pacific, we performed molecular ecological analysis targeting deep-sea amphipods, which are well diversified group in deep-sea area. We established baited traps in several sites and succeeded in collecting many amphipods specimens, likely including several species with different life characters. With these amphipod specimens, DNA barcoding and MOTUs community analysis detected different community structures among depths and seamounts. In addition, we also performed population genetic analysis by targeting several putative species and detected connectivity patterns between seamounts. Our molecular ecological approach using deep-sea amphipods around cobalt-rich ferromanganese crusts demonstrates its usefulness for performing environmental baseline studies and impact assessments in consideration of future deep-sea mining projects.

Keywords: Seamounts, Cobalt-rich ferromanganese crust, Amphipods, DNA barcoding, Connectivity

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[E] Oral | EVENT：EVENT

Thu. Jun 3, 2021 12:20 PM - 1:00 PM JST | Thu. Jun 3, 2021 3:20 AM - 4:00 AM UTC | Ch.01 Zoom Room 01

[EV-11] Lunchtime Special Lecture

World renowned scientists will present a series of Special Lectures in Earth and planetary sciences for students and early-career researchers across disciplines during lunch breaks (12:20-13:40) of the Meeting.

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC

[E-11-14] The Earth's coda correlation wavefield: Rise of the new paradigm and recent advances

[E] Oral | EVENT | EVENT

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12:20 PM - 1:00 PM

[E-11-14]The Earth's coda correlation wavefield: Rise of the new paradigm and recent advances

In seismology, progress in imaging the Earth's deepest shells has been impeded by the lack of geometric coverage of body waves from large earthquakes. In seeking the ways forward, global seismologists started experimenting with seismograms recorded many hours after the first arrivals of body-waves. This contributed to the rise of a new paradigm – the correlation wavefield, the focus of my talk. The correlation wavefield is a powerful way to study Earth's deep structure, including its innermost shell – the inner core. As I hope to demonstrate in my review, the coda correlation studies may play a central role in global and planetary seismology in the coming decades.

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Thu. Jun 3, 2021 9:00 AM - 9:45 AM JST | Thu. Jun 3, 2021 12:00 AM - 12:45 AM UTC | Ch.12 Zoom Room 12

[EV-12] Exhibitors' Seminar

昨年と同じく、出展者様にセミナーを開催していただきます。
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9:00 AM - 9:45 AM JST | 12:00 AM - 12:45 AM UTC

[E-11-11] NASA Earth and Planetary Science

[E] Oral | EVENT | EVENT

[EV-12] Exhibitors' Seminar

Thu. Jun 3, 2021 9:00 AM - 9:45 AM Ch.12 (Zoom Room 12)

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[E-11-11]NASA Earth and Planetary Science

NASA Seminar

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Thu. Jun 3, 2021 1:45 PM - 3:15 PM JST | Thu. Jun 3, 2021 4:45 AM - 6:15 AM UTC | Ch.16 Zoom Room 16

[EV-13] Exhibitors' Pop-Up

New for 2021 Meeting !
Exhibitors will introduce the highlights of their organizations and exhibits in about one minute in real time. Exhibitors will be given one minute to introduce their organization and exhibit highlights in real time.
This is a great chance to meet unexpected exhibitors and find information you never knew
There will be an exchange with the moderator, and you may be able to hear things you can't hear anywhere else.

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC

[E-11-15] Exhibitors' Pop-Up

[J] Oral | EVENT | EVENT

[EV-13] Exhibitors' Pop-Up

Thu. Jun 3, 2021 1:45 PM - 3:15 PM Ch.16 (Zoom Room 16)

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1:45 PM - 3:15 PM

[E-11-15]Exhibitors' Pop-Up

Exhibitors' Pop-Up

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Thu. Jun 3, 2021 9:45 AM - 10:30 AM JST | Thu. Jun 3, 2021 12:45 AM - 1:30 AM UTC | Ch.19 Zoom Room 19

[EV-14] Exhibitors' Seminar

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9:45 AM - 10:30 AM JST | 12:45 AM - 1:30 AM UTC

[E-11-12] MATLAB for Analyzing and Visualizing Geospatial Data

[E] Oral | EVENT | EVENT

[EV-14] Exhibitors' Seminar

Thu. Jun 3, 2021 9:45 AM - 10:30 AM Ch.19 (Zoom Room 19)

昨年と同じく、出展者様にセミナーを開催していただきます。
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[E-11-12]MATLAB for Analyzing and Visualizing Geospatial Data

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[E] Oral | EVENT：EVENT

Thu. Jun 3, 2021 10:45 AM - 11:30 AM JST | Thu. Jun 3, 2021 1:45 AM - 2:30 AM UTC | Ch.22 Zoom Room 22

[EV-15] Exhibitors' Seminar

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10:45 AM - 11:30 AM JST | 1:45 AM - 2:30 AM UTC

[E-11-13] "Digital Petrology": How automation and digitalization is revolutionizing microscopy based petrographic studies

[E] Oral | EVENT | EVENT

[EV-15] Exhibitors' Seminar

Thu. Jun 3, 2021 10:45 AM - 11:30 AM Ch.22 (Zoom Room 22)

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