Sun. Jun 6, 2021

[J] Oral | O (Public)：Public

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

[O-02] Natural disasters and people -Listen to the voice of the Earth on the Japanese Geoparks-

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Kyohei Sano(Graduate School of Regional Resource Management, University of Hyogo), Suzuka Koriyama(Itoigawa city), Hikaru Yokoyama(Hokusho University), Chairperson:Kyohei Sano(Graduate School of Regional Resource Management, University of Hyogo), Suzuka Koriyama(Itoigawa city), HIROKO IMAI(Com Support Office /Wakayama University Center for Tourism Research), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Hikaru Yokoyama(Hokusho University)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[O02-04] Achievements and issues of online program development at Hagi Geopark

*Takaaki Shirai[1] (1.Hagi Geopark Promotion Council)

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

[O02-05] Our ancestors who overcame natural disasters: A case study focused on Toya-Usu UNESCO Global Geopark

★Invited Papers

*Asami Nakaya[1] (1.Toya-Usu UNESCO GLobal Geopark Council)

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

[O02-06] The case of One Geopark damaged by 2018 Japan floods -The 3 years for reconstruction of Seiyo City, Ehime Prefecture and the Shikoku Seiyo Geopark-

★Invited Papers

*Takumi Sakakiyama[1] (1.Seiyo City)

[J] Oral | O (Public)：Public

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.02 Zoom Room 02

[O-03] How to cope with meteorological disasters under rapidly changing climate

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

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

[O03-01] Development of typhoon hazard map and typhoon-shot project; Change the "threat" of a typhoon into a "grace" by 2050!

★Invited Papers

*Fudeyasu Hironori[1] (1.Yokohama National University)

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

[O03-02] Recent trends in storm and flood damage and the latest efforts on JMA’s weather warnings and information

★Invited Papers

*Takahashi Kenichi[1] (1.Japan Meteorological Agency)

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

[O03-03] Utilization of typhoon data before the middle 20th century

★Invited Papers

*Fumiaki Fujibe[1] (1.Department of Geography, Tokyo Metropolitan University)

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

[O03-04] Why was coastal damage due to T1915 concentrated in the Port of Yokohama?

★Invited Papers

*Hitoshi Tamura[1] (1.Port and Airport Research Institute)

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

[O03-05] Development of coastal monitoring method immediately after typhoon by remote sensing

★Invited Papers

*Yuji Sakuno[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

[O03-06] Proposal of Build Back Better “insurance” scheme for future wind-related disaster risk reduction

★Invited Papers

*Kazuyoshi Nishijima[1] (1.Disaster Prevention Research Institute, Kyoto University)

[J] Oral | O (Public)：Public

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.02 Zoom Room 02

[O-03] How to cope with meteorological disasters under rapidly changing climate

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

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

[O03-07] Wind-induced damage to buildings and future risk reduction

★Invited Papers

*Yukio Tamura[1] (1.Chongqing University)

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

[O03-08] Behaviors of infrastructures under extreme wind and future challenges

★Invited Papers

*Tomomi Yagi[1] (1.Kyoto University)

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

[O03-09] Simultaneous multiple accident cases and their countermeasures for electric power system against Typhoon

★Invited Papers

*Yoshiharu Shumuta[1] (1.Central Research Institute of Electric Power Industry)

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

[O03-10] Fires Caused by Strong Winds and Storm Surges

★Invited Papers

*U HIROI[1] (1.The University of Tokyo)

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

[O03-11] Discussion

[J] Oral | O (Public)：Public

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

[O-04] Suggestion to teaching Earth science under GIGA school from online lesson

convener:Iida Kazuya(Komaba-Toho Junior and Senior High School), Iwata Makoto(Hiroshima Prefectural Ogaki High School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:syo uranaka(Osaka Institute of Technology Graduate School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Iida Kazuya(Komaba-Toho Junior and Senior High School)

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

[O04-01] Introduction

9:10 AM - 9:25 AM JST | 12:10 AM - 12:25 AM UTC

[O04-02] The Potential of Online Learning to Realize "Independent and Interactive Deep Learning" in Elementary School Social Studies.

★Invited Papers

*Keiko Nakaya[1] (1.Elementary School Affiliated to the Faculty of Education chiba university)

9:25 AM - 9:40 AM JST | 12:25 AM - 12:40 AM UTC

[O04-03] Utilization of a digital globe system, Dagik Earth, in elementary schools

★Invited Papers

*Akinori Saito[1], Takuya Tsugawa[2], Miho Yamamori[3] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology, 3.Tsuru University)

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

[O04-04] Effective use of online lesson and integrate with face to face lesson

★Invited Papers

*Hiroki Ushigome[1] (1.Otsuma nakano Junior and Senior High School)

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

[O04-05] Student presentations using digital devices In GIGA School Concept

★Invited Papers

*Hidenori Takemura[1] (1.Johoku Junior and Senior high school)

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

[O04-06] Discussion

[J] Oral | O (Public)：Public

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

[O-04] Suggestion to teaching Earth science under GIGA school from online lesson

convener:Iida Kazuya(Komaba-Toho Junior and Senior High School), Iwata Makoto(Hiroshima Prefectural Ogaki High School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Hiroaki Akimoto(Faculty of Economics,Dokkyo University), syo uranaka(Osaka Institute of Technology Graduate School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Iida Kazuya(Komaba-Toho Junior and Senior High School)

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

[O04-07] Report on the Online Teaching Experience with WebGIS in the High School Geography Classes under the COVID-19 Pandemic

★Invited Papers

*Yoshihiko Shibata[1] (1.Tokyo Metropolitan KOKUBUNJI Highschool)

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

[O04-08] Development of Educational Materials for the Kanagawa version of “Geological Fieldworks conducted in a Classroom" appling for High School Subject "Basic Earth Science" —Using Strata from Ikuta Ryokuchi Park—

★Invited Papers

*Yasushi Fujiwara[1], Shungo Kawagata[2] (1.Graduate School of Education, Yokohama National University, 2.College of Education, Yokohama National University)

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

[O04-09] Supporting school teachers with GSI’s Toolbox for geography education in the era of Society 5.0

★Invited Papers

*Yuki Kurisu[1] (1.Geospatial Information Authority of Japan)

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

[O04-10] The trial and error of on-line bidirectional lecture

★Invited Papers

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

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

[O04-11] General Discussion

★Invited Papers

*Iida Kazuya[1], Hiroaki Akimoto[2], Iwata Makoto[3], Satoshi Miyajima[4] (1.Komaba-Toho Junior and Senior High School, 2.Faculty of Economics, Dokkyo University, 3.Hiroshima Prefectural Ogaki High School, 4.Saitama Prefectural Kumagaya High School)

[J] Oral | O (Public)：Public

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

[O-05] How to become a scientist? What can they do?

convener:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Chairperson:Rie Hori(Department of Earth Science, Faculty of Science, Ehime University), Mayumi ARAI(National Museum of Emerging Science and Innovation), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University)

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

[O05-01] Introduction

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

[O05-02] Why do you need a PhD?

★Invited Papers

*Manabe Makoto[1] (1.National Museum of Nature and Science)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[O05-03] From Organic Chemistry, Coral Study to Ocean Policy, My Journey through Carbon

★Invited Papers

*Nobuko Nakamura[1,2] (1.The Ocean Policy Research Institute of The Sasakawa Peace Foundation, 2.Keio Univ.)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[O05-04] Living with solar sytem exploration

★Invited Papers

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

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[O05-05] Introduction to IODP and the works inside

★Invited Papers

*Michiko Yamamoto[1] (1.Scripps Institution of Oceanography, UCSD)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[O05-06] I’m working as a nature guide, an environmental activist, and a facilitator.

★Invited Papers

*hisashi Oiwane[1] (1.Musuhi LLC)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[O05-07] Discussion

[J] Oral | O (Public)：Public

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

[O-06] Let's talk about "the 10 years of reconstruction from the Great East Japan Earthquake"

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Mamoru Hayashi(University of TOYAMA), Tetsuhiko Asano(Senshu University Matsudo Junior High School High School), Chairperson:Mamoru Hayashi(University of TOYAMA), Tetsuhiko Asano(HunabashiKeimei High School), Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education)

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

[O06-01] Overview of reconstruction status for the 10th anniversary of the Great East Japan Earthquake

★Invited Papers

*Yoshihiro Okumura[1] (1.Kansai University)

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

[O06-02] Problems caused by and positive lessons to be inherited from the reconstruction of the Great East Japan Earthquake

★Invited Papers

*Hiromi ENSHU

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

[O06-03] One decade after the earthquake, reconstruction still not complete

★Invited Papers

*YUKIKO KIKUCHI[1] (1.general incorporated association Otsuchi Shimbun)

[J] Oral | O (Public)：Public

12:30 PM - 1:30 PM JST | 3:30 AM - 4:30 AM UTC | Ch.02 Zoom Room 02

[O-07] Poster presentations by senior high school students

Chairperson:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(Japan Meteorological Agency), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

[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.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Risa Uchida(Japan Automobile Research Institute), Kei Sato(National Institute for Environmental Studies)

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[AAS05-01] Cryosphere-atmosphere biogeochemical cycles: Insights from Arctic Ocean drifting campaign

★Invited Papers

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

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

[AAS05-02] Embedding of HCl droplets on ice crystal surfaces under atmospheric-concentration HCl gas

*Ken Nagashima[1], Ken-ichiro Murata[1], Gen Sazaki[1] (1.The Institute of Low Temperature Science, Hokkaido University)

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

[AAS05-03] A new method for quantifying sodium sulfate, sodium nitrate, and sodium chloride aerosols

*Yuya Kobayashi[1], Nobuyuki Takegawa[1] (1.Graduate School of Science, Tokyo Metropolitan University)

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

[AAS05-04] Investigation of gaseous and heterogeneous reactions of RO_2 radicals using FAGE-LIF method

*Nanase Kohno[1], Jiaru Li[1], Yosuke Sakamoto[1,2], Yoshizumi Kajii[1,2] (1.Kyoto University, 2.National Institute for Environmental Studies)

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

[AAS05-05] Real-time measurement of HO_2 and RO_2 uptake loss rate onto ambient particles during AQUAS-Kyoto summer campaign in 2020

*Yosuke Sakamoto[1,2], Bai Yu[1], Jiaru Li[1], Kohno Nanase[1], Yoshizumi Kajii[1,2] (1.Kyoto University , 2.National Institute for Environmental Studies)

[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.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Nobuyuki Takegawa(Graduate School of Science, Tokyo Metropolitan University)

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

[AAS05-06] **Understanding of Volatile Organic Compound Emissions from Western US Wildfires**

*Kanako Sekimoto[1], Matthew M Coggon[2,3], Georgios Gkatzelis[2,3], Carsten Warneke[2,3] (1.Yokohama City University, 2.NOAA Earth System Research Laboratory, 3.Cooperative Institute for Research In Environmental Sciences)

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

[AAS05-07] New particle formation from ozonolysis of 2-methyl-2-butene and *trans*-2-butene

*Satoshi Inomata[1], Jun Hirokawa[2], Yosuke Sakamoto[3] (1.National Institute for Environmental Studies, 2.Hokkaido University, 3.Kyoto University)

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

[AAS05-08] Structural elucidation of a-pinene originating $C_{10}H_{17}O_6S$ organosulfates from CCS values derived from ion mobility mass spectrometry and theoretical structural modelling

*Yoshiteru Iinuma[1], Satoshi Inomata[2], Kei Sato[2] (1.Okinawa Institute of Science and Technology Graduate University, 2.National Institute for Environmental Studies)

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

[AAS05-09] Wet Deposition of Black Carbon at Ny-Ålesund, Svalbard

*Tatsuhiro Mori[1], Yutaka Kondo[2], Sho Ohata[3,4], Kumiko Goto-Azuma[2,5], Kaori Fukuda[2], Yoshimi Ogawa[2], Nobuhiro Moteki[6], Atsushi Yoshida[6], Makoto Koike[6], Puna Ram Sinha[7], Naga Oshima[8], Hitoshi MATSUI[9], Yutaka Tobo[2,5], Masanori Yabuki[10], Wenche Aas[11] (1.Tokyo University of Science, 2.National Institute of Polar Research, 3.Institute for Space–Earth Environmental Research, Nagoya University, 4.Institute for Advanced Research, Nagoya University, 5.The Graduate University for Advanced Studies, SOKENDAI, 6.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 7.Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, 8.Meteorological Research Institute, 9.Graduate School of Environmental Studies, Nagoya University, 10.Research Institute for Sustainable Humanosphere, Kyoto University, 11.Norwegian Institute for Air Research)

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

[AAS05-10] Improved simulations of global black carbon distributions by modifying wet scavenging processes in convective and mixed-phase clouds

*Mingxu Liu[1], Hitoshi Matsui[1] (1.Graduate school of environmental studies, Nagoya University)

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

[AAS05-11] High potential of Asian dust to act as ice nucleating particles in mixed-phase clouds simulated with a global model

*Kei Kawai[1], Hitoshi Matsui[1], Yutaka Tobo[2,3] (1.Nagoya University, 2.National Institute of Polar Research, 3.SOKENDAI (The Graduate University for Advanced Studies))

[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.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Chika Minejima(International Christian University)

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

[AAS05-12] Validation and correction of TROPOMI tropospheric NO_2 column density data using 4AZ-MAXDOAS at Chiba, Japan

*Hikaru Saito[1], Hitoshi Irie[1], Alessandro Damiani[1] (1.University of Chiba)

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

[AAS05-13] **NO_X emission estimation over Japan based on satellite data with wind field divergence**

*Masahiro Yamaguchi[1], Yugo Kanaya[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[AAS05-14] Introducing new lightning schemes to a chemistry climate model CHASER (MIROC)

*Yanfeng He[1], Kengo Sudo[1] (1.Nagoya University)

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

[AAS05-15] Methane emissions from populated areas of Tokyo and five prefectures: Emission ratios with NOx and their trends over 2009-2018

*Yugo Kanaya[1], Kanami Saima[2], Akira Fukuike[2] (1.JAMSTEC, 2.MURATA Keisokuki Service Co., Ltd.)

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

[AAS05-16] An impact of tropospheric air pollution changes over Japan due to future climate and emission change

*Natsumi Kawano[1], Tatsuya Nagashima[1], Masayuki Hara[2], Satoru Chatani[1], Syuichi Itahashi[3] (1.National Institute for Environmental Studies, 2.Center for Environmental Science in Saitama, 3.Central Research Institute of Electric Power Industry)

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

[AAS05-17] An Empirical Approach toward the Reduction Targets of CH4 and O3 as SLCP: For Asia as an example

*Hajime Akimoto[1], Tatsuya Nagashima[1], Hiroshi Tanimoto[1], Zbigniew Klimont[2], Markus Amann[2] (1.National Institute for Environmental Studies, 2.International Institute for Applied System Analysis)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Naoko Saitoh(Center for Environmental Remote Sensing), Shigeyuki Ishidoya(Advanced Industrial Science and Technology)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AAS05-18] **Earth system modeling on interactions between ecosystem and atmospheric chemistry**

★Invited Papers

*Tomohiro Hajima[1], Manabu Abe[1], Akinori Ito[1], Akihiko Ito[2], Rumi Ohgaito[1], Kazuyuki Saito[1], Kengo Sudo[3], Michio Kawamiya[1], Maki Noguchi Aita[1], Prabir Patra[1], Akitomo Yamamoto[1], Tokuta Yokohata[2], Shingo Watanabe[1], Michio Watanabe[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Environmental Studies, 3.Nagoya University)

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

[AAS05-19] **Seasonal variations of methane sources in South Asia inferred from observations of stable carbon isotope ratio of atmospheric methane**

*Yukio Terao[1], Taku Umezawa[1], Manish Naja[2], Md. Kawser Ahmed[3], Shohei Nomura[1], Toshinobu Machida[1], Motoki Sasakawa[1], Hitoshi Mukai[1], Prabir Patra[4] (1.National Institute for Environmental Studies, 2.Aryabhatta Research Institute of Observational Sciences, 3.Department of Oceanography, Faculty of Earth & Environmental Sciences, University of Dhaka, 4.Research Institute for Global Change, JAMSTEC)

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

[AAS05-20] The interhemispheric transport pathways of methane as observed by GOSAT and simulated by ACTM

*Dmitry Belikov[1], Naoko Saitoh[1], Prabir Patra[1,2] (1.Center for Environmental Remote Sensing, Chiba University, 2.Research Institute for Global Change (RIGC), JAMSTEC)

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

[AAS05-21] **Signal of CO_2 emitted from 2020 Western U. S. wildfire captured by commercial airliner observations**

*Kentaro Ishijima[1], Toshinobu Machida[2], Taku Umezawa[2], Yosuke Niwa[2,1], Kazuhiro Tsuboi[1], Ryo Fujita[1], Hidekazu Matsueda[3,1], Taichu Y Tanaka[1], Takashi Maki[1], Takashi Nakamura[4] (1.Meteorological Research Institute, 2.National Institute for Environmental Studies, 3.Dokkyo University, 4.Japan Meteorological Agency)

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

[AAS05-22] Secular trend of atmospheric N_2O isotopocule ratios observed at Syowa staion, Antarctica

*Sakae Toyoda[1], Tsutomu Mizuno[1], Daisuke Goto[2], Shinji Morimoto[3] (1.School of Materials and Chemical Technology, Tokyo Institute of Technology, 2.National Institute of Polar Research, 3.Center for Atmospheric and Oceanic Studies, Tohoku University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

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

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Masaya Yasuhara(Rissho Univ.), Takashi Nakamura(International Research Center for River Basin Environment, University of YAMANASHI), Kazuyoshi Asai(Geo Science Laboratory), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

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

[AHW23-01] Introduction

9:05 AM - 9:30 AM JST | 12:05 AM - 12:30 AM UTC

[AHW23-02] Seasonal and spatial variations of chemical weathering in the Mekong Basin: From the headwaters to the lower reaches

★Invited Papers

*Hiroto Kajita[1], Yuki Ota[2], Toshihiro Yoshimura[3], Daisuke Araoka[2], Takuya Manaka[4], Ziyu Ouyang[1], Shinya Iwasaki[3], Takuya Yanase[1], Akihiko Inamura[2], Etsuo Uchida[5], Hongbo Zheng[6], Qing Yang[6], Ke Wang[1], Atsushi Suzuki[2], Hodaka Kawahata[1] (1.The University of Tokyo, 2.National Institute of Advanced Industrial Science and Technology, 3.Japan Agency for Marine-Earth Science and Technology, 4.Forestry and Forest Products Research Institute, 5.Waseda University, 6.Yunnan University)

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

[AHW23-03] Stable Isotope Dynamics of Hydrological Interactions in The Chao Phraya River System in Thailand

*Jeerapong Laonamsai[1], Kimpei Ichiyanagi[1] (1.Deaprtment of Earth and Environmental Sciences, Graduate School of Science and Technology, Kumamoto University)

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

[AHW23-04] Groundwater in the area where ground flow with long displacement occurred due to the 2018 Sulawesi Island Earthquake in Indonesia

★Invited Papers

*Susumu Yasuda[1], Hisashi Furuichi[2] (1.Tokyo Denki University, 2.Yachiyo Engineering Co., Ltd.)

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

[AHW23-05] The formation of a temporary pond, Akaike, at the Northern Foot of Mount Fuji, Japan, in 2020

*Shinya Yamamoto[1], Takashi Nakamura[2], Seongwon Lee[3], Masaya Yasuhara[3] (1.Mount Fuji Research Institute, Yamanashi Prefectural Government, 2.International Research Center for River Basin Environment, University of Yamanashi, 3.Faculty of Geo-Environmental Science, Rissho University)

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

[AHW23-06] Discussion

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

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

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Kazuyoshi Asai(Geo Science Laboratory), Masaya Yasuhara(Rissho Univ.), Noritoshi Morikawa(Geological Survey of Japan, AIST), Kohei Kazahaya(Geological Survey of Japan, AIST)

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

[AHW23-07] Supply processes of dissolved inorganic carbon and flow system of groundwater in Fukui-Ohno Basin

★Invited Papers

*Yamanaka Masaru[1], Seongwon Lee[2], ZHAO MINGZHE[1], Takanori Nakano[3] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University, 2.Rissho University, 3.The Research Institute for Humanity and Nature)

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

[AHW23-08] Origin and hydro-chemical evolution of geothermal waters from Nozawa-Onsen hydrothermal springs in the northern Nagano Prefecture, central Japan

*Shunsuke Akazawa[1], Madhusoodhan Satish-Kumar[2], Naoki Watanabe[3], Cheibany Ould-Elemine[4], Masaki Yuhara[5] (1.Graduate School of Science and Technology, Niigata University, Japan, 2.Department of Geology, Faculty of Science, Niigata University, Japan , 3.Research Institute for Natural Hazards and Disaster Recovery, Niigata University, Japan, 4.Ensero Solutions, Canada, 5.Department of Earth System Science, Faculty of Science, Fukuoka University, Japan)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[AHW23-09] Composition of ammonium nitrogen isotope in Oita Plain, eastern Kyushu Island, Japan

*Takashi Nakamura[1], Kazuhiro Amita[2], Shinji Ohsawa[3] (1.Interdisciplinary Center for River Basin Environment, University of Yamanashi, 2.Research Center for Engineering Science, Akita University, 3.Beppu Geothermal Research Laboratory, Kyoto University)

11:40 AM - 12:05 PM JST | 2:40 AM - 3:05 AM UTC

[AHW23-10] The continuing story of mathmatical modelling for nitrogen pollution analysis in groundwater

★Invited Papers

*Kei Nishida[1], Ken Yokozawa[2], Bijjay Man Shakya[1], Hiroshi Ishidaira[1], Tadashi Toyama[1], Takashi Nakamura[1] (1.Interdisciplinary Centre for River Basin Environment, Interdisciplinary Graduate School, University of Yamanashi, 2.Shizuoka Prefecture)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

[AHW23-11] Discussion

[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-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

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

[ACG38-01] Toward numerical modeling systems that seamlessly link coastal seas to open oceans

★Invited Papers

*Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[ACG38-02] Long-term variability of sea level along the coast of Japan during the 20th century reproduced by an eddy resolving model

*Hideyuki Nakano[1], Shogo Urakawa[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1] (1.Meteorological Research Institute)

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

[ACG38-03] Dynamics of the estern-boundary currents

★Invited Papers

*Ryo Furue[1] (1.APL/JAMSTEC)

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

[ACG38-04] Impacts of bottom topography on the formation of the North Pacific subtropical-subarctic frontal zone

*Humio Mitsudera[1], Hayato Ashida[2], Toru Miyama[3] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science, Hokkaido University, 3.JAMSTEC)

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

[ACG38-05] Stability of a Flow over Bottom Topography: A General Condition and a Linear Analysis in a Two-Layer Quasi-Geostrophic Model

*Yuki Tanaka[1] (1.Faculty of Marine Science and Technology, Fukui Prefectural University)

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

[ACG38-06] Eddy-mean flow interactions and vertical energy redistribution associated with the standing meander in the Antarctic Circumpolar Current

*Takuro Matsuta[1], Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

[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-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

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

[ACG38-07] Irreversible energy extraction from negative temperature two-dimensional turbulence

*Yohei Onuki[1] (1.Ocean Modeling Group, Center for Oceanic and Atmospheric Research, Research Institute for Applied Mechanics, Kyushu University)

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

[ACG38-08] Near-inertial oceanic internal waves observed by LADCP (lowered acoustic Doppler current profiler)

*Katsuro Katsumata[1] (1.JAMSTEC)

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

[ACG38-09] The pathway of the Indonesian Throughflow transport increase due to tidal mixing

*Shiraishi Takeki[1], Shinichiro Kida[2], Hideharu Sasaki[3], Ryo Furue[3] (1.Kyushu University Interdisciplinary Graduate School of Engineering Sciences, 2.Research Institute for Applied Mechanics, Kyushu University, 3.Application Laboratory , Japan Agency for Marine-Earth Science and Technology)

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

[ACG38-10] Biogeophysical Interactions in transport of marine organisms

★Invited Papers

*Atsushi Fujimura[1] (1.University of Guam)

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

[ACG38-11] Wave resolving numerical simulation of non-breaking wave-induced mixing

*Haruka Imamura[1], Yutaka Yoshikawa[1], Yasushi Fujiwara[2] (1.Graduate School of Science, Kyoto University, 2.Graduate School of Frontier Sciences, the University of Tokyo)

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

[ACG38-12] Origin of swells propagated into small bays on the Sanriku rias coast facing the western North Pacific

*Kosei Komatsu[1,2], Takaki Fujii[3], Kiyoshi Tanaka[2] (1.Graduate School of Frontier Sciences, University of Tokyo, 2.Atmosphere and Ocean Research Institute, University of Toky, 3.Bank of Japan)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 4:45 PM JST | 6:30 AM - 7:45 AM UTC | Ch.10 Zoom Room 10

[A-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Norihiko Sugimoto(Keio University, Department of Physics), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

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

[ACG38-13] Formulation and application of phase-independent energy conversion terms for quasi-geostrophic eddies on a zonally-varying basic flow

★Invited Papers

*Takaya Koutarou[1] (1.Kyoto Sangyo University)

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

[ACG38-14] Recirculation of atmospheric wave energy associated with idealized MJO events

*Hidenori AIKI[1], Yoshiki Fukutomi[1], Yuki Kanno[2], Tomomichi Ogata[3], Takahiro Toyoda[4], Hideyuki Nakano[4] (1.Nagoya University, 2.Central Research Institute of Electric Power Industry, 3.Japan Agency for Marine-Earth Science and Technology, 4.Meteorological Research Institute)

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

[ACG38-15] Extratropical forcing of intraseasonal equatorial Kelvin waves over the Indian and Pacific Oceans

*Fukutomi Yoshiki[1], Hidenori Aiki[1] (1.Institute for Space-Earth Environmental Reasearch, Nagoya University)

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

[ACG38-16] Influence of marginal seas' hotspot on extratropical cyclones: explosive and binary cyclogenesis in idealized experiments

*Masaru Yamamoto[1] (1.Research Institute for Applied Mechanics, Kyushu University)

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

[ACG38-17] Discussion

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

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

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

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

[HDS08-01] Introduction

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

[HDS08-02] Measurement of landslide deformation velocity at Jure in Sunkoshi River Wateshed, Nepal using LiCSBAS

*Hiroshi, P. Sato[1] (1.College of Humanities and Sciences, Nihon University)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[HDS08-03] Map of Earthquake-induced Landslides Potential on Artificially Transformed Hills in the Depositional Area of Tephric Soil Deposits

*Takehiko Suzuki[1], Masahiro Chigira[2], Yuki Matsushi[3], Daichi Nakayama[1] (1.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 2.Fukada Geological Institute, 3.Disaster Prevention Research Institute Kyoto University)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[HDS08-04] **Elucidation of the cause that the H / L value of volcanic sector collapse is very small compared to non-volcanic landslides**

*Shunichi Sato[1] (1. Graduate School of Frontier Science, The University of Tokyo)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[HDS08-05] Natural disasters and countermeasures in Ratnapura, Sri Lanka

*Takahito Kuroki[1], Kensuke Goto[2], Panditharathne N. G. S. [3] (1.Faculty of Letters, Kansai University, 2.Faculty of Education, Osaka Kyoiku Univ., 3.Health Service Rathnapura, Ministry of Health, Government of Sri Lanka)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[HDS08-06] Policy for creating a liquefaction trend map based on geomorphologic classification for recognition of regional liquefaction risk

*Takayuki Nakano[1], Ryo Endo[1], Hiroyuki Inoue[2], Nozomi Yamashina[2], Shingo Watanabe[3], Keita Takada[3], Takuma Fujita[3] (1.Geospatial Information Authority of Japan, 2.City Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 3.Fukken Co., Ltd.)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[HDS08-07] Discussion

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

3:30 PM - 4:30 PM JST | 6:30 AM - 7:30 AM UTC | Ch.15 Zoom Room 15

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

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

[HDS08-08] Current problems of submarine geological risks

*Kiichiro Kawamura[1] (1.Yamaguchi University)

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

[HDS08-09] **Verification of “Past” seismic intensity and estimation of “Future” ground motion by “Present-day” seismic observation: The Yanesen area**

*Motoko Ishise[1], Ryoichi Nakamura[1], Jun Muragishi[3], Shin'ichi Sakai[2,1] (1.Earthquake Reseach Institute, University of Tokyo, 2.Thr university of Tokyo III/GSII, 3.Yashima Gakuen University)

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

[HDS08-10] Characteristics of International Risk Communication over Trans-boudary Volcanic Disaster-The Case of 2010 Iceland Volcano Erution

*Mayumi Sakamoto[1], Haruhisa Nakamichi[2], Wakana Takahashi[3], Chizu Arashima[4], Masaru Arakida[5] (1.Graduate School of Disaster Resilience and Governance, University of Hyogo, 2.Disaster Prevention Research Institute, Kyoto University, 3.School of International Studies, Utsunomiya University, 4.Faculty of Global Communication, Kobe Gakuin University, 5.Asian Disaster Reduction Center)

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

[HDS08-11] Discussion

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.14 Zoom Room 14

[H-TT19] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanaka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), W. Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology)

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

[HTT19-01] Introduction

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

[HTT19-02] Map representation of estimated concentration distribution of $PM_{2.5}$ using WebGIS

*Junji Yamakawa[1] (1.Graduate School of Natural Science and Technology, Okayama University)

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

[HTT19-03] Proposal of nocturnal light data as a proxy variable for building height

*Go Kazawa[1], Daikichi SEKI[1], Yosuke Alexandre Yamashiki[1], Fusanori Iwasaki[2], Keola Souknilanh[3] (1. Graduate School of Advanced Integrated Studies in Human Survivability, 2.Economic Research Institute for ASEAN and East Asia, 3.Institute of Developing Economies, Japan External Trade Organization)

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

[HTT19-04] A Consideration of the Spatio-Temporal Expansion of "Deep Wonder" Evoked by Forest Image Archives

*Kazuhiko W. Nakamura[1] (1.The University of Tokyo)

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

[HTT19-05] An analysis of Children’s school route with GPS: A case study of 30 elementary schools in Toyama city

*Koji Ohnishi[1] (1.Department of Humanities, University of Toyama)

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

[HTT19-06] Red Relief Image Map using Hyper Resolution DEM, New Development of Topography recognition

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

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.14 Zoom Room 14

[H-TT19] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanaka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), W. Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazuhiko W. Nakamura(The University of Tokyo)

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

[HTT19-07] Relationship between the Image of the Town and the Seams of Asphalt Pavement Works

*Kazunari Tanaka[1], Miku Ogawa[1], Hitomi Tsukioka[1] (1.Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology)

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

[HTT19-08] On Spatial Cognition of Children by Distortion and Color on the Cognitive Map

*Ami Hasegawa[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

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

[HTT19-09] On Evaluation of Environmental Sound by Degree of Human Concentration

*Haru Kanda[1] (1.Osaka Institute Technology)

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

[HTT19-10] On the Meaning of Affordance and Personal-Space in the COVID-19

*Kazuki Miyake[1], Shota Tanaka[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

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

[HTT19-11] Discussion

[J] Oral | H (Human Geosciences)：H-CG Complex & General

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

[H-CG26] Adaptation to climate change and its social implementation

convener:Hiroya Yamano(National Institute for Environmental Studies), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(University of Tsukuba), Makoto Tamura(Global and Local Environment Co-creation Institute, Ibaraki University), Chairperson:Hiroya Yamano(National Institute for Environmental Studies), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(University of Tsukuba), Makoto Tamura(Global and Local Environment Co-creation Institute, Ibaraki University)

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

[HCG26-01] Enhancing resilience of atoll islands against sea level rise

★Invited Papers

*Hajime Kayanne[1], Masafumi Fujita[2], Nori Fujita[1], Takashi Hosono[3], Yoich Ide[4], Yuji Kuwahara[2], Fumiko Matsudate[13], Satoru Mimura[5], Nobuko Nakamura[6], Susumu Onaka[7], Daisaku Sato[8], Tomoko Takeda[9], Koji Yamada[10], Toru Yamaguchi[11], Hiroya Yamano[12], Hiromune Yokoki[2] (1.the University of Tokyo, 2.Ibaraki Univ., 3.JAMSTEC, 4.Oceanic Planning Corp., 5.JICA, 6.Sasakawa Peace Foundation, Ocean Policy Res. Inst., 7.Nippon Koei, 8.Setsunan Univ., 9.IGES, 10.Japan Construction Information Center Found., 11.Keio Univ., 12.National Inst. Environmental Studies, 13.Heart Biz)

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

[HCG26-02] **Developments of future climate scenario selection method for impact and adaptation studies**

*Hideo Shiogama[1], Noriko N. Ishizaki[1], Naota Hanasaki[1], Kiyoshi Takahashi[1], Seita Emori[1], Rui Ito[2,3], Toshiyuki Nakaegawa[3], Izuru Takayabu[3], Yasuaki Hijioka[1], Yukari N. Takayabu[4], Ryosuke Shibuya[4] (1.National Institute for Environmental Studies, 2.Japan Meteorological Business Support Center, 3.Meteorological Research Institute, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[HCG26-03] Added values of regional multi-ensemble statistical downscaling approach in CORDEX Asia

*KOJI DAIRAKU[1] (1.University of Tsukuba)

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

[HCG26-04] Temperature rises and extreme rainfall intensity derived from observations and d4PDF in Japan

*Sayaka Yoshikawa[1,3], Megumi Watanabe[2], Shinjiro Kanae[3] (1.Ibaraki university, 2.The university Tokyo, 3.Tokyo institute of technology)

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

[HCG26-05] Adaptation measures based on future projections of corals and macroalgae, use/conservation status on the southwest coast of Shikoku

*Hiroya Abe[1], Haruka Suzuki[1], Yuko F Kitano[1], Naoki H Kumagai[1], Satomi Mitsui[1], Hiroya Yamano[1] (1.National Institute for Environmental Studies)

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

[HCG26-06] Workshop on Disaster Prevention Training to Improve Disaster Preparedness of Local Governments and Staff: As Part of Social Implementation of Disaster Prevention Policy for Climate Change Adaptation

*kouhei yoshimura[1,2], Seigo Nasu[2], Shingen Horiuchi[3] (1.Nippon Koei, 2.Kochi University of Technology, 3.Kochi City)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.15 Zoom Room 15

[H-CG29] Advanced life support systems with closed bio-ecosystems and thier applications

convener:Masanori Shinohara(Teikyo University of Science), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Shunta Kimura(Institute of Space and Astronautical Science / Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency), Midori Ong(University of Tsukuba), Chairperson:Midori Ong(University of Tsukuba), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Masanori Shinohara(Teikyo University of Science)

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

[HCG29-01] Introduction

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

[HCG29-02] Recent Trends of Advanced and Closed Ecological Life Support System.

*Masanori Shinohara[1], Tamiyasu Shimamiya[2] (1.Teikyo University of Science, 2.Japan Manned Space Systems Corporation)

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

[HCG29-03] Establishment of food self-sufficiency system for functional space foods to support manned space activities

★Invited Papers

*Takeshi Nikawa[1] (1.Institute of Nutrition, Tokushima University Graduate School)

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

[HCG29-04] Searching for gene related to environments adaptation

*Hiroshi Katoh[1] (1.Mie University)

10:00 AM - 10:25 AM JST | 1:00 AM - 1:25 AM UTC

[HCG29-05] Current status of planetary protection and its importance in closed eco-systems

★Invited Papers

*Shunta Kimura[1,2], Shino Suzuki[1,2], Yuko Inatomi[1,2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency)

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

[HCG29-06] Discussion

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.18 Zoom Room 18

[S-SS11] Strong Ground Motion and Earthquake Disaster

convener:Kazuhiro Somei(Geo-Research Institute), Yasuhiro Matsumoto(Kozo Keikaku Engineering), Chairperson:Kenichi Tsuda(Institute of Technology, Shimizu Corporation), Asako Iwaki(National Research Institute for Earth Science and Disaster Prevention)

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

[SSS11-07] Development of data-driven strong motion model and common integrated database

*Hiroyuki Fujiwara[1], Nobuyuki Morikawa[1], Asako Iwaki[1], Takahiro Maeda[1], Shinichi Akiyama[1], Kenichi Kato[2], Toshiaki Sato[3], Takayuki Hayashi[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.KOBORI RESEARCH COMPLEX INC., 3.Ohsaki Research Institute, Inc., 4.Tokio Marine & Nichido Risk Consulting Co., Ltd.)

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

[SSS11-08] Consideration of Uncertainty in Seismic Hazard Assessment Based on Strong Motion Observation Record Database

*Nobuyuki Morikawa[1], Hiroyuki Fujiwara[1], Asako Iwaki[1], Takahiro Maeda[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS11-09] On applicabiltiy of ground-motion simulation data to data-driven ground-motion prediction model

*Asako Iwaki[1], Hiroyuki Fujiwara[1], Nobuyuki Morikawa[1], Takahiro Maeda[1] (1.National Research Institute for Earth Science and Disaster Prevention)

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

[SSS11-10] Spatial complexity characteristics of faut parameters based on self-similar models - Comparison of earthquake slip of Japan and all over the world-

*Fumino Suzuki[1], Kenichi Kato[1], Tetsushi Watanabe[1] (1.KOBORI RESEARCH COMPLEX INC.)

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

[SSS11-11] A scaling relation of crustal earthquakes assuming constant stress drop - in a case when fault width is used as a parameter -

*Kazuhito Hikima[1], Akihiro Shimmura[1] (1.Tokyo Electric Power Company Holdings, Inc.)

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

[SSS11-12] **Correlation of Kinematic Source Parameters from Rupture Models Simulated by the Full Dynamic Earthquake Cycles**

*Anatoly Petukhin[1], Percy Galvez[2,3], Paul Somerville[4], Ken Miyakoshi[1], Kojiro Irikura[5] (1.Geo-Research Institute, 2.ETH Zurich, Earth Science, 3.KAUST University, 4.AECOM, Los Angeles, 5.Aichi Institute of Technology)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.18 Zoom Room 18

[S-SS11] Strong Ground Motion and Earthquake Disaster

convener:Kazuhiro Somei(Geo-Research Institute), Yasuhiro Matsumoto(Kozo Keikaku Engineering), Chairperson:Hisahiko Kubo(National Research Institute for Earth Science and Disaster Resilience), Hongjun Si(Seismological Research Institute Inc.)

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

[SSS11-13] Long-period incident waves to the Echigo basin during the 2011 off the Pacific coast of Tohoku Earthquake

*Tomiichi Uetake[1] (1.R&D Department, TEPCO research Institute, Tokyo Electric Power Company)

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

[SSS11-14] On the attenuation characteristics of peak ground motion from three M_w7 class intraplate earthquakes along the Japan Trench

*Hongjun Si[1] (1.Seismological Research Institute Inc.)

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

[SSS11-15] Comparison of seismic wave fields from the earthquakes off Fukushima prefecture, northeastern Japan

*Yasumaro Kakehi[1] (1.Department of Planetology, Graduate School of Science, Kobe University)

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

[SSS11-16] ESTIMATE TIME AND SPATIAL EVOLUTION OF THE RUPTURE PROCESS OF THE 2021 OFF-FUKUSHIMA BASED ON THE FINITE-FAULT SOURCE INVERSION

*Kenichi Tsuda[1], Chen Ji[3], Ralph J Archuleta[3,4], Toshiaki Sato[2] (1.Institute of Technology, Shimizu Corporation, 2.Ohsaki Research Institute, Inc., 3.University of California, Santa Barbara, 4.RJA Ground Motion Analysis, Inc.)

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

[SSS11-17] Source process of the 2021 off Fukushima, Japan, intraslab earthquake derived from strong motion data

*Hisahiko Kubo[1], Wataru Suzuki[1], Shin Aoi[1], Haruko Sekiguchi[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SSS11-18] Strong motion characteristics at MYGH10 (KiK-net), Yamamoto, during the Off Fukushima pref. earthquake of 13th Feb., 2021

*Tomotaka Iwata[1] (1.Disaster Prevention Research Institute, Kyoto University)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.21 Zoom Room 21

[S-EM13] Geomagnetism, paleomagnetism and rock magnetism

convener:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Chairperson:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Yutaka Yoshimura(Faculty of Social and Cultural Studies, Kyushu University)

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

[SEM13-01] **Revised magnetostratigraphy and eruption timing of Afro-Arabian Large Igneous Province using new $^{40}Ar/^{39}Ar$ ages**

*Yutaka Yoshimura[1], Osamu Ishizuka[2], Toshitsugu Yamazaki[1], Yuhji Yamamoto[3], Hyeon-Seon Ahn[3], Tesfaye Kidane[4], Yo-ichiro Otofuji[5,6] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3.Center for Advanced Marine Core Research, Kochi University, 4.School of Agricultural, Earth, and Environmental Sciences, University of KwaZulu Natal, 5.Institute of GeoHistory, 6.Kobe University)

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

[SEM13-02] Palaeomagnetism of ca. 3-4 Ma lavas from Borgarfjordur, Iceland - magnetostratigraphy and paleosecular variation of direction

Maxwell Christopher Brown[1,2], *Yuhji Yamamoto[3], Hiroyuki Hoshi[4], Masaru Kono[5], Hidefumi Tanaka[3], Takehiro Koyaguchi[6], Brian Jicha[7], Kohei Masaoka[3,8], Vivian Sinnen[2], Justin Tonti-Filippini[2,9], Hiroto Ishikawa[3], Richard Bono[10] (1.University of Minnesota, 2. University of Iceland, 3.Kochi University, 4.Aichi University of Education, 5.Tokyo Institute of Technology, 6.University of Tokyo, 7.University of Wisconsin-Madison, 8.Kyushu University, 9.Ludwig Maximilian University of Munich, 10.University of Liverpool)

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

[SEM13-03] Archeointensity variation for the past millennium from Reunion Island

*Koji Fukuma[1], Hisatoshi Ito[2] (1.Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2.Central Research Institute for Electric Power Industry)

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

[SEM13-04] Analyzing the early 19th century's geographical points in latitude and longitude of 0.2 second level and geomagnetic declination through Japan from Tadataka Inoh's magnetic survey azimuth ledger simultaneously.

*Motohiro Tsujimoto[1] (1.none)

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

[SEM13-05] Effects of cooling from the CMB on geodynamo with different Rayleigh numbers and inner core radii

*Yuki Nishida[1], Yuto Katoh[1], Hiroaki Matsui[2], Masaki Matsushima[3], Takumi Kera[1], Atsushi Kumamoto[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Dept. of Earth and Planetary Sciences, University of California, Davis, 3.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

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

[SEM13-06] An attempt to detect a stratified layer at the core surface from a geomagnetic field model

*Masaki Matsushima[1] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.21 Zoom Room 21

[S-EM13] Geomagnetism, paleomagnetism and rock magnetism

convener:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Chairperson:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Yutaka Yoshimura(Faculty of Social and Cultural Studies, Kyushu University)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SEM13-07] **Unmixing complex sedimentary magnetic mineral assemblages**

★Invited Papers

*Andrew P Roberts[1], Jinhua Li[2,3,4,5], Yan Liu[2,3,4,5], Shuangchi Liu[2,5], Hongmiao Pan[4,6], Tian Xiao[4,6], Yongxin Pan[2,3,4,5] (1.Research School of Earth Sciences, Australian National University, Canberra, ACT 2601, Australia, 2.Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Innovation Academy for Earth Sciences, Chinese Academy of Sciences, Beijing 100029, China, 3.Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266061, China, 4.International Associated Laboratory of Evolution and Development of Magnetotactic Multicellular Organisms (LIA-MagMC), CNRS-CAS, Beijing 100029, China, 5.College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing 100049, China, 6.Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China)

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

[SEM13-08] Examination of the properties of remanent magnetization carried by magnetotactic bacteria in the early stages of sediment formation; example of mixed system with magnetic particles of inorganic origin

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[3], Yuhji Yamamoto[3], Masao Ohno[1] (1.Kyushu University, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 3.Kochi University)

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

[SEM13-09] Analysis of magnetic mineral composition of a sediment core taken from the Ontong-Java Plateau and its implications to relative paleointensity estimations

*Jiaxi Li [1], Toshitsugu Yamazaki[1], Yoichi Usui[2], Takuya Sagawa[3], Junichiro Kuroda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kanazawa University)

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

[SEM13-10] **Environmental magnetic study of a Holocene sediment core from the Yeongsan Estuary, Southwest Korea**

*Hyeon-Seon Ahn[1], Jaesoo Lim[2] (1.Kochi University, 2.Korea Institute of Geoscience and Mineral Resources)

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

[SEM13-11] **Relationship between the abundance of the exsolved magnetite and the valence state of iron in single plagioclase crystal separated from Doshi gabbro**

*Yujiro Tamura[1], Masahiko Sato[2], Ryoichi Nakada[3], Chie Kato[4], Shinji Yamamoto[1] (1.Yokohama National University, 2.The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Kyushu University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.20 Zoom Room 20

[S-MP25] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[SMP25-01] Prolonged subduction metamorphism and deep forearc accumulation of Sanbagawa Complex: an example from Okawara district, southern Japanese Alps

*Kazuhiro Miyazaki[1], Yoshihiro Nakamura[1], Hiroshi Makimoto[1] (1.Institute of Geology and Geoinformation, Geological Survey of Japan/National Institute of Advanced Industrial Science and Technology)

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

[SMP25-02] High mobility of Sr and Ba in subduction-related metamorphism: Application of Machine-learning mass transfer analyses to mafic shists, the Sanbagawa belt

*Matsuno Satoshi[1], Masaoki Uno[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies Tohoku University)

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

[SMP25-03] U–Pb garnet dating of HP marble from the Eastern Iratsu body, Sanbagawa metamorphic terrane: decoupled isotopic signature and compositional zoning

*Sota Niki[1], Kenta Yoshida[2], Hikaru Sawada[2], Ryosuke Oyanagi[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

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

[SMP25-04] **Crystal size distribution of garnet formed by two-stage growth in the Kotsu eclogite, Sanbagawa belt**

*OTGONBAYAR DANDAR[1], Atsushi Okamoto[1], Masaoki Uno[1] (1.Graduate School of Environmental Studies, Tohoku University)

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

[SMP25-05] A shape change model of isolated K-feldspar inclusions within a micro-shear zone developed in Teshima granite, the Ryoke metamorphic belt

*Tae-Hoon Uhmb[1], Katsuyoshi Michibayashi[1] (1.Department of Earth and Planetary Sciences, Research group of Petrology and Mineralogy, Nagoya University)

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

[SMP25-06] C-O-H fluid was present during garnet-forming partial melting reaction in a pelitic migmatite from the Ryoke belt, Japan

*Natsumi Yoshimoto[1], Tetsuo Kawakami[1] (1.Kyoto University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.20 Zoom Room 20

[S-MP25] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[SMP25-07] Rheological and metamorphic evolutions of high-grade Shimanto accretionary complex in Kerama islands, Ryukyu

*Ippei Yamamoto[1], Yoshihiro Nakamura[2], Yumiko Harigane[2], Yui Kouketsu[3], Kenichiro Tani[4], Asuka Yamaguchi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Institute of Advanced Industrial Science and Technology, 3.Nagoya University, 4.National Museum of Nature and Science)

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

[SMP25-08] Rheological Properties of Ductile Shear Zone Developed in Mado Megamullion, Shikoku Basin, Philippine Sea

*Kohei Nimura[1], Katsuyoshi Michibayashi[2], Yumiko Harigane[3], Yasuhiko Ohara[4,5] (1.Department of Earth and Planetary Science, Faculty of Science, Nagoya University , 2.Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 3.Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 4.Hydrographic and Oceanographic Department of Japan, 5.JAMSTEC)

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

[SMP25-09] Possibility of CPO development during diffusion creep of the lower crustal minerals

*Bunrin Natsui[1], Kosuke Yabe[1], Takehiko Hiraga[1] (1.Earthquake Research Institute, University of Tokyo)

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

[SMP25-10] **The effect of fluid compositions on pore formation during plagioclase replacement under supercritical conditions**

*Astin Nurdiana[1], Atsushi Okamoto[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1] (1.Tohoku University)

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

[SMP25-11] Garnet–aluminosilicate–spinel–plagioclase geobarometer

*Toshiaki Shimura[1], Yuki Harada[1,2], Geoffrey L. Fraser[3], Noriyoshi Tsuchiya[4] (1.Yamaguchi University, 2.i-SHOT Inc., 3.Geoscience Australia, 4.Tohoku University)

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

[SMP25-12] Porosity wave and mineral banding in the metamorphism

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.20 Zoom Room 20

[S-MP25] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[SMP25-13] Different entrapment timings of melt inclusions in garnet and quartz in an UH *T* granulite from Rundvågshetta

*Kota Suzuki[1], Tetsuo Kawakami[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

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

[SMP25-14] **Effect of syn-metamorphic fluids on HP-LT chloritoid-bearing assemblages: a study case from the Monti Romani (Italy)**

*Samuele Papeschi[1], Alessio Pontesilli[2], Claudia Romano[3], Federico Rossetti[3] (1.Kochi (X-Star), JAMSTEC, Japan, 2.INGV, Roma, Italy, 3.University Roma Tre, Italy)

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

[SMP25-15] **Newly discovered eclogite in the Khungui zone, Zavkhan terrane, Western Mongolia: P-T evolution and tectonic implication**

*Manzshir Bayarbold[1], Atsushi Okamoto[1], OTGONBAYAR DANDAR[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

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

[SMP25-16] Serpentinization and Carbonation processes of Ultramafic rocks in Manlay Ophiolite, Southern Mongolia

*Nomuulin Amarbayar[1], Atsushi Okamoto[1], Masaoki Uno[1], OTGONBAYAR DANDAR[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

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

[SMP25-17] Petrological characteristics of the slab-mantle interface during incipient subduction: insights from Dalrympole Amphibolite, Palawan, Philippines

*Gabriel Theophilus Vinalay Valera[1], Tetsuo Kawakami[1], Betchaida Duetes Payot[2] (1.Graduate School of Science, Kyoto University, 2.National Institute of Geological Sciences, University of the Philippines)

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

[SMP25-18] New deformation proxy for alkaline felsic rocks: Na-K zoning of alkali feldspar in syenites from the Wadi Dib alkaline ring complex, Eastern Desert, Egypt

*Kazuhito Ozawa[1], Eman Saad Hassan[2], Hideto Yoshida[1], Ali Abdel-Kader Khudeir[2] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Geology Department, Assiut University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

10:45 AM - 11:50 AM JST | 1:45 AM - 2:50 AM UTC | Ch.23 Zoom Room 23

[S-MP26] Physics and Chemistry of Minerals

convener:Masahiro KAYAMA(Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Itaru Ohira(Department of Chemistry, Faculty of Science, Gakushuin University), Chairperson:Masahiro KAYAMA(Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Itaru Ohira(Department of Chemistry, Faculty of Science, Gakushuin University)

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

[SMP26-01] **Skew-normal peak fitting of cathodoluminescence on shocked quartz: a statistical model for impact pressure estimation**

Yu Chang[2], Shintaro Kadoya[3], *Keisuke Yano[1], Masahiro KAYAMA[2], Eiichi Tajika[2], Yasuhito Sekine[4], Toshimori Sekine[5], Hirotsugu Nishido[6], Takamichi Kobayashi[7] (1.The Institute of Statistical Mathematics, 2.The University of Tokyo, 3.University of Washington , 4.Tokyo Institute of Technology, Earth-Life Science Institute (ELSI), 5.Osaka University, 6.Okayama University of Science, 7.National Institute for Materials Science)

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

[SMP26-02] Magnetite oxidation investigated by synchrotron X-ray diffraction and X-ray absorption spectroscopy

*Atsushi Kyono[1], Ibuki Kinebuchi[1] (1.Division of Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba)

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

[SMP26-03] *P-T* dependence of hydrogen-bond geometry of β-CrOOD

Chikara Shito[1], *Hiroyuki Kagi[1], Asami Sano-Furukawa[2,3], Sho Kakizawa[4], Kazuki Komatsu[1], Riko Iizuka-Oku[1], Katsutoshi Aoki[1], Jun Abe[5], Shinichi Machida[5], Takashi Saito[3], Takashi Kamiyama[3], Noboru Furukawa[6], Akio Suzuki[7] (1.Graduate School of Science, University of Tokyo, 2.Japan Atomic Energy Agency, 3.High Energy Accelerator Research Organization, 4.Graduate School of Advanced Science and Engineering, Hiroshima University, 5.Comprehensive Research Organization for Science and Society, 6.Graduate School of Science, Chiba University, 7.Graduate School of Science, Tohoku University)

11:30 AM - 11:50 AM JST | 2:30 AM - 2:50 AM UTC

[SMP26-04] Discussion

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.25 Zoom Room 25

[S-VC27] Mitigation of volcanic disasters - basic and applied researches

convener:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government), Tatsuro Chiba(Asia Air Survey Co., Ltd.), Yousuke Miyagi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[SVC27-01] Ash Fall Hazard Map using Newly Developed Simulation Model

*Tsuyoshi Nakatani[1], Toshiyuki Asano[1] (1.The Research and Education Center for Natural Hazards, Kagoshima University)

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

[SVC27-02] On the Effects of the Inertial Forces of the Falling Volcano Ash on the Ash absorption by an External Unit of Building Air Conditioning

*Kiyotoshi Otsuka[1], Arihide Nobata[1], Hitoshi Suwa[1], Tomohiro Kubo[2], Yosuke Miyagi[3], Masamitsu Miyamura[3] (1.Obayashi Corporation, 2.Mount Fuji Research Institute, Yamanashi Prefectural Government , 3.National Research Institute for Earth Science and Disaster Resilience)

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

[SVC27-03] Experimental Study on Safety of Wooden Building Roofs Against Impact of Ballistic Ejecta

*Kohei Tateyama[1], Hiroyuki Yamada[2], Ryo Honda[3], Tomohiro Kubo[3], Mitsuhiro Yoshimoto[3] (1.Ritsumeikan University, 2.National Defense Academy, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[SVC27-04] **A trajectory analysis of a rockfall on a steep slope at Mt. Fuji to determine the possible source area of the falling rock**

*Taishi Sakurada[1], Ryodo Hemmi[2], Yasuhiro Ishimine[3], Hideaki Miyamoto[1] (1.The University of Tokyo, 2.The University Museum, The University of Tokyo, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[SVC27-05] Improvement of Proto-type Educational Web Contents for the Municipalities' Disaster Response Staff.

*Tomohiro Kubo[1], Mitsuhiro Yoshimoto[1], Yosuke Miyagi[2], Ryo Honda[1], Yasuhiro Ishimine[1] (1. Mount Fuji Research Institute, 2.National Research Institute for Earth Science and Disaster Resilience)

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

[SVC27-06] Training of the human resource development for volcanic disaster management officers at Mt Fuji

*Mitsuhiro Yoshimoto[1], Tomohiro Kubo[1], Ryo Honda[1], Yasuhiro Ishimine[1], Kenji Niihori[2], Makoto Kanano[2] (1.Mount Fuji Research Institute, Yamanashi Prefectural Government, 2.Organization of Volcanic Disaster Mitigation, NPO.)

[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-VC29] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology)

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

[SVC29-01] Compositional variability of rare earth elements in spring waters around Aso Volcano

*Hitomi Nakamura[1], Noritoshi Morikawa[1], Hikaru Iwamori[2], Shuhei Sakata[2], Qing Chang[3] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology)

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

[SVC29-02] Deep-seated fluid supply around Kusatsu-Shirane volcano revealed by helium and carbon isotope ratios

*Hirochika Sumino[1], Takiguchi Takahiro[2], Tomoya Obase[1], Kotaro Toyama[3], Akihiko Terada[4] (1.Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo, 2.Department of Integrated Science, College of Arts and Science, The University of Tokyo, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Volcanic Fluid Research Center, Tokyo Institute of Technology)

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

[SVC29-03] Evolution of the magmatic-hydrothermal system of Mendeleev volcano (Kunashir Island)

*Alexey Andreevich Kotov[1], Sergey Zakharovich Smirnov[2], Noriyoshi Tsuchiya[1], Masaoki Uno[1] (1.Graduate School of Environmental Studies, Tohoku University, 2.Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia)

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

[SVC29-04] Volcanic unrests after the 2015 phreatic eruption of Hakone volcano and its hydrothermal system

*Kazutaka Mannen[1], Yuki Abe[1], Ryosuke Doke[1], Yohei Yukutake[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

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

[SVC29-05] Structure of the shallow hydrothermal system in Hakone volcano inferred from InSAR analysis

*Ryosuke Doke[1], Kazutaka Mannen[1], Kazuhiro Itadera[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

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

[SVC29-06] Ground deformations at Kuju volcano, Japan, revealed by PALSAR-2 InSAR

*Shohei Narita[1], Takahiro Ohkura[1] (1.Aso Volcanological Laboratory, Institute for Geothermal Science, Graduate School of Science, Kyoto University)

[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-VC29] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University)

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

[SVC29-07] The plumbing system of a Miyakejima volcano: insights into magmatic-hydrothermal interactions

*Marceau Gresse[1], Makoto Uyeshima[1], Takao Koyama[1], Hideaki Hase[2], Koki Aizawa[3], Yusuke Yamaya[4], Yuichi Morita[1], Derek Weller[1], Tawat Rung-Arunwan[5], Takayuki Kaneko[1], Yoichi Sasai[6], Jacques Zlotnicki[7], Tsuneo Ishido[8], Hideki Ueda[9], Maki Hata[1] (1.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 2.Geothermal Energy Research & Development Co., Ltd., Tokyo, Japan, 3.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, Fukuoka, Japan, 4.National Institute of Advanced Industrial Science and Technology (AIST), Renewable Energy Research Center, Fukushima, Japan, 5.Curl-E Geophysics Co., Ltd., Thailand, 6.Earthquake Prediction Research Center, Tokai University, Shizuoka, Japan, 7.CNRS, EMSEV, OPGC-UMR6524, Aubière, France, 8.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 9.National Research Institute for Earth Science and Disaster Resilience (NIED), Tsukuba, Japan)

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

[SVC29-08] Ability of the magnetotelluric method to image a deep conductor: Exploration of a supercritical geothermal system

*Keiichi Ishizu[1], Yasuo Ogawa[1], Toru Mogi[1], Yusuke Yamaya[2], Toshihiro Uchida[2] (1.Tokyo Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[SVC29-09] Analysis and interpretation of DAS-seismic results obtained at the Ohnuma geothermal field in the Hachimantai volcanic region, in Japan

*Junzo Kasahara[1,2], Yoko Hasada[1,3], Kuzume Haruyasu[1] (1.ENAA, 2.Shizuoka University, 3.Daiwa Exploration and Consulting Co. Ltd.)

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

[SVC29-10] Thermal property measurements by drilling cuttings obtained from a geothermal well in the Hachimantai area and thermal structure analysis

*Haruto Sugamoto[1], Kazuya Ishitsuka[1], Weiren Lin[1], Takemi Sakai[2] (1. Graduate School of Engineering, Kyoto University, 2.Geothermal Engineering Co., Ltd.)

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

[SVC29-11] Characteristics of eruption periodicity observed at Shikabe geyser and estimation of the factor of long term periodicity change

*Ayuta Tsuge[1], Hiroshi Aoyama[2] (1.Institute of Seismology and Volcanology, Graduate School of Sciences, Hokkaido University, 2.Institute of Seismology and Volcanology, Fuculty of Science, Hokkaido University)

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

[SVC29-12] Modeling of multidisciplinary observations during an inter-eruptive period by using a hydrothermal simulation with post-processors

*Ryo Tanaka[1], Takeshi Hashimoto[1], Shohei Narita[2] (1.Hokkaido University,Institute of Seismology and Volcanology, 2.Kyoto University, Graduate School of Science, Institute for Geothermal Sciences, Aso Volcanological Laboratory)

[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.23 Zoom Room 23

[S-CG44] Petrology, Mineralogy & Resource Geology

convener:Koichi Momma(National Museum of Nature and Science), Yu Nishihara(Geodynamics Research Center Ehime University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Yu Nishihara(Geodynamics Research Center Ehime University), Koichi Momma(National Museum of Nature and Science), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

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

[SCG44-01] Consolidation anisotropy of Mio–Pleistocene sedimentary soft rocks in the eastern part of the Boso Peninsula, central Japan

*Nana Kamiya[1], Masahiro Miyazaki[1], Weiren Lin[1] (1.Graduate School of Engineering, Kyoto University)

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

[SCG44-02] Prograde and progressive metamorphism of low-pressure and high-temperature terrane in the Tenzan area, Saga prefecture, north Kyusyu, Southwest Japan

*Yusaku Tanaka[1], Masaaki Owada[1] (1.Yamaguchi University)

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

[SCG44-03] ZIRCON U–Pb AGES AND GEOCHEMISTRY OF GRANITOIDS FROM SOUTHWEST MONGOLIA

*Dolzodmaa Boldbaatar[1], Yasuhito Osanai[1], Nobuhiko Nakano[1], Tatsuro ADACHI[1], Ippei Kitano[1], Kundyz Syeryekhan[2] (1.Kyushu University, 2.Golden Hill LLC)

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

[SCG44-04] Zircon U–Pb ages of plutonic rocks from Iwafune area, Ibaraki Prefecture

*Haruki Yamazaki[1], Terumi Ejima[1], Yoshiaki Kon[2], Yuki Tsunazawa[2] (1.Shinshu University Faculty of Science Department of Geology, 2.National Institute of Advanced Industrial Science and Technology)

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

[SCG44-05] Petrogenetic study on the cretaceous granitoids on the Takanawa Peninsula, northwest Shikoku, southwest Japan

*Kazuya Shimooka[1], Satoshi SAITO[1], Kenichiro Tani[2], Toshiro Takahashi[3] (1.Graduate School of Science and Engineering, Ehime University, 2.Department of Geology and Paleontology, National Museum of Nature and Science, 3.Graduate School of Science and Technology, Niigata University)

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

[SCG44-06] The kinetics and heat conduction model of thermoluminescence of orthoclase

*Takahiro Sato[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1] (1.Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.23 Zoom Room 23

[S-CG44] Petrology, Mineralogy & Resource Geology

convener:Koichi Momma(National Museum of Nature and Science), Yu Nishihara(Geodynamics Research Center Ehime University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

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

[SCG44-07] Formation of bipyramidal quartz within the hydrothermal vents: inights from Kuroko samples and hydrothermal experiments

*Jumpei Sugioka[1], Atsushi Okamoto[1], Ryoichi Yamada[1] (1.Tohoku University)

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

[SCG44-08] Copper mobilization systems associated with the Neogene magmatism in the Northeast Japan arc

*Shota Satori[2,1], Yoshiaki Kon[2], Yasushi Watanabe[1], Takuya Echigo[1] (1.Graduate School of International Resource Sciences, Akita University, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[SCG44-09] Discussion

[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.18 Zoom Room 18

[S-CG53] Reducing risks from earthquakes, tsunamis & volcanoes: new applications of realtime geophysical data

convener:Masashi Ogiso(Meteorological Research Institute, Japan Meteorological Agency), Masumi Yamada(Disaster Prevention Research Institute, Kyoto University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), YAMAMOTO Naotaka CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

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

[SCG53-01] An advanced system for automatic strong gust detection and warning for railroads using deep learning

★Invited Papers

*Kusunoki Kenichi[1], Toru Adachi[1], Hanako Inoue[1], Osamu Suzuki[1], Naoki Ishitsu[2], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd., 3.East Japan Railway Company)

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

[SCG53-02] Tsunami observation and development of real-time tsunami detection by using ocean surface radar

★Invited Papers

*Ryotaro Fuji[1], Kohei Ogata[2], Hirofumi Hinata[3] (1.Kokusai Kogyo Co., Ltd., Ehime University, 2.Kokusai Kogyo Co., Ltd., 3.Ehime University)

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

[SCG53-03] Preliminary comparison of strong-motion parameters at the land & ocean bottom sites for the 2021 Mw 7.1 Off Fukushima Prefecture earthquake

*Yadab Prasad Dhakal[1], Wataru Suzuki[1], Takashi Kunugi[1], Takeshi Kimura[1], Shin Aoi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SCG53-04] Development of GNSS Real-time analysis including QZSS

*Satoshi ABE[1], Keitaro Ohno[1], Naofumi Takamatsu[1], MURAMATSU Hiroki[1], Tomoaki FURUYA[1], Yohei HIYAMA[1] (1.Geospatial Information Authority of Japan)

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

[SCG53-05] IPFx: extended integrated particle filter method for earthquake early warning and visualization of its results with social networking service

*Masumi Yamada[1], Koji Tamaribuchi[2], Stephen Wu[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Meteorological Research Institute, 3.Institute of Statistical Mathematics)

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

[SCG53-06] Near real-time estimation of hypocenter distribution from seismic amplitudes

*Masashi Ogiso[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[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.17 Zoom Room 17

[S-CG54] Ten years from the 2011 Tohoku Earthquake: A milestone of Solid Earth Science

convener:Ryota Hino(Graduate School of Science, Tohoku University), Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Chairperson:Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

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

[SCG54-01] Introduction

9:05 AM - 9:30 AM JST | 12:05 AM - 12:30 AM UTC

[SCG54-02] **Modeling stress field and deformation associated with the Tohoku-Oki earthquake: Understanding the dynamics of the northeastern Japan islands arc-trench system**

★Invited Papers

*Bunichiro Shibazaki[1], Ryohei Sasajima[2] (1.International Institute of Seismology and Earthquake Engineering, Building Research Institute, 2.Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

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

[SCG54-03] Temporal evolution of seafloor crustal deformation obtained by the 10-year-long GNSS-A observations after the 2011 Tohoku-oki earthquake

*Shun-ichi Watanabe[1], Tadashi Ishikawa[1], Yuto Nakamura[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, University of Tokyo)

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

[SCG54-04] The slow earthquake spectrum in the Japan Trench illuminated by the S-net seafloor observatories

★Invited Papers

*Tomoaki Nishikawa[1], Takanori Matsuzawa[2], Kazuaki Ohta[2], Naoki Uchida[3], Takuya NISHIMURA[1], Satoshi Ide[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Graduate School of Science and International Research Institute of Disaster Science, Tohoku University, 4.Department of Earth and Planetary Science, University of Tokyo)

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

[SCG54-05] A Decade of Lessons Learned from the 2011 Tohoku-oki Earthquake

*Naoki Uchida[1], Roland Bürgmann[2] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2.Department of Earth and Planetary Science, University of California, Berkeley)

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

[SCG54-06] Temporal and spatial variations in background seismicity after the 2011 Tohoku-Oki earthquake estimated from HIST-ETAS model

*Taku Ueda[1], Aitaro Kato[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.17 Zoom Room 17

[S-CG54] Ten years from the 2011 Tohoku Earthquake: A milestone of Solid Earth Science

convener:Ryota Hino(Graduate School of Science, Tohoku University), Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Chairperson:Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Ryota Hino(Graduate School of Science, Tohoku University)

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

[SCG54-07] **Seismic Imaging and Physical Properties of Underthrust Sediments at the Japan Trench Subduction Zone**

*Ehsan Jamali Hondori[1], Jin-Oh Park[1] (1.The University of Tokyo, Atmosphere and Ocean Research Institute)

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

[SCG54-08] Inputs to the Japan Trench subduction zone and its implications for the subduction zone processes

★Invited Papers

*Gou Fujie[1], Shuichi Kodaira[1], Yasuyuki Nakamura[1], Seiichi Miura[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[SCG54-09] Frictional properties of incoming sediments and rocks at shallow conditions of the Japan Trench subduction zone

*Kyuichi Kanagawa[1], Sayumi Sagano[2], Takuma Hayashi[3], Junya Fujimori[2], Michiyo Sawai[1] (1.Graduate School of Science, Chiba University, 2.Graduate School of Science and Engineering, Chiba University, 3.Faculty of Science, Chiba University)

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

[SCG54-10] **Earthquake faulting in the Japan Trench subduction zone: lessons learned from deep ocean drilling and the fault rocks in the exhumed accretionary complex**

*Kohtaro Ujiie[1], Keisuke Ito[2], Ayaka Nagate[2], Hiroki Tabata[2] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Graduate School of Life and Environmental Sciences, University of Tsukuba)

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

[SCG54-11] Development of near-field tsunami forecasting method using ocean-bottom pressure sensor network (S-net)

*Yuichiro Tanioka[1] (1.Hokkaido University, Institute of Seismology and Volcanology)

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

[SCG54-12] Real-time Tsunami Inundation Forecast in Japan - Present and Future

*Shunichi Koshimura[1,5], Ryota Hino[2,5], Yusaku Ohta[2,5], Akihiro Musa[3,5], Takayuki Suzuki[5], Takashi Abe[1], Hiroaki Kobayashi[4,5] (1.International Research Institute of Disaster Science, Tohoku University, 2.Graduate School of Science, Tohoku University, 3.Cyberscience Center, Tohoku University, 4.Graduate School of Information Sciences, Tohoku University, 5.RTi-cast, Inc.)

[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-CG55] Oceanic plate as inputs to subduction zone: from oceanic spreading ridge to subduction trench

convener:Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Takanori Kagoshima(University of Toyama), Chairperson:Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Takanori Kagoshima(University of Toyama)

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

[SCG55-01] The Earth recycle and verification of ocean extinction hypothesis - New development in ocean plate research

★Invited Papers

*Katsuyoshi Michibayashi[1] (1.Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University)

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

[SCG55-02] Prolonged mantle history recorded in zircons from the Horoman peridotite, Hokkaido, Japan

*Shinji Yamamoto[1], Yibing Li[2], Kiyoaki Niida[3], Shuhei Sakata[4], Takeshi Ohno[5] (1.Graduate School of Environment and Information Sciences, Yohohama National University, 2.Institute of Geology Chinese Academy of Geological Science, 3.Hokkaido University Museum, 4.Earthquake Research Institute, The University of Tokyo, 5.Gakushuin University)

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

[SCG55-03] Depth profile of hydration along the crust - mantle section of the Oman ophiolite: insights from holes CM1A and CM2B

*Kazuki Yoshida[1], Atsushi Okamoto[1], Ryosuke Oyanagi[2], Noriyoshi Tsuchiya[1], Oman Drilling Project Phase2 Science Party (1.Tohoku university, 2.Japan Agency for Marine-Earth Science and Technology)

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

[SCG55-04] The geochemical structure of pre-subducting oceanic lithosphere explored from petit-spot volcano

*Kazuto Mikuni[1], Naoto Hirano[1], Norikatsu Akizawa[2], Shiki Machida[3] (1.Tohoku University , 2.University of Tokyo, 3.Chiba Institute of Technology)

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

[SCG55-05] Rejuvenated extension of the Philippine Sea plate and its effect on subduction dynamics in the Nankai Trough

*Gaku Kimura[1], Yasuyuki Nakamura[2], Kazuya Shiraishi[2], Gou Fujie[2], Shuichi Kodaira[2], Asuka Yamaguchi[3], Rina Fukuchi[4], Yoshitaka Hashimoto[5] (1.Tokyo University of Marine Science and Technology, 2.JAMSTEC, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Dia Consultants Co., Ltd., 5.Kochi University)

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

[SCG55-06] Thermal structure of the Tohoku subduction zone: effects of plate cooling models

*Manabu Morishige[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.19 Zoom Room 19

[S-CG55] Oceanic plate as inputs to subduction zone: from oceanic spreading ridge to subduction trench

convener:Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Takanori Kagoshima(University of Toyama), Chairperson:Takanori Kagoshima(University of Toyama), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University)

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

[SCG55-07] Interpretation for variation in the incoming Pacific Plate structure around the Kuril Trench axial region by an OBS/MCS seismic survey

★Invited Papers

*Ryosuke Azuma[1], Shuichi Kodaira[2], Ryota Hino[1], Gou Fujie[2], Koichiro Obana[1], Fumiaki Tomita[2], Yusaku Ohta[1] (1.Recearch Center for Prediction of Earthquake and Volcanic Eruption, Graduate School of Science, Tohoku University, 2.Japan Agency for Marin-Earth Science and Technology)

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

[SCG55-08] **Characteristics of normal faults developing in the outer rise of the Japan Trench**

*YUE SUN[1], Ehsan Jamali Hondori[1], Jin-Oh Park[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[SCG55-09] Complicated fault geometry of outer-trench normal-faulting earthquakes based on the ocean bottom seismograph observations

*Koichiro Obana[1], Tsutomu Takahashi[1], Yojiro Yamamoto[1], Yasuyuki Nakamura[1], Gou Fujie[1], Seiichi Miura[1], Shuichi Kodaira[1] (1.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology)

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

[SCG55-10] Mantle-derived helium released through the Japan Trench bend-faults

★Invited Papers

*Jin-Oh Park[1], Naoto Takahata[1], Ehsan Jamali Hondori[1], Asuka Yamaguchi[1], Takanori Kagoshima[2], Tetsuro Tsuru[3], Gou Fujie[4], Yue Sun[1], Juichiro Ashi[1], Makoto Yamano[5], Yuji Sano[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Environmental Biology and Chemistry, University of Toyama, 3.Department of Marine Resources and Energy, Tokyo University of Marine Science and Technology, 4.Japan Agency for Marine-Earth Science and Technology, 5.Earthquake Research Institute, University of Tokyo)

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

[SCG55-11] Heat flow distribution seaward of the Japan and Kuril trenches: Implications for fluid circulation in the oceanic crust

*Makoto Yamano[1], Yoshifumi Kawada[2], Kouta Sasaki[3], Masataka Kinoshita[1] (1.Earthquake Research Institute, the University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kozo Keikaku Engineering Inc.)

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

[SCG55-12] Resistivity imaging around the Japan trench based on ocean bottom electromagnetic surveys

★Invited Papers

*Hiroshi Ichihara[1], Takafumi Kasaya[2], Tada-nori Goto[3], Kiyoshi Baba[4], Shinya Sato[5], Makoto Yamano[4] (1.Graduate school of environmental studies, Nagoya University, 2.JAMSTEC, 3.ERI, University of Tokyo, 4.University of Hyogo, 5.Graduate School of Engineering, Kyoto University)

[J] Oral | B (Biogeosciences)：B-PT Paleontology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.26 Zoom Room 26

[B-PT02] Biotic History

convener:Isao Motoyama(Faculty of Science, Yamagata University), Takao Ubukata(Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University), Kazuyoshi Moriya(Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University), Chairperson:Isao Motoyama(Faculty of Science, Yamagata University), Takao Ubukata(Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University), Kazuyoshi Moriya(Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University)

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

[BPT02-01] Reconstruction of paleovegetation changes by pollen, palynomorph, and kerogen analyses of the Late Cretaceous sediments from the Kotanbetsu area, Hokkaido, Japan

*Maho Hayakawa[1], Ken Sawada[2], Masashi A. Ikeda[1], Reishi Takashima[3], Hiroshi Nishi[4] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.The Center for Academic Resources and Archives, The Tohoku University Museum, Tohoku University, 4.Institute of Dinosaur Research, Fukui Prefectural University)

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

[BPT02-02] Depth habitat of the late Eocene planktic foraminifers

*Kazuyoshi Moriya[1], Taku Oyama[2], Toyoho Ishimura[3] (1.Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.Major in Earth Sciences, Resources and Environmental Engineering, Graduate School of Creative Science and Engineering, 3.Department of Interdisciplinary Environment, Graduate School of Human and Environmental Studies, Kyoto University)

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

[BPT02-03] Micro sensory organs reveal the perception system and ecology of the Cretaceous cockroach

*Ryo Taniguchi[1], Yasuhiro Iba[1], Hiroshi Nishino[2], Hidehiro Watanabe[3], Kosuke Tateishi[3] (1.Faculty of Science, Hokkaido University, 2.Research Institute for Electronic Science, Hokkaido University, 3.Department of Earth System Science, Faculty of Science, Fukuoka University)

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

[BPT02-04] Computed tomography scanning reveals morphological development of a burrow produced by the tiger pistol shrimp *Alpheus bellulus*

*Miyu Umehara[1], Koji Seike[2], Seishiro Furuyama[1] (1.Tokyo University of Marine Science and Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[BPT02-05] Shell microstructure of extinct protobranch bivalves

*Kei Sato[1] (1.Faculty of Education and Integrated Arts and Sciences, Waseda University)

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

[BPT02-06] A unification of absolute growth, allometric, and theoretical morphologic models: a case of molluscan shells

*Takao Ubukata[1] (1.Department of Geology & Mineralogy, Division of Earth & Planetary Sciences, Kyoto University)

[J] Oral | G (General) : General

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

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education), Tetsuhiko Asano(Senshu University Matsudo Junior High School High School), Chairperson:Shintaro Hayashi(Akita University Graduate School of Education), Tetsuhiko Asano(HunabashiKeimei High School), Jiro Komori(Teikyo Heisei University), Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education)

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

[G01-01] Subjects on science education based on lower secondary school Students' cognition of triggers and first causes of natural disasters caused by flood and earthquake: A case of F City, Japan

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

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

[G01-02] School education of disaster prevention through stone monuments for historical natural disasters and SfM technique

*Wataru Tanikawa[1], Go-Ichiro Uramoto[2], Kazuhisa Iwaka[3], Group General Affairs Division[1] (1.Japan Agency for Marine-Earth Science and Technology, Kochi Instutute for Core Sample Research, 2.Kochi University, 3.Tokushima University)

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

[G01-03] A Teaching Material as an Education for Volcanic Disaster Prevention in No Active Volcanic Area - Kikai-Akahoya Volcanic Ash at Tarumi-Hyuga Site in Kobe -

*Tatsuya KODA[1], Eiichi Sato[2] (1.Yanagi Gakuen Soukai Senior High School, 2.Hokkaido University of Education at Asahikawa)

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

[G01-04] Disaster prevention education on volcanic disasters
Development of Sakurajima version HUG

*Yuko Matsunari[1], Yasuhiro Ishimine[2], Tatsuo Takama[3], Hideaki Yoshihara[4], Tsuyoshi Nakatani[1], kaori Kaimoto[5], Keiko Imamura[1], Mitsuhito Sato[4], Naoyuki Hironiwa[6] (1.Kagoshima University, 2.Mount Fuji Research Institute, Yamanashi Prefectural Government, 3.Kagoshima prefecture Hospital , 4.Kagoshima City Hospital , 5.Kagoshima Women's College, 6.Minami-Nippon Shimbun)

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

[G01-05] The Necessity of Expanding Disaster Literacy toward the Era of "Society 5.0" "SDGs"

*Mamoru Hayashi[1] (1.University of TOYAMA)

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

[G01-06] Disaster prevention education through on-demand classes at universities

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

[J] Oral | G (General) : General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.03 Zoom Room 03

[G-02] Outreach and geoscience education

convener:Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Ken Tsukada(Hiratsuka City Museum), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies)

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[G02-01] The strategy and implementation of the Hayabusa2 outreach activities during the phase of the near asteroid operation

★Invited Papers

*Chisato Ikuta[1] (1.Japan Aerospace Exploration Agency)

9:30 AM - 10:00 AM JST | 12:30 AM - 1:00 AM UTC

[G02-02] How to activate discussion on on-line science cafe: Case study of "Science Agora 2020"

★Invited Papers

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3], Junya Terazono[4] (1.Kyoto City University of Arts, 2.Kyoto University, 3.University of Tokyo, 4.National Institute of Information and Communications Technology)

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

[G02-03] A practical report of virtual field activities with high-resolution panorama (GigaPans) at multiple scales and live broadcasting

*Norihito Kawamura[1], Takashi Sawaguchi[2], Jiro Komori[3] (1.School of Regional Resource Management, Graduate School, University of Hyogo, 2.Toyo Univ., 3.Teikyo Heisei Univ.)

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

[G02-04] Verification of demands for a location-based geological site interpretation service

*Keisuke Ito[1] (1.Geokatsu Inc.)

[J] Oral | G (General) : General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.03 Zoom Room 03

[G-02] Outreach and geoscience education

convener:Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Jiro Komori(Teikyo Heisei University), Satoko Oki(Faculty of Environment and information Studies)

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

[G02-05] History of public understanding of global warming -When were we able to recognize it?-

★Invited Papers

*Jiro Komori[1] (1.Teikyo Heisei University)

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

[G02-06] Visual demonstration of greenhouse gas using 15μm absorption band of carbon dioxide.

*Akira Yamamoto

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

[G02-07] Class proposals and practices for remote learning of chemistry experiments for earth science students.

*Mana Yasui[1], Taisei Fujimura[2], Chiharu Tano[3], Fumitaka Kondo[3], Kenji Yonemochi[3] (1.Waseda research institute for science and engineering, 2.The department of resources and environmental engineering, Waseda University, 3.Faculty of Education and Integrated Arts and Sciences, Waseda University)

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

[G02-08] Trial of composing a melody using ground motion records of the 2013 earthquake near Awaji Island

*Nobuyuki Yamada[1], Shiina Yamamoto[1] (1.Kochi University)

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

[G02-09] Education for awareness about sediment related disasters and trial of providing risk information at an elementary school

*Shusuke Miyata[1], Kensuke Takenouchi[2], Ryoko Shimasaki[1], Akira Kamata[2], Daizo Tsutsumi[3], Kotaro Ichida[1], Masaharu Fujita[1] (1.Kyoto University, 2.Kagawa University, 3.Mie University)

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

[G02-10] Discussion

[J] Oral | G (General) : General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.03 Zoom Room 03

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo), Chairperson:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo)

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

[G03-01] Authentic learning from perspective of aerospace - JAXA space education material "Earth Observation Coloring" -

*Yusuke Koga[1], Kenta Nomura[1] (1.Japan Aerospace Exploration Agency)

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

[G03-02] Home Science of Astronomy and Earth Science for Childcare Educators and Elementary School Teachers

*Akihiko Tomita[1] (1.Wakayama University)

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

[G03-03] Promotion of STEAM education (focus on space) with public-private partnership using an online tool.

*Norika Numa[1,3], Yoshiki Teramoto[2], Kaori Shoda[2], Asuki Yokoyama[3] (1.School of science, The University of Tokyo, 2.NPO Ikeda eco staff, 3.math channel Co., Ltd)

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

[G03-04] Visualization of crustal deformations in Japan -10 years before and after the 2011 Tohoku Earthquake viewed with GNSS dates.-

*Tadayoshi Kato[1] (1.Moegino Junior High School)

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

[G03-05] A case study of bringing online field tip closer to reality
- how to deliver the online excursion with on-site live broadcasting-

*Jiro Komori[1], Norihito Kawamura[2], SAWAGUCHI TAKASHI[3] (1.Teikyo Heisei University, 2.University of Hyogo, 3.Toyo University)

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

[G03-06] Geoscience・Geography education experiences at seven Japanese universities during the COVID-19 pandemic.

*Wonsuh SONG[1] (1.Waseda University)

[J] Oral | G (General) : General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.03 Zoom Room 03

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo), Chairperson:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo)

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

[G03-07] **A study of the cognition regarding natural disasters of junior high school students in Kobe City, Japan.**

*Toshio Arimichi[1,2], Norihito Kawamura[2] (1.Kobe Municipal Ibukidai Junior High School, 2.Graduate School of Regional Resource Management, University of Hyogo)

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

[G03-09] Thin-Section Making Recipe in a classroom Ver3.0 -using 3D printer-

*Yoshio Okamoto[1] (1.Osaka-Kyoiku University (temporary lecturer))

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

[G03-10] Development to teaching materials related to GIGA school

*Iida Kazuya[1] (1.Komaba-Toho Junior and Senior High School)

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

[G03-11] The report of the International Earth Science Olympiad (IESO) ,2021

*Norihito Kawamura[1], Yutaka Takigami[2] (1.School of Regional Resource Management, University of Hyogo, 2.JESOC)

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

[G03-12] Discussion

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.25 Zoom Room 25

[M-IS13] Dynamics of eruption cloud and cumulonimbus; modelling and observation

convener:Eiichi Sato(Meteorological Research Institute), Fukashi Maeno(Earthquake Research Institute, University of Tokyo), Takeshi Maesaka(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Eiichi Sato(Meteorological Research Institute)

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

[MIS13-01] Radar Meteorological Study on Falling Volcaic Ash Particles

★Invited Papers

*Masayuki Maki[1] (1.Research and Education Center for Natural Hazards, Kagoshima University)

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

[MIS13-02] PUFF Model Prediction of Volcanic Ash Plume Dispersal for Sakurajima Using MP Radar Observation

*Hiroshi Tanaka[1], Haruhisa Nakamichi[2], Masato Iguchi[2] (1.Center for Computational Sciences, University of Tsukuba, 2.Sakurajima Volcano Research Center, DPRC, Kyoto University, Kagoshima)

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

[MIS13-03] Numerical simulation of wind flow around Sakurajima with eruption

*Takashi Maruyama[1], Masato Iguchi[1] (1.Disaster Prevention Research Institute, Kyoto University)

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

[MIS13-04] Highspeed image observation of ballistic projectiles at Sakurajima volcano and a numerical model of ballistics

*Kae Tsunematsu[1], Saruta Shusaku[1], Taishi Yamada[2], Masato Iguchi[2] (1.Yamagata University, 2.Kyoto University)

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

[MIS13-05] Pattern classification of parent clouds of tornadoes in Tosa Bay

*Koji Sassa[1], Kotarou Fujii[2] (1.Natural Science Cluster, Kochi University, 2.Graduate School of Integrated Arts and Sciences, Kochi University)

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

[MIS13-06] Cloud-Scientific Study of Volcano Eruption -perspective-

★Invited Papers

*Yasushi Fujiyoshi[1] (1.Emeritus Prof. of Hokkaido University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.17 Zoom Room 17

[M-IS15] Tsunami deposit: research progress after the 2011 Tohoku-oki earthquake and prospects

convener:Masaki Yamada(Department of Geology, Faculty of Science, Shinshu University), Takashi Ishizawa(International Research Institute of Disaster Science, Tohoku University), Masashi Watanabe(Chuo University), Koichiro Tanigawa(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Masaki Yamada(Department of Geology, Faculty of Science, Shinshu University), Takashi Ishizawa(International Research Institute of Disaster Science, Tohoku University)

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

[MIS15-01] Sedimentation and erosion by the 2011 Tohoku-oki tsunami

★Invited Papers

*Kazuhisa Goto[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

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

[MIS15-02] How much we had understood a history of giant earthquakes along the Japan trench - progress and remaining problems-

★Invited Papers

*Yuki Sawai[1] (1.Geological Survey of Japan, AIST)

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

[MIS15-03] Advances in tsunami numerical modeling after the 2011 Tohoku earthquake and future challenges related to tsunami deposit research

★Invited Papers

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

[J] 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-IS15] Tsunami deposit: research progress after the 2011 Tohoku-oki earthquake and prospects

convener:Masaki Yamada(Department of Geology, Faculty of Science, Shinshu University), Takashi Ishizawa(International Research Institute of Disaster Science, Tohoku University), Masashi Watanabe(Chuo University), Koichiro Tanigawa(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Masashi Watanabe(Chuo University), Koichiro Tanigawa(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MIS15-04] **Application of DNN inverse model to large scale tsunamis to reconstruct the flow conditions of modern and ancient tsunamis**

★Invited Papers

*Rimali Mitra[1], Hajime Naruse[1], Tomoya Abe[2], Shigehiro Fujino[3], Daisuke Sugawara[4] (1.Kyoto University, Graduate School of Science, 2.Research Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 3.University of Tsukuba, 4.Tohoku University, IRIDeS)

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

[MIS15-05] Analysis of the Response of Tsunami Sediment Transport Numerical Simulation to Parameter Uncertainty

*Hidetoshi Masuda[1], Daisuke Sugawara[2], Shuro Yoshikawa[3], Hideyuki Sakurai[3], Fumihiko Imamura[2] (1.Division of Geoenviromental Science, Faculty of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Institute of Technology, Shimizu Corporation)

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

[MIS15-06] Event deposits in Lake Jusan, western part of Aomori Prefecture, NE Japan

*Fumika Hirano[1], Atsushi Urabe[2] (1.Faculty of Science, Niigata University, 2.Research Institute for Natural Hazards and Disaster Recovery, Niigata University)

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

[MIS15-07] Features of 17th-century tsunami deposits formed by tsunami crossing river channel and detection using X-ray computed tomography

*Kohei Iwaki[1], Yasuhiro Takashimizu[2], Yuichi Nishimura[3], Takashi Chiba[4] (1.Graduate School of Science and Technology, Niigata University, 2.Mathematical and Natural Sciences, Institute of Humanities, Social Sciences and Education, Niigata University, 3.Graduate School of Science, Hokkaido University, 4.Faculty of Bioresource Sciences, Akita Prefectural University)

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

[MIS15-08] Identification of invisible tsunami deposits formed by the 2011 Tohoku-oki tsunami

*Tetsuya Shinozaki[1], Yuki Sawai[1], Dan Matsumoto[1], Koichiro Tanigawa[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.16 Zoom Room 16

[M-IS22] Geopark

convener:Takayuki Arima(Yokohama City University), Keiichi Tadokoro(Research Center for Seismology, Volcanology and Earthquake and Volcano Research Center, Nagoya University), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Takayuki Ogata(Graduate School of Engineering and Science, University of the Ryukyus), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Takayuki Arima(Yokohama City University)

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

[MIS22-01] Academic Support for Geoparks: Efforts of the Geopark Assistance Committee, the Seismological Society of Japan

★Invited Papers

*Yoshihiro Hiramatsu[1] (1.School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University)

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

[MIS22-02] Preservation and utilization of earth heritage in Japan's natural monument system

★Invited Papers

*Tadahiro Shibata[1] (1.The Unit of Natural Monuments, Monuments and Sites Division, Cultural Properties Department, Agency for Cultural Affaire)

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

[MIS22-03] Developing virtual field experience with high-resolution panorama (GigaPans) at multiple scales: Constructing a core technology for online geotours

*Norihito Kawamura[1], Takashi Sawaguchi[2] (1.School of Regional Resource Management, Graduate School, University of Hyogo, 2.Toyo University)

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

[MIS22-04] Subaqueous volcanic rocks as the object for the geo tourism-related to NHK Buratamori and geoparks

*Hiromitsu Yamagishi[1], Yoshiaki Matsuda[1], Kazuo Shimura[2] (1.NPO Hokkaido Research Center of Geology(HRCG), 2.Shin Engineering Consultant)

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

[MIS22-05] Disaster risk reduction in Geopark from social geographical approach : focusing on social capital for community resilience

*Akifumi Nakamura[1] (1.Muroto Geopark Promotion Committee)

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

[MIS22-06] The Land Use Change and Socio-economic Impact of Baiyankeng Geo-cultural Village, China

*Wenqi ZHAO[1] (1.University of Tsukuba)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

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

[M-IS24] Geophysical fluid dynamics-Transfield approach to geoscience

convener:Keita Iga(Atmosphere and Ocean Research Institute, The University of Tokyo), Shigeo Yoshida(Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University), Takatoshi Yanagisawa(Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Hidenori AIKI(Nagoya University), Chairperson:Kensuke Nakajima(Department of Earth and Planetary Sciences,Flculty of Sciences,Kyushu University)

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

[MIS24-01] Balance of baroclinicity and restoring force due to stable temperature stratification in developing horizontal convection in a finite fluid layer

*Tomomi Terada[1], Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3,2], Takehiro Miyagoshi[3], Yuichi Murai[2] (1.Graduate School of Engineering, Hokkaido University , 2.Faculty of Engineering, Hokkaido University, 3.Japan Agency for Marine-Earth Science and Technology)

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

[MIS24-02] Quasi-periodic oscillations of convection patterns and heat transport in horizontally finite geometries

*Takatoshi Yanagisawa[1], Megumi Akashi[2], Yuji Tasaka[3], Ataru Sakuraba[4] (1.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology, 2.Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf, 3.Faculty of Engineering, Hokkaido University, 4.Department of Earth and Planetary Science, University of Tokyo)

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

[MIS24-03] Cyclonic-anticyclonic asymmetry on maintained vortices near the westerlies focused on external vortices

*Koryu Yamamoto[1], Keita Iga[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[MIS24-04] High-frequency measurement of a double helical vortex with a sonic anemometer thermometer for laboratory use

*Toshihisa Itano[1] (1.National Defense Academy)

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

[MIS24-05] Numerical experiments of surface flows on giant planets produced by forcings representing thunderstorms

Ryoma Suzuki[2], *Youhei SASAKI[1], Masaki Ishiwatari[3] (1.Institute of Fundamental Sciences, Faculity of Science and Engineering, Setsunan University, 2.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

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

[MIS24-06] Discussion

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.11 Zoom Room 11

[M-IS25] Atmospheric electricity: Electrical phenomena associated with extreme weather

convener:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Daohong Wang(Gifu University), Chairperson:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Daohong Wang(Gifu University)

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

[MIS25-01] Understanding of fine structure of cumulonimbus using new observational method

★Invited Papers

*Fumiaki Kobayashi[1] (1.National Defense Academy)

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

[MIS25-02] Various common meteorological characteristics obtained by multiple observation results of downburst

*Hisato Iwashita[1], Fumiaki Kobayashi[2] (1.Meisei Electric Co.,Ltd, 2.National Defense Academy)

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

[MIS25-03] Observations of summer thunderstorms using dual polarized phased array weather radar and three-dimensional lightning location system using LF band in Kanto area

*Hiroshi Kikuchi[1], Yuhei Kamei[1], Yoshitaka Nakamura[3], Eiichi Yoshikawa[5], Takeshi Morimoto[4], Tomoo Ushio[2], Yasuhide Hobara[1] (1.The University of Electro Communications, 2.Osaka University, 3.Kobe City College of Technology, 4.Kinki University, 5.Japan Aerospace Exploration Agency)

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

[MIS25-04] 3D characteristics of lightning activity in Typhoon Faxai (2019)

*Namiko Sakurai[1], Hironori Fudeyasu[2], Paul R. Krehbiel[3], Ronald J. Thomas[3], William Rison[4], Daniel Rodeheffer[4] (1.National Research Institute For Earth Science and Disaster Prevention, 2.Yokohama National University, 3.New Mexico Tech, 4.LMA technologies)

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

[MIS25-05] Citizen science "Thundercloud project" for mapping observations of gamma rays from thunderstorms

*Teruaki Enoto[1], Yuko Ikkatai[2], Yuuki Wada[1], Gabriel Diniz[1], Masaki Numazawa[1], Yo Kato[1], Shoko Miyake[3], Kazuhiro Nakazawa[4], Shohei Hisadomi[4], Yuna Tsuji[4], Takayuki Yuasa, Harufumi Tsuchiya[5], Takeshi Morimoto[6], Yoshitaka Nakamura[7], Masashi Kamogawa[8] (1.RIKEN, 2.The University of Tokyo, 3.National Institute of Technology, Ibaraki College, 4.Nagoya University, 5.JAEA, 6.Kinki University, 7.Kobe City College of Technology, 8.Global Center for Asian and Regional Research, University of Shizuoka)

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

[MIS25-06] Radioluminescence appeared above the epicenter immediately before and after the 1995 Kobe earthquake

*Yuji Enomoto[1], Tsuneaki Yamabe[1], Shigeki Sugiura[2], Hitoshi Kondo[2] (1.Shinshu Univeristy, Ueda Campus Fii, 2.Genesis Research Institute Inc.)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

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

[M-IS26] Gas hydrates in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[MIS26-01] Massive seafloor methane release near the edge of the gas hydrate stability zone in southern Brazil

★Invited Papers

*Marcelo Ketzer[1], Daniel Praeg[2], Luiz F. Rodrigues[3], Adolpho Augustin[3], Maria A. G. Pivel[4], Mahboubeh Rahmati-Abkenar[1], Dennis J. Miller[5], Adriano R. Viana[5], José A. Cupertino[3] (1.Department of Biology and Environmental Science, Faculty of Health and Life Sciences, Linnaeus University, 2.Géoazur, 3.Petroleum and Natural Resources Institute, Pontificia Universidade Catolica do Rio Grande do Sul, 4.Instituto de Geociências, Universidade Federal do Rio Grande do Sul, 5.Petrobras)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[MIS26-02] **Experimental Verification of CH_4-CO_2 Replacement Occurring in Natural Gas Hydrates for Energy Recovery and CO_2 Sequestration**

★Invited Papers

*Yongwon Seo[1] (1.Ulsan National Institute of Science and Technology, Republic of Korea)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[MIS26-03] **Gashydrate accumulations in the Asian Seas and perspective on comparable research in the Indo-Pacific Region**

★Invited Papers

*Renat B. Shakirov[1], Hitoshi Tomaru[2], Pawan Dewangan[3], Prakash Kumar[4], Anatoly Obzhirov[1], Ryo Matsumoto[5] (1.POI FEB RAS, 2.Chiba University, 3.CSIR-NIO, 4.CSIR-NGRI, 5.Meiji University)

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

[MIS26-04] High-resolution seafloor observation of a shallow methane hydrate area off Sakata, eastern margin of the Sea of Japan, using a three-dimensional pictorial mapping system

*Miho Asada[1], Mikio Satoh[1], Manabu Tanahashi[1], Toshiyuki Yokota[1], Shusaku Goto[1] (1.NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST))

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

[MIS26-05] Survey of methane hydrate off Tokachi, Pacific Ocean

*Satoshi Yamashita[1], Akihiro Hachikubo[1], Hirotoshi Sakagami[1], Masaaki Konishi[1], Kzutaka Tateyama[1], Hirotsugu Minami[1] (1.Kitami Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.12 Zoom Room 12

[M-IS26] Gas hydrates in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University)

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

[MIS26-06] Geochemical processes in surface sediments in a shallow gas hydrate reserve area off Sakata, eastern margin of the Japan Sea

*Yuki Ota[1], Masahiro Suzumura[1], Ayumi Tsukasaki[1], Atsushi Suzuki[1] (1.National Institute of Advanced Industrial Science and Technology)

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

[MIS26-07] Vp anomalies of gas hydrate-bearing sediments inferred from BSR and BGHS

*Ryo Matsumoto[1], Shiro Ohkawa[1] (1.Meiji University)

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

[MIS26-08] Purity and specific surface area of methane hydrate synthesized from fine ice powder and gas

*Daisuke Yahagi[1], Akihiro Hachikubo[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[MIS26-09] Three-dimensional nondestructive observation of natural methane hydrate

*Satoshi Takeya[1], Akihiro Hachikubo[2], Satoshi Yamashita[2], Hirotsugu Minami[2], Hirotoshi Sakagami[2], Kazuyuki Hyodo[3], Akio Yoneyama[4] (1.National Institute of Advanced Industrial Science and Technology, 2.Kitami Institute of Technology, 3.High Energy Accelerator Research Organization, 4.SAGA Light Source)

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

[MIS26-10] Concentration of helium at the formation of methane and helium mixed-gas hydrate

*Yuki Moriya[1], Hiromi Kimura[1], Akihiro Hachikubo[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[MIS26-11] **Simulation of methane hydrate formation in coarse-/fine-grained sediments in the Nankai Trough, Japan**

*CHAO XU[1] (1.Chiba University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.16 Zoom Room 16

[M-IS27] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature)

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

[MIS27-01] Sharing historical materials: An example of multi-disciplinal examination of historical materials in Edo period

★Invited Papers

*Hirotaka Terashima[1] (1.National Archives of JAPAN)

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

[MIS27-02] Improvement of climate reconstruction by focusing on the degree of detailed description of historical daily weather record

*Kenjiro Sho[1], Yoshimi Ikeda[2], Mika Ichino[3], Junpei Hirano[4], Kooiti Masuda[5], Asanobu Kitamoto[3,6] (1.Nagoya Institute of Technology, 2.Ikeda Gakuen Ikeda Senior High School, 3.Center for Open Data in the Humanities, 4.Teikyo University, 5.Tokyo Metropolitan University, 6.National Institute of Informatic)

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

[MIS27-03] Historical atmospheric analyses by weather information assimilation using Gaussian transformation

★Invited Papers

*Xiaoxing Wang[1], Kei Yoshimura[2], Kinya Toride[2] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Institute of Industrial Science, The University of Tokyo)

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

[MIS27-04] Descriptions of natural phenomena in textbooks and people's perceptions

*Harufumi Tamazawa[1,2] (1.Kyoto City University of Arts, 2.Kyoto University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.16 Zoom Room 16

[M-IS27] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Harufumi Tamazawa(Kyoto City University of Arts)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MIS27-05] Accomplishments and Potential Applications of Historical GIS: Researching Old Maps and Contributing Locally

★Invited Papers

*Akihiro Tsukamoto[1] (1.Tokushima Univ.)

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

[MIS27-06] Analysis of aftershocks of the 1855 Ansei Edo Earthquake using old documents discovered around Kanto Ko-Shinetsusing old documents discovered around Kanto Ko-Shinetsu

*Baba Michito[1], Yasuyuki Kano[1] (1.Earthquake Research Institute,University of Tokyo)

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

[MIS27-07] A historical record of frequent felt earthquakes on 1870 May and the destructive earthquake on 1870 May 13 felt in Yokohama

*Kentaro Hattori[1], Junzo Ohmura[2] (1.Kyoto Univ., 2.Tokyo Univ.)

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

[MIS27-08] Integrated IDP catalog considering the continuity of historical and modern earthquake catalog

*Yasuyuki Kano[1,2], Junzo Ohmura[1,2] (1.Earthquake Research Institute, The University of Tokyo, 2.Collaborative Research Organization for Historical Materials on Earthquakes and Volcanoes, UTokyo)

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

[MIS27-09] Discussion

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.09 Zoom Room 09

[M-AG38] Ten years after the Fukushima Dai-ichi NPP Accident : Dynamics of radionuclides in the environment

convener:Daisuke Tsumune(Central Research Institute of Electric Power Industry), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

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

[MAG38-01] New X-ray spectroscopic methods for the speciation of cesium in environment

★Invited Papers

*Yoshio Takahashi[1], Hikaru Miura[3], Daisuke Tsumune[3], Yuichi Kurihara[2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.JAEA, 3.CRIEPI)

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

[MAG38-02] 10-year variation of atmospheric Cs radioactivity concentration observed at highly polluted area in Fukushima

*Kazuyuki Kita[1], Naho Hayashi[1], Peng Tang[1], Kotaro Hatanaka[1], Takeshi Kinase[2], Kouji Adachi[2], Yuji Zaizen[2], Ishizuka Masahide[5], Jun Furukawa[3], Yuko Hatano[3], Keisuke Sueki[3], Yuichi Onda[3], Kazuhiko Ninomiya[4], SHINOHARA ATSUSHI[4], Sakae Toyoda[6], Keita Yamada[6], Naohiro Yoshida[6], Yukihiko Satou[7], Yasuhito Igarashi[8] (1.Faculty of Science, Ibaraki University, 2.Meteorological Research Instutite, 3.Tsukuba University, 4.Osaka University, 5.Kagawa University, 6.Tokyo Institute of Technology, 7.JAEA, 8.University of Kyoto)

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

[MAG38-03] Temporal variations and future estimations of ^{90}Sr and ^{137}Cs in atmospheric depositions after the Fukushima Daiichi Nuclear Power Plant accident with long-term observations

★Invited Papers

*Takeshi Kinase[1,2], Kouji Adachi[2], Thomas Sekiyama[2], Mizuo Kajino[2], Yuji Zaizen[2], Yasuhito Igarashi[3,4] (1.Japan Agency for Marine-earth Science and Technology, 2.Meteorological Research Institute, 3.Institute for Integrated Radiation and Nuclear Science, Kyoto University, 4.Ibaraki University)

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

[MAG38-04] Comprehensive evaluation on wet scavenging schemes for ^{137}Cs transport modeling following the Fukushima Daiichi accident

*Shuhan Zhuang[1], sheng fang[1] (1.Tsinghua University)

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

[MAG38-05] Migration and distribution of radiocesium in forest 10 years after the Fukushima nuclear accident

*Hiroaki Kato[1], Yuichi Onda[1], Zul Hilmi Saidin[1], Hikaru Iida[1], Satoru Akaiwa[1], Tomoki Shinozuka[1] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

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

[MAG38-06] Discussion

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.09 Zoom Room 09

[M-AG38] Ten years after the Fukushima Dai-ichi NPP Accident : Dynamics of radionuclides in the environment

convener:Daisuke Tsumune(Central Research Institute of Electric Power Industry), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University)

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

[MAG38-07] 10-year monitoring of ^{137}Cs transport in 30 river monitoring sites in 80km from the Fukushima Daiichi nuclear power plant

★Invited Papers

*Keisuke Taniguchi[1], Yuichi Onda[1], Kazuki Fujita[2], Yukio Takeuchi[2], Kazumi Katsuno[2], Hirotsugu Arai[2], Kouki Nasu[2] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 2.Fukushima Prefectural Centre for Environmental Creation)

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

[MAG38-08] Impact of different land use along the Kasumigaura lake on suspended sediment delivery and particulate ^{137}Cs discharge

*Bin FENG[1], Yuichi Onda[1], Manabu Motohashi[1], Keisuke Taniguchi[1] (1.Center for research in isotopes and environmental dynamics, University of Tsukuba)

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

[MAG38-09] Ten years behavior of radiocaesium derived from TEPCO Fukushima Dai-ichi Nuclear Power Plant accident in surface water in the adjacent seas of the North Pacific Ocean

*Michio Aoyama[1,2], Yasunori Hamajima[3], Yayoi Inomata[3], Yuichiro Kumamoto[4], Hyoe Takata[2] (1.Center for Research in Isotopes and Environmental Dynamic, Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Institute of Environmental Radioactivity, Fukushima University, 3.The Institute of Nature and Environmental Technolog, Kanazawa University, 4.Research Institute of Global Change, The Japan Agency for Marine-Earth Science and Technology)

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

[MAG38-10] On large-scale transport of suspended particulate matter on the continental shelf break off Fukushima, Japan.

*Kohei Kawano[1], Yusuke Uchiyama[1], Yuki - Kamidaira[2] (1.Graduate school of Engineering Faculty of Engineering, Kobe University, 2.Japan Atomic Energy Agency)

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

[MAG38-11] **Long-term simulation of oceanic ^{137}Cs with direct release and river discharge after the Fukushima Dai-ichi Nuclear Power Plant accident**

*Daisuke Tsumune[1], Tsubono Takaki[1], Kazuhiro Misumi[1], Hikaru Miura[1], Yutaka Tateda[1], Michio Aoyama[2] (1.Central Research Institute of Electric Power Industry, 2.University of Tsukuba)

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

[MAG38-12] Discussion

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

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

[M-TT43] Brand-new scope of coupling geophysics being established by infrasound and associated waves

convener:Masa-yuki Yamamoto(Department of systems engineering, Kochi University of Technology), Takayuki Otsu(Japan Weather Association), Mie Ichihara(Earthquake Research Institute, University of Tokyo), Nobuo Arai(Disaster Mitigation Research Center, Nagoya University), Chairperson:Yoshihiro Kakinami(Hokkaido Information University), Masa-yuki Yamamoto(Department of systems engineering, Kochi University of Technology)

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

[MTT43-01] HTV Infrasound Phase Identification in Near and Far Field Records

*I. H. HAMAMA[1,2], Masa-yuki Yamamoto[1] (1.School of Systems Engineering, Kochi University of, Japan, 2.National Research Institute of Astronomy and Geophysics, NRIAG, Egypt)

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

[MTT43-02] An estimation of acoustic velocity in lower thermosphere using GNSS TEC after the foreshock of the 2011 Tohoku Earthquake

*Yoshihiro Kakinami[1], Hiroaki Saito[2], Tetsuo Yamamoto[2], Chia-Hung Chen[3], Masa-yuki Yamamoto[4], Kensuke Nakajima[5], Jann-Yenq LIU[6], Shigeto Watanabe[1] (1.Hokkaido Information University, 2.Hokkaido University, 3.National Cheng Kung University, 4.Kochi University of Technology, 5.Kyushu University, 6.National Central University)

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

[MTT43-03] Evaluation of prototype miniature microphones for observing infrasound

*Ryouichi Nishimura[1], Taira Itoh[2], Dai Adachi[2], Yasutaka Nakajima[2], Kenichi Kidokoro[2], Toshiyuki Hasumi[2], Yôiti Suzuki[1] (1.National Institute of Information and Communications Technology, 2.RION Co., Ltd.)

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

[MTT43-04] A prompt report of multiple-site infrasound observation by the nation-wide infrasound observation consortium for M 7.3 Fukushima offshore earthquake on Feb. 13, 2021

*Masa-yuki Yamamoto[1], Nobuo Arai[2], Takayuki Otsu[3], Ryouichi Nishimura[4], Takuma Oi[5], Kensuke Nakajima[6], Hideki Ueda[7], Makiko Iwakuni[3], Yoshihiro Kakinami[8], Kosuke Heki[9], Islam H. HAMAMA[1] (1.Kochi University of Technology, 2.Nagoya University, 3.JWA, 4.NICT, 5.Toho Merchantile, 6.Kyushu University, 7.NIED, 8.Hokkaido Information University, 9.Hokkaido University)

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

[MTT43-05] Three-dimensional large-scale numerical simulation of infrasound associated with tsunami generation considering wave source and atmospheric models

*Yoshiki Saito[1], Kan Okubo[1], Kentaro Uehara[2], Hidee Tatehata[2], Hiromu Yokosu[3] (1.Tokyo Metropolitan University, 2.Japan Weather Association, 3.Chubu Electric Power Company)

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

[MTT43-06] Continuous excitation of atmospheric free oscillation by cumulus heating

★Invited Papers

*Kensuke Nakajima[1] (1.Department of Earth and Planetary Sciences,Flculty of Sciences,Kyushu University)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-ZZ Others

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.16 Zoom Room 16

[M-ZZ48] Geology and culture

convener:Hisashi Suzuki(Otani University), Tohru Sakiyama(Institute of Geo History, Japan Geochronology Network), Naoki Takahashi(Natural History Museum and Institute, Chiba), Chairperson:Tohru Sakiyama(Institute of Geo History, Japan Geochronology Network), Naoki Takahashi(Natural History Museum and Institute, Chiba)

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

[MZZ48-01] A use of tuff beds in strata for natural resources at the Boso Peninsula – 'Bosyu white clay' or 'Bosyu sand'

*Naoki Takahashi[1], Junichi Ohki[1] (1.Natural History Museum and Institute, Chiba)

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

[MZZ48-02] Change of usage patterns of Innai Tuff Member from Yuzawa City, Akita prefecture, northeast Japan: From 'rolling stones' in early modern to 'Innai Ishi' in modern

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

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

[MZZ48-03] Japanese marbles used in some historic western style houses in Tokyo

*Mutsuko Inui[1], Shoji Nishimoto[2] (1.School of Science and Engineering, Kokushikan University, 2.Nagoya City Science Museum)

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

[MZZ48-04] Brewing culture and geology in Japan: examples of Satsuma shochu spirits and Koshu wine

*Hisashi Suzuki[1] (1.Otani University)

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

[MZZ48-05] The investigation of the relationship between the artificial terrain change of medieval mountain castles and the landslides in 2018

*Masami Inomata[1] (1.National University Corporation Hiroshima University)

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

[MZZ48-06] **Historical distribution of granitic stone materials from Setouchi area in the San-in and Hokuriku regions, Southwest Japan**

*Tohru Sakiyama[1] (1.Institute of Geo History, Japan Geochronology Network)

[J] Oral | EVENT : EVENT

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC | Ch.01 Zoom Room 01

[EV-25] Lunchtime Special Lecture

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC

[E-11-26] Chemical constraints on the origin and early evolution of the Solar System

[J] Oral | EVENT : EVENT

3:30 PM - 4:15 PM JST | 6:30 AM - 7:15 AM UTC | Ch.13 Zoom Room 13

[EV-26] Exhibitors' Seminar

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

[E-11-27] GRC virtual lab tour & the making of a diamond powder with Hime-diamond mortar

[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.01 Zoom Room 01

[O-02] Natural disasters and people -Listen to the voice of the Earth on the Japanese Geoparks-

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Kyohei Sano(Graduate School of Regional Resource Management, University of Hyogo), Suzuka Koriyama(Itoigawa city), Hikaru Yokoyama(Hokusho University), Chairperson:Kyohei Sano(Graduate School of Regional Resource Management, University of Hyogo), Suzuka Koriyama(Itoigawa city), HIROKO IMAI(Com Support Office /Wakayama University Center for Tourism Research), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Hikaru Yokoyama(Hokusho University)

People benefit from the earth, while sometimes geological activities bring disaster to human society. Geoparks aim to reconnect human society at all levels to our home planet and to celebrate how the planet with 4.6 billion years long history has shaped every aspect of our lives and society. Many geoparks in tectonically active areas of the world have a crucial role in helping mitigate geo-hazards through awareness-raising and constructing disaster response strategies. In this session, we discuss how people have lived with geological activities and natural hazards, and how to deal with new threats, including COVID-19, in nature through geoparks.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[O02-04] Achievements and issues of online program development at Hagi Geopark

*Takaaki Shirai[1] (1.Hagi Geopark Promotion Council)

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

[O02-05] Our ancestors who overcame natural disasters: A case study focused on Toya-Usu UNESCO Global Geopark

★Invited Papers

*Asami Nakaya[1] (1.Toya-Usu UNESCO GLobal Geopark Council)

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

[O02-06] The case of One Geopark damaged by 2018 Japan floods -The 3 years for reconstruction of Seiyo City, Ehime Prefecture and the Shikoku Seiyo Geopark-

★Invited Papers

*Takumi Sakakiyama[1] (1.Seiyo City)

Achievements and issues of online program development at Hagi Geopark

*Takaaki Shirai[1]

1. Hagi Geopark Promotion Council

Hagi Geopark has systematically conducted lectures and geotours that emphasize experiences such as outdoor experiences and cooking classes. However, we were forced to stop these activities due to the influence of COVID-19. Therefore, after April 2020, we started to develop a new method for the purpose of continuing educational activities and tourism activities in the with COVID-19 era. As a result, we have begun full-scale operation of programs that utilize the Internet, such as holding regular online tours once a month. I will share the process of these efforts and the challenges for the post COVID-19 era.

Keywords: geopark, online tour, with CORONA, after CORONA

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Our ancestors who overcame natural disasters: A case study focused on Toya-Usu UNESCO Global Geopark

*Asami Nakaya[1]

1. Toya-Usu UNESCO GLobal Geopark Council

Toya-Usu UNESCO Global Geopark is located in the southwestern part of Hokkaido (the northernmost island of Japan). The geopark includes Mt.Usu, an active volcano, as a major geosite as shown by its major theme of coexistence with the volcano. The area to the south of Mt.Usu faces the sea and has been inhabited by people since the prehistoric Jomon period. Inhabitants of the area have been supported by abundant seafood and spring water from the volcano. Many settlements were formed along the coast, but the volcano's eruption during the Edo period (17th to 19th centuries) cost many lives. The indigenous Ainu of Hokkaido, who were living in the Mt. Usu area, described the volcanic eruption and their aftermath in epics (known as *yukar* in the Ainu language) and passed them down to ensure their descendants would be prepared for another possible eruption.
This presentation will focus on Ainu epics and archaeological sites that remain in the coastal area to highlight the history of those who have overcome natural disaster, such as repeated volcanic eruptions and tsunami. We will also share information about disaster mitigation efforts that have been under way at the geopark.

Keywords: Geopark, Eruption disaster, Ainu People

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The case of One Geopark damaged by 2018 Japan floods -The 3 years for reconstruction of Seiyo City, Ehime Prefecture and the Shikoku Seiyo Geopark-

*Takumi Sakakiyama[1]

1. Seiyo City

The Shikoku Seiyo Geopark located in the southwestern part of Ehime Prefecture, has many geological landscapes of the Chichibu Belts, contained the Kurosegawa Tectonic Zone, various landforms from the ria coast at 0m above sea level to the Shikoku Karst at an altitude of about 1,400m and climates and the traditional culture, within an area of about 50 km east to west.During 2018 Japan floods, a lot of houses and buildings were damaged by flooding of rivers and landslides in various places. Particularly, a large-scale flood damage occurred in a residential area in the Nomura district of Nomura Town. Six precious lives were lost in a series of disasters in Seiyo City. In addition, out of 23 sites, a total of 5 sites were damaged to prevent access in the Geopark. Four of them have been restored, but the Katsuragawa Valley is still restricted except near the entrance. Our secretariat of the Shikoku Seiyo Geopark Counsil had to be suspended for a while after the disaster. Fortunately, we were supported such as receiving donations from Japanese Geoparks Network (JGN) and related people based on the Disaster Response Guidelines of JGN. In addition, Japanese Geopark Officers and researchers conduct disaster surveys about once a year and provide advice the recovery and course of actions on future.
After the disaster, the inhabitants became more interested in disaster prevention and the landforms around them. Following his, we have carried out many disaster prevention and programs such as "Seiyo Nature and Culture College" consisted mainly field excursions, the lectures with hazard maps, geography map, "NIED Quake map!" for elementary and junior high schools, public halls, labor unions, and so on. In October 2020, Disaster Tradition Exhibition Room was opened in the room renovated Otoi Kaikan. The aim to pass down the records and memories of the disaster, and its exhibition is incorporated the perspectives of Geoparks, such as the history of the earth and the blessings of the earth. In addition, we have devised ways to make various uses, such as providing guidance by the "Disaster Storyteller" and preparing disaster VR / AR content. And these efforts have been disseminated at Bosai Kokutai sponsored the secretariat of isaster prevention promotion mass meeting Japan, the National Conference of JGN, and many other workshops and lectures.
Looking back on the three years since the disaster, the disaster prevention awareness of past in this area has focused on the measure to act in the event of a disaster such as disaster drills. I realized that people are not able to fully acquire the disaster risk they had due to the characteristics of the landforms. Creating and distributing hazard maps is not enough to foster that perspective, and it is important to bring awareness through field excursions that actually follow the formation of the earth. In fact, these activities are being actively promoted in Geoparks around the world, and their experience has been accumulated. Geopark are an international certification system that started with the purpose of conservating geological heritage, but I supposed that it will make a great contribution to society in terms of disaster prevention and reduction.

Keywords: Shikoku Seiyo Geopark, Seiyo City, 2018 Japan floods, Disaster Prevention and Reduction, Disaster Tradition

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.02 Zoom Room 02

[O-03] How to cope with meteorological disasters under rapidly changing climate

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

In September 2018, we experienced severe storm damages over West Japan which paralyzed the Kansai International Airport. In September 2019, we also experienced severe storm damages by Typhoon No. 15 over East Japan, and huge electric power was down over wide areas in Chiba Prefecture. In October 2019, another Typhoon No. 19 caused extensive flood disasters over central Japan. In July 2020, severe flood disasters occurred in many places in Kyushu, Southwest Japan as well as in central Japan. We will discuss how to cope with such severe meteorological disasters under changing climate including participants. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016.

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

[O03-01] Development of typhoon hazard map and typhoon-shot project; Change the "threat" of a typhoon into a "grace" by 2050!

★Invited Papers

*Fudeyasu Hironori[1] (1.Yokohama National University)

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

[O03-02] Recent trends in storm and flood damage and the latest efforts on JMA's weather warnings and information

★Invited Papers

*Takahashi Kenichi[1] (1.Japan Meteorological Agency)

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

[O03-03] Utilization of typhoon data before the middle 20th century

★Invited Papers

*Fumiaki Fujibe[1] (1.Department of Geography, Tokyo Metropolitan University)

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

[O03-04] Why was coastal damage due to T1915 concentrated in the Port of Yokohama?

★Invited Papers

*Hitoshi Tamura[1] (1.Port and Airport Research Institute)

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

[O03-05] Development of coastal monitoring method immediately after typhoon by remote sensing

★Invited Papers

*Yuji Sakuno[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

[O03-06] Proposal of Build Back Better “insurance” scheme for future wind-related disaster risk reduction

★Invited Papers

*Kazuyoshi Nishijima[1] (1.Disaster Prevention Research Institute, Kyoto University)

Development of typhoon hazard map and typhoon-shot project; Change the "threat" of a typhoon into a "grace" by 2050!

*Fudeyasu Hironori[1]

1. Yokohama National University

Typhoon Faxai, also known as “Reiwa 1 Boso Peninsula Typhoon”, made landfall in the Kanto region in September 2019. It was the strongest typhoon to make landfall in the region since 1991, the year the Japan Meteorological Agency (JMA) began to keep such records. The extreme winds of this typhoon left scars that exposed the vulnerabilities of the metropolitan area in Japan. A year earlier, the extremely powerful Typhoon Jebi in 2018 passed through western Japan, causing devastation to the Kinki area. According to the General Insurance Association of Japan (GIAJ), the damage caused by Typhoon Jebi resulted in the highest claims ever paid for wind and flooding damage in Japan. Typhoons remain a serious threat despite recent advances in science and technology. We meteorologists are working on the new challenges highlighted by typhoons in recent years. My presentation will introduce the typhoon hazard map developed by the latest research results and new project for typhoons, typhoon-shot project; change the "threat" of a typhoon into a "grace" by 2050.

Keywords: Typhoon, hazard map

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Recent trends in storm and flood damage and the latest efforts on JMA’ s weather warnings and information

*Takahashi Kenichi[1]

1. Japan Meteorological Agency

Japan Meteorological Agency issues Emergency Warnings, Warnings and Advisories in response to the significance of possible disasters in association with meteorological phenomena so that disaster management authorities and residents can take appropriate measures to mitigate possible disasters.

During the "Heavy Rainfall in July 2018", JMA issued warnings from an early stage through the announcement of disaster prevention weather information, support to municipalities, and a press conference. However, the announcement of such information did not necessarily lead to evacuation behavior of residents. Based on this, in fiscal 2018, JMA held a “Review Committee on Dissemination of Disaster Prevention Weather Information” with the participation of the media, local government officials, and related ministries and agencies.

Keywords: Disaster mitigation information, Severe weather

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Utilization of typhoon data before the middle 20th century

*Fumiaki Fujibe[1]

1. Department of Geography, Tokyo Metropolitan University

There were a number of strong typhoons that caused wind and rain disaster in Japan before the middle 20th century. For example, a typhoon attacked southern Kyushu on 15 August 1899, destroying sixteen thousand houses in Kagoshima Prefecture. On 28 September 1902, another typhoon attacked the Kanto area, destroying twenty thousand houses in Ibaraki Prefecture. Issues in using data from typhoons before the mid-20th century as lessons for future disasters will be discussed.

Keywords: typhoon, database, data collection

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Why was coastal damage due to T1915 concentrated in the Port of Yokohama?

*Hitoshi Tamura[1]

1. Port and Airport Research Institute

Typhoon Faxai (T1915), which occurred in September 2019, was one of the strongest typhoons on record to make landfall in the Tokyo metropolitan area and it caused extensive damage along the coast in Tokyo Bay. Two intriguing phenomena are reported by a post-event survey, which motivated this study. The first was that although the storm impacted the whole bay, significant damage was concentrated in a small area near the Port of Yokohama. The second was about the direction of the hazardous waves, which came from both the northeast and the southeast. The underlying wave dynamics that lead to these events were unknown. Here, we elucidate characteristics of the waves incident to the Port of Yokohama that caused a concentration of severe damage, and we clarify the mechanism responsible for the two disparate wave directions observed.

Keywords: Typhoon1915, Coastal damage, Tokyo Bay

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Development of coastal monitoring method immediately after typhoon by remote sensing

*Yuji Sakuno[1]

1. Graduate School of Advanced Science and Engineering, Hiroshima University

Heavy rains in recent years, represented by the western Japan region in July 2018, the Kanto region in September 2019, and the Kyushu region in July 2020, occur almost every year. The Remote Sensing Society of Japan is working on immediate disclosure of the damage situation using satellites and aircraft in the event of such a disaster. However, in most cases, land is the priority for such efforts. Therefore, even if there is a serious impact on the aquaculture industry, little is known about the damage situation in coastal waters and changes in the water quality environment. On the other hand, in recent years, the GCOM-C SGLI sensor with 250 spatial resolution and Himawari-8 AHI sensor with 2.5-minute observation cycle increase the possibility of coastal surveillance in the event of a disaster. Therefore, in this presentation, I will introduce the development of a disaster turbidity monitoring method using both SGLI and AHI sensors in order to monitor the outflow route of seafloor sediments during a disaster.

Keywords: satellite, turbidity, disaster

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Proposal of Build Back Better “insurance” scheme for future wind-related disaster risk reduction

*Kazuyoshi Nishijima[1]

1. Disaster Prevention Research Institute, Kyoto University

This presentation proposes a Build Back Better “insurance” scheme for future wind-related disaster risk reduction, identifies and reports current progress on challenges in the proposed insurance scheme. It also introduces a simple study on the impact of the proposed insurance scheme on future wind-related disaster risk reduction in Japan.

Keywords: Residential house, Insurance, Strong wind

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.02 Zoom Room 02

[O-03] How to cope with meteorological disasters under rapidly changing climate

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

In September 2018, we experienced severe storm damages over West Japan which paralyzed the Kansai International Airport. In September 2019, we also experienced severe storm damages by Typhoon No. 15 over East Japan, and huge electric power was down over wide areas in Chiba Prefecture. In October 2019, another Typhoon No. 19 caused extensive flood disasters over central Japan. In July 2020, severe flood disasters occurred in many places in Kyushu, Southwest Japan as well as in central Japan. We will discuss how to cope with such severe meteorological disasters under changing climate including participants. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016.

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

[O03-07] Wind-induced damage to buildings and future risk reduction

★Invited Papers

*Yukio Tamura[1] (1.Chongqing University)

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

[O03-08] Behaviors of infrastructures under extreme wind and future challenges

★Invited Papers

*Tomomi Yagi[1] (1.Kyoto University)

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

[O03-09] Simultaneous multiple accident cases and their countermeasures for electric power system against Typhoon

★Invited Papers

*Yoshiharu Shumuta[1] (1.Central Research Institute of Electric Power Industry)

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

[O03-10] Fires Caused by Strong Winds and Storm Surges

★Invited Papers

*U HIROI[1] (1.The University of Tokyo)

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

[O03-11] Discussion

Wind-induced damage to buildings and future risk reduction

*Yukio Tamura[1]

1. Chongqing University

Wind pressures act on the surfaces of buildings, and the majority of wind-induced damage to buildings is initiated by damage to claddings and components, rather than to main frames. Small damage to eaves or breakage of windows can develop into larger damage to roofs and entire buildings. Therefore, “cladding and component design” is critical in the wind resistant design of buildings. Broken metal roof sheets, clay tiles, and other parts of buildings can be blown off, creating “wind-borne debris” that attacks downstream buildings and other structures, causing a chain of damage. “Damage chain” is a special feature of wind-induced damage. The impact of wind-borne debris is much higher than that of wind pressure, and claddings and components should have resistance to debris impacts, not only to strong wind pressures. Wind resistant design of buildings is basically made by comparing “wind action (load)” and “structural performance (resistance)”, but almost all past studies in the wind engineering field have focused on accurate estimations of wind actions (loads) on buildings and structures. Structural performance has not been sufficiently studied.

Many structures damaged by severe local storms are categorized as temporary ones such as construction site offices, and some of them, such as scaffoldings or movable roof structures, are designed assuming appropriate operation based on site wind speed. However, design criteria and maintenance discipline for these structures have not been well established.

This presentation describes recent examples of building damage due to typhoons and severe local storms resulting from the above mentioned problems. It also discusses the need for a full-scale storm simulator (FSSS) to cope with hypothesized future increase in wind-related disaster risks.

Keywords: Typhoon, Tornado, Wind Resistance, Claddings and components, Wind-borne Debris, Full-scale Storm Simulator

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Behaviors of infrastructures under extreme wind and future challenges

*Tomomi Yagi[1]

1. Kyoto University

Behaviors of long-span bridges under the extreme wind speed and future challenges for the wind resistant design of bridges and their maintenance under the extreme weather due to the climate change will be discussed.

Keywords: Bridge, Wind registant design, Wind-induced vibration

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Simultaneous multiple accident cases and their countermeasures for electric power system against Typhoon

*Yoshiharu Shumuta[1]

1. Central Research Institute of Electric Power Industry

In Japan, meteorological severe disasters including typhoon have recently continued to occur and have been intensifying damage to infrastructures. On the basis of recent disaster experiences, particular attention is paid to issues related to “Resilience” as a key concept of disaster control measures for electric power systems. This presentation introduces simultaneous multiple accident cases and their countermeasures for electric power system against Typhoon. At first, as typical typhoon disaster in metropolitan area, the damage and emergency restoration process of the electric power distribution equipment, caused by Typhoons occurred in 2018, 2019, and 2020, are illustrated. In addition, electric power resilience working group, organized by METI, suggests that in order to increase regional disaster mitigation performance (regional resilience), a disaster information collecting and sharing system, and damage prediction system are needed for wide-area collaboration among power transmission and distribution network companies. As an example of resilience improvement of electric power system, recent our research and practical use cases including a damage prediction tool for electric power distribution equipment, are also illustrated.

Keywords: Typhoon, disaster measures, electric power transmission and distribution equipment, resilience, local disaster prevention

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Fires Caused by Strong Winds and Storm Surges

*U HIROI[1]

1. The University of Tokyo

This paper presents an overview of fires caused by typhoon-related storm winds, storm surges and power restoration after power outages, using the Typhoon No. 21 in 2018 and the Typhoon Boso Peninsula in 2019 as specific examples.

Keywords: fires, typhoon, storm surges

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[J] Oral | O (Public) | Public

[O-03] How to cope with meteorological disasters under rapidly changing climate

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

Sun. Jun 6, 2021 10:45 AM - 12:15 PM Ch.02 (Zoom Room 02)

In September 2018, we experienced severe storm damages over West Japan which paralyzed the Kansai International Airport. In September 2019, we also experienced severe storm damages by Typhoon No. 15 over East Japan, and huge electric power was down over wide areas in Chiba Prefecture. In October 2019, another Typhoon No. 19 caused extensive flood disasters over central Japan. In July 2020, severe flood disasters occurred in many places in Kyushu, Southwest Japan as well as in central Japan. We will discuss how to cope with such severe meteorological disasters under changing climate including participants. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016.

11:45 AM - 12:15 PM

[O03-11]Discussion

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.01 Zoom Room 01

[O-04] Suggestion to teaching Earth science under GIGA school from online lesson

convener:Iida Kazuya(Komaba-Toho Junior and Senior High School), Iwata Makoto(Hiroshima Prefectural Ogaki High School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:syo uranaka(Osaka Institute of Technology Graduate School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Iida Kazuya(Komaba-Toho Junior and Senior High School)

In this session, we will discuss teaching Earth science under GIGA school. GIGA school means Global and Innovation Gateway for All, which aims to provide computer and internet environment for all students in the school. In the online lessons due to the epidemic of the COVID-19, many practices using computer and internet were conducted. Based on suggestions from both online and face-to-face classes using computers, we will discuss teaching Earth science under GIGA school.

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

[O04-01] Introduction

9:10 AM - 9:25 AM JST | 12:10 AM - 12:25 AM UTC

[O04-02] The Potential of Online Learning to Realize "Independent and Interactive Deep Learning" in Elementary School Social Studies.

★Invited Papers

*Keiko Nakaya[1] (1.Elementary School Affiliated to the Faculty of Education chiba university)

9:25 AM - 9:40 AM JST | 12:25 AM - 12:40 AM UTC

[O04-03] Utilization of a digital globe system, Dagik Earth, in elementary schools

★Invited Papers

*Akinori Saito[1], Takuya Tsugawa[2], Miho Yamamori[3] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology, 3.Tsuru University)

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

[O04-04] Effective use of online lesson and integrate with face to face lesson

★Invited Papers

*Hiroki Ushigome[1] (1.Otsuma nakano Junior and Senior High School)

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

[O04-05] Student presentations using digital devices In GIGA School Concept

★Invited Papers

*Hidenori Takemura[1] (1.Johoku Junior and Senior high school)

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

[O04-06] Discussion

[J] Oral | O (Public) | Public

[O-04] Suggestion to teaching Earth science under GIGA school from online lesson

convener:Iida Kazuya(Komaba-Toho Junior and Senior High School), Iwata Makoto(Hiroshima Prefectural Ogaki High School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:syo uranaka(Osaka Institute of Technology Graduate School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Iida Kazuya(Komaba-Toho Junior and Senior High School)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.01 (Zoom Room 01)

In this session, we will discuss teaching Earth science under GIGA school. GIGA school means Global and Innovation Gateway for All, which aims to provide computer and internet environment for all students in the school. In the online lessons due to the epidemic of the COVID-19, many practices using computer and internet were conducted. Based on suggestions from both online and face-to-face classes using computers, we will discuss teaching Earth science under GIGA school.

9:00 AM - 9:10 AM

[O04-01]Introduction

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The Potential of Online Learning to Realize "Independent and Interactive Deep Learning" in Elementary School Social Studies.

*Keiko Nakaya[1]

1. Elementary School Affiliated to the Faculty of Education chiba university

The new coronavirus pandemic forced schools to close temporarily. In our school, we started online learning for the whole school using a groupware called "Microsoft Teams" (hereinafter referred to as "Teams") during the school closure period in March.

In addition, the period from July 13th to July 31st was designated as the "online school period," and online learning was conducted in the same way as during the closed period. During this period, the third-grade social studies class focused on the city of Chiba and worked on the following topics: *"Scenes in Chiba City"* and *"Changes in Scenes in Chiba City"*. The students did not use the online learning methods of "synchronous classes" or "real-time interaction where students communicate with each other. But instead we have used the asynchronous class where students do not communicate in real time, but present and submit assignments using videos, worksheets, and the face-to-face class during the online school period and after the summer vacation.

Furthermore, we designed a hybrid type unit by efficiently combining face-to-face classes during the online school period and after the summer vacation.

Through this practice, it became clear that online learning is highly compatible with social studies teaching and learning, as materials and tasks can be easily shared and viewed, and research and study can be conducted without any time restrictions.

In the case of online learning, children who were not good at speaking found it enjoyable to interact with their friends in the form of chats and comments. We were able to provide a new way of interaction.

Nevertheless, it was also very effective to have the students take the time to research and study online, which would lead to discussion and learning during the school day. It was also unexpected that many of the children took advantage of the online classes to go to museums and libraries with their parents during the summer vacation. This was also an unexpected outcome. However, in case, when the school is forced to close again for a long period of time due to a sudden disaster or other reasons, a major issue will be how to realize the discussion activities and cooperative learning that had been conducted in face-to-face classes.

Keywords: Online learning, Hybrid learning, Microsoft Teams, Elementary school social studies

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Utilization of a digital globe system, Dagik Earth, in elementary schools

*Akinori Saito[1], Takuya Tsugawa[2], Miho Yamamori[3]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. National Institute of Information and Communications Technology, 3. Tsuru University

Dagik Earth, a digital globe system, is an educational digital tool that displays various earth and planetary data in a three-dimensional format, allowing users to view the data in a way that is not possible with ordinary photographs or videos. It has been developed since 2007 and is being used in schools, science museums, and others. In elementary school science, content and instructional plans are being developed for use in "Weather" (5th grade) and "The Moon and the Sun" (6th grade), and are also being used in the "Planets" unit, although it is a developmental topic. The software can be used in elementary schools in two ways: (A) three-dimensional display using a spherical screen, and (B) flat display using a tablet or other device. In usage (A), a PC projector is used to project images of the earth and planets onto a spherical screen for a three-dimensional display. It is used not only in the classroom, but also in events in auditoriums where large screens with diameters of 2m or 4m are used for display. This presentation make students to have the feeling of looking down on the earth from space. In usage (B), students can manipulate and view the contents of "Dagik Earth" by using digital textbooks and applications. This allows for independent learning, as learners can select content, rotate, zoom in, and still/play the earth. In addition to these digital learning materials, the materials for hand-made globes and origamis are provided. These are used in "demae" classes and science events. In the lecture, we will also discuss the challenges of using teaching materials developed by university researchers in elementary schools.

Keywords: digital globe, science class, elementary school, digital text book, application

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Effective use of online lesson and integrate with face to face lesson

*Hiroki Ushigome[1]

1. Otsuma nakano Junior and Senior High School

Many schools introduced online lessons after the epidemic of the COVID-19. There are many online lesson methods. For example, it is one-way or interactive communication. In the future, it will be necessary to use it properly effectively what to learn online and what to learn face-to-face. In addition, online lessons are not limited to school. Therefore, online lessons are restricted by the Internet environment of the students' homes. When we do online lessons, it is necessary to consider not only the lesson content but also internet capacity and communication speed. Every student owns a PC in our school. And I have practiced lessons that incorporate interactive communication using Internet.In this presentation, I will report on the use of ICT in our junior high school geography classes. And I propose how to cultivate students' proactive learning using both face-to-face and online classes.

Keywords: online lesson, proactive learning

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Student presentations using digital devices In GIGA School Concept

*Hidenori Takemura[1]

1. Johoku Junior and Senior high school

The junior high school learning guidance guideline (notification in March 2017) says that the following three points should be realized without bias.
"(1) To acquire knowledge and skills."
"(2) To develop thinking ability, judgment ability, expressive ability, etc."
"(3) To cultivate the ability to learn and humanity."
Especially recently, due to the reform of university entrance examinations, universities are trying to evaluate not only (1) but also other abilities.

In order to realize the above (1) to (3) without bias, the science item of the learning guidance guideline say "time for sufficient observation and experiment, time for exploration to solve problems, etc." ". At that time, it says, "Enrich your language activities." To achieve this, we have been conducting experiments and group work. But we've done much with paper.
In GIGA School Concept, each student would have one computer. This has expanded the range of experiments and group work we have conducted so far, and has enabled us to conduct lessons different from the past. As an example, I will use a digital device to summarize the observation results and give a presentation.

Keywords: GIGA School Concept, ICT, presentation, Loilo Note, group work

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[J] Oral | O (Public) | Public

[O-04] Suggestion to teaching Earth science under GIGA school from online lesson

convener:Iida Kazuya(Komaba-Toho Junior and Senior High School), Iwata Makoto(Hiroshima Prefectural Ogaki High School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:syo uranaka(Osaka Institute of Technology Graduate School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Iida Kazuya(Komaba-Toho Junior and Senior High School)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.01 (Zoom Room 01)

In this session, we will discuss teaching Earth science under GIGA school. GIGA school means Global and Innovation Gateway for All, which aims to provide computer and internet environment for all students in the school. In the online lessons due to the epidemic of the COVID-19, many practices using computer and internet were conducted. Based on suggestions from both online and face-to-face classes using computers, we will discuss teaching Earth science under GIGA school.

10:10 AM - 10:30 AM

[O04-06]Discussion

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.01 Zoom Room 01

[O-04] Suggestion to teaching Earth science under GIGA school from online lesson

convener:Iida Kazuya(Komaba-Toho Junior and Senior High School), Iwata Makoto(Hiroshima Prefectural Ogaki High School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Hiroaki Akimoto(Faculty of Economics,Dokkyo University), syo uranaka(Osaka Institute of Technology Graduate School), Satoshi Miyajima(Saitama Prefectural Kumagaya High School), Iida Kazuya(Komaba-Toho Junior and Senior High School)

In this session, we will discuss teaching Earth science under GIGA school. GIGA school means Global and Innovation Gateway for All, which aims to provide computer and internet environment for all students in the school. In the online lessons due to the epidemic of the COVID-19, many practices using computer and internet were conducted. Based on suggestions from both online and face-to-face classes using computers, we will discuss teaching Earth science under GIGA school.

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

[O04-07] Report on the Online Teaching Experience with WebGIS in the High School Geography Classes under the COVID-19 Pandemic

★Invited Papers

*Yoshihiko Shibata[1] (1.Tokyo Metropolitan KOKUBUNJI Highschool)

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

[O04-08] Development of Educational Materials for the Kanagawa version of “Geological Fieldworks conducted in a Classroom" appling for High School Subject "Basic Earth Science" —Using Strata from Ikuta Ryokuchi Park—

★Invited Papers

*Yasushi Fujiwara[1], Shungo Kawagata[2] (1.Graduate School of Education, Yokohama National University, 2.College of Education, Yokohama National University)

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

[O04-09] Supporting school teachers with GSI’s Toolbox for geography education in the era of Society 5.0

★Invited Papers

*Yuki Kurisu[1] (1.Geospatial Information Authority of Japan)

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

[O04-10] The trial and error of on-line bidirectional lecture

★Invited Papers

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

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

[O04-11] General Discussion

★Invited Papers

*Iida Kazuya[1], Hiroaki Akimoto[2], Iwata Makoto[3], Satoshi Miyajima[4] (1.Komaba-Toho Junior and Senior High School, 2.Faculty of Economics, Dokkyo University, 3.Hiroshima Prefectural Ogaki High School, 4.Saitama Prefectural Kumagaya High School)

Report on the Online Teaching Experience with WebGIS in the High School Geography Classes under the COVID-19 Pandemic

*Yoshihiko Shibata[1]

1. Tokyo Metropolitan KOKUBUNJI Highschool

In April 2020, schools across the country were suddenly required to offer online lessons due to the state of emergency associated with the Corona disaster.

However, the ICT environment of public schools at that time was extremely low quality and the security was excessively strict, and schools could hardly do anything.

However, in the spare time of the work-at-home system, many geography teachers were able to actually operate WebGIS such as Geographical Survey Institute maps, Google Earth, and GSMaP, and realize their effectiveness.

For this reason, some teachers have used them to conduct online geography lessons from home, and their effects, issues, and know-how have been showed to islands where they cannot usually participate in workshops through online conferences that were explosively spread at the time, and shared with teachers who were on maternity leave.

In addition, we realized that digital teaching materials are easy to copy and spread, and launched a geography teaching materials sharing project to deliver useful geographic information to non-specialized teachers when geography becomes compulsory in 2022.

At this time, we will report on the merits and demerits of online lessons and the project to share geography teaching materials, and talk about geography education during the GIGA school era.

Keywords: Geography, WebGIS, Online lesson

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Development of Educational Materials for the Kanagawa version of “Geological Fieldworks conducted in a Classroom" appling for High School Subject "Basic Earth Science" —Using Strata from Ikuta Ryokuchi Park—

*Yasushi Fujiwara[1], Shungo Kawagata[2]

1. Graduate School of Education, Yokohama National University, 2. College of Education, Yokohama National University

Purpose

The next Japanese High School Curriculum Guideline emphasizes the importance of Experiential learning for the Subject Area "Science" including "Basic Earth Science". However, this is not easy for not well-trained teachers in geoscience to teach the local geology for real by field observation. Thus, we develop a package of educational materials containing digital learning and hands-on training materials for geology which those teachers allow students to easily experience outdoor geological observations in classrooms and facilitate hands-on activities with sediment samples.

Target of research: Mt.Masugata in Ikuta Ryokuchi Park

In Kanagawa Pref., the Quaternary terrestrial sediments of the Kanto Loam cover the underlying marine deposits (Kazusa and Sagami Groups). These strata are well exposed along the 1 km circuit course in the Mt. Masugata in the Ikuta Ryokuchi Park, Kawasaki City, where we can observe the Iimuro Formation of Kazusa Group uncomformably overlain by the Oshinuma Sand and Gravel Formation of Sagami Group, and conformably overlying terrestrial Kanto Loam, in ascending order. The Iimuro Fm. yields fossil molluscs and fossil foraminifera, and the Kanto Loam interbeds wide-spread tephra. Therefore, these strata are suitable for students to learn a part of the Quaternary formation history in Kanagawa Pref. even at 1 location.

Developed Educational Materials

We have developed three digital materials, as follows; (1) "Ikuta Ryokuchi Park Fieldwork" for students to experience outdoor geological observations in classrooms, (2) "Fossil Foraminifera from the Iimuro Fm." and (3) "Rock-Minerals in Key Tephra". Each material involves worksheet and taxonomic search list for classification of foraminifera and rock-minerals for students, digital learning materials for students by operating with electronic devices of tablet terminals and smartphones, digital teaching materials for teachers and real sediment samples". These materials are expected to be used in the classes as shown below.

(1) Ikuta Ryokuchi Park Fieldwork (Estimated time: 1 to 2 class hours)

Students observe the overview of strata by moving the images of the 6 outcrops obtained by a 360 degrees camera around in any direction by themselves, and the details of sediment characters by enlarging the high-resolution spot images. They can compare their observations to images of boling sediment-core samples exhibited in Kawasaki Municial Science Museum and summarize the name of stratum in each outcrop and its characteristics, then draw geological columnar section.

(2) Fossil Foraminifera from the Iimuro Fm. (Estimated time: 2 class hours)

Students can wash sediments from the Iimuro Fm. within minutes using tea filter bags and obtain fossil

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foraminifera from the residues (ca. >250 μm in size). They identify foraminifera by using the digital taxonomic search catalog named "Foraminifera search card". Based on the species lists compiled all results of classmates, they try to reconstract the past environment and depositional age of the sediments.

(3) Rock-Minerals in Key Tephra (Estimated time: 1 class hour)

Students can wash tephra sediments from the Kanto Loam in a short time using tea filter bags and can extract rock-minerals from the "Hakone Tokyo Tephra (Hk-TP)" and "Ontake Daiichi Tephra (On-Pm1) ". They identify rock-minerals by using taxonomic search catalog named "Mineral Search Card". Based on the observations, they estimate the type of magma for each tephra.

Summary

We have developed educational materials that help geologically not well-trained high school science teachers to teach the local geology for real by field observation in the Subject.
By three materials using the Parks with samples from the same strata in the other areas, students can deepen the understanding of formation history of the common land of Kanagawa Pref. with spatial relationships among strata.
Every student can operate the digital materials. So, they can do fieldwork in a regular classroom, which enables them to understand the scale of the entire outcrop and the geological formation using regional materials. They can extract the desired material from the sediment sample low cost and short time processes, and then identify fossils and minerals. Hence, those teachers can allow students to spend much time in observing and considering. Classes with these developed materials could shorten the necessary class times about an hour compared with traditional classes. "Fossil Foraminifera from the Iimuro Fm." is also a new material, which can lead to the understanding of depositional age.
We plan to distribute our newly developed materials and give a lecture on this package to teachers.

Keywords: Digital Educational Material, Non Geoscience-Based Teacher, Experiential Learning, Local Geology, Geological Fieldwork, Real Sediment Sample

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図1. 教室で行う野外実習デジタル教材「生田緑地フィールドワーク」の操作例
生徒たちは、各露頭の360° カメラ(RICOH THETA V)による全天球画像とデジタル一眼レフカメラ等による詳細な画像を、自らの操作によって、模擬野外観察を行う。

Fig1. Operation example of the digital educational material named "Ikuta Ryokuchi Park Fieldwork" for students to experience outdoor geological observations in classrooms
Students observe the overview of strata by moving the images of outcrops obtained by a 360 degrees camera around in any direction by themselves, and the details of sediment characters by enlarging the high-resolution spot images.



図2. デジタル教材も併用した実物実習教材「有孔虫化石の観察」で、プロジェクター等で表示する授業進行用(教員用)資料の画面例(左)と、生徒が分類・同定に用いるデジタル教材「有孔虫 検索カード」の画面例(右)

Fig2. Screen example of materials for class progress (for teachers) displayed on a projector (left) and screen example of the digital taxonomic search catalog named "Foraminifera search card" (right) , in the educational material named "Fossil Foraminifera from the Iimuro Fm." using real sediment samples

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Supporting school teachers with GSI’s Toolbox for geography education in the era of Society 5.0

*Yuki Kurisu[1]

1. Geospatial Information Authority of Japan

It is important for children to develop ICT skills in daily life as well as learning opportunities in the era of Society5.0: a new society which incorporates advanced technologies into every industry and social life, seeking for balanced solution between social agenda and economic development. GIGA school, which realizes a classroom provided with high-speed internet connection and individual ICT device such as tablet, and STEAM education, which enriches cross-curricular learning by integrating each subject such as Science, Technology, Engineering, liberal Arts, and Mathematics for solving the problems in the real world, have been well recognized for developing children’s ICT skills. Realizing GIGA school is further hoped as online teaching has imperatively prevailed in response to COVID-19 pandemic.
On the other hand, increased burden on teachers for preparation is concerned, if online education contents are not sufficient, resulting in insufficient learning experience of children. In this regard, Geospatial Information Authority of Japan (GSI) launched the Toolbox for geographic education (https://www.gsi.go.jp/CHIRIKYOUIKU/) (here in after “the Toolbox”) in support of school teachers in June 2016. In this article, we report the advantage of educational contents in the Toolbox, with a view to fully utilizing them in GIGA school and STEAM education.
First; data and cross-media accessibility. We posted all the contents on the Toolbox website so that anyone can easily download them through a web browser: an anticipated environment in GIGA school classrooms. We provided the contents as images and PDF files so that teachers can easily prepare their teaching materials for an online class. With easy links to "GSI maps" included in the contents, we also help teachers develop adequate story-telling for their teaching subject. Further, embedding attractive SNS postings in the contents is intended to make students feel closer to geography subjects.
Second; contents classification according to national school curricula. We first classified the contents into grade levels (3-4G(grade), 5G, 7-9G and 10-12G). Further we classified those according to themes such as neighborhood, Japanese landform and natural disasters in Japan. This classification help teachers find appropriate contents easily and quickly.
Third; contents for cross-curricular learning for STEAM education. Geography should not only be regarded us a subject, but can also be used as a connector to promote cross-curricular learning. For example, we developed a content which relates a section of a three-dimensional object (mathematics) to topographic sectional profile (geography). Another one relates three primary colors of light (visual art) to topographic/cartographic representation (geography).
Fourth; contents with story-telling aspects. These contents are intended to attract students for animating class teachings. For example, a character in a content poses a question toward students about the important points in understanding a hazard map. Another example is a cartoon style content where student can learn relationship between disaster and landform.
We asked 28 teachers about the possibility of utilizing contents in the Toolbox. Most teachers answered that the contents can be useful. Some respondents suggested the possibility of saving time for class preparation by using the contents in the Toolbox.
GSI will continuously support promotion of geography education through the Toolbox and introduce features and effectiveness of the contents in the Toolbox in various opportunities to help school teachers.

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Keywords: Toolbox for geography education, cross-curricular learning, GIGA school, STEAM education

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The trial and error of on-line bidirectional lecture

*Yukari Kido[1]

1. Japan Agency for Marine-Earth Science and Technology

The UN decade of Ocean Science for Sustainable Development (2021–2030, hereafter the UN Decade) by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) began in January, 2021. We are involved in the marine research and technology field and would like to provide access to “Ocean, Marine, and Sea” to the general public. “Ocean, Marine, and Sea” contains information on the latest oceanographic investigations, future global environmental problems and their impacts on human lives, and the continuation of development objectives worldwide. Sustainable development goals are directed at men and women of all ages. Thus, we perform education and outreach activities at schools and conduct ongoing research expeditions. In this session, under the GIGA school framework, we conducted trial and error activities with student and teachers from the Saitama Prefectural Kumagaya High School during COVID-19 circumstances. We focused on outreach activities and provided online information that participants accessed using their tablets. Our online education and outreach activities are associated with three SSH schools of Shizuoka in collaboration with the Drilling Vessel "Chikyu" which are currently conducting operations in an accretionary prism in the Nankai Trough. We addressed the state of operations aboard the ship, which hosts international participants, in January, 2019. During a voyage on the American scientific drilling vessel "Joides Resolution" on Exp. 378 in the South Pacific Ocean in January 2020. Using a narrow internet network connection, students and teachers at Meijyo University Senior High School received online instruction and vivid real-time access to a drilling field. We would like to thank all the participants, supporting schools, and onboard researchers.

Keywords: GIGA network connection, Online lecture, bidirectional

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General Discussion

*Iida Kazuya[1], Hiroaki Akimoto[2], Iwata Makoto[3], Satoshi Miyajima[4]

1. Komaba-Toho Junior and Senior High School, 2. Faculty of Economics, Dokkyo University, 3. Hiroshima Prefectural Ogaki High School, 4. Saitama Prefectural Kumagaya High School

Based on the presentations in this session, we will exchange opinions on future issues and how to use them in class.

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.01 Zoom Room 01

[O-05] How to become a scientist? What can they do?

convener:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Chairperson:Rie Hori(Department of Earth Science, Faculty of Science, Ehime University), Mayumi ARAI(National Museum of Emerging Science and Innovation), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University)

The earth and planetary sciences deal with many issues that are very close to our daily lives. Such researchers in this area are active in many parts of Japan. In this session, we introduce such researchers and people involved in this field and their activities, how they landed their current position. Many people may not know how to become a scientist. Either many of students may wonder how they apply their learned in university and their skills to society? We will have presentations on what they have learned and how they can use the skills they have acquired during their studies at universities and graduate schools in society.
Junior and senior high school students who want to go into the field of earth and planetary sciences are welcome to participate in this session and ask questions. We also welcome submissions from people who develop human resources and expand their colleagues.

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

[O05-01] Introduction

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

[O05-02] Why do you need a PhD?

★Invited Papers

*Manabe Makoto[1] (1.National Museum of Nature and Science)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[O05-03] From Organic Chemistry, Coral Study to Ocean Policy, My Journey through Carbon

★Invited Papers

*Nobuko Nakamura[1,2] (1.The Ocean Policy Research Institute of The Sasakawa Peace Foundation, 2.Keio Univ.)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[O05-04] Living with solar sytem exploration

★Invited Papers

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

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[O05-05] Introduction to IODP and the works inside

★Invited Papers

*Michiko Yamamoto[1] (1.Scripps Institution of Oceanography, UCSD)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[O05-06] I’m working as a nature guide, an environmental activist, and a facilitator.

★Invited Papers

*hisashi Oiwane[1] (1.Musuhi LLC)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[O05-07] Discussion

[J] Oral | O (Public) | Public

[O-05] How to become a scientist? What can they do?

convener:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Chairperson:Rie Hori(Department of Earth Science, Faculty of Science, Ehime University), Mayumi ARAI(National Museum of Emerging Science and Innovation), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University)
Sun. Jun 6, 2021 1:45 PM - 3:15 PM Ch.01 (Zoom Room 01)

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1:45 PM - 1:50 PM

[O05-01]Introduction

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Why do you need a PhD?

*Manabe Makoto[1]

1. National Museum of Nature and Science

You do not need a PhD to get your work published. Why do you need a PhD? During a PhD program at a graduate school, you will find out if you really like to do research for the rest of your life. Even if you do not get a research job in your field after a PhD, your experience of finishing the PhD will help you in your next phase of life. (Photo by Matsuichi YOKOTA)

Keywords: Vertebrate Palaeontology, Dinosaurs, PhD, Graduate School



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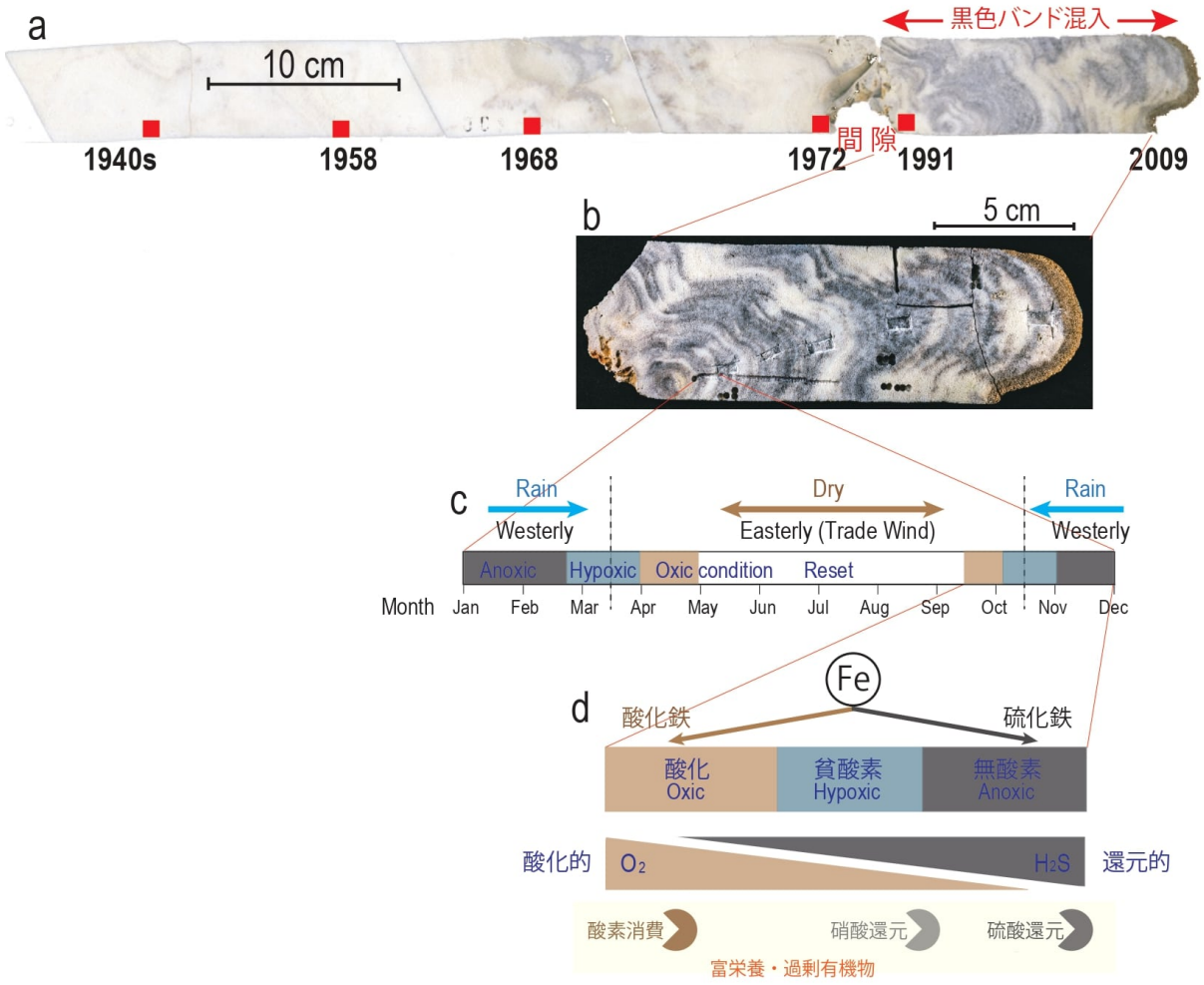
From Organic Chemistry, Coral Study to Ocean Policy, My Journey through Carbon

*Nobuko Nakamura[1,2]

1. The Ocean Policy Research Institute of The Sasakawa Peace Foundation, 2. Keio Univ.

I am currently looking at the world of "ocean policy". Around me there are various people who know about coral reefs and mangrove ecosystems, people who have conducted research on the ecology of sea turtles and whales by attaching sensors to them, people who have observed the Arctic Ocean, and experts in ocean climatology modeling and underwater noise. There are not only researchers in natural science and fisheries. There are professor of maritime culture and ethnology, people who have worked in maritime affairs such as transporting, ships, and ports, researchers in law and economics, experts in international relations and security, and people who have worked for the United Nations. It was like a cross-cultural exchange, a very unique place. I was reminded that the oceans, which I had seen in the natural sciences, were really a place of human activity. And I understand that if humans are to use the ocean, there must be rules. Strangely enough, however, there are not many experts in "ocean policy". It's a field where people with various backgrounds come together to think and build. I used to think that policy was in a different dimension for me, but I don't know how I ended up looking into this world . . . Let me tell you a little about the path I have taken so far. The starting point was studying chemistry at university. I was interested in pharmaceuticals, so I studied synthetic organic chemistry. Organic reagents and organic solvents are petroleum products. At that time, while using a lot of solvents such as hexane, I vaguely wondered how much more oil could be drilled. Next, I taught science in junior high and high school. The "science" part of the teaching license was relentless, and I was required to take physics, chemistry, biology, and geology. However, at that time, I was not familiar with the planetary space-time scale, and it was difficult for me to understand the subject and communicate it in my own words. I had always been interested in field science, so I dove into the world of earth science. There I encountered the science of coral reefs and the study of reconstruction of paleoclimate and paleoenvironment using coral annual rings. Annual rings are a visible measure of time. I was shocked to learn that the annual rings of calcium carbonate coral skeletons record information on seawater temperature and salinity, the flow of materials from the land through rivers, and even traces of human activity and waste. From the Kenyan coral rings I reconstructed the climatic mode of the Indian Ocean over the past 115 years, and clearly showed the rise in sea temperature in the Indian Ocean. The coral rings of Tuvalu in the South Pacific, which is threatened by sea level rise, have been showing black contamination since the 1990s. From the annual rings, we were able to elucidate the process by which the increase in domestic wastewater due to population growth affected the coral reef ecosystem. Through these jobs, I came to have a closer look at the issues of climate change and global warming related to increasing CO_2, and environmental changes. Looking around at Earth science, I became familiar with its spatio-temporal scale, and came to see my own position in the 4.6 billion years of planetary evolution.
And now, besides science, what else can I do? . . The journey continues.

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ツバルのサンゴ年輪が記録する人為影響

(**a**) ツバル フォンガファレ島のサンゴ年輪, 成長停止により年輪が途切れ, 放射性炭素 (14C) 年代測定を行った. 1991 年に成長開始するが, その後 黒色バンドの混入が見られる (**b**) 黒色バンド部分拡大
(**c**) 月単位の酸素同位体比 (δ18O) 測定から年輪内に季節を入れ, 黒色バンドの位置を重ねた結果, 11 月から翌年 3 月頃にかけて, 西風の雨季に混入することが分かった.
(**d**) 黒色バンドには赤褐色 - 灰青色 - 黒色のグラデーションがある. また黒色部は鉄を多く含み, 色グラデーションは鉄の酸化還元状態を反映していた. 黒色部からは外部由来の有機物と嫌気性バクテリアの遺伝子断片も検出された. 過剰有機物のバクテリア分解過程で, 硫酸還元まで進行し, 無酸素環境下 硫化鉄がサンゴ骨格に沈殿する.

Nakamura, N., Kayanne, H., Takahashi, Y., Sunamura, M., Hosoi, G., & Yamano, H. (2020),
Anthropogenic Anoxic History of the Tuvalu Atoll Recorded as Annual Black Bands in Coral. Sci Rep 10, 7338,
https://doi.org/10.1038/s41598-020-63578-4
東京大学　ツバルのサンゴが記録していたサンゴ礁劣化の歴史 サンゴ年輪に黒色バンドとして記録された無酸素環境
UTOKYO FOCUS　https://www.u-tokyo.ac.jp/focus/ja/articles/z0508_00048.html

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Living with solar sytem exploration

*Takeshi Imamura[1]

1. Graduate School of Frontier Sciences, The University of Tokyo

As one of the researchers involved in solar system exploration, I will talk about how I came to this research field, how I spend my life in my lab, and what I try to do in my life as a researcher. I will also introduce paths to the field of solar system exploration where various researchers and engineers with different skills cooperate.

Keywords: solar system exploration, researcher

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Introduction to IODP and the works inside

*Michiko Yamamoto[1]

1. Scripps Institution of Oceanography, UCSD

International Ocean Discovery Program (IODP) has been a very successful international Earth science program over the past five decades with many scientific accomplishments in paleoclimatology, microbiology, marine geology, geophysics, and more. If you will major in Earth science at university or you are doing now in undergraduate, you wouldn't miss seeing the name in textbooks or papers or presentations at least once in your study life even if you are not directly participated in the program as IODP has been one of the largest data sources for the scientists in this field to study on or refer to. In this presentation, I will introduce the program and inside management work as sample of non-research role in academia, and I hope it will be helpful for you to broaden your perspective of possible career after PhD or MS and could be any hint in your future career planning.

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I’ m working as a nature guide, an environmental activist, and a facilitator.

*hisashi Oiwane[1]

1. Musuhi LLC

I’ m working as a nature guide, an environmental activist, and a facilitator.

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[J] Oral | O (Public) | Public

[O-05] How to become a scientist? What can they do?

convener:Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Chairperson:Rie Hori(Department of Earth Science, Faculty of Science, Ehime University), Mayumi ARAI(National Museum of Emerging Science and Innovation), Natsue Abe(Mantle Drilling Promotion Office, MarE3, Japan Agency for Marine-Earth Science and Technology), Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University)
Sun. Jun 6, 2021 1:45 PM - 3:15 PM Ch.01 (Zoom Room 01)

The earth and planetary sciences deal with many issues that are very close to our daily lives. Such researchers in this area are active in many parts of Japan. In this session, we introduce such researchers and people involved in this field and their activities, how they landed their current position. Many people may not know how to become a scientist. Either many of students may wonder how they apply their learned in university and their skills to society? We will have presentations on what they have learned and how they can use the skills they have acquired during their studies at universities and graduate schools in society.

Junior and senior high school students who want to go into the field of earth and planetary sciences are welcome to participate in this session and ask questions. We also welcome submissions from people who develop human resources and expand their colleagues.

3:05 PM - 3:15 PM

[O05-07]Discussion

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.02 Zoom Room 02

[O-06] Let's talk about "the 10 years of reconstruction from the Great East Japan Earthquake"

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Mamoru Hayashi(University of TOYAMA), Tetsuhiko Asano(Senshu University Matsudo Junior High School High School), Chairperson:Mamoru Hayashi(University of TOYAMA), Tetsuhiko Asano(HunabashiKeimei High School), Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education)

The year 2021 marks the 10th anniversary of the Great East Japan Earthquake. The severity and scale of the damage also shocked people who lived outside the disaster area. However, since earthquakes and floods have occurred regularly in various places since then, anyone who is not directly affected has tended to become oblivious of how reconstruction is progressing following the massive quake. The government designated the first five years after the disaster as an intensive reconstruction period, and the next five years, that is, the years up to March 2021, as the first period of reconstruction and creation. According to the "Roadmap and Prospects for Reconstruction from the Great East Japan Earthquake" posted on the Reconstruction Agency website, both private housing and public housing for disaster victims are now 99% complete. It states that most of the infrastructure was restored by the end of the intensive reconstruction period. In addition, it is reported that, as of August 2020, the number of evacuees has decreased from the initial 470,000 to 43,000. However, the lives of these 43,000 people under the conditions of evacuation are still severely impaired. Of these, 37,000 in Fukushima Prefecture (as of July 2020) are still unable to return to the towns and villages where they used to live. However, these numerical data cannot clearly convey a realistic picture of how people work and live, the status of their physical and mental health, and cannot evoke in us a sense of empathy for the victims. Therefore, the convenors would like to make this session an opportunity to get to know the current situation of the victims by inviting those involved in reconstruction to give lectures. We believe this session will provide useful information for recovery from future catastrophes.

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

[O06-01] Overview of reconstruction status for the 10th anniversary of the Great East Japan Earthquake

★Invited Papers

*Yoshihiro Okumura[1] (1.Kansai University)

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

[O06-02] Problems caused by and positive lessons to be inherited from the reconstruction of the Great East Japan Earthquake

★Invited Papers

*Hiromi ENSHU

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

[O06-03] One decade after the earthquake, reconstruction still not complete

★Invited Papers

*YUKIKO KIKUCHI[1] (1.general incorporated association Otsuchi Shimbun)

Overview of reconstruction status for the 10th anniversary of the Great East Japan Earthquake

*Yoshihiro Okumura[1]

1. Kansai University

Ten years have passed since the Great East Japan Earthquake, and it seems that the affected peoples are recovering their daily lives. However, there are many challenges. I will overview the current state of reconstruction, focusing on the disaster areas of Miyagi Prefecture.

Keywords: Great East Japan Earthquake, recovery, reconstruction

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Problems caused by and positive lessons to be inherited from the reconstruction of the Great East Japan Earthquake

*Hiromi ENSHU

1 The current state of reconstruction in Miyagi prefecture
In March 2020, Miyagi Prefecture released the results of a review of the prefecture's earthquake recovery plan. It provides a glimpse into the current state of disaster recovery in Miyagi Prefecture.
The verification is based on the evaluation of the progress rate of 24 items in 7 fields included in the earthquake recovery plan, and those are categorized in the following 4 levels; A: certainty of achievement, B: achievement of 80% or more, C: achievement of less than 80%, and N: unmeasurable.
The following are the main points that can be read from the report.
(1) The selection of verification indicators is arbitrary, and there are no indicators that allow us to correctly grasp the progress in rebuilding the lives of disaster victims.
(2) Highly evaluated items are easily to control for local governments and biased to construction projects.
(3) Difficult to achieve are those that are beyond the control of local governments, in which private businesses and disaster victims are involved.
(4) Delaying in rebuilding livelihoods is obvious.
(5) The recovery plan in agricultural production that intends to introduce large-scale and entrepreneurial management has not been successful.
(6) Employment of disaster victims cannot be verified.
(7) Delays in the construction of seawalls, especially in the improvement of river levees for tsunami countermeasures are serious, whose main causes are skyrocketing construction costs caused by massive construction projects themselves.

2 Problem of victims living in poorly repaired houses and difficulties in community formation
685 households in Ishinomaki City were officially identified that they had been living in poorly repaired houses. Furthermore, based on the number of households with reduced property tax, not repaired houses may exceed 10,000 in Sendai City.
In addition, only less than one-third of households living in former villages moved in small-scale housing complexes constructed in remote peninsular areas, making community formation impossible and marginalization inevitable. The residents of public disaster housing are aging and becoming increasingly impoverished, and the formation and maintenance of a community is becoming a heavy burden on the leaders of neighborhood associations.

3 Characteristics of the recovery process in Miyagi Prefecture

The reconstruction process in Miyagi Prefecture can be characterized in the following three points. First, the rebuilding of the lives of the victims was neglected and massive civil engineering development was carried out to take advantage of the disaster. Secondly, the destruction of communities and self-governance proceeded, and thirdly, neoliberal structural reforms under the name of "creative reconstruction" were enforced, leaving "human reconstruction" behind and causing the selection and division of the victims in the project process.

4 What the Great Earthquake Left Behind
(1) What should be inherited

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The following is a list of possible candidates. (1) Development of disaster case management, (2) Group subsidies for small and medium-sized enterprises, (3) Mandatory maintenance of registers of disaster victims and those who need support for evacuation, (4) Expansion of support for rebuilding the lives of disaster victims to medium scale collapses, (5) Lifting of the ban on moving into temporary housing during emergency repairs, (6) Use of existing rental houses as temporary housing and provision of wooden temporary housing, (7) Establishment of a comprehensive subsidy for supporting disaster victims.

(2) Possible negative legacy of the earthquake reconstruction
i. Arbitrary use of inundation simulations.
ii. Promotion of huge land readjustment with special exceptions and special zones for reconstruction.
iii. Relaxation of requirements for disaster prevention group relocation projects.

Keywords: reconstruction of earthquake disaster, creative reconstruction, unfair selection and division in disaster victims, human reconstruction, disaster case management

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One decade after the earthquake, reconstruction still not complete

*YUKIKO KIKUCHI[1]

1. general incorporated association Otsuchi Shimbun

It has been ten years since the Great East Japan Earthquake. The media often report that reconstruction projects are a waste of taxpayers’ money and that the victims still lead difficult lives. What does “reconstruction” of a town mean? When can we say that reconstruction is complete? Did you know that the concept, "reconstruction," conveys an idea that is "more than simple disaster recovery"?

Otsuchi Town (Kamihei District, Iwate Prefecture) was devastated by the earthquake and tsunami that occurred on March 11, 2011. After the disaster, the townspeople lacked the information they needed just to survive. Given this situation, in 2012, I (the author) decided to publish a weekly newspaper, the "Otsuchi Shimbun." I had never before attempted to compile and publish a newspaper. I did everything by myself from interviewing to editing. Starting in the following year, the weekly newspaper was distributed free of charge to all households in the town. I have learned a lot about the town and thought more deeply about it as a consequence of publishing the newspaper. Initially, the newspaper was intended to deliver reconstruction information to the townspeople, but gradually it began to uncover problems that arose in the process of reconstruction.

Immediately after the earthquake, Otsuchi Town set up a disaster response headquarters in front of the town office building. However, the tsunami struck the headquarters, killing 38 local government employees including the mayor with the result that it was not possible to issue the evacuation order. Among Otsuchi Town’s population of 15,276 (according to the 2010 census), 1,286 died, including disaster-related deaths. Otsuchi is often referred to as "a town where 1 in 10 people died" in the disaster. It is one of the municipalities with the highest percentage of victims in the three affected prefectures: Iwate, Miyagi, and Fukushima. With about 70% of the houses damaged by the tsunami and subsequent fires, the town’s urban area was virtually destroyed. Most hardware projects covered by reconstruction budgets were completed by the end of 2019. New seawalls, floodgates, bridges, etc. have been constructed. Regarding the housing reconstruction to accommodate victims, 967 lots were created in the land readjustment area project, 422 residences were relocated in the disaster prevention group relocation project, and 876 disaster public housing units were built. The main current issues are restoring the town office organization, which suffers from a shortage of human resources, utilizing vacant lots, and investigating the effects of the earthquake disaster and what was lacking in the disaster prevention measures that were in place before the tsunami hit the town.

There is a concern that reports that are rooted in the media’s stereotyped perception that the reconstruction budget is a "waste of taxpayers’ money" may rob people of the memory of the disaster. Reconstruction has focused on hardware projects until now. However, budgets were additionally allocated to software projects, such as psychological support for the victims. The national "Basic Law for Reconstruction from the Great East Japan Earthquake" states the following reconstruction principles: "Take drastic measures with a view to revitalizing Japan beyond mere disaster recovery," and “carry out what should be accomplished now with a vision of what form Japan should take by the middle of the 21st century." We must achieve creative reconstruction that will remain valid for Japan 30 years from now. There are able people in Otsuchi who are working hard to make the town better than it was before the disaster, although the town government constantly suffers from a shortage of human resources. What is

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most needed now is to revisit the principles of reconstruction without being swept away by the ongoing processes of reconstruction.

Keywords: earthquake, tsunami, Otsuchi Shimbun, reconstruction, restoration

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[J] Oral | O (Public)：Public

Sun. Jun 6, 2021 12:30 PM - 1:30 PM JST | Sun. Jun 6, 2021 3:30 AM - 4:30 AM UTC | Ch.02 Zoom Room 02

[O-07] Poster presentations by senior high school students

Chairperson:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(Japan Meteorological Agency), Keiko Konya(Japan Agency for Marine-Earth Science and Technology)

Senior high school students provide poster presentations on subjects in fields of earth and planetary sciences. This session provides an opportunity for senior high school students to give their presentations in the JpGU meeting and to have discussions with researchers. This session has been conducted as a public outreach session since 2006.

12:30 PM - 1:30 PM JST | 3:30 AM - 4:30 AM UTC

Poster presentations by senior high school students

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

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Risa Uchida(Japan Automobile Research Institute), Kei Sato(National Institute for Environmental Studies)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[AAS05-01] Cryosphere-atmosphere biogeochemical cycles: Insights from Arctic Ocean drifting campaign

★Invited Papers

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

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

[AAS05-02] Embedding of HCl droplets on ice crystal surfaces under atmospheric-concentration HCl gas

*Ken Nagashima[1], Ken-ichiro Murata[1], Gen Sazaki[1] (1.The Institute of Low Temperature Science, Hokkaido University)

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

[AAS05-03] A new method for quantifying sodium sulfate, sodium nitrate, and sodium chloride aerosols

*Yuya Kobayashi[1], Nobuyuki Takegawa[1] (1.Graduate School of Science, Tokyo Metropolitan University)

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

[AAS05-04] Investigation of gaseous and heterogeneous reactions of RO_2 radicals using FAGE-LIF method

*Nanase Kohno[1], Jiaru Li[1], Yosuke Sakamoto[1,2], Yoshizumi Kajii[1,2] (1.Kyoto University, 2.National Institute for Environmental Studies)

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

[AAS05-05] Real-time measurement of HO_2 and RO_2 uptake loss rate onto ambient particles during AQUAS-Kyoto summer campaign in 2020

*Yosuke Sakamoto[1,2], Bai Yu[1], Jiaru Li[1], Kohno Nanase[1], Yoshizumi Kajii[1,2] (1.Kyoto University , 2.National Institute for Environmental Studies)

Cryosphere-atmosphere biogeochemical cycles: Insights from Arctic Ocean drifting campaign

*Daiki Nomura[1]

1. Field Science Center for Northern Biosphere, Hokkaido University

Sea ice has until now rarely been considered in estimates of global biogeochemical cycles, especially gas exchanges, because of the assumption that, in ice-covered oceans, sea-ice acts as a barrier for atmosphere–ocean exchange. In order to understand the effects of sea-ice growth and decay processes on the biogeochemical cycles in the polar oceans, field observations in the Arctic, Antarctic, and Sea of Okhotsk as well as laboratory experiments were carried out. Observations over recent decades suggest that sea ice plays a significant role in global biogeochemical cycles, providing an active biogeochemical interface at the cryosphere-atmosphere boundary. In this presentation, I will show preliminary results obtained during the international drift campaign MOSAiC in the central Arctic for the gas dynamics and exchange process between sea ice/water surface and atmosphere.

Keywords: biogeochemical cycles, gas exchange process, sea ice

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Embedding of HCl droplets on ice crystal surfaces under atmospheric-concentration HCl gas

*Ken Nagashima[1], Ken-ichiro Murata[1], Gen Sazaki[1]

1. The Institute of Low Temperature Science, Hokkaido University

Surfaces of ice act as sites of various chemical reactions of atmospheric acidic gases, which cause serious environmental issues, such as the catalytic ozone depletion by hydrogen chloride (HCl) gas. As a means of direct observation of QLLs on ice surfaces, we and Olympus Engineering Co. Ltd., have developed laser confocal microscopy combined with differential interference contrast microscopy (LCM-DIM), which can directly visualize 0.37-nm-thick elementary steps [1] and QLLs on ice crystal surfaces [2].
Recently, we studied effects of HCl gas (10^2 Pa) on the behavior of QLLs on ice basal faces by LCM-DIM [3-4]. Then we found that the QLLs were not pure water but an HCl aqueous solution, whose HCl concentration was very close to that of a liquidus line of a binary phase diagram of water and HCl. Therefore, the HCl droplets did not disappear and were embedded in ice crystals stably without freezing [4]. However, in our previous studies, we used the HCl gas of 10^2 Pa HCl partial pressure, which is extremely higher than ordinary atmospheric partial pressure of HCl. Here, we show direct observations of ice basal faces by advanced optical microscopy under atmospheric-concentration HCl gases of from 10^{-4} to 10^{-2} Pa. Then, we investigated the appearance/disappearance of liquid water on ice surfaces and their effects on the growth of ice crystals [5].
Under atmospheric-concentration HCl gas, we found that liquid droplets and thin layers appeared/disappeared on the ice basal faces at about -1 ˚C with increasing/decreasing temperatures. These behaviors were similar to those in the absence of the HCl gases. In contrast, at temperatures below -10 ˚C, surprisingly we found that with decreasing temperature, the HCl gases induced the appearance of droplets of an HCl aqueous solution on the basal faces. In addition, the HCl droplets pinned the lateral advancement of spiral steps, resulting in the formation of bunched steps. The HCl droplets were finally embedded in the ice crystals by further growth of the bunched steps. In contrast, with increasing temperatures, the HCl droplets and the bunched steps disappeared at -10 ˚C.
These results indicate that a bulk of an ice crystal plays an important role in the uptake of HCl. So far, it has been believed that the contribution of a bulk of an ice crystal to the HCl uptake is less important than that of an ice surface, because of the small solubility of HCl and the slow diffusion of chloride ions in an ice crystal. Hence, the results found in this study suggest that the uptake of HCl in an ice crystal can be promoted via the bunching and embedding mechanism at temperatures below -10 ˚C. Our findings will give significant insights into various environmental issues caused by acidic gases in polar regions. However, it is crucially important to study whether the similar phenomena occur at -70 ˚C, at which temperature HCl on ice crystals plays an important role in the ozone depletion by the heterogeneous photochemical reactions in polar stratospheric clouds.

[1] Sazaki et al. (2010) PNAS 107, 19702.
[2] Sazaki et al. (2012) PNAS 109, 1052.
[3] Nagashima et al. (2016) Cryst. Growth Des. 16, 2225.
[4] Nagashima et al. (2018) Cryst. Growth Des. 18, 4117.
[5] Nagashima et al., Cryst. Growth Des. submitted.

We will present this study from other viewpoints in " M-IS17 Growth and dissolution of crystal".

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Keywords: ice crystal, air-snow interaction, atmospheric-concentration HCl gas, bunched step, HCl uptake, advanced optical microscopy

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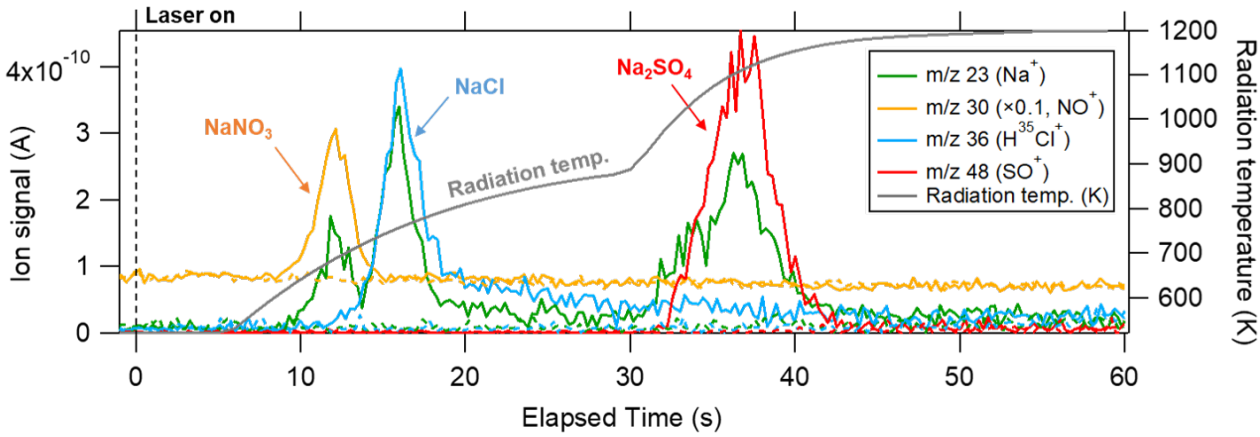
A new method for quantifying sodium sulfate, sodium nitrate, and sodium chloride aerosols

*Yuya Kobayashi[1], Nobuyuki Takegawa[1]

1. Graduate School of Science, Tokyo Metropolitan University

Sea salt aerosols are abundant in the marine boundary layer and have large influences on the Earth's radiative budget. Significant conversion of sodium chloride (NaCl) to sodium sulfate (Na_2SO_4) or sodium nitrate ($NaNO_3$) can take place via the reactions with sulfuric acid (H_2SO_4) or nitric acid (HNO_3) in polluted air exported from urban areas to coastal regions. In situ, continuous measurements of NaCl, Na_2SO_4, and $NaNO_3$ aerosols are needed to understand the chemical transformation of sea salt particles with air mass aging. However, there is no established method for quantifying these aerosol compounds with high time resolution. We have developed a new online particle mass spectrometer (refractory aerosol thermal desorption mass spectrometer; rTDMS) to quantify non-refractory and refractory sulfate aerosols. The combination of a graphite particle collector and a carbon dioxide (CO_2) laser enables high desorption temperature (radiation temperature > 1200 K). The evolved gas molecules are detected by using a quadrupole mass spectrometer. The purpose of this study is to develop a new method for quantifying the mass concentrations of NaCl, Na_2SO_4, and $NaNO_3$ aerosols by optimizing the laser desorption scheme of the rTDMS. Laboratory experiments were performed to test the instrument sensitivities to these aerosol compounds. The temporal evolution of ion signals at m/z 23 (Na^+), 30 (NO^+), 36 (HCl^+), and 48 (SO^+) during the laser desorption were monitored. Preliminary data indicate that ion signals originating from $NaNO_3$, NaCl, and Na_2SO_4 particles were clearly identified by three sequential peaks associated with an increase in the radiation temperature. The limit of detection, linearity of the instrument response, and potential artifacts under real world conditions are discussed.

Keywords: Sea salt aerosols, Online measurement, Quantification of each sodium salts



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Investigation of gaseous and heterogeneous reactions of RO_2 radicals using FAGE-LIF method

*Nanase Kohno[1], Jiaru Li[1], Yosuke Sakamoto[1,2], Yoshizumi Kajii[1,2]

1. Kyoto University, 2. National Institute for Environmental Studies

Peroxy (RO_2) radicals are produced by oxidation of various volatile organic compounds (VOCs) in the atmosphere and play an important role. They are mainly removed by self-reactions under clean air conditions. On the other hand, they oxidize NO and produce NO_2. Since NO_2 produces O_3 via photochemical reactions, RO_2 radicals act as a part of the cyclic reaction producing tropospheric O_3. RO_2 radicals also react with NO_2 and generate a RO_2NO_2 complex, which can reproduce NO_2 via thermal decomposition and act as an atmospheric NOx reservoir. Furthermore, in recent years, it has been suggested that the loss processes of ROx radicals via heterogeneous reactions on the aerosol surface may be important. Despite these importance, there are limited kinetics data about RO_2. In particular, there were few reports of detection under atmospheric conditions, and it was limited to some RO_2 radicals. In this study, we improved a combination technique of Fluorescence Assay by Gas Expansion and Laser Induced Fluorescence (FAGE-LIF) system for detection of various RO_2 radicals and investigated their reactions including not only gaseous reactions but aerosol uptake processes.

All experiments were performed at 1 bar, 298 K. O_3/H_2O/sample VOC/N_2 carrier mixture were added into the reaction cell. By irradiation of pump laser pulses, OH radicals were generated by the photolysis of O_3 and subsequent reaction with H_2O. OH radicals reacted with VOC rapidly and generated RO_2 radicals. A part of main flow was added into the detection cell. In order to convert RO_2 radicals to OH radicals again, NO and O_2 were added into the detection cell. Then, OH radicals were detected by LIF method. The relative concentration of RO_2 radicals were measured from the LIF intensity of OH radicals.

Figure 1 shows time profiles of CH_3O_2 radicals, which were produced by the reaction of OH with CH_4, measured at various NO_2 concentrations. CH_3O_2 radicals decay single exponentially in the absence of NO_2. With the existence of NO_2, however, profiles include two decay components due to the reverse reaction. In order to determine the rate constants, double exponential fitting including the reverse reaction was performed. The fitting results are shown in figure as red lines. All lines reproduce the experimental results very well. The reaction rate constants including also reverse reaction have been determined from the NO_2 concentration dependence. Those rate constants agree with previous reported values. This indicates that the improved FAGE-LIF system allows us to measure the kinetics of RO_2 radicals appropriately. We also performed same experiments using $C_2H_5O_2$ radicals. We will discuss at the presentation.

Additionally, we investigated uptake processes of RO_2 radicals onto aerosols. Sample aerosols were deliquesced NaCl particles generated from 0.1 −0.3 g L^{-1} aqueous NaCl solutions via a collision-type atomizer. Those particles were added into the reaction cell with zero air carrier and another sample gases. The decay rates of RO_2 radicals due to aerosols were determined by the difference between the fitting results with and without aerosols. By using the decay rates due to the aerosols and aerosol size distributions, uptake coefficients have been determined for some RO_2 radicals (as shown in Fig.2). The aerosol size distributions were employed from the separate experiments under the almost same conditions. As a result, the increase of the uptake coefficients with the size of RO_2 radicals was observed for the first time. In addition, even small RO_2 radicals were uptaken into aerosols, although their values were small. This indicates that the heterogeneous reactions of RO_2 radicals can affect the O_3 production

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mechanisms. Consequently, there is possibility that the considering the interaction between RO_2 radicals and aerosols should improve the accuracy of the atmospheric model.

This work was supported by JSPS KAKENHI Grant Nos. JP16H06305, JP18K18179, JP19J40218, and JP19H04255.

Keywords: RO2 radical, reaction rate coefficient, NO2, aerosol, uptake coefficient

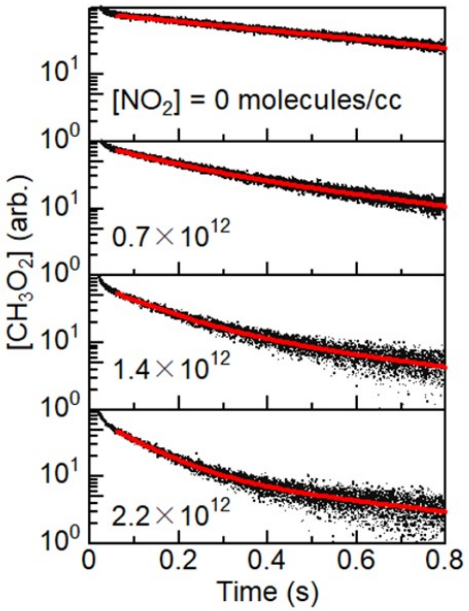


Figure 1. Time profiles of CH_3O_2 radicals.
Red lines show the fitting analysis results.

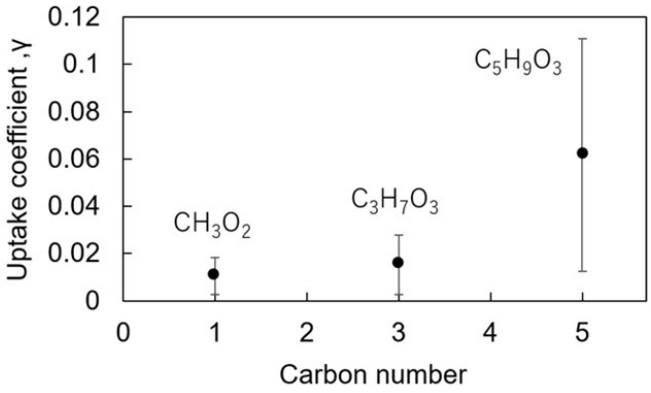


Figure 2. Radical size dependence of uptake coefficient.

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Real-time measurement of HO_2 and RO_2 uptake loss rate onto ambient particles during AQUAS-Kyoto summer campaign in 2020

*Yosuke Sakamoto[1,2], Bai Yu[1], Jiaru Li[1], Kohno Nanase[1], Yoshizumi Kajii[1,2]

1. Kyoto University , 2. National Institute for Environmental Studies

Peroxy radicals, HO_2 and RO_2, play a central role in the daytime photochemistry in the troposphere, since they compose daytime radical recycling chain reaction through OH →RO_2 →HO_2 →OH, namely HO_x cycle, which dominate tropospheric O_3 formation. The gas phase reactions of peroxy radicals that produce non-radical species, e.g. HO_2 + HO_2 →H_2O_2 + O_2, HO_2 + RO_2 →ROOH + O_2, work as termination reaction of the HO_x cycle, and thus affect efficiency for O_3 formation. It has been suggested indirectly for decades that HO_2 uptake by ambient particles also work as termination process based on laboratory experiments with artificially produced particles. Recently, we achieved real-time measurement of HO_2 uptake kinetics onto ambient particles and reported the HO_2 loss rate and uptake coefficient for ambient particles during AQUAS-Kyoto summer campaign in 2018. [Zhou et al. 2020] In this study, we examined HO_2 uptake kinetics onto ambient particles in Kyoto again during AQUAS-Kyoto summer campaign in 2020, with the aim of investigating temporal variation of uptake kinetics from previous campaign. Additionally, we expanded the system to real-time measurement of isoprene-derived RO_2 (C_5H_8(OH)OO) uptake kinetics onto ambient particles. Daily average of HO_2 loss rate was similar but uptake coefficient was smaller compared with previous campaign. Observed loss rate was comparable to those of gas phase termination reactions. Temporal variation of aerosol components might be possible explanation of variation of uptake coefficient during the present campaign and difference from the previous campaign. We found that daily average of RO_2 loss rate and then uptake coefficient had significant values. Observed loss rate for RO_2 was also comparable to those of gas phase termination reactions as well as HO_2. Our results suggest that further investigations of not only HO_2 but also RO_2 uptake kinetics are required for complete understanding of O_3 formation in the troposphere.

Reference: Zhou et al. *Atmospheric Environment*, 223 (2020) 117189.
Acknowledgements: This work was supported by the Japan Society for the Promotion of Science (JSPS NO. 16H06305 and NO. JP19H04255). We would like to thank the technical support from KIMOTO ELECTRIC CO., LTD. in construction of aerosol enrichment system.

Keywords: heterogeneous reaction, aerosol, PM2.5, photochemical ozone, HOx cycle

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

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Nobuyuki Takegawa(Graduate School of Science, Tokyo Metropolitan University)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

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

[AAS05-06] **Understanding of Volatile Organic Compound Emissions from Western US Wildfires**

*Kanako Sekimoto[1], Matthew M Coggon[2,3], Georgios Gkatzelis[2,3], Carsten Warneke[2,3] (1.Yokohama City University, 2.NOAA Earth System Research Laboratory, 3.Cooperative Institute for Research In Environmental Sciences)

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

[AAS05-07] New particle formation from ozonolysis of 2-methyl-2-butene and *trans*-2-butene

*Satoshi Inomata[1], Jun Hirokawa[2], Yosuke Sakamoto[3] (1.National Institute for Environmental Studies, 2.Hokkaido University, 3.Kyoto University)

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

[AAS05-08] Structural elucidation of a-pinene originating $C_{10}H_{17}O_6S$ organosulfates from CCS values derived from ion mobility mass spectrometry and theoretical structural modelling

*Yoshiteru Iinuma[1], Satoshi Inomata[2], Kei Sato[2] (1.Okinawa Institute of Science and Technology Graduate University, 2.National Institute for Environmental Studies)

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

[AAS05-09] Wet Deposition of Black Carbon at Ny-Ålesund, Svalbard

*Tatsuhiro Mori[1], Yutaka Kondo[2], Sho Ohata[3,4], Kumiko Goto-Azuma[2,5], Kaori Fukuda[2], Yoshimi Ogawa[2], Nobuhiro Moteki[6], Atsushi Yoshida[6], Makoto Koike[6], Puna Ram Sinha[7], Naga Oshima[8], Hitoshi MATSUI[9], Yutaka Tobo[2,5], Masanori Yabuki[10], Wenche Aas[11] (1.Tokyo University of Science, 2.National Institute of Polar Research, 3.Institute for Space–Earth Environmental Research, Nagoya University, 4.Institute for Advanced Research, Nagoya University, 5.The Graduate University for Advanced Studies, SOKENDAI, 6.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 7.Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, 8.Meteorological Research Institute, 9.Graduate School of Environmental Studies, Nagoya University, 10.Research Institute for Sustainable Humanosphere, Kyoto University, 11.Norwegian Institute for Air Research)

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

[AAS05-10] Improved simulations of global black carbon distributions by modifying wet scavenging processes in convective and mixed-phase clouds

*Mingxu Liu[1], Hitoshi Matsui[1] (1.Graduate school of environmental studies, Nagoya University)

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

[AAS05-11] High potential of Asian dust to act as ice nucleating particles in mixed-phase clouds simulated with a global model

*Kei Kawai[1], Hitoshi Matsui[1], Yutaka Tobo[2,3] (1.Nagoya University, 2.National Institute of Polar Research, 3.SOKENDAI (The Graduate University for Advanced Studies))

Understanding of Volatile Organic Compound Emissions from Western US Wildfires

*Kanako Sekimoto[1], Matthew M Coggon[2,3], Georgios Gkatzelis[2,3], Carsten Warneke[2,3]

1. Yokohama City University, 2. NOAA Earth System Research Laboratory, 3. Cooperative Institute for Research In Environmental Sciences

Biomass burning is a large source of volatile organic compounds (VOCs) and many other trace species to the atmosphere. These VOCs can act as precursors to formation of secondary pollutants such as ozone and fine particles, and some VOCs can also have direct effects on human and ecosystem health. Multiple different and complex processes take place in biomass burning, e.g., distillation, flaming, and smoldering combustion processes. In a given fire, most of these processes occur simultaneously, but the relative importance of each can change over the course of a fire. This gives rise to some of the variability in VOC emissions between different fires. To study gas-phase emissions from biomass burning in western US, a proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS) was deployed during the FIREX 2016 laboratory intensive (at the US Forest Service Fire Sciences Laboratory in Missoula, Montana) and the FIREX-AQ field campaign (https://csl.noaa.gov/projects/firex-aq/). Measurements performed with the PTR-ToF-MS were analyzed with positive matrix factorization (PMF) to parameterize the VOC emissions. The results are summarized as follows:

1. Despite the complexity and variability of emissions, a PMF solution including just two emission profiles explained on average 85% of the VOC emissions across 15 different fuel types including pines, firs, spruce, grass, shrubs, chaparrals, and wood wool.
2. The two profiles were identified as resulting from high-temperature and low-temperature pyrolysis processes, and the profiles were remarkably similar (correlation coefficient $r > 0.9$) across nearly all the fuel types described in 1).
3. The VOC emissions from real-world wildfires were described on average of 80% by just three emission profiles, i.e., (i) high-temperature profile, (ii) low-temperature profile, and (iii) a profile related to chemical aging.
4. Contributions of high-temperature profile, low-temperature profile, and aging profile can be parameterized using fire radiation power and emissions of maleic anhydride and furan.

Keywords: Volatile organic compound, Wildfire, Proton-transfer-reaction mass spectrometry (PTR-MS)

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New particle formation from ozonolysis of 2-methyl-2-butene and *trans*-2-butene

*Satoshi Inomata[1], Jun Hirokawa[2], Yosuke Sakamoto[3]

1. National Institute for Environmental Studies, 2. Hokkaido University, 3. Kyoto University

Atmospheric aerosols scatter and absorb incoming solar radiation, which directly impacts the global radiative balance of the atmosphere. If these aerosols are hydrophilic, they can act as cloud condensation nuclei (CCN) and have an indirect effect on the climate by modifying the properties of clouds. New particle formation (NPF) through nucleation is believed to contribute up to half of the global CCN concentrations. The nucleation and growth mechanisms of new particles in the atmosphere have therefore been topics of study in atmospheric research. Recently, we observed NPF during ozonolysis of isoprene (C_5H_8) and ethene (C_2H_4). We proposed that oligomeric hydroperoxides originated from stabilized Criegee intermediates (sCIs) that were generated during the ozonolysis of isoprene and ethene potentially contribute to the NPF. In the present work, we investigated the ozonolysis of 2-methyl-2-butene (C_5H_{10}) and *trans*-2-butene (C_4H_8), in order to investigate the role of C2-sCI ((CH_3)CHOO) on the new particle formation.

Keywords: 2-methyl-2-butene, trans-2-butene, ozonolysis, secondary organic aerosol,, Criegee intermediate

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Structural elucidation of a-pinene originating $C_{10}H_{17}O_6S$ organosulfates from CCS values derived from ion mobility mass spectrometry and theoretical structural modelling

*Yoshiteru Iinuma[1], Satoshi Inomata[2], Kei Sato[2]

1. Okinawa Institute of Science and Technology Graduate University, 2. National Institute for Environmental Studies

Organosulfates (OS) are recognised as one of the important classes of marker compounds for atmospheric oxidation of biogenic volatile compounds (BVOCs) as it can account as high as 30% of the organic mass fraction in PM_{10} (Brüggemann et al., 2020). While a number of studies report the presence of OS in laboratory generated and ambient biogenic SOA based on LC/MS data, little is known about their formation mechanism and exact structures owing to a wide variety of possible formation mechanisms and structures. Nevertheless, several formation mechanisms are accepted in the community based on laboratory experimental data. These include the reaction of BVOC oxidation products with acidic sulfate or sulfoxy radical anion in the particle phase, and the reactions of unsaturated hydrocarbons and SO_2 in the gas phase (Brüggemann et al., 2020). The structural elucidation of OS species remains challenging owing to lack of authentic standard compounds.

In this work, we present the results from the structural elucidation experiments of *m/z* 265 ($C_{10}H_{17}O_6S^-$) organosulfates originating from the photo-oxidation and ozonolysis of a-pinene in the presence of neutral and acidic seed particles at two different temperatures. The resulting SOA were collected on Teflon filter, and extracted in acetonitrile, dried using a centrifugal evaporator, and reconstituted in a 50/50 (v/v) acetonitrile/water solution. The samples were analysed using high-performance liquid chromatography coupled to ion mobility spectrometry tandem time-of-flight mass spectrometry (Agilent 1290 HPLC and Bruker TimsTOF) to obtain collision cross section (CCS) values of *m/z* 265 organosulfates. To further evaluate the structures of *m/z* 265 compounds, the theoretical CCS value of a previously reported structure for *m/z* 265 organosulfate, specifically sulfated pinonaldehyde, was calculated with MobCal-MPI (Ieritano et al., 2019), and compared to the measured CCS values. The measured CCS values of *m/z* 265 compounds are in the range of 154 to 158 $Å^2$ that are much smaller than the theoretical CCS value of 164.7 $Å^2$. The theoretical CCS values of positional isomers of sulfated pionaldehyde (i.e. a sulfate group is attached at a different position than the previously reported structure) are also greater than those of measured CCS values, indicating that *m/z* 265 organosulfates likely have closed shell structures rather than open shell structures. To support this, theoretical CCS values of two of $C_{10}H_{17}O_6S^-$ compounds that are analogous to closed shell *m/z* 249 ($C_{10}H_{17}O_5S^-$) organosulfates were calculated and compared to measured values. The theoretical CCS values of both the closed shell *m/z* 265 compounds are in the order of 156 $Å^2$, suggesting that they are likely structures of *m/z* 265 organosulfates.

Brüggemann, M., Xu, R., Tilgner, A., Kwong, K.C., Mutzel, A., Poon, H.Y., Otto, T., Schaefer, T., Poulain, L., Chan, M.N., Herrmann, H., 2020. Organosulfates in Ambient Aerosol: State of Knowledge and Future Research Directions on Formation, Abundance, Fate, and Importance. Environ. Sci. Technol. 54, 3767–3782. https://doi.org/10.1021/acs.est.9b06751

Ieritano, C., Crouse, J., Campbell, J.L., Hopkins, W.S., 2019. A parallelized molecular collision cross section

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package with optimized accuracy and efficiency. Analyst 144, 1660–1670. https://doi.org/10.1039/C8AN02150C

Keywords: SOA, Organosulfate, Ion mobility mass spectrometry, Collision Cross Section

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Wet Deposition of Black Carbon at Ny-Ålesund, Svalbard

*Tatsuhiro Mori[1], Yutaka Kondo[2], Sho Ohata[3,4], Kumiko Goto-Azuma[2,5], Kaori Fukuda[2], Yoshimi Ogawa[2], Nobuhiro Moteki[6], Atsushi Yoshida[6], Makoto Koike[6], Puna Ram Sinha[7], Naga Oshima[8], Hitoshi MATSUI[9], Yutaka Tobo[2,5], Masanori Yabuki[10], Wenche Aas[11]

1. Tokyo University of Science, 2. National Institute of Polar Research, 3. Institute for Space–Earth Environmental Research, Nagoya University, 4. Institute for Advanced Research, Nagoya University, 5. The Graduate University for Advanced Studies, SOKENDAI, 6. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 7. Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, 8. Meteorological Research Institute, 9. Graduate School of Environmental Studies, Nagoya University, 10. Research Institute for Sustainable Humanosphere, Kyoto University, 11. Norwegian Institute for Air Research

Black carbon (BC) aerosol deposited in and onto Arctic snow increases the snow’s absorption of solar radiation and accelerates snowmelt. Concentrations of BC in the Arctic atmosphere and snow are controlled by wet deposition; however, details of this process are poorly understood owing to the scarcity of time-resolved measurements of BC in hydrometeors. We measured mass concentrations of BC in hydrometeors (C_{MBC}) and in air (M_{BC}) with 16% and 15% accuracies, respectively, at Ny-Ålesund, Svalbard during 2012–2019. Median monthly M_{BC} and C_{MBC} values showed similar seasonal variations, being high in winter-spring and low in summer. Median monthly BC wet deposition mass flux (F_{MBC}) was highest in winter and lowest in summer, associated with seasonal patterns of C_{MBC} and precipitation. Seasonally averaged BC size distributions in hydrometeors were similar except summer. Measurements of BC in air and hydrometeors in spring 2017 showed a size-independent removal efficiency, showing efficient activation of BC-containing particles into cloud droplets. These parameters observed at Ny-Ålesund were compared with those observed at Barrow, Alaska, during 2013–2017. The near surface M_{BC} at Ny-Ålesund and Barrow had similar seasonal patterns; however, they differed for C_{MBC} and F_{MBC}. In summer, C_{MBC} was low at Ny-Ålesund but moderate at Barrow, likely reflecting differences in M_{BC} in the lower troposphere. Seasonally averaged BC size distributions in hydrometeors were similar at both sites, suggesting similar BC size distributions in the Arctic lower troposphere, on average. Coating of BC particles at lower latitudes likely influence the BC size distributions in the Arctic.

Keywords: black carbon, wet deposition, Arctic, Seasonal variation, Laser-induced incandescence technique

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Improved simulations of global black carbon distributions by modifying wet scavenging processes in convective and mixed-phase clouds

*Mingxu Liu[1], Hitoshi Matsui[1]

1. Graduate school of environmental studies, Nagoya University

In-cloud wet scavenging dominates the wet removal of aerosols in the atmosphere, but is not well represented in climate models. Aircraft measurements of black carbon (BC) concentrations suggest that models commonly overestimate BC concentrations in the upper troposphere of the tropics by more than one order of magnitude but underestimate BC burdens in polar latitudes. In this study, we improved the in-cloud wet scavenging parameterizations for convective clouds and mixed-phase clouds to better characterize BC abundances in the remote atmosphere (remote oceans and polar regions) with a global model, CAM5-ATRAS2. The modified wet scavenging processes in the model achieved a more realistic simulation of BC concentrations over both the tropics and the Arctic. The new, unified scheme for vertical transport and wet removal during deep convection generally reproduced the observed low mixing ratios (about 0.1 ng kg^{-1}) of BC in the middle and upper troposphere over the tropics, and the Wegener–Bergeron–Findeisen process lowered the wet removal efficiency of BC from mixed-phase clouds and consequently increased BC burdens in the Arctic by about a factor of 2. The BC direct radiative forcings increased by 20% globally (from 0.26 to 0.31 W m^{-2}), and more importantly by a factor of 2 in the Arctic (from 0.09 to 0.18 W m^{-2}). Our results indicated that good agreement between modeled and observed BC concentrations could be obtained in the remote atmosphere without requiring the relatively short global BC lifetime (~4 days) suggested by previous studies.

Keywords: Black carbon, Global climate model, Aerosol-cloud interactions, Deep convection, Mixed-phase clouds

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High potential of Asian dust to act as ice nucleating particles in mixed-phase clouds simulated with a global model

*Kei Kawai[1], Hitoshi Matsui[1], Yutaka Tobo[2,3]

1. Nagoya University, 2. National Institute of Polar Research, 3. SOKENDAI (The Graduate University for Advanced Studies)

Mineral dust is recognized as the most important ice nucleating particle (INP) in mixed-phase clouds, which consist of supercooled water droplets and ice crystals. Dust INPs affect the microphysical and radiative properties of mixed-phase clouds and hence the radiative balance of the Earth. Although ice nucleating ability of dust has been measured with a cloud chamber, it is not well understood how much dust is transported to higher altitudes and acts as INPs. Asian dust (Kosa), which is emitted from arid and semi-arid regions of East Asia (e.g., the Gobi and Taklimakan Deserts), may have high potential to act as INPs because of high altitudes of the source regions and upward transport by cold frontal systems. In this study, we examined the contribution of Asian dust to global dust INP number and its effect on cloud radiative forcing (CRF) using a global aerosol model, CAM/ATRAS. We replaced the default ice nucleation scheme for mixed-phase clouds in the model with a parameterization that calculates INP number concentrations from the ambient temperature and dust number concentrations. We performed simulations for the years 2012–2017 and analyzed results for the last 5 years.
Our model well reproduces INP number concentrations measured at Tokyo Skytree during May 2017, when Asian dust was transported to Japan. The simulated emission flux of Asian dust is 283 Tg/yr, representing 7.1% of global dust emission flux. Asian dust extends from East Asia to the North Pacific, North America, and the Arctic. The annual mean atmospheric loading of Asian dust is 1.2 Tg, which accounts for 3.4% of global dust loading. In particular, this contribution increases to 13% for the temperature regimes relevant for the formation of mixed-phase clouds (i.e., between −38˚C and 0˚C). The contribution of Asian dust to global dust INP number is 15%, which is 2.1 times higher than the contribution to global dust emission flux and 4.4 times higher than the contribution to the global dust loading. These results show that Asian dust is efficiently transported into low-temperature regions and has high potential to act as INPs in mixed-phase clouds. According to sensitivity simulations, Asian dust INPs induce an annual mean positive CRF of 0.054–0.19 W/m^2 (cf. 0.092–1.0 W/m^2 for dust from other regions) in East Asia and the North Pacific.

Keywords: Asian dust, Kosa, ice nucleating particles, mixed-phase clouds, global aerosol model

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

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Chika Minejima(International Christian University)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

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

[AAS05-12] Validation and correction of TROPOMI tropospheric NO_2 column density data using 4AZ-MAXDOAS at Chiba, Japan

*Hikaru Saito[1], Hitoshi Irie[1], Alessandro Damiani[1] (1.University of Chiba)

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

[AAS05-13] **NO_X emission estimation over Japan based on satellite data with wind field divergence**

*Masahiro Yamaguchi[1], Yugo Kanaya[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[AAS05-14] Introducing new lightning schemes to a chemistry climate model CHASER (MIROC)

*Yanfeng He[1], Kengo Sudo[1] (1.Nagoya University)

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

[AAS05-15] Methane emissions from populated areas of Tokyo and five prefectures: Emission ratios with NOx and their trends over 2009-2018

*Yugo Kanaya[1], Kanami Saima[2], Akira Fukuike[2] (1.JAMSTEC, 2.MURATA Keisokuki Service Co., Ltd.)

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

[AAS05-16] An impact of tropospheric air pollution changes over Japan due to future climate and emission change

*Natsumi Kawano[1], Tatsuya Nagashima[1], Masayuki Hara[2], Satoru Chatani[1], Syuichi Itahashi[3] (1.National Institute for Environmental Studies, 2.Center for Environmental Science in Saitama, 3.Central Research Institute of Electric Power Industry)

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

[AAS05-17] An Empirical Approach toward the Reduction Targets of CH4 and O3 as SLCP: For Asia as an example

*Hajime Akimoto[1], Tatsuya Nagashima[1], Hiroshi Tanimoto[1], Zbigniew Klimont[2], Markus Amann[2] (1.National Institute for Environmental Studies, 2.International Institute for Applied System Analysis)

Validation and correction of TROPOMI tropospheric NO_2 column density data using 4AZ-MAXDOAS at Chiba, Japan

*Hikaru Saito[1], Hitoshi Irie[1], Alessandro Damiani[1]

1. University of Chiba

To quantify and solve the reported negative bias in tropospheric nitrogen dioxide ($tropNO_2$) column data from the latest sensor TROPOspheric Monitoring Instrument (TROPOMI) aboard the Sentinel-5 Precursor satellite, we conducted ground-based four-different-azimuth-viewing multi-axis differential optical absorption spectroscopy (4AZ-MAXDOAS) observations at Chiba, Japan (35.63ºN, 140.10ºE, 21 m a.s.l.) in 2019. A comparison with simultaneous $tropNO_2$ observations by 4AZ-MAXDOAS enabled an evaluation of the spatial inhomogeneity of $tropNO_2$, which was considered responsible for a bias in results. Supported by inter-directional differences of up to 40% among 4AZ-MAXDOAS data, we found a significant horizontal spatial inhomogeneity in $tropNO_2$ around the observation site. We then compared 4AZ-MAXDOAS data with coincident TROPOMI data. TROPOMI data had a 53% smaller $tropNO_2$ column density as an annual average compared to 4AZ-MAXDOAS data, confirming the negative bias in TROPOMI data. However, the correlation between the magnitude of the bias and the coefficient of variance in four-azimuth directional data from 4AZ-MAXDOAS observations was not evident. This suggested that NO_2 horizontal inhomogeneity couldn't fully explain the observed bias. We also applied a correction using the $tropNO_2$ vertical profiles from 4AZ-MAXDOAS and the averaging kernels from TROPOMI. The correction reduced the bias to ~30% for annual average data, depending on the $tropNO_2$ profiles used, indicating that there was a significant contribution of $tropNO_2$ vertical profiles to the bias. These results not only quantified the reported negative bias but also emphasized the effectiveness of validation and correction using multi-directional ground-based data.

Keywords: Atmosphere, Satellite observation, Nitrogen dioxide, Atmospheric science, Atmospheric chemistry

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NO_X emission estimation over Japan based on satellite data with wind field divergence

*Masahiro Yamaguchi[1], Yugo Kanaya[1]

1. Japan Agency for Marine-Earth Science and Technology

Nitrogen dioxide (NO_2) is a form of NO_X as important air pollutants, that leads to acid rain, ozone formation, and adverse impacts on human health. Anthropogenic activities involving the fossil fuel combustion such as vehicle engines and power plants are big sources of atmospheric NO_2. Despite their importance, it is not easy to create high-resolution emission maps with top-down estimation by direct measurement. In this study, we investigated the wide and detailed NO_2 emission map over Japan, based on the divergence of the NO_2 horizontal fluxes calculated from the datasets of satellite observation and meteorological model. According to the continuity equation for steady state, the divergence of NO_2 flux yields the net balance of sources and sinks. This approach has been demonstrated for the urban scale estimations (Shaiganfar et al., 2011, Shaiganfar et al., 2017, Beirle et al., 2019), and for a global catalog of point sources (Beirle et al., 2020). We also applied this local form of conservation laws to the NO_2 emission maps over Japan. Our method used datasets of tropospheric NO_2 vertical column density derived from the Sentinal-5P/TROPospheric Ozone Monitoring Instrument (TROPOMI) satellite and wind vector derived from The Meso-Scale Model (MSM). TROPOMI Level 2 data products has daily spatial coverage with high resolution for; 3.5 x 7.0 km^2 at beginning of mission in 2018, 3.5 x 5.5 km^2 since 6 August 2019. MSM which is one of the numerical weather prediction models operated by JMA provides 51-hour or 39-hour forecasts every 3 hours on 5 km grid all over Japan. Using these datasets, divergence calculations for daily estimation with high spatial resolution can be conducted. Our temporal averaged results showed well linear correlation with NO_X emission from EAGrid2010-Japan (Fukui et al., 2014) and revealed clear distribution of point sources.

Keywords: Nitrogen oxides (NOx), Emission estimation, Nitrogen dioxide (NO2), TROPOMI, Satellite data

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Introducing new lightning schemes to a chemistry climate model CHASER (MIROC)

*Yanfeng He[1], Kengo Sudo[1]

1. Nagoya University

The formation of NO_x associated with lightning activities (hereinafter referred to as LNO_x) is estimated to contribute approximately 10% of the global NO_x source and is considered to be the most dominant NO_x source in the upper troposphere. NO_x, associated with many chemical reactions in the atmosphere, causes the production of tropospheric O_3 and OH radical which controls the oxidation capacity of the atmosphere. Consequently, LNO_x has significant influences on the atmospheric chemistry and global climate. Therefore, it is crucial to improve the prediction accuracy of lightning and LNO_x in chemical climate models.

This study implemented two new lightning schemes into a global chemical transport/climate model CHASER (MIROC). The first lightning scheme is based on upward cloud ice flux (hereinafter referred to as ICEFLUX scheme), while the second one, also adopted in the ECMWF forecasting system, calculates lightning flash rates as a function of frozen precipitation convective flux, CAPE, and convective cloud-base height (hereinafter referred to as ECMWF scheme). In the original version of CHASER (MIROC), lightning is initially parameterized by the widely-used cloud top height scheme (hereinafter referred to as CTH scheme). The lightning prediction accuracy by the ICEFLUX scheme, ECMWF scheme, and CTH scheme has been tested against the climatological lightning distributions by the LIS/OTD satellite observation.

Comparing the annual mean lightning flash rate of OTD 1996-2000 and the CHASER calculation for the years 2007-2011 exhibits spatial correlation coefficients of 0.80 and 0.79 for the ICEFLUX and ECMWF schemes respectively, which are slightly higher than that of the CTH scheme (0.78). In the case of the ECMWF scheme, by tuning the convective cloud-base height and factors for land and ocean (hereinafter referred to as modified ECMWF scheme), the spatial correlation is a bit more improved to 0.81. The RMSE of the ICEFLUX and modified ECMWF schemes are 3.30 fl./km^2/year and 3.39 fl./km^2/year respectively, which is slightly lower than that of the CTH scheme of 3.44 fl./km^2/year.

In conclusion, the new ICEFLUX lightning scheme and original/modified ECMWF lightning scheme both improved the prediction of global lightning in the CHASER model. This result suggests that LNO_x simulation in CHASER will be also improved with the new lightning schemes.

Keywords: Lightning scheme, Lightning NOx, Chemistry climate model, NOx

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Methane emissions from populated areas of Tokyo and five prefectures: Emission ratios with NOx and their trends over 2009-2018

*Yugo Kanaya[1], Kanami Saima[2], Akira Fukuike[2]

1. JAMSTEC, 2. MURATA Keisokuki Service Co., Ltd.

Regarding methane as an important greenhouse gas, national reports on its annual emission fluxes are mandated. However, the reported fluxes, based on socioeconomical statistics of activities and assumed emission factors, have seldom been evaluated from atmospheric observations of methane concentrations. On the implementation of Paris Agreement/global stocktakes, efforts in the emission reduction have to be repeatedly quantified, particularly using ground/satellite-based observations. To obtain relevant scientific information, we focused on analysis of CH4 data included in the governmental air pollution monitoring. We identified positive correlations between methane and NOx in Tokyo during winter of 2018, indicating presence of urban sources of methane. Regarding the slope of the regression line (ΔCH4/ΔNOx = ca. 2.5 ppm/ppm) as the emission ratio, we preliminary estimated methane emissions of 36 kt/y from Tokyo Metropolitan area. We then extended the analysis to other five prefectures (Chiba, Saitama, Kanagawa, Osaka and Aichi) and found similar positive correlations with regression slopes ranging from 1.5 to 4.5 ppm/ppm, implying regional commonality. The slopes per sites showed a positive correlation with population densities. The emission ratio had a significant long-term increasing trend of ~4.1%/y over 2009-2018. Considering NOx concentrations had a ~4.0%/y decreasing trend over Tokyo, the methane flux was regarded as constant over the decade. Based on these analyses, we studied possibilities of leakage of methane distributed for residential use. As the upcoming satellite missions including GOSAT-GW aim combined, high-precision measurements of greenhouse gases and air pollutants, detectability of such sources from satellite CH4/NO2 measurements is also to be discussed.

Keywords: Atmospheric composition, Urban Area, GHG-AQ joint analysis, emissions

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An impact of tropospheric air pollution changes over Japan due to future climate and emission change

*Natsumi Kawano[1], Tatsuya Nagashima[1], Masayuki Hara[2], Satoru Chatani[1], Syuichi Itahashi[3]

1. National Institute for Environmental Studies, 2. Center for Environmental Science in Saitama, 3. Central Research Institute of Electric Power Industry

Air pollutants and climate change, which are known as critical environmental issues, have inter-related closely (Jacob and Winner (2008)). Besides, an increase of anthropogenic emissions arising from future urban expansion, which are responsible for the emission of gaseous and particulate pollutants, is also concerned to have adverse influences on their surrounding environments (Fenger (1999); Martins (2012); Monks *et al.*, 2015). In order to address these issues, it is necessary for evaluating the impacts of change in climate and air pollutant emission in the future on regional air quality.
In this study, we investigated the projected changes in tropospheric ozone (O_3) and fine particulate matter ($PM_{2.5}$) concentrations over Japan by examining regional-scale chemical transport model with considering future climate and air pollutant emissions under future climate change scenarios. To predict the future climate in a specific region, the Pseudo global warming (PGW) method (Sato *et al.*, 2007), which is a tool to downscale future climate simulated by global circulation models (GCM), are widely used in regional to urban scale climate studies (Hara *et al.*, 2010; Kusaka *et al.*, 2014; Adachi *et al.*, 2018; Darmanto *et al.*, 2019). Here, we applied the PGW method to the regional-scale chemical transport modelling study as following steps. First, a PGW dataset is required which is calculated from the difference of decadal average monthly climatologies in the future climate (2030s, 2050s, 2090s) and present climate (2010s). The output of MIROC5 model in the 5th Coupled Model Intercomparison Project (CMIP5) datasets under the RCP 2.6 and RCP 8.5 climate scenarios was used to calculate climatologies in future. Second, the PGW dataset is added to the present initial and lateral boundary datasets (i.e. JRA-55, NCEP1, and RTGSST data). Moreover, the future change in air pollutant emission, which consist of emissions from vegetation sources (VG) and from anthropogenic sources (ANTH) were estimated from MIROC_CHEM as well as climatologies estimated from MIROC5.
To discuss the impact of future changes in climate and emission, we performed three different setups of experiments; one for the present climate with present VG and ANTH emission, second for the future climate with future VG and present ANTH emissions (for climate impact only), and the other for the future climate with future VG and ANTH emission (for both climate and emission impact). In the presentation, we plan to quantify the impacts on changes in tropospheric O_3 and $PM_{2.5}$ by dividing into seasons and day/night.

Keywords: ozone, fine particulate matter, regional air quality prediction, dynamical downscaling

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An Empirical Approach toward the Reduction Targets of CH4 and O3 as SLCP: For Asia as an example

*Hajime Akimoto[1], Tatsuya Nagashima[1], Hiroshi Tanimoto[1], Zbigniew Klimont[2], Markus Amann[2]

1. National Institute for Environmental Studies, 2. International Institute for Applied System Analysis

Although importance of co-control of SLCPs together with the emission reduction of CO_2, has been well recognized for both of mid- and long-term climate change mitigation, discussion on the implementation into the policymaking process often meet difficulty due to the complexity ascribed to interrelationship between SLCPs and their precursors, particularly for CH_4 and O_3. The chemistry-climate model analysis usually used for presenting future scenarios which can treat such interaction scientifically, tends to give a “black box” for the contribution of each species of SLCPs. In order to deliver a more straightforward message on the effectiveness of the reduction of each SLCP to policymakers, we propose “top-down” method for determining reduction targets of CH_4 and tropospheric O_3 based on the historical levels of their radiative forcing (RF)*.

The increase of RF due to the increase of atmospheric concentration of CO_2 in mid-term future would reach e.g. ~0.80Wm^{-2}in 2040 regardless of the stringent emission control scenarios due to the long atmospheric lifetime more than 100 years. In order to compensate this, if the atmospheric concentrations of CH_4, and O_3 can be decreased to the levels of 1980, 1970, 1960, and 1950 from the 2010 level, RF of CH_4 and O_3 can be reduce to from 0.48 to 0.41, 0.34, 0.27, and 0.22 Wm^{-2}, and from 0.40 to 0.29, 0.23, 0.19, and 0.15 Wm^{-2}, respectively, according to the IPCC 2013 database. Thus, for example, if the atmospheric concentrations of CH_4 and O_3 can be reduced to their levels of 1970, the sum of RF for CH_4 and O_3 will be reduced by 0.31 Wm^{-2}, which can compensate the increase of RF due to CO_2 by 40%.

Here, the global reduction ratios of CH_4, NO_x, and NMVOC necessary to attain the 1970 levels of CH_4 and O_3 have been applied to Asia, and the estimated results were compared by sector with the GAINS model-based cost-beneficial reduction amount proposed by Solution Report (2018) prepared under UN Environment Asia and the Pacific Office. The results show that the emission reduction of CH_4 to the 1970 level is feasible for rice paddies and waste treatment, but for attaining the reduction of livestock emission, new technology/practice would be required. As for NO_x, the possibility of attaining the necessary reduction is high for transport sector. Also, the possibility of attaining the necessary reduction of NMVOC is high for the transport and waste treatment sectors. In contrast, the emission reduction of CH_4 and NMVOC from coal/natural gas/oil production sector, and NO_x from industry/power plant sector is not enough in Solution Report. It can be concluded that in order to attain these targeted reduced emission levels, energy transformation from fossil fuel to renewable energy sources would be highly advantageous.

* H. Akimoto, T. Nagashima, H. Tanimot1, Z. Klimont and M. Amann, An empirical approach toward the SLCP reduction targets in Asia for the mid-term climate change mitigation, Prog. Earth Planet, Sci., 7:73, https://doi.org/10.1186/s40645-020-00385-5, 2020.

Keywords: Short-lived Climate Pollutants , SLCP, CH4, O3, NOx, NMVOC

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

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.08 Zoom Room 08

[A-AS05] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Naoko Saitoh(Center for Environmental Remote Sensing), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Risa Uchida(Japan Automobile Research Institute), Chairperson:Naoko Saitoh(Center for Environmental Remote Sensing), Shigeyuki Ishidoya(Advanced Industrial Science and Technology)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AAS05-18] Earth system modeling on interactions between ecosystem and atmospheric chemistry

★Invited Papers

*Tomohiro Hajima[1], Manabu Abe[1], Akinori Ito[1], Akihiko Ito[2], Rumi Ohgaito[1], Kazuyuki Saito[1], Kengo Sudo[3], Michio Kawamiya[1], Maki Noguchi Aita[1], Prabir Patra[1], Akitomo Yamamoto[1], Tokuta Yokohata[2], Shingo Watanabe[1], Michio Watanabe[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Environmental Studies, 3.Nagoya University)

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

[AAS05-19] Seasonal variations of methane sources in South Asia inferred from observations of stable carbon isotope ratio of atmospheric methane

*Yukio Terao[1], Taku Umezawa[1], Manish Naja[2], Md. Kawser Ahmed[3], Shohei Nomura[1], Toshinobu Machida[1], Motoki Sasakawa[1], Hitoshi Mukai[1], Prabir Patra[4] (1.National Institute for Environmental Studies, 2.Aryabhatta Research Institute of Observational Sciences, 3.Department of Oceanography, Faculty of Earth & Environmental Sciences, University of Dhaka, 4.Research Institute for Global Change, JAMSTEC)

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

[AAS05-20] The interhemispheric transport pathways of methane as observed by GOSAT and simulated by ACTM

*Dmitry Belikov[1], Naoko Saitoh[1], Prabir Patra[1,2] (1.Center for Environmental Remote Sensing, Chiba University, 2.Research Institute for Global Change (RIGC), JAMSTEC)

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

[AAS05-21] Signal of CO_2 emitted from 2020 Western U. S. wildfire captured by commercial airliner observations

*Kentaro Ishijima[1], Toshinobu Machida[2], Taku Umezawa[2], Yosuke Niwa[2,1], Kazuhiro Tsuboi[1], Ryo Fujita[1], Hidekazu Matsueda[3,1], Taichu Y Tanaka[1], Takashi Maki[1], Takashi Nakamura[4] (1.Meteorological Research Institute, 2.National Institute for Environmental Studies, 3.Dokkyo University, 4.Japan Meteorological Agency)

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

[AAS05-22] Secular trend of atmospheric N_2O isotopocule ratios observed at Syowa staion, Antarctica

*Sakae Toyoda[1], Tsutomu Mizuno[1], Daisuke Goto[2], Shinji Morimoto[3] (1.School of Materials and Chemical Technology, Tokyo Institute of Technology, 2.National Institute of Polar Research, 3.Center for Atmospheric and Oceanic Studies, Tohoku University)

Earth system modeling on interactions between ecosystem and atmospheric chemistry

*Tomohiro Hajima[1], Manabu Abe[1], Akinori Ito[1], Akihiko Ito[2], Rumi Ohgaito[1], Kazuyuki Saito[1], Kengo Sudo[3], Michio Kawamiya[1], Maki Noguchi Aita[1], Prabir Patra[1], Akitomo Yamamoto[1], Tokuta Yokohata[2], Shingo Watanabe[1], Michio Watanabe[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Institute for Environmental Studies, 3. Nagoya University

Terrestrial ecosystems and ocean biogeochemistry interact with atmospheric chemistry –natural ecosystems can be source/sink of GHGs and sometimes get impacted from atmospheric deposition. Such ecosystem–atmosphere interactions are now being modeled and incorporated into Earth system models, which are realized by embedding atmosphere, land, and ocean chemical/biogeochemical components into climate models. Such models are first developed by incorporating ecosystem processes to represent climate-carbon cycle feedback, and now becoming a more complicated system by incorporating mutual interaction between ecosystems and atmospheric chemistry (e.g., nitrogen cycle). In this presentation, a brief introduction on the ecosystem role in the global carbon cycle will be made, based on CMIP6 (Coupled Model Intercomparison Project Phase6) simulations. The carbon sink/source of land and ocean play a crucial role in the global carbon cycle because of the quite long CO_2 life-time in the atmosphere, and recent studies suggest the importance to reduce the carbon cycle feedback uncertainties and sometimes focus on the long-term dynamics after the stoppage of anthropogenic emission (Arora et al. 2020; MacDougall et al. 2020). In addition, an ESM (MIROC-ES2L, Hajima et al. 2020 GMD) has been developed in which interactions between ecosystems and atmospheric processes are improved, by incorporating nutrient deposition on land/ocean ecosystems to alter the biogeochemical processes. In addition, we have started a modeling to include ecosystem feedback processes regarding CH_4 and N_2O, based on the model.

Keywords: Earth system models, Biogeochemistry, Atmospheric chemistry

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Seasonal variations of methane sources in South Asia inferred from observations of stable carbon isotope ratio of atmospheric methane

*Yukio Terao[1], Taku Umezawa[1], Manish Naja[2], Md. Kawser Ahmed[3], Shohei Nomura[1], Toshinobu Machida[1], Motoki Sasakawa[1], Hitoshi Mukai[1], Prabir Patra[4]

1. National Institute for Environmental Studies, 2. Aryabhatta Research Institute of Observational Sciences, 3. Department of Oceanography, Faculty of Earth & Environmental Sciences, University of Dhaka, 4. Research Institute for Global Change, JAMSTEC

Various types of methane (CH_4) sources reside in South Asia, including ruminant, rice paddy, biomass burning, fossil fuel industry, and landfills. For effective reduction of CH_4 emissions, observations of stable carbon isotope ratio of CH_4 ($\delta^{13}C$-CH_4) play an important role. The $\delta^{13}C$-CH_4 data provide better understanding of CH_4 emission sources because of distinct $\delta^{13}C$-CH_4signatures for individual source types: −60‰ for microbial, −40‰ for fossil fuel, and −25‰ for biomass burning sources.

Here we present the first observations of atmospheric $\delta^{13}C$-CH_4 at two sites in South Asia. We have performed weekly air sampling at Nainital (29.36˚ N, 79.46˚ E, 1940 m a.s.l.) in the Himalaya mountain area, northern India since 2006 and at Comilla (23.43˚ N, 91.18˚ E, 30 m a.s.l.) in the paddy area, central Bangladesh since 2012. The air samples were analyzed for atmospheric GHGs and related tracers (Nomura et al., submitted to ACP). Using a newly developed measurement system for $\delta^{13}C$-CH_4 (Umezawa et al., JMSJ, 2020), we started $\delta^{13}C$-CH_4 analysis for air samples collected at both sites from August 2018. The observational data were grouped into three seasons for Comilla (from August to November (ASON), from December to March (DJFM) and from April to July (AMJJ)) and two seasons for Nainital (July and August (JA) and others) by considering the monsoon and agricultural cycles in the regions.

Large increases in the CH_4 concentration were observed during ASON and DJFM at Comilla. The relationship between $\delta^{13}C$-$CH_4$and the reciprocal of CH_4 concentration (Keeling plot) at Comilla inferred that the $\delta^{13}C$-CH_4 signature of the CH_4 source was −52‰ for ASON and −45‰ for DJFM, while no significant correlation was found for AMJJ. Our result suggested that 75% of CH_4emission come from microbial sources and 19% from biomass burning during ASON, while the estimated relative contributions are 55% and 39% during DJFM, by assuming that 6% of the total CH_4 emission was from fossil fuels in Bangladesh (EDGAR V4.3.2). These estimates of contribution of biomass burnings to the total CH_4 emission were much higher than those in the EDGAR inventory, suggesting that the EDGAR inventory underestimate the CH_4 emission from biomass burnings in Bangladesh. Our observation also showed higher carbon monoxide (CO) concentrations during DJFM than ASON, consistent with the above results suggesting the large contribution of biomass burnings during DJFM. At Nainital, increases in the CH_4 concentration and decreases in $\delta^{13}C$-CH_4 were observed during JA, although the ranges of variations in the CH_4 concentration and $\delta^{13}C$-CH_4 were much smaller than those at Comilla. The $\delta^{13}C$-CH_4 signature of the regional source was estimated to be −51‰ throughout the year, showing no seasonal variations of CH_4 sources. The Nainital data might represent a typical $\delta^{13}C$-CH_4 signature over the region.

Keywords: methane, carbon cycle, isotope, emission inventory

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The interhemispheric transport pathways of methane as observed by GOSAT and simulated by ACTM

*Dmitry Belikov[1], Naoko Saitoh[1], Prabir Patra[1,2]

1. Center for Environmental Remote Sensing, Chiba University, 2. Research Institute for Global Change (RIGC), JAMSTEC

Observations of long-lived tracers indicate that mixing tropospheric air between the Northern Hemisphere (NH) and Southern Hemisphere (SH) extratropics is about 1–1.5 yr. The importance of the seasonal migration of the zonally averaged Hadley circulation and intertropical convergence zone (ITCZ) oscillation on interhemispheric (IH) transport of tracers has been recognized. The mechanisms for transport through the tropics and the role of the monsoonal circulation, however, are not well understood. This study aiming to identify the transport pathways that connect NH and SH by analyzing CH_4 global distributions as measured by thermal infrared (TIR) band observations by the Thermal And Near-infrared Sensor for carbon Observation-Fourier Transform Spectrometer (TANSO-FTS) onboard the Greenhouse gases Observation SATellite (GOSAT) and simulated by MIROC4.0-based Atmospheric Chemistry Tracer Model (MIROC4-ACTM) for the period 2010-2013.

We found several longitudinal zones of active IH transport located in the Upper Troposphere and Lower Stratosphere (UTLS) zone (levels of 400– 200hPa). The IH exchange over Amazonia and tropical Africa is active both for winter and summer, while in the Asia region there is significant seasonal variability. Presented results confirm the role of the Asian Summer Monsoon Anticyclone (ASMA) zonally asymmetric heating on IH transport and highlight that the monsoon-induced eddy circulation plays an important role in the interhemispheric transport of long-lived chemical constituents. The dual role of ASMA has been revealed. On the one hand, its influence blocks IH in the tropical zone of the Indian Ocean and Southeast Asia, on the other, it enhances vertical ventilation in northern India, where significant methane fluxes are concentrated. Fast convective transport caused by ASMA accelerates the saturation of the middle and upper troposphere in NH with methane-rich surface air. These stratospheric levels are the origin of two west-directed jets (TEJ and AEJ) transported air mass to tropical Africa and further to SH.

Keywords: interhemispheric transport, GOSAT, methane

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Signal of CO_2 emitted from 2020 Western U. S. wildfire captured by commercial airliner observations

*Kentaro Ishijima[1], Toshinobu Machida[2], Taku Umezawa[2], Yosuke Niwa[2,1], Kazuhiro Tsuboi[1], Ryo Fujita[1], Hidekazu Matsueda[3,1], Taichu Y Tanaka[1], Takashi Maki[1], Takashi Nakamura[4]

1. Meteorological Research Institute, 2. National Institute for Environmental Studies, 3. Dokkyo University, 4. Japan Meteorological Agency

In 2020, the Western United States experienced a series of serious wildfires, ignited in August across California, Oregon, and Washington, followed by expansion of the burning in early September. In the early September, the color of the sky turned orange due to huge aerosols emitted from the wildfires in those regions. The preliminary estimate of the annual wildfire emission of CO_2 in California by the California Air Resources Board is more than twice of the largest emission in the past 20 years.

The Comprehensive Observation Network for TRace gases by AIrLiners (CONTRAIL) with Continuous Measuring Equipment (CME) onboard aircraft of Japan Airlines can continuously obtain atmospheric CO_2 mole fraction on the flight path. In 2020, considerable number of measurement flights to Los Angeles (~40 profiles) were carried out in September compared to previous years. Vertical profiles of CO_2 mole fraction obtained by CONTRAIL-CME over Los Angeles showed high magnitude of variability throughout the troposphere, in comparison to those in September of the preceding years. This resulted in exceptionally large median and mean values of the CO_2 mole fraction calculated from all profiles in September of 2020.

We also tried model simulations using the latest biomass burning emission inventory of GFED and GFAS. Preliminary simulations by an on-line atmospheric tracer transport model (GSAM-TM) reproduces some of CO_2 enhancement observed in relatively wide altitude range of more than a few kilometers in the vertical profile. More detailed analysis results will be prepared in our presentation.

Keywords: wildfire, co2, aircraft observation

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Secular trend of atmospheric N_2O isotopocule ratios observed at Syowa staion, Antarctica

*Sakae Toyoda[1], Tsutomu Mizuno[1], Daisuke Goto[2], Shinji Morimoto[3]

1. School of Materials and Chemical Technology, Tokyo Institute of Technology, 2. National Institute of Polar Research, 3. Center for Atmospheric and Oceanic Studies, Tohoku University

Nitrous oxide (N_2O) is one of the increasing greenhouse gases in the troposphere and is the most important stratospheric ozone-depleting gas in the 21st century. Sources of atmospheric N_2O include oceans, natural soils, and human activity such as agriculture, fossil fuel combustion, and chemical industry. In addition to conventional concentration or flux measurements of N_2O, isotopocule ratios of N_2O, which include not only elemental $^{15}N/^{14}N$ and $^{18}O/^{16}O$ ratios but also site-specific $^{15}N/^{14}N$ ratio in asymmetric NNO molecule, have been used as parameters to infer the origin and production–consumption mechanisms of N_2O. Since secular trend of isotopocule ratios of atmospheric N_2O can be used to deduce relative contribution from each source, several efforts have been made by analyzing air trapped in the polar firn or air samples collected at monitoring stations. However, there have been only a few reports on long-term monitoring of atmospheric N_2O isotopocule ratios in the Southern Hemisphere. Moreover, the north-to-south gradient of isotopocule ratios remains uncertain because published data by different laboratories cannot be compared directly due to calibration problems.

In this study, we aimed at revealing isotopocule ratios of atmospheric N_2O and their trend in the Southern Hemisphere, and comparing with their counterparts in the Northern Hemisphere which were measured by the same laboratory. Surface air samples were collected into an aluminum cylinder at about 15MPa at Syowa station, Antarctica (69˚S, 40˚E) with 2–4 month interval in 1998–2020. They have been archived at NIPR, and were sub sampled to 1-L glass flasks for concentration and isotopic analyses of N_2O.
Isotopocule ratios of N_2O were measured using a GC-IRMS system which is also used to elucidate the secular trend of N_2O isotopes at three Northern Hemispheric sites, Hateruma Island, Japan (24˚N, 124˚E), Novosibirsk, Russia (55˚N, 83˚E), and Churchill, Canada (59˚N, 94˚W). Concentration was measured with GC-ECD.
Results showed that the bulk nitrogen isotope ratio ($\delta^{15}N^{bulk}$) in N_2O at Syowa station is decreasing at the similar rate (about -0.04‰ yr^{-1}) as observed in the Northern Hemispheric sites. When compared at the same year, the value of $\delta^{15}N^{bulk}$ is about 0.2‰ higher in the southern hemisphere. The oxygen isotope ratio ($\delta^{18}O$) also shows decreasing trend that is similar to the trend in the Northern Hemisphere, but north-to-south gradient is not detectable with the precision of the analysis. The ^{15}N-site preference in N_2O (SP) does not show secular increasing nor decreasing trend, and north-to-south gradient is not detectable.

These results suggest that contribution from southern hemispheric sources to atmospheric increase in N_2O is very small if we take into account the fact that concentration is higher in the Northern Hemisphere and that distributions of natural and anthropogenic sources are different between the two hemispheres. Further analysis of isotopic signature of N/S sources with simple model approaches will be discussed.

Keywords: Greenhouse gas, Stable isotope ratio, N2O, Southern Hemisphere

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.12 Zoom Room 12

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Masaya Yasuhara(Rissho Univ.), Takashi Nakamura(International Research Center for River Basin Environment, University of YAMANASHI), Kazuyoshi Asai(Geo Science Laboratory), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

The purpose of the session is to review the present state of knowledge of isotope hydrology, by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

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

[AHW23-01] Introduction

9:05 AM - 9:30 AM JST | 12:05 AM - 12:30 AM UTC

[AHW23-02] Seasonal and spatial variations of chemical weathering in the Mekong Basin: From the headwaters to the lower reaches

★Invited Papers

*Hiroto Kajita[1], Yuki Ota[2], Toshihiro Yoshimura[3], Daisuke Araoka[2], Takuya Manaka[4], Ziyu Ouyang[1], Shinya Iwasaki[3], Takuya Yanase[1], Akihiko Inamura[2], Etsuo Uchida[5], Hongbo Zheng[6], Qing Yang[6], Ke Wang[1], Atsushi Suzuki[2], Hodaka Kawahata[1] (1.The University of Tokyo, 2.National Institute of Advanced Industrial Science and Technology, 3.Japan Agency for Marine-Earth Science and Technology, 4.Forestry and Forest Products Research Institute, 5.Waseda University, 6.Yunnan University)

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

[AHW23-03] Stable Isotope Dynamics of Hydrological Interactions in The Chao Phraya River System in Thailand

*Jeerapong Laonamsai[1], Kimpei Ichiyanagi[1] (1.Deaprtment of Earth and Environmental Sciences, Graduate School of Science and Technology, Kumamoto University)

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

[AHW23-04] Groundwater in the area where ground flow with long displacement occurred due to the 2018 Sulawesi Island Earthquake in Indonesia

★Invited Papers

*Susumu Yasuda[1], Hisashi Furuichi[2] (1.Tokyo Denki University, 2.Yachiyo Engineering Co., Ltd.)

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

[AHW23-05] The formation of a temporary pond, Akaike, at the Northern Foot of Mount Fuji, Japan, in 2020

*Shinya Yamamoto[1], Takashi Nakamura[2], Seongwon Lee[3], Masaya Yasuhara[3] (1.Mount Fuji Research Institute, Yamanashi Prefectural Government, 2.International Research Center for River Basin Environment, University of Yamanashi, 3.Faculty of Geo-Environmental Science, Rissho University)

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

[AHW23-06] Discussion

[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-HW Hydrology & Water Environment

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Masaya Yasuhara(Rissho Univ.), Takashi Nakamura(International Research Center for River Basin Environment, University of YAMANASHI), Kazuyoshi Asai(Geo Science Laboratory), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.12 (Zoom Room 12)

The purpose of the session is to review the present state of knowledge of isotope hydrology, by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

9:00 AM - 9:05 AM

[AHW23-01]Introduction

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Seasonal and spatial variations of chemical weathering in the Mekong Basin: From the headwaters to the lower reaches

*Hiroto Kajita[1], Yuki Ota[2], Toshihiro Yoshimura[3], Daisuke Araoka[2], Takuya Manaka[4], Ziyu Ouyang[1], Shinya Iwasaki[3], Takuya Yanase[1], Akihiko Inamura[2], Etsuo Uchida[5], Hongbo Zheng[6], Qing Yang[6], Ke Wang[1], Atsushi Suzuki[2], Hodaka Kawahata[1]

1. The University of Tokyo, 2. National Institute of Advanced Industrial Science and Technology, 3. Japan Agency for Marine-Earth Science and Technology, 4. Forestry and Forest Products Research Institute, 5. Waseda University, 6. Yunnan University

Chemical weathering in the Himalayan river basins is among the highest in the world and has received vast research attention related to past climate change. Many early estimates of chemical weathering are based on a small number of water property data, that ignore those spatial and seasonal variations. Therefore, this study analyzed spatial and seasonal variations in chemical weathering in the Mekong River, where the geology, climate, and hydrologic cycle of the basin vary significantly from the lower to upper reaches, and from dry to rainy seasons. We separately estimated the origins of dissolved elements and potential CO_2 consumption rates using the numerous chemical compositions of river water throughout the entire basin and in both seasons. The CO_2 consumption rate in the rainy season is three to five times that in the dry season, which may be due to the high temperature and precipitation. Despite the low temperatures and dryness of the upper and middle basins, the CO_2 consumption rate is approximately twice that in the lower reaches; this can be attributed to active physical denudation in steep mountainous areas which increases the surface area for water-rock interactions. The total CO_2 consumption obtained by combining each season and basin was 48~70*10^9 mol/a and 148~159*10^9 mol/a for silicate and carbonate weathering, respectively, which are almost half the values of previous estimates. Our results suggest that seasonally and spatially separated evaluations are important for generating estimates of chemical weathering in large Himalayan rivers.

Keywords: Mekong River, Chemical weathering, Carbon cycle, Seasonal variation, Spatial variation

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Stable Isotope Dynamics of Hydrological Interactions in The Chao Phraya River System in Thailand

*Jeerapong Laonamsai[1], Kimpei Ichiyanagi[1]

1. Deaprtment of Earth and Environmental Sciences, Graduate School of Science and Technology, Kumamoto University

The present study focuses on a detailed seasonally varying interaction study and flux quantification between the river and monsoon precipitation and groundwater in the Chao Phraya River system which is the main river system that feeds an enormous population. Contributing parameters to the total river discharge on a temporal scale are estimated through three-component hydrograph separation and end-member mixing analysis using high-resolution water isotope ($\delta^{18}O$ and $\delta^{2}H$). This model reports groundwater discharge in the river to be the highest in monsoon (30%), whereas the contribution lowers to 15% during the dry season. During peak monsoon, the monsoon precipitation directly generates river runoff which is also justified using isotopic amplitude damping approach of both river water and precipitation. The mean water transit time is about 26 days. Furthermore, hydrological interaction reflects quantitative variability depending on river morphometry. The current study also provides insight into aquifer vulnerability due to chemical mixing through interaction and reasonable water resources management efforts.

Keywords: Hydrology, Isotopic interactions, Tropical catchment, Water transit time

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Groundwater in the area where ground flow with long displacement occurred due to the 2018 Sulawesi Island Earthquake in Indonesia

*Susumu Yasuda[1], Hisashi Furuichi[2]

1. Tokyo Denki University, 2. Yachiyo Engineering Co., Ltd.

The earthquake that struck Sulawesi, Indonesia on September 28, 2018 caused flow of the ground with long displacement in several areas in Palu City. A large amount of groundwater also spouted out with the earthquake. Similar damage has occurred in the past in this area, and it is called "Nalodo". For the purpose of elucidating the mechanism of damage and disaster prevention in the future, JICA has been studying it as part of the investigation of " Project for Development of Regional Disaster Risk Resilience Plan in Central Sulawesi in the Republic of Indonesia", and the authors have participated in it. So, we would like to report based on the study report by JICA[1)].

This area is the triple junction of the three plates and rotates clockwise. This causes a Palu-Koro left strike-slip fault, the displacement rate of which is very fast. A long and narrow pull-apart sedimentary basin is formed between the faults from north-northwest to south-southeast. The Palu River runs from south to north in the center, and gently sloping grounds of 1 to 3% spreads from the river to both sides. There is a hot spring near the area where Nalodo occurred.

Due to the earthquake, surface soil with a length of 1 to 3 km and a width of several hundred meters slipped and flowed toward the downstream side on the gently sloping ground in one area on the west side and four areas on the east side. According to interviews with several residents in and near Narodo, (1) a large vertical shaking and swelling occurred at the same time as the horizontal shaking of the earthquake ended, and (2) groundwater spouted and the ground started to flow at the same time as the horizontal shaking ended or within about 2 minutes. There was also testimony that hot water spouted out in some sites.

In the area where Nalodo occurred, spring belts crossed in the north-south direction before the earthquake. In order to study the origin of this spring, groundwater was sampled from the spring belts and others to test water quality. However, several months have passed since the earthquake, and the groundwater spouted by the earthquake has not been collected. Water was sampled at 29 locations, including springs in Nalodo, boring holes, a hot spring resort, deep wells, shallow wells, and rivers. A total of 37 samples were collected. Of these, 2 samples of spring water in the hot spring resort and 2 samples of deep wells are hot water with a temperature above 40 ˚C. When the results were shown by the relationship between the oxygen isotope ratio $\delta^{18}O$ and the hydrogen isotope ratio δD (δ diagram), they were plotted on the meteoric water line except for three points. On the other hand, the water of the hot spring is plotted to the right of the meteoric water line, and if it is extended, it will be between the “Arima-type” slab-related deep-seated fluid and the paleo-seawater (Yasuhara, personal communication). The other two points were spring water from a Nalodo and water from a deep well (120 m), which were plotted between the hot spring water and the meteoric water line.

It is thought that the groundwater spouted just after the shaking generated long-displacement flow. There are three possible eruption mechanisms: (1) the shallow ground is liquefied and groundwater is ejected, (2) the shallow groundwater flowing from the mountains spouted out, and (3) the pressurized deep groundwater in the fault fracture zones erupted. However, although various ground surveys and analyzes

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have been conducted, it is complicated and no conclusion has been reached yet.

Reference 1) JICA : Project for Development of Regional Disaster Risk Resilience Plan in Central Sulawesi in the Republic of Indonesia / Japanese support committee for liquefaction - landslide (inland) / Technical Report / (in progress).

Keywords: groundwater, earthquake, flow of the ground, fault

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The formation of a temporary pond, Akaike, at the Northern Foot of Mount Fuji, Japan, in 2020

*Shinya Yamamoto[1], Takashi Nakamura[2], Seongwon Lee[3], Masaya Yasuhara[3]

1. Mount Fuji Research Institute, Yamanashi Prefectural Government, 2. International Research Center for River Basin Environment, University of Yamanashi, 3. Faculty of Geo-Environmental Science, Rissho University

Akaike is a small, temporary pond that appears about 1 km east of Lake Shoji following heavy precipitation events at the northern foot of Mt. Fuji. It is widely accepted that the pond is connected to Lake Shoji by groundwater. However, such a connection has not yet been established because of the lack of water quality and isotopic data from both the Akaike Pond and Lake Shoji. In this study, we measured the major dissolved ion and trace element contents, the hydrogen (dD) and oxygen ($d^{18}O$) stable isotope ratios of water, and the nitrogen and oxygen stable isotope ratios of nitrate ions in water samples from the Akaike Pond in July 2020, and compared these data with surface water and precipitation samples collected from the surrounding area to identify the source of Akaike Pond water. The water qualities and isotopic compositions of Akaike Pond are clearly different from those of Lake Shoji, and showed close proximity in the dD and $d^{18}O$ values to the precipitation. These results suggest that the water in the Akaike Pond is likely derived from recent precipitation. The major dissolved ion compositions in the Akaike Pond showed lower Ca^{2+} and HCO_3^- concentrations than the water samples around the pond. This suggests that the water in the Akaike Pond accumulates in a relatively short period (within a few days) after precipitation, without deep underground percolation.

Keywords: Mount Fuji, temporary pond, water quality, stable isotopes

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-HW Hydrology & Water Environment

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Masaya Yasuhara(Rissho Univ.), Takashi Nakamura(International Research Center for River Basin Environment, University of YAMANASHI), Kazuyoshi Asai(Geo Science Laboratory), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.12 (Zoom Room 12)

The purpose of the session is to review the present state of knowledge of isotope hydrology, by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

10:25 AM - 10:30 AM

[AHW23-06]Discussion

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.12 Zoom Room 12

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Kazuyoshi Asai(Geo Science Laboratory), Masaya Yasuhara(Rissho Univ.), Noritoshi Morikawa(Geological Survey of Japan, AIST), Kohei Kazahaya(Geological Survey of Japan, AIST)

The purpose of the session is to review the present state of knowledge of isotope hydrology, by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

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

[AHW23-07] Supply processes of dissolved inorganic carbon and flow system of groundwater in Fukui-Ohno Basin

★Invited Papers

*Yamanaka Masaru[1], Seongwon Lee[2], ZHAO MINGZHE[1], Takanori Nakano[3] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University, 2.Rissho University, 3.The Research Institute for Humanity and Nature)

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

[AHW23-08] Origin and hydro-chemical evolution of geothermal waters from Nozawa-Onsen hydrothermal springs in the northern Nagano Prefecture, central Japan

*Shunsuke Akazawa[1], Madhusoodhan Satish-Kumar[2], Naoki Watanabe[3], Cheibany Ould-Elemine[4], Masaki Yuhara[5] (1.Graduate School of Science and Technology, Niigata University, Japan, 2.Department of Geology, Faculty of Science, Niigata University, Japan , 3.Research Institute for Natural Hazards and Disaster Recovery, Niigata University, Japan, 4.Ensero Solutions, Canada, 5.Department of Earth System Science, Faculty of Science, Fukuoka University, Japan)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[AHW23-09] Composition of ammonium nitrogen isotope in Oita Plain, eastern Kyushu Island, Japan

*Takashi Nakamura[1], Kazuhiro Amita[2], Shinji Ohsawa[3] (1.Interdisciplinary Center for River Basin Environment, University of Yamanashi, 2.Research Center for Engineering Science, Akita University, 3.Beppu Geothermal Research Laboratory, Kyoto University)

11:40 AM - 12:05 PM JST | 2:40 AM - 3:05 AM UTC

[AHW23-10] The continuing story of mathmatical modelling for nitrogen pollution analysis in groundwater

★Invited Papers

*Kei Nishida[1], Ken Yokozawa[2], Bijjay Man Shakya[1], Hiroshi Ishidaira[1], Tadashi Toyama[1], Takashi Nakamura[1] (1.Interdisciplinary Centre for River Basin Environment, Interdisciplinary Graduate School, University of Yamanashi, 2.Shizuoka Prefecture)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

[AHW23-11] Discussion

Supply processes of dissolved inorganic carbon and flow system of groundwater in Fukui-Ohno Basin

*Yamanaka Masaru[1], Seongwon Lee[2], ZHAO MINGZHE[1], Takanori Nakano[3]

1. Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University, 2. Rissho University, 3. The Research Institute for Humanity and Nature

A combination of carbon stable isotopic compositions, $d^{13}C$, and chemical compositions of groundwater in the lowland of the Fukui-Ohno Basin, FOB, was employed to elucidate supply processes of dissolved inorganic carbon, DIC, and additionally to give some constraints on groundwater flow systems in the FOB. Ca-HCO_3 type groundwater is dominated with relatively high concentrations of Ca^{2+} and HCO_3^-, which can be attributed to weathering processes of anorthite and partially of peridot in the aquifer with partial CO_2 pressure as typically observed in soil. Moreover, $d^{13}C$ values for the CO_2 gas initially equilibrated with DIC in the FOB groundwater are calculated to be -28.6~-22.8‰, indicating that the FOB groundwater has two carbon sources; one is C3 organic material mainly distributed in mountainous area, ≈-28‰, and another is organic materials in lacustrine deposits in the lowland, ≈-15‰. Considering a model calculation that 20~50% of DIC is lacustrine deposit origin, the FOB groundwater is likely composed of two components; 20~50% of penetrated precipitation in the lowland and 50~80% of groundwater which has been recharged mainly in mountainous area and horizontally transported in the aquifer.

Keywords: groundwater, carbon isotope

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Origin and hydro-chemical evolution of geothermal waters from Nozawa-Onsen hydrothermal springs in the northern Nagano Prefecture, central Japan

*Shunsuke Akazawa[1], Madhusoodhan Satish-Kumar[2], Naoki Watanabe[3], Cheibany Ould-Elemine[4], Masaki Yuhara[5]

1. Graduate School of Science and Technology, Niigata University, Japan, 2. Department of Geology, Faculty of Science, Niigata University, Japan , 3. Research Institute for Natural Hazards and Disaster Recovery, Niigata University, Japan, 4. Ensero Solutions, Canada, 5. Department of Earth System Science, Faculty of Science, Fukuoka University, Japan

Nozawa-Onsen hydrothermal springs are located between the northern segment in the active fault zone along the western margin of the Nagano basin and the Quaternary Kenashi Volcano that was active during the period from 1.7 to 1.0 Ma at approximately 40 km northeast of Nagano City, central Japan. Geothermal waters have temperatures ranging from 85.4 to 26.4 degree centigrade, pH values from 8.1 to 9.2 and electric conductivity from 47.6 to 149.0 mS/m, which is correlated to the total ion concentration. They are categorized as sodium-sulfate type, even though respective waters have different temperatures and concentrations. In this study we have carried out hydro-chemical and isotopic analyses to better understand the origin and evolution of geothermal waters. The isotopic results of delta O-18 and delta D values reveals that these waters are meteoric in origin. In addition, delta S-34 values of sulfate indicate that volcanic fluids did not contribute to the formation of geothermal waters. Relationship between chloride concentration and water temperature suggest that several waters were diluted with low-temperature groundwater. Variations of sulfate and hydrogen sulfide concentration in these waters can be explained by the precipitation of native sulfur. It is likely that the calcite was removed as precipitates from some geothermal waters during transportation through faults on the basis of the relationship between Sr-87/Sr-86 and Rb-87/Sr-86 ratios. In conclusion, the evolution process of geothermal waters from Nozawa-Onsen hydrothermal springs are closely related to (1) the recharge of meteoric waters to deep zone, (2) dissolution of soluble minerals such as plagioclase, gypsum and pyrite in Neogene sediments, (3) removal of calcite from these waters during transportation through faults, (4) dilution with low-temperature groundwaters around shallow aquifers and (5) precipitation of the small amount of native sulfur near the earth surface.

Keywords: Nozawa-Onsen, Geothermal water, Isotope composition, Hydrological geochemistry, Fault

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Composition of ammonium nitrogen isotope in Oita Plain, eastern Kyushu Island, Japan

*Takashi Nakamura[1], Kazuhiro Amita[2], Shinji Ohsawa[3]

1. Interdisciplinary Center for River Basin Environment, University of Yamanashi, 2. Research Center for Engineering Science, Akita University, 3. Beppu Geothermal Research Laboratory, Kyoto University

To identify the composition of ammonium nitrogen isotope in hot spring water, the water samples from hot spring, as well as deep groundwater wells and surface spring, were collected from Oita city in Kyusyu island, Japan. Major dissolved ions were then analyzed from the collected samples, while the ammonium nitrogen isotope from the samples was determined by the ammonium diffusion method (Cao et al., 2018). The Cl^- and NH_4-N concentrations in hot spring samples were detected ranging from 2506 to 19395 mg/L and 14.4 to 53.9 mg/L, respectively. The positive relationship between Cl^- and NH_4-N concentrations (R^2 =0.49) suggests the nitrogen load from deep-seated saline layers. The $d^{15}N\text{-}NH_4$ values of the hot spring range from -2.6 to +2.0 per mil. On the other hand, a relatively high isotopic value (+5.5 per mil) was detected in the groundwater sample collected from a deep tube well. These nitrogen isotope values showed relatively low values in high Cl^- concentration (>13000mg/L) and high values samples in low Cl^- concentrations. Similarly, the highest isotopic values obtained from the collected deep well samples were located close to the end-member of the trend line observed between Cl^- concentration, and $d^{15}N\text{-}NH_4$ values. These results presumably suggest the origin of the ammonium nitrogen in hot spring as mixed water from deep-seated layer and surface layer.

Acknowledgment: This study was financially supported by Grants-in-Aid for Scientific Research (KAKENHI No.19H0199, PM: Takao Hirashima).

Reference: Thi Thuy Hai Cao et al. (2018) Effect of dissolved organic nitrogen contamination on $d^{15}N\text{-}NH^4$ determination in water samples by modification of the diffusion method with gas-phase trapping. Rapid Communications in Mass Spectrometry. DOI: 10.1002/rcm.8091

Keywords: Oita Plain, Hot spring water, Nitrogen isotope in Ammonium

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The continuing story of mathmatical modelling for nitrogen pollution analysis in groundwater

*Kei Nishida[1], Ken Yokozawa[2], Bijjay Man Shakya[1], Hiroshi Ishidaira[1], Tadashi Toyama[1], Takashi Nakamura[1]

1. Interdisciplinary Centre for River Basin Environment, Interdisciplinary Graduate School, University of Yamanashi, 2. Shizuoka Prefecture

We will update the results of analysis on groundwater nitrogen pollution in Kathmandu Valley, Nepal.

Keywords: nitrate, stable isotope ratio, microbial reaction, source mixing

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-HW Hydrology & Water Environment

[A-HW23] Isotope Hydrology 2021

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Kazuyoshi Asai(Geo Science Laboratory), Masaya Yasuhara(Rissho Univ.), Noritoshi Morikawa(Geological Survey of Japan, AIST), Kohei Kazahaya(Geological Survey of Japan, AIST)

Sun. Jun 6, 2021 10:45 AM - 12:15 PM Ch.12 (Zoom Room 12)

The purpose of the session is to review the present state of knowledge of isotope hydrology, by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

12:05 PM - 12:15 PM

[AHW23-11]Discussion

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.10 Zoom Room 10

[A-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

Oceanic and atmospheric dynamics aims at abstracting general principles from observed phenomena and constructing a system of mathematical models, thereby leading to the understanding, prediction, and parameterization of those phenomena. It provides perspectives for the advancement of sciences in various areas such as turbulence, wind waves, internal waves, Rossby waves, tides, coastal and equatorial boundary processes, mesoscale and submesoscale eddies, meandering of jets and fronts, general circulation, and ocean-atmosphere coupled modes. It has also been and will continue to be benefited by new uses of ideas and methods from such theories as resonance, nonlinear interaction, stability analysis, spectral analysis, probability, statistics, and dynamical systems. In this session, we solicit presentations on observational, experimental, numerical, and theoretical studies of oceanic and atmospheric dynamics and on exploratory use of new ideas and methods. We also welcome presentations on interdisciplinary studies in fields such as ecosystems, climate, and environment.

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

[ACG38-01] Toward numerical modeling systems that seamlessly link coastal seas to open oceans

★Invited Papers

*Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[ACG38-02] Long-term variability of sea level along the coast of Japan during the 20th century reproduced by an eddy resolving model

*Hideyuki Nakano[1], Shogo Urakawa[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1] (1.Meteorological Research Institute)

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

[ACG38-03] Dynamics of the estern-boundary currents

★Invited Papers

*Ryo Furue[1] (1.APL/JAMSTEC)

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

[ACG38-04] Impacts of bottom topography on the formation of the North Pacific subtropical-subarctic frontal zone

*Humio Mitsudera[1], Hayato Ashida[2], Toru Miyama[3] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science, Hokkaido University, 3.JAMSTEC)

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

[ACG38-05] Stability of a Flow over Bottom Topography: A General Condition and a Linear Analysis in a Two-Layer Quasi-Geostrophic Model

*Yuki Tanaka[1] (1.Faculty of Marine Science and Technology, Fukui Prefectural University)

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

[ACG38-06] Eddy-mean flow interactions and vertical energy redistribution associated with the standing meander in the Antarctic Circumpolar Current

*Takuro Matsuta[1], Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

Toward numerical modeling systems that seamlessly link coastal seas to open oceans

*Hiroyasu Hasumi[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Studies on the ocean have traditionally been separated into those on coastal seas and open oceans, and numerical modeling of the ocean has also developed separately. That is because the spatio-temporal scales are significantly different between these two targets. Recent advancement in observational technologies and computers, however, has led studies on open oceans to cover small scale phenomena such as submesoscales. Studies on coastal seas, on the other hand, have becoming to deal with not only individual bays but interactions between bays or with open oceans. Furthermore, the need is growing for such studies that synthetically deal with coastal seas and open oceans due to our awareness of the influence of global warming on human societies and the oceanic environmental problems caused by human activities. In this regard, we need numerical ocean modeling systems that seamlessly link coastal seas to open oceans. Development and application of such systems are attempted by many groups now, but there remain various problems to be solved because of the large difference between the spatio-temporal scales which control each of them. In this presentation, I would like to show my personal view on the objectives, requirements, and problems in “seamless ocean modeling systems”.

Keywords: ocean modeling, seamless modeling

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Long-term variability of sea level along the coast of Japan during the 20th century reproduced by an eddy resolving model

*Hideyuki Nakano[1], Shogo Urakawa[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1]

1. Meteorological Research Institute

Long-term changes in sea level along the coast of Japan during the 20th century are characterized by decadal variations: a peak in the 1950s and a decline in the 1980s, followed by a consistent upward trend since 1980s. There are also weak fluctuations of sea level with a period of 10 to 20 years. In order to elucidate the mechanism of these coastal sea level variations, we drive an ocean general circulation model that can reproduce the Kuroshio/Kuroshio Extension and coastal trapped waves (CTWs) using multiple reanalysis data for the 20th century. This is the first experiment that uses an eddy-resolving model forced by reanalysis data for the entire 20th century. Since the effect of adjustment by longshore trapped waves is important in coastal areas, we also condust ideal experiments on CTWs. Although the ocean model is based on the Boussinesq approximation, the sea level rise due to thermal expansion of seawater can be diagnosed by its global mean because its local contribution spreads rapidly around the world. This global average sea level rise has been a major contributor to rising coastal sea levels since the 1980s. Prior to the 1980s, the contribution of the thermal expansion was small, with variations due to the change in wind stress curl dominating. The high coastal sea levels in the 1950s, with similar amplitudes along the northern coast of Honshu and Hokkaido, are found to be caused by the arrival of high sea level anomaly on the eastern coast of Hokkaido and their adjustment by CTWs. Since the 1980s, the sea level variation around Hokkaido is smaller than that of Honshu, except for the contribution of thermal expansion, suggesting that the sea level change around Japan was largely related to the path variability of the Kuroshio Current.

Keywords: coastal sea level rise, Kuroshio/Kuroshio Extension, Eddy resolving model

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Dynamics of the estern-boundary currents

*Ryo Furue[1]

1. APL/JAMSTEC

This presentation is mostly a review of the eastern boundary structure with emphasis on the Leeuwin Current System along the west coast of Australia. Some preliminary descriptive results will also be shown about the annual variability of LCS.

Baroclinic coastal Kelvin waves propagate poleward along the eastern boundary of the ocean basin. If there is some forcing along the coast or a flow into or out of the eastern boundary, such as Ekman drift, pressure anomaly is generated and is propagated by the coastal Kelvin wave. This process establishes a coastal current in the wake of the wave.

Equatorward of the critical latitude, however, pressure anomaly along the eastern boundary is carried away offshore by Rossby waves. For this reason, for a narrow current to exist along the eastern boundary, some mechanism is necessary to arrest the propagation of Rossby waves. One potentially powerful mechanism is the bottom slope (topographic beta). The Leeuwin Current (LC), a shallow, permanent, poleward-flowing eastern boundary current anchored to the shelf break, owes its existence to the bottom slope.

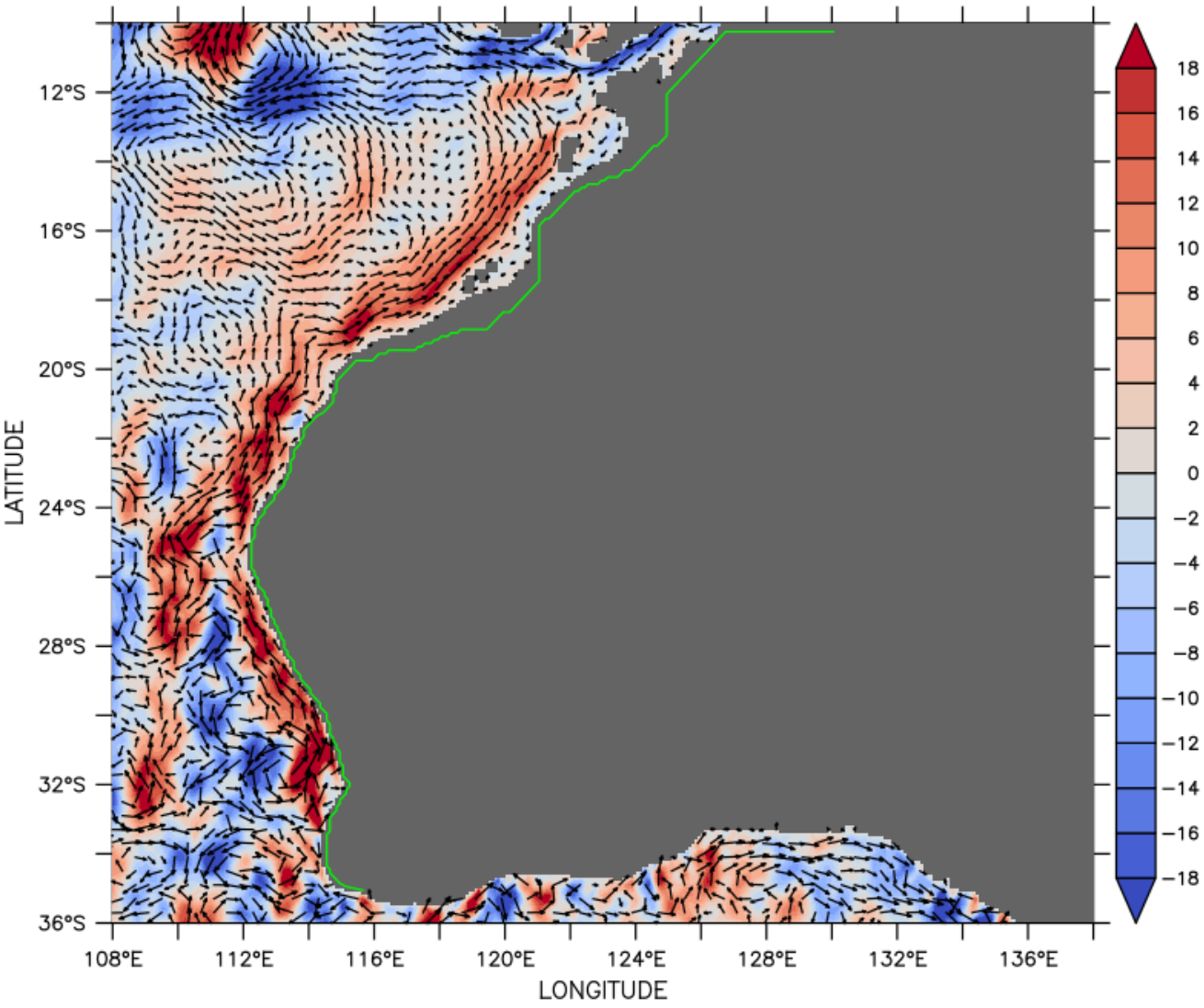
There is a permanent undercurrent flowing equatorward hugging the continental slope beneath the LC. The mechanism of its generation is a mystery. Qualitatively the pair of the LC and the undercurrent looks like a baroclinic mode of the coastal trapped wave. Can such a mode, however, remain trapped against the Rossby waves? If it can, what is the forcing?

There is also variability at various time scales. It is not known whether or not baroclinic variability due to the various modes of coastal trapped waves can remain trapped to the eastern boundary. There have been reports that during its normal annual cycle, the LC sheds eddies when it is strong. This may be a mechanism for the LCS to lose energy into the interior.

The structure of the eastern-boundary current system is crucial to determine the baroclinic structure of the interior ocean as its structure propagates as Rossby waves.

Keywords: coastal trapped waves, planetary Rossby waves, eastern boundary currents, baroclinic flow

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Impacts of bottom topography on the formation of the North Pacific subtropical-subarctic frontal zone

*Humio Mitsudera[1], Hayato Ashida[2], Toru Miyama[3]

1. Institute of Low Temperature Science, Hokkaido University, 2. Graduate School of Environmental Science, Hokkaido University, 3. JAMSTEC

The subtropical-subarctic frontal zone in the North Pacific exhibits a complex water mass structure because the water of Kuroshio origin and the water of Oyashio origin are confluent, stirred there and mixed. Despite this complexity, two quasi-stationary fronts form in this region that characterize the frontal zone, which are the subarctic front (SAF), recognized by potential temperature of 4 ℃ contour at a depth of 100 m, and the subarctic boundary (SAB), recognized by salinity of 34 contour at a depth of 100 m; the so-called transition domain forms in between. This frontal zone is generally considered as a wind-driven gyre boundary between the subtropical and subarctic gyres. However, the frontal zone is located around 40 ˚N, which is further south than the location of the Sverdrup gyre boundary that forms at approximately ~45 ˚N. Here, we study the effects of bottom topography on the formation of the subtropical-subarctic frontal zone in the western North Pacific, with a particular attention to the Emperor Seamounts. We conducted an eddy-resolving two-layer modeling with a realistic topography of the ETOPO1, forced by a zonally-averaged wind stress derived from the JRA-55 do. The model exhibits a realistic frontal zone structure of the North Pacific comprising the SAF and SAB, as well as the transition domain. Eddy driven bottom currents are generated over topography, which in turn causes substantial impacts on the formation of upper layer frontal-zone structures. By conducting topography on/off experiments, we found that the Emperor Seamounts bring the subarctic thin layer southward across the Sverdrup gyre boundary. The thinner layer of the subarctic origin and thicker layer of the subtropical origin meet and mix there, leading to the formation of the SAB and the transition domain.

Keywords: subtropical-subarctic frontal zone, Emperor Seamounts, transition domain, quasi-stationary jets

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Stability of a Flow over Bottom Topography: A General Condition and a Linear Analysis in a Two-Layer Quasi-Geostrophic Model

*Yuki Tanaka[1]

1. Faculty of Marine Science and Technology, Fukui Prefectural University

Bottom topography is an essential factor that controls the pattern and variability of ocean currents. In the present study, the stability of a two-layer quasi-geostrophic flow over bottom topography is examined by combining a method of obtaining a sufficient condition for stability and a linear stability analysis. First, using a conserved quantity referred to as pseudoenergy that is proportional to the square of the disturbance amplitude, a sufficient condition for stability is derived for the simplest steady background field in which the potential vorticity and the stream function are proportional to each other. The obtained stability condition is unique in that no specific form is assumed for the background field except for the linear relationship between the potential vorticity and the stream function, and that it depends on the minimum possible wavenumber of the disturbance. These features enable us to judge the stability of various background fields by explicitly taking into account the limitation imposed on the disturbance scale by the domain size and/or boundary conditions. Applying the stability condition to a special case of a sinusoidal background field shows that the stable range extends to the area where the currents flow with shallower water on their right in both the upper and lower layers. The stable range is broadened as the disturbance becomes limited to smaller horizontal scales, mainly due to the suppression of barotropic instability which works effectively at large scales. Finally, a linear stability analysis confirms the validity of the stability condition for background fields with a wide range of parameters.

Keywords: Two-Layer Quasi-Geostrophic Flow, Bottom Topography, Stability Theory, Barotropic and Baroclinic Instability

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Eddy-mean flow interactions and vertical energy redistribution associated with the standing meander in the Antarctic Circumpolar Current

*Takuro Matsuta[1], Yukio Masumoto[1]

1. Graduate School of Science, The University of Tokyo

A remarkable feature of the Antarctic Circumpolar Current (ACC) is its insensivity to changes in surface forcing. This feature is explained by balances between a wind-driven overturning circulation and an eddy-driven circulation in the zonally averaged framework. However, the residulal mean theories miss the representation of the ACC's heterogeneity in eddy distributions. Active eddy activities are confined near the vicinity of standing meanders associated with the large topography. In this presentation, local eddy-mean flow interactions are discussed from the Lorentz diargram framework using a realistic eddy-resolution model. Our finding is that large amount of the wind energy input is locally dispersed near the standing meanders through baroclinic instability. Eddy energy is generated in the upper 3000m and dispersed near the bottom. This mismatch between the depth of energy production and dispersion is reconciled by the downward vertical energy flux.

Keywords: eddy-mean flow interactions, Antarctic Circumpolar Current, Lorentz diagram, energy flux

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.10 Zoom Room 10

[A-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

Oceanic and atmospheric dynamics aims at abstracting general principles from observed phenomena and constructing a system of mathematical models, thereby leading to the understanding, prediction, and parameterization of those phenomena. It provides perspectives for the advancement of sciences in various areas such as turbulence, wind waves, internal waves, Rossby waves, tides, coastal and equatorial boundary processes, mesoscale and submesoscale eddies, meandering of jets and fronts, general circulation, and ocean-atmosphere coupled modes. It has also been and will continue to be benefited by new uses of ideas and methods from such theories as resonance, nonlinear interaction, stability analysis, spectral analysis, probability, statistics, and dynamical systems. In this session, we solicit presentations on observational, experimental, numerical, and theoretical studies of oceanic and atmospheric dynamics and on exploratory use of new ideas and methods. We also welcome presentations on interdisciplinary studies in fields such as ecosystems, climate, and environment.

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

[ACG38-07] Irreversible energy extraction from negative temperature two-dimensional turbulence

*Yohei Onuki[1] (1.Ocean Modeling Group, Center for Oceanic and Atmospheric Research, Research Institute for Applied Mechanics, Kyushu University)

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

[ACG38-08] Near-inertial oceanic internal waves observed by LADCP (lowered acoustic Doppler current profiler)

*Katsuro Katsumata[1] (1.JAMSTEC)

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

[ACG38-09] The pathway of the Indonesian Throughflow transport increase due to tidal mixing

*Shiraishi Takeki[1], Shinichiro Kida[2], Hideharu Sasaki[3], Ryo Furue[3] (1.Kyushu University Interdisciplinary Graduate School of Engineering Sciences, 2.Research Institute for Applied Mechanics, Kyushu University, 3.Application Laboratory , Japan Agency for Marine-Earth Science and Technology)

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

[ACG38-10] Biogeophysical Interactions in transport of marine organisms

★Invited Papers

*Atsushi Fujimura[1] (1.University of Guam)

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

[ACG38-11] Wave resolving numerical simulation of non-breaking wave-induced mixing

*Haruka Imamura[1], Yutaka Yoshikawa[1], Yasushi Fujiwara[2] (1.Graduate School of Science, Kyoto University, 2.Graduate School of Frontier Sciences, the University of Tokyo)

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

[ACG38-12] Origin of swells propagated into small bays on the Sanriku rias coast facing the western North Pacific

*Kosei Komatsu[1,2], Takaki Fujii[3], Kiyoshi Tanaka[2] (1.Graduate School of Frontier Sciences, University of Tokyo, 2.Atmosphere and Ocean Research Institute, University of Toky, 3.Bank of Japan)

Irreversible energy extraction from negative temperature two-dimensional turbulence

*Yohei Onuki[1]

1. Ocean Modeling Group, Center for Oceanic and Atmospheric Research, Research Institute for Applied Mechanics, Kyushu University

Large-scale motions of the atmosphere and ocean are idealized as two-dimensional turbulence. Energy transfer and structure formation of two-dimensional turbulence have attracted attention for a long time, and many past studies have analyzed them within an open domain or surrounded by a fixed lateral boundary. In this study, to extend our understanding of two-dimensional turbulence, we consider a flow system in a bounded domain whose shape is distorted by an externally imposed force. Unlike fixed boundary cases, this system exchanges energy with the external system via pressure work through the moving boundary. At the same time, the flow field is still constrained by vorticity conservation. When the vorticity equation is expanded onto the Laplacian eigenfunctions and truncated at a finite number, it satisfies Liouville's theorem. Consequently, based on energy and enstrophy constraints, a grand-canonical ensemble (GCE) with the temperature either positive or negative sign is defined. Starting from GCE, when one distorts the domain from one to another in a finite time, the Jarzynski equality establishes. The pressure work exerted on the system is thus related to the difference in the Helmholtz free energy. The direction of the inequality derived from the Jarzynski equality depends on the sign of the initial temperature. For a negative-temperature state, the moving boundary irreversibly extracts turbulence energy from the system via pressure work. This peculiar result gives a new interpretation for the inter-scale energy transfer in geophysical flows.

Keywords: Two-dimensional turbulence, Statistical mechanics, Jarzynski equality

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Near-inertial oceanic internal waves observed by LADCP (lowered acoustic Doppler current profiler)

*Katsuro Katsumata[1]

1. JAMSTEC

Frequency spectra of oceanic internal waves often show peaks around the inertial frequency of the observed location. These near-inertial waves are ubiquitous as many generation machnisms are possible such as surface wind, ocean currents interacting with bottom topography, and spontaneous break down of eddies. On the other hand, observation data of near-inertial waves are limited because of their intermittency, due partly to the transient and unsteady nature of their generation. The polarisation relationship of the internal wave constrains the particle movements of near-inertial waves within a horizontal plane which makes near-inertial wavs "invisible" to conventional conductivity temperature depth profilers (CTD) observations. Here, we attemp to observe these waves by using lowered acoustic Doppler current profiler (LADCP) used with CTDs in ship-based hydrographic observations. Since the near-inertial waves are peaks, we boldly assume that observed horizontal velocity is inertial waves, superposed upon which are other components (e.g. internal waves at other frequencies and geostrophic flows). At one station, the sensor package passes a depth twice, decent and ascent, giving meridional and zonal components of horizontal velocities each, which enables estimate of amplitude and phase of the inertial wave.
We applied this method to several sections in the Indian Ocean. On a section nominally along 55˚E, one CTD station lasting about 4 hours could capture inertial waves at poleward of about 30˚S where the inertial period is 24 hours. Their group velocity was more often downward than upward, not inconsistent with surface generation. Many had wavelengths longer than 2000 m, suggesting vertical structures of gravest modes. The magnitude was of the order of cm/s. On the other hand, there were unnegligible waves with upward group velocity with depths scatterd around the water column; suggesting contribution from other generation mechanims than wind.

Keywords: oceanic internal waves, inertial waves, ocean observation

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The pathway of the Indonesian Throughflow transport increase due to tidal mixing

*Shiraishi Takeki[1], Shinichiro Kida[2], Hideharu Sasaki[3], Ryo Furue[3]

1. Kyushu University Interdisciplinary Graduate School of Engineering Sciences, 2. Research Institute for Applied Mechanics, Kyushu University, 3. Application Laboratory , Japan Agency for Marine-Earth Science and Technology

Indonesian through-flow (ITF) is an ocean current that passes through the Indonesian Seas from the Pacific Ocean to the Indian Ocean. In this area, vertical mixing is believed to be actively excited by the tide because the seafloor topography of the Indonesian Seas is complex. In Sakaki et al. (2018), the presence of a tidal mixing scheme was suggested to increase the ITF transport by 0.88 Sv. However, the mechanism of this increase. The mass balance of the increased transport due to tidal mixing was estimated by dividing the region around the Indonesian Seas into seven sections, such as the Celebes Sea, Makassar Strait, and the Molucca Sea. As a result, it was found that there are two main routes for the ITF increase. The first route is the upwelling that occurs within the Indonesian Seas (lower layer to upper layer). The second route is the upper layer flow from the eastern coast of the Philippines to the Makassar Strait. This second route is likely induced by tidal mixing that occurred in the Pacific Ocean.

Keywords: Indonesian Throughflow, Tidal mixing, OFES2

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Biogeophysical Interactions in transport of marine organisms

*Atsushi Fujimura[1]

1. University of Guam

Population dynamics of marine organisms largely depend on transport of larvae, propagules and holoplankton. A number of factors influence their transport and multiple biological and geophysical processes are involved in various spatiotemporal scales. These processes and scales are often taxa specific, making it difficult to understand transport mechanisms as species-specific information may be required. Moreover, observing transport of such tiny planktonic organisms is challenging since they cannot be tagged and tracked effectively. Some techniques and methods were developed to describe transport mechanisms of the organisms over the last decades, and biological-physical coupling models are used more and more. The current status of our understanding of the transport processes and study methods will be discussed, and some results from recent research will be presented. For example, a biophysical simulation models indicate that cross-shore transport of larvae and phytoplankton in the surf zone are controlled by wave/wind-driven currents, turbulence, vertical positions of plankton, and bathymetric features. The study indicates that physical dynamics, biological traits, and geological characteristics are all important to understand plankton transport in coastal areas.

Keywords: Biophysical interaction, Larval transport, Coastal oceanography, Surf zone, Modeling, Plankton

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Wave resolving numerical simulation of non-breaking wave-induced mixing

*Haruka Imamura[1], Yutaka Yoshikawa[1], Yasushi Fujiwara[2]

1. Graduate School of Science, Kyoto University, 2. Graduate School of Frontier Sciences, the University of Tokyo

Recent studies suggest that non breaking surface waves induce vertical mixing in the ocean surface layer. Langmuir circulations (LCs), generated by the interaction between surface waves and wind-driven shear flow, are one example of the processes that cause mixing without wave breaking. Some laboratory and numerical experiments, on the other hand, showed the mixing caused only by the non-breaking wave without wind-induced shear (hereafter referred as the non-breaking wave-induced mixing). Dai et al. (2010) observed that initially stratified water in their windless laboratory tank was homogenized under the monochromatic surface waves with wave steepness ak = 0.08 ~ 0.21. Savelyev et al. (2012) conducted windless laboratory experiments and identified an elongated streaky structure at the water surface in the presence of surface waves. Wave resolving numerical simulations showed that counterrotating streamwise vortex pairs like LCs (Tsai et al.,2015, 2017, Fujiwara et al.,2020) and elongated surface streaks (Tsai et al.,2015,2017) were formed even without wind stress at the surface. These numerical studies suggested that the structures can be formed by the CL2 instability mechanism, the interaction between surface waves and the sheard current as in LCs, but the current is produced by the wave viscous attenuation (Tsai et al.,2017, Fujiwara et al.,2020). However, there remain several issues to be resolved. For example, the numerical experiments used steeper waves (ak = 0.25; Tsai et al.,2015,2017) than the laboratory experiments (ak = 0.08 ~ 0.21; Dai et al.,2010) and larger viscosity than that of water (Fujiwara et al.,2020). The magnitude of mixing caused by this vortex structure was not evaluated in the studies. Furthermore, the velocity characteristics are different from those of LCs. Thus, the condition, magnitude, and mechanism of non-breaking wave-induced mixing need to be clarified.

The purpose of this study is to examine whether the non-breaking surface waves with relatively small steepness can induce the mixing in the water with molecular viscosity and to evaluate how strong it is. To this aim, we conduct the numerical experiments under the similar condition as the laboratory experiment by Dai et al. (2010). A sigma-coordinate free-surface nonhydrostatic model similar to Tsai and Hung (2007) and Yang and Shen (2011) was used. We considered a surface wave with a wavelength of λ = 75cm and an amplitude of 1cm (ak = 0.08) propagating on the surface of homogeneous water with an average depth of 20cm. The length and width of the computational domain are λ and $\lambda/2$ respectively with periodic boundary condition in both directions. No tangential stress at the surface was imposed. Initial surface elevation and velocity were set as those of the third-order Stokes wave. To visualize motion of water, a passive tracer with a linear vertical profile was distributed in the initial field. The domain was discretized with 256× 128× 64 grid points. The simulated wave kept propagating until at least 100 wave periods with less deformation from the stokes wave (except for the wave viscous attenuation).

Simulated velocity field showed that convergent (divergent) zones of the spanwise velocity at the surface and divergent (convergent) zones at depth correspond with the zones of downward (upward) velocity and acceleration (deceleration) of the streamwise (downwave) velocity. Tracer distribution at the surface was also characterized by elongated streaks. These features can be explained by the formation of streamwise vortices near the water surface. The vertical diffusivity estimated from the tracer distribution was O(10^{-5})m

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^{2}/s, with its maximum at about 2cm depth and becoming almost zero at and below about 6cm depth.

Magnitude of the estimated diffusivity is similar to that of Dai et al. (2010). More detailed analysis about the mechanism of this mixing and dependences of vertical diffusivity on wave parameters and stratification will be presented.

Keywords: ocean surface mixing, streamwise vortex pairs, wave viscous attenuation

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Origin of swells propagated into small bays on the Sanriku rias coast facing the western North Pacific

*Kosei Komatsu[1,2], Takaki Fujii[3], Kiyoshi Tanaka[2]

1. Graduate School of Frontier Sciences, University of Tokyo, 2. Atmosphere and Ocean Research Institute, University of Toky, 3. Bank of Japan

Real-time monitoring of wind and surface waves in Otsuchi Bay, a ria located in the northeastern portion of Japan, had been continued over four years since October 2012, using a mooring buoy with an ultrasonic anemometer and a single-mode GPS wave sensor. The monitoring revealed that waves in the bay were dominated by swells propagated from the northeastern offshore region in all seasons. Time-lag correlation coefficient between the significant wave height in the bay and the offshore wind velocity component blowing in the direction to the bay was maximized in the region approximately 300 km northeast of the bay, from which waves developed by the local wind are accessible within the corresponding time-lag to the bay at a speed of the group velocity of the swell observed in the bay. As an interesting feature common to swell-dominant waves observed in the rias bays adjacent to Otsuchi Bay, the region of the significant correlation between the wave height and the offshore wind velocity extends to the direction that faces the bay mouth. It implies that the source region of the swell depends heavily on the coastal shape of the bay. Consequently, the relation between the offshore wind field and the decay-rate of the swells propagating to Otsuchi Bay indicates that the source region of the swell influential in the bay is located in the offshore region several hundreds of kilometers northeast of the bay, which is on the typical migration route of high and low pressures in the Northern temperate zone.

Keywords: swell, rias coast, western North Pacific

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. Jun 6, 2021 3:30 PM - 4:45 PM JST | Sun. Jun 6, 2021 6:30 AM - 7:45 AM UTC | Ch.10 Zoom Room 10

[A-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Norihiko Sugimoto(Keio University, Department of Physics), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

Oceanic and atmospheric dynamics aims at abstracting general principles from observed phenomena and constructing a system of mathematical models, thereby leading to the understanding, prediction, and parameterization of those phenomena. It provides perspectives for the advancement of sciences in various areas such as turbulence, wind waves, internal waves, Rossby waves, tides, coastal and equatorial boundary processes, mesoscale and submesoscale eddies, meandering of jets and fronts, general circulation, and ocean-atmosphere coupled modes. It has also been and will continue to be benefited by new uses of ideas and methods from such theories as resonance, nonlinear interaction, stability analysis, spectral analysis, probability, statistics, and dynamical systems. In this session, we solicit presentations on observational, experimental, numerical, and theoretical studies of oceanic and atmospheric dynamics and on exploratory use of new ideas and methods. We also welcome presentations on interdisciplinary studies in fields such as ecosystems, climate, and environment.

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

[ACG38-13] Formulation and application of phase-independent energy conversion terms for quasi-geostrophic eddies on a zonally-varying basic flow

★Invited Papers

*Takaya Koutarou[1] (1.Kyoto Sangyo University)

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

[ACG38-14] Recirculation of atmospheric wave energy associated with idealized MJO events

*Hidenori AIKI[1], Yoshiki Fukutomi[1], Yuki Kanno[2], Tomomichi Ogata[3], Takahiro Toyoda[4], Hideyuki Nakano[4] (1.Nagoya University, 2.Central Research Institute of Electric Power Industry, 3.Japan Agency for Marine-Earth Science and Technology, 4.Meteorological Research Institute)

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

[ACG38-15] Extratropical forcing of intraseasonal equatorial Kelvin waves over the Indian and Pacific Oceans

*Fukutomi Yoshiki[1], Hidenori Aiki[1] (1.Institute for Space-Earth Environmental Reasearch, Nagoya University)

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

[ACG38-16] Influence of marginal seas' hotspot on extratropical cyclones: explosive and binary cyclogenesis in idealized experiments

*Masaru Yamamoto[1] (1.Research Institute for Applied Mechanics, Kyushu University)

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

[ACG38-17] Discussion

Formulation and application of phase-independent energy conversion terms for quasi-geostrophic eddies on a zonally-varying basic flow

*Takaya Koutarou[1]

1. Kyoto Sangyo University

A new formulation of energy conversion terms for quasi-geostrophic disturbances is proposed under an assumption that an eddy is almost a plane wave in the WKB sense. Estimating energy conversions could be valid to explore dynamics of low-frequent variability of the disturbances. A traditional form of the energy conversion terms contains quadratic terms in disturbance amplitudes, such as a momentum transport u’v’ and a heat transport v’T’. Therefore, it inherently includes an oscillatory component of one-half wavelength of the disturbances. For transient eddies, time-averaging longer than one wave period can be equivalent to eliminating the half-wavelength oscillatory components in the energy conversion terms, so that the traditional form of the terms may be available. However, for stationary waves, time-averaging is not equivalent to phase-averaging and therefore inappropriate. A new form of the energy conversion proposed in this study can be proved to be phase-independent of the eddies without any spatial- and time-averaging taken, and thus can represent a “snapshot” distribution of the energy conversion terms. Therefore, the new formulation can be applicable to estimating energy conversions for stationary eddies or snapshot features of transient eddies.

Actual applications of the new form of the energy conversions to some teleconnection patterns will also be given. Our analysis based on the new formulation suggests that energy extraction from the basic state and energy dispersion by group velocity can be essential for formation and/or maintenance mechanisms of the teleconnection patterns.

Keywords: energy conversion, Rossby wave

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Recirculation of atmospheric wave energy associated with idealized MJO events

*Hidenori AIKI[1], Yoshiki Fukutomi[1], Yuki Kanno[2], Tomomichi Ogata[3], Takahiro Toyoda[4], Hideyuki Nakano[4]

1. Nagoya University, 2. Central Research Institute of Electric Power Industry, 3. Japan Agency for Marine-Earth Science and Technology, 4. Meteorological Research Institute

A recent analytical study has derived an exact universal expression for the energy flux which can indicate the direction of the group velocity for linear shallow-water waves at all latitudes. This analytical result is extended in the present study to a height-dependent framework for three-dimensional waves in the atmosphere. This is achieved by investigating the classical analytical solution of both equatorial and midlatitude waves in a Boussinesq fluid. For the horizontal component of the energy flux, the same expression has been obtained between equatorial waves and midlatitude waves in the height-dependent framework, which is linked to a scalar quantity inverted from the isentropic perturbation of Ertel's potential vorticity (EPV). This EPV-inverted scalar quantity reduces to the geostrophic streamfunction for midlatitude Rossby waves and vanishes for gravity waves, a novel aspect for considering the universal expression of the energy flux. The expression of the vertical component of the energy flux requires computation of another scalar quantity which may be interpreted as the zonal integral of a variant of streamfunction and may be obtained by the time integration of a prognostic equation. The new energy flux diagnosis scheme, mentioned above, has been tested for three-dimensional Rossby and equatorial Kelvin waves induced by an idealized MJO-like heat forcing. The horizontal recirculation of wave energy is identified in each hemisphere with a smooth transition between equatorial and off-equatorial regions. The vertical flux of wave energy is mostly revealed by the pressure flux component of the energy flux, as it is maintained mainly by equatorial Kelvin waves.

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Extratropical forcing of intraseasonal equatorial Kelvin waves over the Indian and Pacific Oceans

*Fukutomi Yoshiki[1], Hidenori Aiki[1]

1. Institute for Space-Earth Environmental Reasearch, Nagoya University

Equatorial Kelvin waves (KWs) are major convective disturbances accompanying tropical super cloud clusters (SCCs) which propagate eastward along the equatorial belt. KWs generally span the broad range from synoptic to intraseasonal time scales and they have horizontal scales of about zonal wavenumber 1-10. This study examines characteristics and origins of intraseasonal equatorial KWs which have periods of about 10-20 days in the Indian Ocean-western Pacific region during Austral winter. They are distinguished from synoptic-scale (about 2-8 days) KWs. An extended empirical orthogonal function (EEOF)-based composite analysis is performed on 8-25-day filtered outgoing longwave radiation and atmospheric circulation fields during June-August 1979-2018. The analysis results reveal the structure and evolution of the KWs and associated extratropical-tropical interactions. The composite KW patterns exhibit a zonal wave number 3 structure with eastward phase speed of around 12-16m/s. The KWs initially develop over the Indian Ocean, then they propagate eastward into the eastern Pacific after passing through the Maritime Continent (MC). Initiation mechanisms of KWs due to Southern Hemisphere extratropical wave activity is explored by identifying precursor wave signals in the extratropics. Southerly surge-like flows in the lower troposphere are identified over the western Indian Ocean and the western Pacific close to the MC associated with the KW development. These two southerly flows are linked to initiation of KWs at each location. They are originated in the extratropical wave train which progress eastward into the central-eastern South Pacific. There is strong evidence that equatorward advection of westerly momentum is enhanced by the southerly surge-like flow. This equatorward transport of westerly momentum plays a vital role in initiating KWs at these two locations.

Keywords: Equatorial Kelvin waves, Intraseasonal variability, Extratropical-tropical interaction

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Influence of marginal seas' hotspot on extratropical cyclones: explosive and binary cyclogenesis in idealized experiments

*Masaru Yamamoto[1]

1. Research Institute for Applied Mechanics, Kyushu University

Over the marginal seas of the western North Pacific, the active region of extratropical cyclones is divided into two (the Sea of Japan and the southern coast of the Japanese main islands) and some cyclones often develop explosively. In addition, binary extratropical cyclones, called twin extratropical cyclones, are also often observed. A few works have studied cases of binary lows associated with (i) upper-level double jets (Ogura et al. 2006; Hitsuma 2006), (ii) the formation of binary lows in single jets (Yamamoto 2012, 2018), and (iii) transition from double jets to single jets (Yokoyama & Yamamoto 2019). At the present stage, one does not fully understand why binary cyclone structures often form around Japan. In winter, high sea surface heat fluxes are concentrated into the marginal seas of the western North Pacific. Recently, such a localized, strong surface heat flux at midlatitudes is called a "hotspot" in the climate system (e.g., Nakamura et al. 2015). The atmospheric response to the hotspots in the marginal seas has been studied in idealized atmospheric general circulation models from the viewpoint of geophysical fluid dynamics, to discuss the temperature decrease around the east coast of the continent and cyclonic activity over the North Pacific Basin (e.g., Kaspi & Schneider 2011).

The purposes of this study are to reconsider the atmospheric response to localized heating over marginal seas of the western North Pacific, and to clarify the impact of the sea hotspot on binary cyclones near Japan. In idealized experiments used, the setup of Held & Suarez (1994) was applied to the global Weather Research and Forecasting model (e.g., Dias Pinto & Mitchell, 2014). The present work assumed that the North Pacific marginal seas' hotspot heats the lower atmosphere. The steady and localized heating was given by the triangular region. Several sensitivity experiments were conducted by changing the location and thickness of this heating region.

In the area of enhanced westerly, the baroclinicity and short-period disturbance activity at low levels are enhanced by the hotspot. In addition, the frequency of explosive cyclones increases around the hotspot. Over the marginal seas of the western North Pacific, a pressure trough extends in a north-south direction and two maxima of cyclone activity (intensity of short-period disturbances) forms. These two maxima form even when the heating parameters are altered, and thus the hotspot is an important factor in forming the bifurcation of the cyclone activity area around Japan (Japan Sea path and south coast path). In the time-latitude cross-section of sea level pressure over the hotspot, a binary cyclone appears under the condition that a deep pressure trough has developed. A binary cyclone system appears in the early stage of the cyclone development, and the contact cyclone pair merges during the fully developed stage. This is consistent with several case studies of explosive, binary cyclones (Yamamoto 2018; Yokoyama & Yamamoto 2019).

A simple framework for investigating the atmospheric response to an oceanic hotspot in the western North Pacific shows that the heating of the lower atmosphere by the hotspot leads to the formation of a north-south bifurcation of the active cyclone area and increases the frequency of explosive cyclones. The formation of binary lows in the absence of the Japanese Islands suggests the importance of enhanced pressure troughs associated with heating over the marginal seas' hotspot.

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Keywords: extratropical cyclone, binary cyclone, marginal seas' hotspot

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[J] Oral | A (Atmospheric and Hydrospheric Sciences) | A-CG Complex & General

[A-CG38] Dynamics of Oceanic and Atmospheric Waves, Vortices, and Circulations

convener:Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Norihiko Sugimoto(Keio University, Department of Physics), Kunihiro Aoki(Japan Agency for Marine Earth Science and Technology), Yuki Tanaka(Faculty of Marine Science and Technology, Fukui Prefectural University)

Sun. Jun 6, 2021 3:30 PM - 4:45 PM Ch.10 (Zoom Room 10)

Oceanic and atmospheric dynamics aims at abstracting general principles from observed phenomena and constructing a system of mathematical models, thereby leading to the understanding, prediction, and parameterization of those phenomena. It provides perspectives for the advancement of sciences in various areas such as turbulence, wind waves, internal waves, Rossby waves, tides, coastal and equatorial boundary processes, mesoscale and submesoscale eddies, meandering of jets and fronts, general circulation, and ocean-atmosphere coupled modes. It has also been and will continue to be benefited by new uses of ideas and methods from such theories as resonance, nonlinear interaction, stability analysis, spectral analysis, probability, statistics, and dynamical systems. In this session, we solicit presentations on observational, experimental, numerical, and theoretical studies of oceanic and atmospheric dynamics and on exploratory use of new ideas and methods. We also welcome presentations on interdisciplinary studies in fields such as ecosystems, climate, and environment.

4:30 PM - 4:45 PM

[ACG38-17]Discussion

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.15 Zoom Room 15

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

This session discusses disaster risks being inherent in the natural and human environment, which sometimes happen to appear at a disaster, from the viewpoint of not only natural sciences but also social and human sciences. Examples of discussion subjects are as follows: uncertainty of forecasting disaster and problems of huge disaster with low frequency that raised from the 2011 Tohoku earthquake, the methodology for improving hazard maps, national recovery plans considering probable changes or sustainability of the society, international cooperation for disaster mitigation, problems of active faults or liquefaction, adjusting disaster mitigation plan to the regional characteristics, technical development for supporting disaster prevention, education for the disaster mitigation.

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

[HDS08-01] Introduction

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

[HDS08-02] Measurement of landslide deformation velocity at Jure in Sunkoshi River Wateshed, Nepal using LiCSBAS

*Hiroshi, P. Sato[1] (1.College of Humanities and Sciences, Nihon University)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[HDS08-03] Map of Earthquake-induced Landslides Potential on Artificially Transformed Hills in the Depositional Area of Tephric Soil Deposits

*Takehiko Suzuki[1], Masahiro Chigira[2], Yuki Matsushi[3], Daichi Nakayama[1] (1.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 2.Fukada Geological Institute, 3.Disaster Prevention Research Institute Kyoto University)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[HDS08-04] **Elucidation of the cause that the H / L value of volcanic sector collapse is very small compared to non-volcanic landslides**

*Shunichi Sato[1] (1. Graduate School of Frontier Science, The University of Tokyo)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[HDS08-05] Natural disasters and countermeasures in Ratnapura, Sri Lanka

*Takahito Kuroki[1], Kensuke Goto[2], Panditharathne N. G. S. [3] (1.Faculty of Letters, Kansai University, 2.Faculty of Education, Osaka Kyoiku Univ., 3.Health Service Rathnapura, Ministry of Health, Government of Sri Lanka)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[HDS08-06] Policy for creating a liquefaction trend map based on geomorphologic classification for recognition of regional liquefaction risk

*Takayuki Nakano[1], Ryo Endo[1], Hiroyuki Inoue[2], Nozomi Yamashina[2], Shingo Watanabe[3], Keita Takada[3], Takuma Fujita[3] (1.Geospatial Information Authority of Japan, 2.City Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 3.Fukken Co., Ltd.)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[HDS08-07] Discussion

[J] Oral | H (Human Geosciences) | H-DS Disaster geosciences

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

Sun. Jun 6, 2021 1:45 PM - 3:15 PM Ch.15 (Zoom Room 15)

This session discusses disaster risks being inherent in the natural and human environment, which sometimes happen to appear at a disaster, from the viewpoint of not only natural sciences but also social and human sciences. Examples of discussion subjects are as follows: uncertainty of forecasting disaster and problems of huge disaster with low frequency that raised from the 2011 Tohoku earthquake, the methodology for improving hazard maps, national recovery plans considering probable changes or sustainability of the society, international cooperation for disaster mitigation, problems of active faults or liquefaction, adjusting disaster mitigation plan to the regional characteristics, technical development for supporting disaster prevention, education for the disaster mitigation.

1:45 PM - 1:50 PM

[HDS08-01]Introduction

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Measurement of landslide deformation velocity at Jure in Sunkoshi River Wateshed, Nepal using LiCSBAS

*Hiroshi, P. Sato[1]

1. College of Humanities and Sciences, Nihon University

Jure landslide at the west side slope of Sunkoshi river occurred on 2 Aug 2014, 70 km E away from Kathmandu. And now the denuded slope surface appears on the ground. Ao et al. (2020) has already reported that deformation at the speed of -100 mm/yr along LoS in Jure landslide using time-series analysis on C-band Sentinel-1 SAR data. Anyway, Morishita et al. (2020) provided the free analysis tool of 100-m-resolution “LiCSBAS” using the Sentinel-1 SAR data. This study found the result of LoS change of -28 mm/yr at the source site (27.77128˚N, 85.866˚E) of the landslide using this tool, as analyzing the SAR data measured from 7 Oct 2017 to 8 Sep 2018.

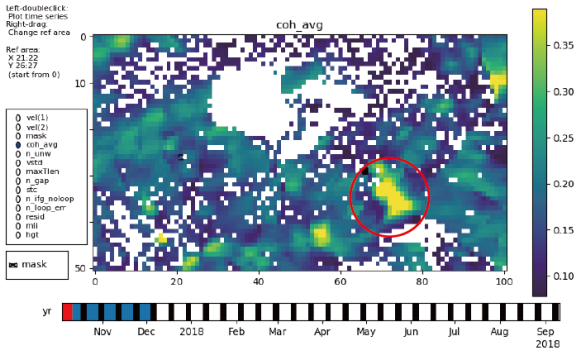
Acknowledgement
This study was supported by KAKEN 18KK0027.

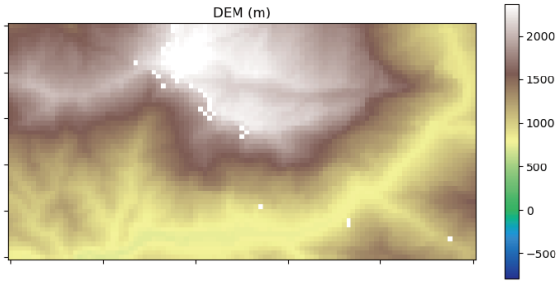
References
Ao et al., 2020: Characterizing the evolution life cycle of the Sunkoshi landslide in Nepal with multi-source SAR data. Nature Scientific Report, 10: 17988.
Morishita et al., 2020: LiCSBAS: An Open-source InSAR time series analysis package integrated with the LiCSAR Automated Sentinel-1 InSAR Processor. Remote Sensing, 12: 424.

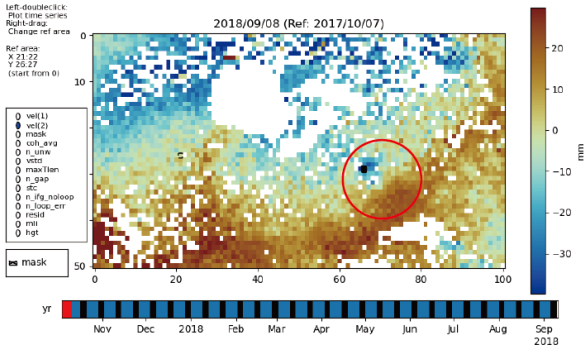
Keywords: LiCSBAS, Sentinel-1, Nepal, landslide

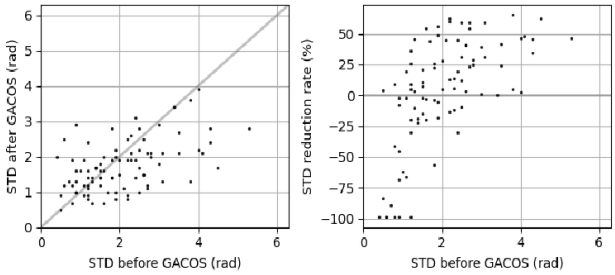
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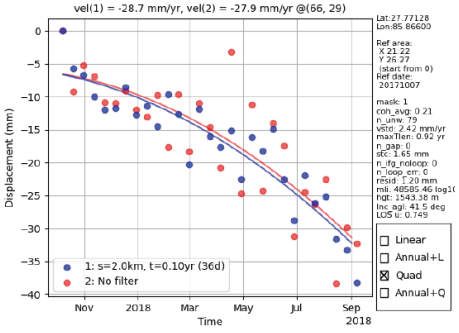


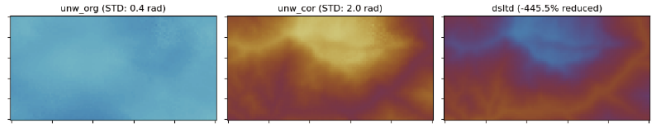




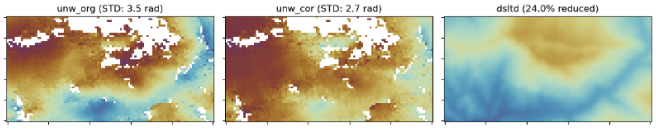




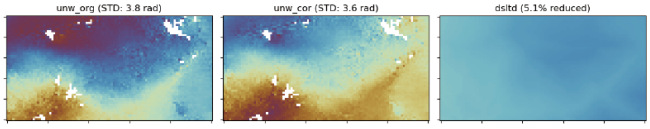




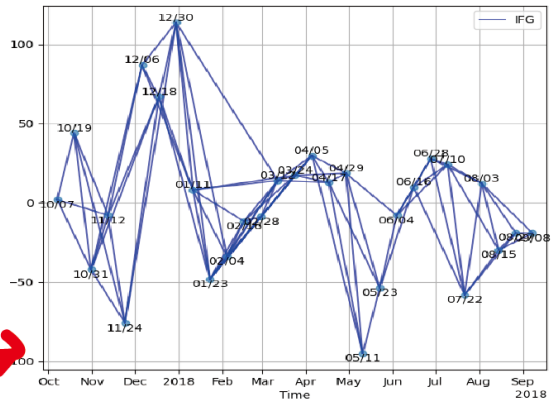
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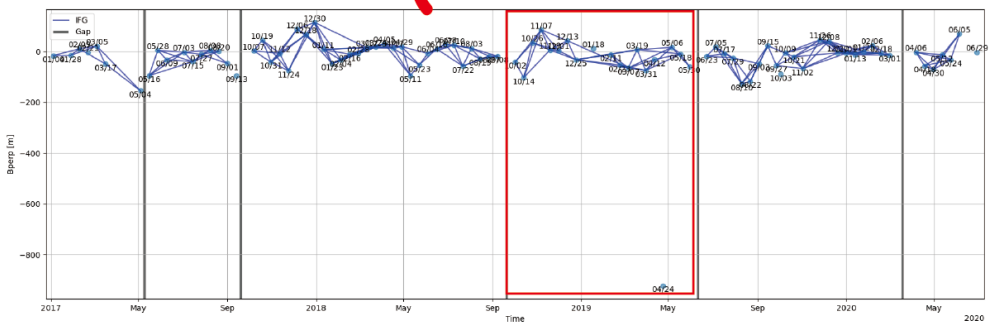


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Map of Earthquake-induced Landslides Potential on Artificially Transformed Hills in the Depositional Area of Tephric Soil Deposits

*Takehiko Suzuki[1], Masahiro Chigira[2], Yuki Matsushi[3], Daichi Nakayama[1]

1. Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 2. Fukada Geological Institute, 3. Disaster Prevention Research Institute Kyoto University

So-called “loam” composed of primary fall-out tephras and tephric soil deposits (tephric loess) is one of the factors causes earthquake-induced landslides on hills where thick loam is preserved. To evaluate potential of slope failure by this condition in the Japanese Island, the distribution of map of loam has been reported. To assess possibilities of earthquake-induced landslides in hilly areas heavily modified by human activities, man-made landforms should be modelled at the micro-landform scale considering original loam thickness. We estimated elevation changes by cutting and fill operation in the Gotentoge and Karakida areas in the Tama Hills where the Tama New Town was built using 1:3,000 topographical maps published in 1950s and present digital elevation model (DEM) with 5 to 2 m mesh. Also, 1:10,000 geological map of loam was used for estimation of thickness distribution of preserved loam. By this method, we tentatively mapped earthquake-induced landslides potential for the Tama Hills, artificially transformed hills in the depositional area of thick tephric soil deposits.

Keywords: earthquake-induced landslide, artificially transformed landform, hills, tephric soil, Tama Hills

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Elucidation of the cause that the H / L value of volcanic sector collapse is very small compared to non-volcanic landslides

*Shunichi Sato[1]

1. Graduate School of Frontier Science, The University of Tokyo

On case of volcanic sector collapse of stratovolcanoes, it has a ratio (H / L value) of the reach distance L of the debris avalanche and the height difference H, which is a very small value that can never be realized by general non-volcanic land sliding. Namely, it is known from previous studies that it has an very large flow distance L, but the cause is still unknown(Iguchi 2005, Moriwaki 1987). Therefore, I aim to elucidate the cause and mechanism, and to use it for the prediction and prevention of large-scale volcanic disasters due to the expected collapse of stratovolcanoes around the world in the future, including Mt. Fuji. Based on the verification results of the ballistic emission mechanism from the magma phreatic crater at the Izu Oshima’ s Habuminato explosion crater in 838, I applied the mechanism by simulation to following three cases, that is, (1) 1952 Myojinsho shallow submarine collapse, (2) 1888 Bandai collapse, and (3)1980 Mount St. Helens one. As a result, in each case, a part of the crater edge of the mountaintop was lifted vertically by the initial steam explosion, and almost at the same time, the slope of the collapse side started to slide down like a rigid plate. Therefore, it has been foreseen that by the reaction of the explosion will gain momentum and kinetic energy. And then, I came to think that the possibility of elucidating mystery of the small value H / L at the time of the sector collapse may become to rearise. Furthermore, there is a possibility that my assumption can well explain some field survey results of topographical changes, for example, Avalanche valley and so on.

Keywords: sector collapse, stratovolcano, H/L value, equivalent coefficient of friction, mechanism of ballistic explosion, steam explosion

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Natural disasters and countermeasures in Ratnapura, Sri Lanka

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1. Faculty of Letters, Kansai University, 2. Faculty of Education, Osaka Kyoiku Univ., 3. Health Service Rathnapura, Ministry of Health, Government of Sri Lanka

The purpose of this study is to investigate the basics of disaster countermeasure that can be used for disaster prevention education and that is flexible against nature and sustainable. We started to investigate them in the study area of Ratnapura district in southern Sri Lanka. Residents' awareness of the danger of natural disasters is still low there, so disaster prevention education has recently started in some areas. The education is conducted by the staff of the Ministry of Health, Government of Sri Lanka. In September 2019, we carried out a field survey on the natural disasters and the countermeasures for flood and landslide. In the survey, we received the support by them. Geologic map data of the US Department of Interior, Global Map data, ASTER GDEM, SRTM1and Landsat data were used as basic geographic data. From these geographic information, we were able to roughly understand the distribution of roads, water systems, land covers, altitudes, slopes, drainage basins, and geology.

The geology is Precambrian metamorphosed sedimentary rock, which is gneiss. Mountains, hills and lowlands can be seen there. The altitude is several tens of meters in the lowlands and around 500 m in the mountain areas. The mountains are widely covered with forests and have steep slopes, but there are also gentle slopes in some places. The landform with gentle slope is widely used as a tea plantation, and public facilities such as hospitals are often located in landform with such conditions. We were able to observe a lot of cracks in the foundation of a hospital building that indicated landslide is occurring. The landslides occurred on steep slopes in the mountain areas. This makes it difficult for roads in mountainous areas to pass. Most of the landslides which we investigated were slide-type slope failures caused by highly weathered basement rocks. The lowland is subdivided into alluvial plain and upland. Residential areas and agricultural lands are widely distributed in the alluvial plain. We confirmed that flood damage is likely to occur in lower elevation areas of the plain. There, the pedestals of the Buddha statue are unusually raised to escape flooding. High-class residential areas and public facilities such as hospitals are often located on the uplands. The hills are widely covered with forests. In urban areas, residential areas also develop at the foot of the hills with gentle slopes.

From the field survey, we understood some flexible responses of local people to natural disasters in their society. We confirmed countermeasures to use gentle slopes against landslide, and to use higher landforms or to raise the foundation against flood. However, the basic geographic data used was not able to represent the landform conditions in which the likelihood of landslide and flood could be estimated. In the next stage, we would like to examine in detail the safety landform condition and its land use from the analysis of large scale topographic maps and high resolution satellite data based on field surveys.

Keywords: landslide, flood, Sri Lanka, disaster prevention education

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Policy for creating a liquefaction trend map based on geomorphologic classification for recognition of regional liquefaction risk

*Takayuki Nakano[1], Ryo Endo[1], Hiroyuki Inoue[2], Nozomi Yamashina[2], Shingo Watanabe[3], Keita Takada[3], Takuma Fujita[3]

1. Geospatial Information Authority of Japan, 2. City Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 3. Fukken Co., Ltd.

1. Introduction

Ministry of Land, Infrastructure, Transport and Tourism conducted the General Technology Development Project "Study on liquefaction hazard map creation method for risk communication" in order to promote pre-disaster prevention of liquefaction and reduce its damage from FY2018 to 2020. In order to reduce the damage caused by liquefaction, residents/businesses and the government have a common understanding of the tendency of liquefaction in the area. It is important to think together about the necessity, i.e., to take risk communication.

As the first step in risk communication, in order to confirm and share the liquefaction occurrence tendency of the area between residents/businesses and the government, it is necessary information for understanding the tendency of liquefaction in the area. As the information, the "liquefaction trend map" that evaluates and classifies the liquefaction occurrence tendency for each geomorphologic classification based on the relationship between the liquefied points and the geomorphology in the past earthquakes is effective. In this presentation, we report on the policy for creating this "liquefaction trend map".

2. Basic policy and creation procedure of "Liquefaction trend map"

The "liquefaction trend map" is created based on information such as geomorphologic classification as a material showing the liquefaction occurrence tendency of the target area. In the map, the liquefaction occurrence tendency of the target area is evaluated and classified in 5 stages based on the geomorphology, man-made land, and the occurrence history of liquefaction in past earthquakes. The map scale is about 1:25,000 or larger, and the shape and distribution of geomorphology and man-made land are shown by polygon data.

The creating procedure of the "liquefaction trend map" is as follows. (1) Collection of materials, (2) Creation of geomorphologic classification maps, etc., (3) Evaluation/classification of liquefaction occurrence tendency, (4) Creation of “liquefaction trend map”.

3. Key points when creating "Liquefaction trend map"

(1) Collection of materials

- It collects previous geomorphologic classification maps, aerial photographs, old maps, man-made land creation materials, materials related to past liquefaction occurrence history, and ground information such as borehole data.

(2) Creation of geomorphologic classification maps, etc.

1) Creation of geomorphologic classification map by topography interpretation

- If there is no geomorphologic classification map, the map must be created by topography interpretation using topographic maps, DEMs, aerial photographs, etc.
- If there is a previous geomorphologic classification map, it may be possible to simplify the creation of the

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map by referring to them.
2) Extraction and arrangement of man-made land
- With reference to old maps, aerial photographs, and construction materials, the area of reclaimed land in the water, backfills land after gravel collection, etc. is extracted as much as possible.
3) Arrangement of liquefaction occurrence history in past earthquakes
- The history of liquefaction in the target area is organized based on books, research papers, and materials.

(3) Evaluation/classification of liquefaction occurrence tendency
- Based on the geomorphologic classification map and the information of man-made land created in above (2), the liquefaction occurrence tendency is evaluated and classified using the five stages evaluation criteria shown in Table 1.

(4) Creation of “liquefaction trend map”
- Based on the evaluation result of the liquefaction occurrence tendency in above (3), “Liquefaction trend map” as map information is created at a scale of about 1:25,000.

4. Summary

The "liquefaction trend map" reported in this presentation will be posted as map information of the liquefaction hazard map and will be used together with other disaster learning information.

Keywords: liquefaction trend map, geomorphologic classification, liquefaction hazard map

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表-1　微地形分類に基づく液状化発生傾向の評価区分
Table 1 Evaluation criteria for liquefaction tendency based on geomorphologic classification

液状化発生傾向 Liquefaction tendency		微地形（自然地形）・人工改変地 Geomorphology (natural) / man-made land	
Strong 強		微地形 Geomorphology	**旧河道**（former river channel）、**砂丘縁辺部**（margin of sand dune）、**砂丘間低地・砂州間低地**（lowland between costal dunes and/or bars）
		人工改変地 man-made land	**埋立地**（filled land）、**砂利(砂鉄)採取後の埋戻地**（Backfilled site after collecting gravel and/or iron sand）、**低地(湿地)上の盛土造成地**（filled-up land on lowland and/or marsh）
		微地形 Geomorphology	**三角州・海岸低地**（delta and costal lowland）、**自然堤防**（natural levee）、**砂州上・砂丘上の凹地**（depression on sand dunes and/or bars）
		人工改変地 man-made land	**干拓地**（reclaimed land）、**浅い谷や凹地の盛土地**（filled-up land of shallow valley and/or depression）、**谷埋め盛土造成地**（filled-up valley）
		微地形 Geomorphology	**砂州・砂礫州**（marine sand and gravel bars）、**氾濫低地**（flood plain）、**後背低地**（back marsh）
		微地形 Geomorphology	**砂丘(砂丘縁辺部、砂丘間低地を除く)**（sand dune）、**扇状地**（alluvial fan）※1、**谷底低地**（Valley bottom lowland）
弱 Weak		微地形 Geomorphology	**山地・丘陵**（Mountain and hill）、**山麓堆積地形**（Mountain footslope）、**台地**（Terrace）※2

※1：盛土造成されていない「扇状地上の旧河道」を含む.
(Including the unfilled-up former river channel on the alluvial fan)
※2：盛土造成されていない「台地上の浅い谷・凹地」を含む.
(Including the unfilled-up shallow valley and/or depression on the terrace)

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[J] Oral | H (Human Geosciences) | H-DS Disaster geosciences

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

Sun. Jun 6, 2021 1:45 PM - 3:15 PM Ch.15 (Zoom Room 15)

This session discusses disaster risks being inherent in the natural and human environment, which sometimes happen to appear at a disaster, from the viewpoint of not only natural sciences but also social and human sciences. Examples of discussion subjects are as follows: uncertainty of forecasting disaster and problems of huge disaster with low frequency that raised from the 2011 Tohoku earthquake, the methodology for improving hazard maps, national recovery plans considering probable changes or sustainability of the society, international cooperation for disaster mitigation, problems of active faults or liquefaction, adjusting disaster mitigation plan to the regional characteristics, technical development for supporting disaster prevention, education for the disaster mitigation.

3:05 PM - 3:15 PM

[HDS08-07]Discussion

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Sun. Jun 6, 2021 3:30 PM - 4:30 PM JST | Sun. Jun 6, 2021 6:30 AM - 7:30 AM UTC | Ch.15 Zoom Room 15

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

This session discusses disaster risks being inherent in the natural and human environment, which sometimes happen to appear at a disaster, from the viewpoint of not only natural sciences but also social and human sciences. Examples of discussion subjects are as follows: uncertainty of forecasting disaster and problems of huge disaster with low frequency that raised from the 2011 Tohoku earthquake, the methodology for improving hazard maps, national recovery plans considering probable changes or sustainability of the society, international cooperation for disaster mitigation, problems of active faults or liquefaction, adjusting disaster mitigation plan to the regional characteristics, technical development for supporting disaster prevention, education for the disaster mitigation.

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

[HDS08-08] Current problems of submarine geological risks

*Kiichiro Kawamura[1] (1.Yamaguchi University)

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

[HDS08-09] **Verification of “Past” seismic intensity and estimation of “Future” ground motion by “Present-day” seismic observation: The Yanesen area**

*Motoko Ishise[1], Ryoichi Nakamura[1], Jun Muragishi[3], Shin'ichi Sakai[2,1] (1.Earthquake Reseach Institute, University of Tokyo, 2.Thr university of Tokyo III/GSII, 3.Yashima Gakuen University)

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

[HDS08-10] Characteristics of International Risk Communication over Trans-boudary Volcanic Disaster-The Case of 2010 Iceland Volcano Erution

*Mayumi Sakamoto[1], Haruhisa Nakamichi[2], Wakana Takahashi[3], Chizu Arashima[4], Masaru Arakida[5] (1.Graduate School of Disaster Resilience and Governance, University of Hyogo, 2.Disaster Prevention Research Institute, Kyoto University, 3.School of International Studies, Utsunomiya University, 4.Faculty of Global Communication, Kobe Gakuin University, 5.Asian Disaster Reduction Center)

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

[HDS08-11] Discussion

Current problems of submarine geological risks

*Kiichiro Kawamura[1]

1. Yamaguchi University

I show current problems of submarine geological risks in terms of off-shore wind powers in this presentation. Please discuss about them in this presentation.

Keywords: Submarine slides, Turbidity current, Mud volcano, Off-shore wind farm

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Verification of “Past” seismic intensity and estimation of “Future” ground motion by “Present-day” seismic observation: The Yanesen area

*Motoko Ishise[1], Ryoichi Nakamura[1], Jun Muragishi[3], Shin'ichi Sakai[2,1]

1. Earthquake Reseach Institute, University of Tokyo, 2. Thr university of Tokyo III/GSII, 3. Yashima Gakuen University

We aim to clarify the details of “Future” disastrous earthquakes and ground motions in the Tokyo metropolitan area based on the investigation of “Past” ground motion by using “Present-dat” seismic observation (e.g., Ishise et al., 2020).

In the last fiscal year, we surveyed and collected various historical documents on earthquake damage caused by the 1855 Ansei-Edo Earthquake in the Hokuso area. Then, based on the results of the survey, we conducted seismic observations in the area and reported that the regional variation in seismic intensity of moderate-size earthquakes is consistent with that of the Ansei-Edo Earthquake (Ishise et al., 2021). And since last fall, we have been conducting the same kind of survey and seismic observation in the Yanesen area, as in the Hokuso area. In this study, we introduce the observational study and share a vision of the future.

“Past” ground motion

(1) Survey of historical documents:

Through this survey, we discovered new historical document about the earthquake damage to Tennoji temple cause by the 1855 Anse-Edo earthquake. The newly discovered document includes 13 descriptions of the damage within the temple.

(2) Re-examination of reported historical documents:

We re-examined historical documents used to estimate the seismic intensity map of the Ansei-Edo earthquake. As a result, we found out that some of the location information needed to be corrected.

“Present-day” seismic observation

Since last September, we have been conducting temporary seismic observations using 19 seismometers in the Yanesen area. The locations of seismometers were selected based on analyses of historical documents. Seismic observations will continue until March 2021.

Tentative waveform analysis using some of data shows regional variations in amplitude and frequency components at each site. After the completion of the temporary observation, we plan to quantitatively examine the relative seismic intensity distribution obtained from this observation and the seismic intensity distribution inferred from the analyses using historical documents.

“Future” earthquakes and the ground motion:

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The seismological objective of this study is to predict the ground motion of future disastrous earthquakes, such as M7-class earthquakes in the Tokyo metropolitan area. To help with this, we plan to estimate detail site amplifications based on the present-day seismic observations to help make more realistic seismic intensity predictions. To do this, it is essential to develop a seismic observation network. Therefore, we are considering the construction of a super dense seismic network using seismic data obtained by Meso-net and SUPREME.

It is also important to know the distribution of strong motion caused by earthquakes as soon as possible after the occurrence of an earthquake. If seismometers are installed in advance at each site, they will be useful for in determining evacuation routes and priority of rescue operations. Furthermore, it is possible to start rebuilding livelihoods without survey by experts. In order to consider the construction of such a seismological observation system, we are conducting a pilot observation, which will be reported later.

Keywords: observational seismology, historical earthquake, estimation of seismic intensity

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Characteristics of International Risk Communication over Trans-boudary Volcanic Disaster-The Case of 2010 Iceland Volcano Erution

*Mayumi Sakamoto[1], Haruhisa Nakamichi[2], Wakana Takahashi[3], Chizu Arashima[4], Masaru Arakida[5]

1. Graduate School of Disaster Resilience and Governance, University of Hyogo, 2. Disaster Prevention Research Institute, Kyoto University, 3. School of International Studies, Utsunomiya University, 4. Faculty of Global Communication, Kobe Gakuin University, 5. Asian Disaster Reduction Center

This study tries to identify characteristics of international risk communication over trans-boundary volcanic disaster. By analyzing policy making processes over international air traffic disturbances caused by 2010 Icelandic volcano Eyjafjallajökull eruption, it tries to describe its characteristics.

The 2010 Icelandic volcanic eruption caused airport closures or flight cancelations in Europe which resulted in huge socio-economic damages. The International Civil Aviation Organization (ICAO) had prepared Volcanic Ash Contingency Plan for EUR Region in 2009, however the plan was not sufficient to solve the problem caused by eruption. ICAO set “zero tolerance” for aircraft flying over volcanic eruptions in order to avoid the risk of jet engine shutdowns. In order to solve the problem, "acceptable tolerance" was discussed based on science and technology data, suchg as in-situ ash forecast over Europe or jet engine tolerance to airborne particles were required.

This case demonstrated difficulty of international policy making under an emergent situation regarding to the issue which was not defined in existing systems, but requires precise science and technological data. As for the case of 2010 eruption, the following points were discussed.
The first was the improvement of a communication system to revise volcanic ash forecast. As for the 2010 eruption, the disaster response was decided based on the forecast by the London VAAC, which observes atmospheric volcanic ash clouds including Iceland. However, international communication systems among volcano monitoring institutes were vulnerable. After the eruption, interenational communication system was revised.

Second, the importance of science and technological data regarding to the jet engine tolerance to airborne particles. After the eruption, governments, air plane companies and research institutes examined the effect of volcanic ash to jet engines and discussed engine tolerance.

Third, the necessity of an international policy-making mechanism. After the eruption, video conferences were held by the Ministers of Transportation of EU member states, led by the European Commission, and provisional standards were discussed. After this disaster, the European Commission established the European Aviation Crisis Coordination Cell (EACCC) as a permanent institute for the risk management. The experience demonstrated the necessity of the international risk communication system to share in-situ information among different actors such as countries where volcanoes are located, countries which suffers by volcanic ash dispersion or organizations which monitor volcanic ash.

Keywords: trans-boundary volcanic disaster, Eyjafjallajökull, risk communication

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[J] Oral | H (Human Geosciences) | H-DS Disaster geosciences

[H-DS08] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi, P. Sato(College of Humanities and Sciences, Nihon University), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hiroshi Sato(College of Humanities and Sciences, Nihon University)

Sun. Jun 6, 2021 3:30 PM - 4:30 PM Ch.15 (Zoom Room 15)

This session discusses disaster risks being inherent in the natural and human environment, which sometimes happen to appear at a disaster, from the viewpoint of not only natural sciences but also social and human sciences. Examples of discussion subjects are as follows: uncertainty of forecasting disaster and problems of huge disaster with low frequency that raised from the 2011 Tohoku earthquake, the methodology for improving hazard maps, national recovery plans considering probable changes or sustainability of the society, international cooperation for disaster mitigation, problems of active faults or liquefaction, adjusting disaster mitigation plan to the regional characteristics, technical development for supporting disaster prevention, education for the disaster mitigation.

4:15 PM - 4:30 PM

[HDS08-11]Discussion

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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.14 Zoom Room 14

[H-TT19] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanaka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), W. Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology)

This session discusses various methods which acquire, store, analyze and visualize geospatial data, and presents the outcomes of empirical studies using GIS or mapping methods. The session also deals with applications of digital data, GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in Japanese.

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

[HTT19-01] Introduction

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

[HTT19-02] Map representation of estimated concentration distribution of $PM_{2.5}$ using WebGIS

*Junji Yamakawa[1] (1.Graduate School of Natural Science and Technology, Okayama University)

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

[HTT19-03] Proposal of nocturnal light data as a proxy variable for building height

*Go Kazawa[1], Daikichi SEKI[1], Yosuke Alexandre Yamashiki[1], Fusanori Iwasaki[2], Keola Souknilanh[3] (1. Graduate School of Advanced Integrated Studies in Human Survivability, 2.Economic Research Institute for ASEAN and East Asia, 3.Institute of Developing Economies, Japan External Trade Organization)

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

[HTT19-04] A Consideration of the Spatio-Temporal Expansion of "Deep Wonder" Evoked by Forest Image Archives

*Kazuhiko W. Nakamura[1] (1.The University of Tokyo)

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

[HTT19-05] An analysis of Children’s school route with GPS: A case study of 30 elementary schools in Toyama city

*Koji Ohnishi[1] (1.Department of Humanities, University of Toyama)

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

[HTT19-06] Red Relief Image Map using Hyper Resolution DEM, New Development of Topography recognition

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

[J] Oral | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT19] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanaka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), W. Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.14 (Zoom Room 14)

This session discusses various methods which acquire, store, analyze and visualize geospatial data, and presents the outcomes of empirical studies using GIS or mapping methods. The session also deals with applications of digital data, GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in Japanese.

9:00 AM - 9:15 AM

[HTT19-01]Introduction

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Map representation of estimated concentration distribution of $PM_{2.5}$ using WebGIS

*Junji Yamakawa[1]

1. Graduate School of Natural Science and Technology, Okayama University

Interval estimation is important information in the examination of $PM_{2.5}$ concentration distribution estimated by geostatistical methods. Especially when comparing the estimated concentration with other geographical information and statistical information such as national census, it is indispensable to examine the probability of the impact of the estimated concentration. In the study, a method of expressing the estimated concentration distribution of $PM_{2.5}$ and its confidence interval in Okayama city obtained by the Kriging method, which is one of the methods of geostatistics, using the WebGIS application was examined.
The target area in the study was the entire area of Okayama City, Okayama Prefecture, and the $PM_{2.5}$ estimation was base on the observation data were for 2017 FY (monthly values) published by the National Institute for Environmental Studies (http: //www.nies.go.jp/igreen/). JPGIS (Geographical Survey Institute, 2020), which is government-affiliated open data, was used as the geographic information data required for the analysis. GNU R (R core team, 2020) and Google Colab (Google, 2020) were used for geostatistical analysis. The jSTAT MAP (Statistics Bureau, Ministry of Internal Affairs and Communications, 2020) was used as the WebGIS in the study.
The spatial dependence of $PM_{2.5}$ observation data was estimated using a variogram, and the $PM_{2.5}$ estimated concentration distribution and its variance throughout Okayama City were obtained by the Kriging method. The mesh grid used for estimation used the Japanese 3rd Mesh code. Then, the estimated concentration distribution and its confidence interval were mapped using the jSTAT MAP. The exposure risk examined together with the census data was also expressed in the jSTAT MAP.
Since jSTAT MAP has built-in various geographic information and statistical information, it was possible to perform easily the qualitative comparison with the estimated concentration of $PM_{2.5}$, its confidence interval, and exposure risk with it. Also, since jSTAT MAP is a WebApp, no proprietary GIS application is required to mapping the $PM_{2.5}$ exposure risk assessment data. It is expected that it will be used more as one of the information disclosure means expressed on a map.

Keywords: WebGIS, jSTAT MAP, Kriging, PM2.5, Google Colab

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Proposal of nocturnal light data as a proxy variable for building height

*Go Kazawa[1], Daikichi SEKI[1], Yosuke Alexandre Yamashiki[1], Fusanori Iwasaki[2], Keola Souknilanh[3]

1. Graduate School of Advanced Integrated Studies in Human Survivability, 2. Economic Research Institute for ASEAN and East Asia, 3. Institute of Developing Economies, Japan External Trade Organization

In this study, we examine whether night light can be a proxy for building height.

The height of the building is a very important value for the damage situation of the city at the time of disaster and the urban design. However, building height data can only be obtained for high-rise buildings such as landmarks on Open Street, and it is necessary to purchase data to obtain height data including low-rise buildings nationwide. Another major disadvantage is that it is difficult to acquire data in chronological order. Building height data can be confirmed in chronological order, and user verification can be performed for various studies only after the aging of cities and towns.
In this study, we verified whether it is possible to estimate the height of a building with a high cost by using night light data whose time scale has been released in detail for free in recent years.

So far, active research has been conducted to estimate GDP using Night-Time Light Data. In particular, developing countries with low reliability of statistical data and rural poor areas that have not been surveyed in the first place have achieved very great results in the study area.
On the other hand, economic forecasts using satellite images in urban areas are not very active due to the coarseness of the spatial resolution of satellite images and the complex urban structure. In addition, since it is necessary to verify the accuracy of night light GDP estimation using data based on the presentations of each country, the difficulty of accuracy verification is described in various papers in developing countries due to its low reliability. It has been mentioned as an issue. When using night light to estimate GDP in this way, there is a strong tendency to choose a region.

In this study, we will verify whether it can be a proxy for the height of a building as a new usage of night light.
This takes advantage of the fact that the more floors a building have, the more light it has per unit area. Since this law is universal, it is possible to replace the height of buildings around the world with night light if the correlation between night light and building height can be found.
In this study, we used the 1m-resolution 3D data set released by Hyogo Prefecture for the first time in Japan on January 10, 2020, and the nighttime light data of the Suomi NPP satellite jointly managed by NOAA and NASA, which has been in operation since 2011. Correlation analysis was performed. Among the aerial laser survey results, it is obtained by the difference between the digital elevation model, which is a digital elevation model of the ground surface with buildings, vegetation, etc. removed from the digital surface model of the entire Hyogo prefecture, which is the numerical surface layer including the ground surface and buildings, vegetation, etc. Data on the height of buildings and vegetation above the ground surface. The observation period is from 2012 to 2013. In addition, there were no missing values in each of the Digital Surface Model and Digital Elevation Model. Since the observation period of Hyogo prefecture was from 2012 to 2013, the annual data of 2014 was used for the night light. The spatial resolution was about 450 meters, excluding outliers of the night light and setting the non-light areas to zero.

In order to classify the building as vegetation, the outer circumference data of the building was acquired

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from the basic map information of the Geographical Survey Institute, and the data of only the height of the building was extracted. The night light was layered, and the pixels with 70% or more of the buildings in the 450m square were selected, and the average height of the buildings in those pixels was correlated with the luminous intensity of the night light. The x-axis is the value of night light weighted and averaged by the number of observations in each month for the pixel, and the y-axis is the average height of the buildings in the pixel.

As a result of the correlation analysis, the number of data was 1028 and the coefficient of determination was 0.392. The null hypothesis was rejected because the P-value was well below the significance level of 0.05. In this way, it was found that the night light has a certain correlation with the height of the building. This can be evaluated as having a correlation even if the building uses data with a roughness of 70% or more in Pixel. We calculated more than 50%, more than 60%, more than 80%, and more than 90% of buildings in Pixel, but 70% or more was the most accurate result. In the future, we would like to conduct verification in other regions and countries to investigate whether there is any regional difference in the correlation between night light and building height.

Keywords: Night Time Light, Digital Surface Model, Suomi NPP

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A Consideration of the Spatio-Temporal Expansion of "Deep Wonder" Evoked by Forest Image Archives

*Kazuhiko W. Nakamura[1]

1. The University of Tokyo

In recent years, awareness of the importance of the connection between human society and natural environments, including forests, has been increasing. In this regard, it has become difficult to present the desirable state of this increasingly complex relationship based only on scientific evidence. Within this context, the significance of facing natural phenomena, which includes scientific uncertainty, is sometimes discussed in terms of the concept of wonder, especially in the field of pedagogy from the perspective of fostering the next generation. Schinkel (2017) has discussed the educational importance of wonder not only as a motivational effect but also as a way of making us aware of the limits of our understanding and has distinguished the latter as “deep wonder.” From a similar perspective, L’ Ecuyer (2014) considered the scope of wonder to be beyond mere curiosity and mentioned the visible expression called “beauty” as one of the properties of the environment that evokes wonder. When addressing issues at large spatio-temporal scales, such as climate change and biodiversity, which are important aspects for building a sustainable society, the perspective of "deep wonder" is important because it is difficult to avoid scientific uncertainty in this regard. However, it is extremely difficult to directly experience “deep wonder” as a visual expression. In this presentation, I will discuss the possibility of a virtual expansion of “deep wonder” using forest image archives since 1995. This is a case study of a method used to visualize phenomena virtually at a large temporal and spatial scale.

References:
L’ Ecuyer, C. (2014): The Wonder Approach to learning. *Front. Hum. Neurosci.* 8:764. doi: 10.3389/fnhum.2014.00764
Schinkel, A. (2017): The Educational Importance of Deep Wonder. *Journal of Philosophy of Education*, 51: 538-553. doi: 10.1111/1467-9752.12233

Keywords: Cyberforest, environmental education, image archive

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An analysis of Children’ s school route with GPS: A case study of 30 elementary schools in Toyama city

*Koji Ohnishi[1]

1. Department of Humanities, University of Toyama

In Toyama City, a wireless network using LPWA was constructed in 2018 as a smart city project. Using this IoT, Toyama city is conducting a project to watch over children on school routes. Every elementary school districts will be surveyed the school routes safety by GPS sensors. These sensors are curried by children with their bags, so that we can grasp the state of going to and from school. The purpose of this study is that I analyze the relationship between regional characteristics and the expansion of children's activity spaces with the data of this project from 2018 to 2020. 30 schools data was obtained in the project from 2018 to 2020. The GPS data is obtained at 1-minute intervals, and was visualized and analyzed on GIS. It was found that most elementary schools go to school in groups, and they use the school route to go to school around at 7:45 when the school entrance opens. As a result, there were places where children stayed around the school, and that it was necessary to give consideration to traffic safety in those areas. In addition, it can be seen that children stay at pedestrian bridges and large intersections. It was also found that when the school district is wide, there is a difference in the morning commuting start time of children. On the other hand, it was found that the time of leaving school differs. It depends on the grade, and the start time of transportation to and from after-school care and lessons. In areas differences, far from the city center, they often are taken out by their parents to go some kinds of lessens to city center area or shopping center especially lower grades. At schools near the city center, it was found that these activities could start after they return to their home. In this way, it became clear that the quality and extent of the children's after-school activity space differed depending on the distance from the central city area.

Keywords: GPS, Children, school route

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Red Relief Image Map using Hyper Resolution DEM, New Development of Topography recognition

*Tatsuro Chiba[1], Makoto Ohashi[1]

1. Asia Air Survey Co., Ltd.

1. Introduction

Precise resolution DEM made by airborne LiDAR measurement is getting available. Elevation data of Well distributed Fundamental Geospatial Data (DEM) 5 m Mesh made by LiDAR of Geospatial Information Authority of Japan has been useful for understanding topography. Red Relief Image Map, hereinafter called RRIM (Chiba et al., 2004) is a visualization method which is improved slope map, but not include altitude information. RRIM with overlapping contour map make topography understanding more easily. The problem when overlapping RRIM with 5m DEM and GSI Map of level 15 is that RRIM looks significantly jaggy and is difficult to grasp topography. The resolution of GSI Map level 15 is around 50cm, but DEM 5m ten times lower. It does not solve the issue to make higher resolution DEM by image processing.
This study reports that RRIM with hyper resolution DEM applying interpolation and moving average is decreasing jaggy and increasing three-dimensional effect. Fundamental work-flow of this methodology and several case studies are described.

2. Methodology

Matrix data is split by n times both for X and Y direction. It is desirable that n is odd number. By linear interpolation is acceptable experientially. Loop process for moving average is applied until jaggy becoming inconspicuous. Too much loop process make the result smooth, but deviate from initial value. RRIM is made using hyper resolution DEM. When n equal 9, data volume is 81 times bigger. Since considering mesh number of positive openness and negative openness are becoming n times, computing time is getting longer.

3. Case studies

The comparison between RRIM using 5m resolution DEM and RRIM using Hyper resolution DEM on Asahi-ku, Yokohama City are shown (Fig. 1).Orthogonal roads in the developed residential area and slope feature in the surround hill area are clearly seen as well. The topography of terrace paddy field is better reproduced by Hyper resolution DEM, which was open to the public as WebGIS at Map Gallery of Esri User Conference 2020.[2)]

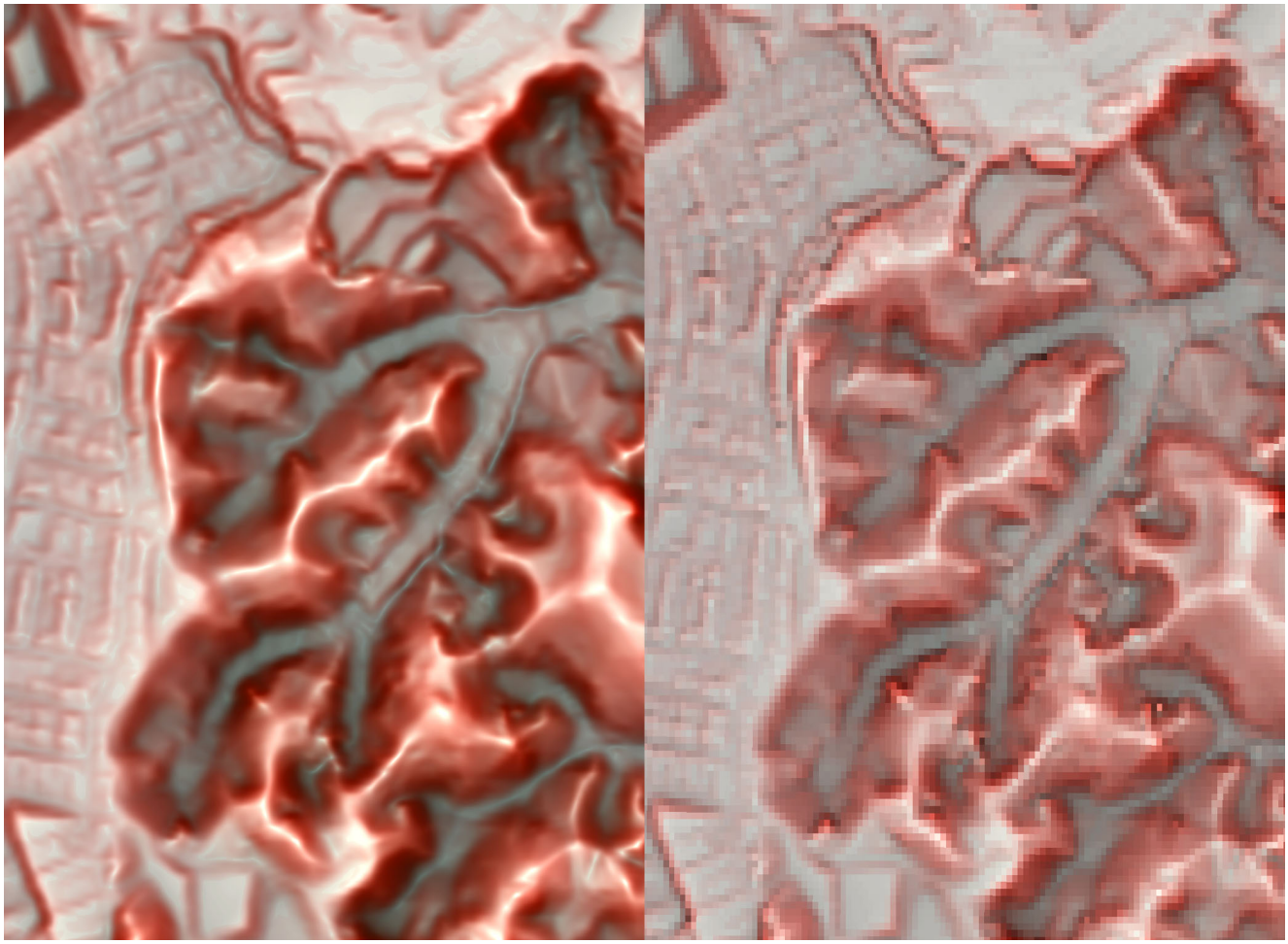
4. Conclusion

RRIM using Hyper resolution DEM visualize topography more smooth and easy to understand, and having high visibility when overlapping with GSI Map.The difficulty is that computing time is 100 times longer than previous method.

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Reference
1) Tatsuro Chiba and Yusuke Suzuki (2004) Red relief image map,new topographical expression method, Proceedings of Applied Surveys, 15, 81-89.
2) Chiba T. and Ohashi M. (2020) Red Relief Image Map using Hyper Resolution DEM, ESRI map gallery 2020 User Conference, https://mapgallery.esri.com/map-detail/5efa4698f3b616cb34d9e11e

Keywords: RED RELIEF IMAGE MAP, Terrain visualization, GIS



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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.14 Zoom Room 14

[H-TT19] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanaka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), W. Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazuhiko W. Nakamura(The University of Tokyo)

This session discusses various methods which acquire, store, analyze and visualize geospatial data, and presents the outcomes of empirical studies using GIS or mapping methods. The session also deals with applications of digital data, GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in Japanese.

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

[HTT19-07] Relationship between the Image of the Town and the Seams of Asphalt Pavement Works

*Kazunari Tanaka[1], Miku Ogawa[1], Hitomi Tsukioka[1] (1.Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology)

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

[HTT19-08] On Spatial Cognition of Children by Distortion and Color on the Cognitive Map

*Ami Hasegawa[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

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

[HTT19-09] On Evaluation of Environmental Sound by Degree of Human Concentration

*Haru Kanda[1] (1.Osaka Institute Technology)

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

[HTT19-10] On the Meaning of Affordance and Personal-Space in the COVID-19

*Kazuki Miyake[1], Shota Tanaka[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

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

[HTT19-11] Discussion

Relationship between the Image of the Town and the Seams of Asphalt Pavement Works

*Kazunari Tanaka[1], Miku Ogawa[1], Hitomi Tsukioka[1]

1. Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology

In general, civil engineering work, based on various underlying plans in the city is carried out as a different project. Therefore, the attractiveness of the completed cityscape may be totally canceled even if a part of areas or individual buildings are good.

Attractive urban development has been considered for buildings and structures on the ground. For example, the undergrounding of buildings and electric wires with a sense of unity, and the maintenance of green spaces such as rows of trees. However, much attention has not been paid to the road surface of the road asphalt that has been peeled off and buried when each construction.

The purpose of this study is to explore the relationship between the condition of this asphalt and the image of the city.

In this study, we focus on the traces of general asphalt pavement work. We will explore the image that people have without noticing, focusing on the state of seams where the difference in texture of asphalt pavement is conspicuous, the size of construction marks, and the difference in color. In addition, by conducting psychological experiments on the consistency between the frontage of surrounding buildings and the size of the pavement, we extract the images which we have without knowing it daily.

In this study, we conducted three experiments to grasp the state of the seams of asphalt pavement, which makes us feel uncomfortable, to extract the sense of harmony due to the slight difference in color of the road surface, and to see the relationship between the building and the pavement traces.

By the experiment using the samples arranging two asphalt pavements with different textures in close contact with each other, we extracted a range that does not feel strange. As a result of conducting experiments on 180 subjects for 7 samples, it was found that the difference in aggregate particle size was within 25%, and that no discomfort was felt when the particle size was fine.

Next, for color combinations, an experiment using 30 colors extracted from actual pavement was conducted on 180 subjects. As a result, it was clarified that although no clear result was obtained, it felt natural in cases other than the contrasting colors.

Finally, a psychological experiment was conducted by the Paired Comparison Method on the relationship between the frontage of the building and the size of the asphalt pavement trace. Based on the results of the experiments so far, we compared the psychological amount of the consistency between the size and the frontage using the preferred pavement. As a result, it became clear that the size of the construction site and the consistency with the frontage affect the impression of a good cityscape.

Keywords: Asphalt, Road surface, Cityscape, Street

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On Spatial Cognition of Children by Distortion and Color on the Cognitive Map

*Ami Hasegawa[1], Kazunari Tanaka[1]

1. Osaka Institute of Technology

With the development of transportation means by improving road and railway spaces, our lives have developed remarkably. On the other hand, traffic spaces may deprive children of playgrounds outside and have negative physical and mental impact on them. In order to solve such problems in public spaces, by clarifying the differences in objects and places that adults and children find attractive, urban space design that both adults and children find attractive is created. I think it should be suggested. In addition, I think it is important for future town development to clarify whether the intentions of adults are being conveyed to children.

While creating a city where adults feel comfortable and comfortable to live in, and the scenery is good, to create a livable city or town, it is important to conserve attractive places for children to play. One of the tasks of urban planning is to create a town where children want to continue living even when they grow up. For this, we need to understand in what ways children find it attractive. Regarding the parks, streets, rivers, etc., it is necessary to know how children perceive the space.

The purpose of this study is to identify the parts of the city that appeal to children, analyzing the cognitive maps drawn by them. Ultimately, the goal is to propose an urban space that will be enjoyable, fun, comfortable and safe for children and adults as well.

There are two research methods for this study. One is a route selection experiment based on the Paired Comparison Method using photographs. By grasping the components of each photograph, the “taste” of the road is analyzed. The other is to conduct a survey using the Basic Drawing Method, where we extract elements that are recognized.

As a research method, I conduct a survey using the Basic Drawing Method, where we extract elements and the colors. I explore the size of the cognitive space and the place where consciousness is easy to direct that are recognized.

From the results of the Basic Drawing Method, it was found that children perceived what they usually see more honestly than adults.

Keywords: Cognitive Map, Distortion, Color, Image

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On Evaluation of Environmental Sound by Degree of Human Concentration

*Haru Kanda[1]

1. Osaka Institute Technology

Currently, COVID-19 is changing the learning environment of students and the working environment of office workers. In this study, we focus on the environmental sound, clarify the difference in the environment of residential areas, which is different from schools, companies, educational districts and office areas, from the viewpoint of concentration. In this study, we clarify the factors that lead to comfort from the two points of deep psychology and physiological response. This result should be useful for future design. In the physiological response experiment, brain waves, which are closely related to concentration, were measured and analyzed.
Before conducting the psychological experiment, the environmental sounds used in the experiment were collected from the subjects as a preliminary survey, and the representative sounds were selected after grouping the environmental sounds. The subjects were shown a limited environmental sound and evaluated the degree to which they could concentrate in five stages. The average value of human speech was 2.89 indoors at home and 2.19 during university lectures. A possible cause for this is the difference in the recognition range of environmental sounds obtained from the preliminary survey, and the number of people who recognize human speech as environmental sounds is higher during university lectures. Furthermore, since it was confirmed from some environmental sounds that the results were divided into two, the cause was analyzed. In addition, as a result of considering the correlation of the average values, regularity was found.
Experiments on physiological reactions were performed using a simple electroencephalograph (EMOTIV EPOC X). EMOTIV EPOC X can measure β wave by dividing it into two types, High β and Low β, and this time, we measured α wave and Low β wave, which are considered to be particularly affected. In the experimental method, the subjects were asked to solve 12 simple arithmetic operations by mental arithmetic, and at that time, the subjects were asked to listen to the sound source created as a sound stimulus at the same time as each environmental sound. The brain waves at that time were measured and compared with psychological experiments for analysis. Comparing the data obtained from the electroencephalogram measurement with the data obtained from the psychological experiment, the four things that actually matched were the sound of turning paper, the clock, the chirping of birds, and the voice of a person. It was found that the most human voice among them hindered concentration.It was also found that the sound of turning paper and the chirping of clocks and birds are environmental sounds that do not interfere with concentration.
In this study, experiments were conducted from two directions: psychological experiments and physiological experiments. Although there was some discrepancy between the auditory image and the response from the sound stimulus, it was noticeable that human speech had an adverse effect on concentration. In this experiment, we fixed the space and let the subject listen to it, and considered the effect of only sound on concentration, but it is also necessary to investigate how changing the space affects concentration.

Keywords: Sound, Pollution, Brain waves

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On the Meaning of Affordance and Personal-Space in the COVID-19

*Kazuki Miyake[1], Shota Tanaka[1], Kazunari Tanaka[1]

1. Osaka Institute of Technology

The chair affords to sit, and the pencil affords to write. Humans get information from the environment and change their behavior. For example, a seat in a university lecture, a seat in a train, a position in an elevator, and so on. In 2020 people's lives have changed due to the spread of telecommuting, online lessons, and delivery services due to the influence of the new covin-19.Behavior is restricted, such as restrictions on admission to shopping malls, stores that cannot be entered without disinfection and temperature measurement, and restrictions on the use of benches and chairs. However, I think that there were other restrictions on people's behavior. I think it is a constraint on psychological behavior such as the sense of distance between people (personal space). The purpose of this study is to investigate how the surrounding environment affects our behavioral choices and how they change.

We compare our behavioral choices before and after the outbreak of the new covin-19 and investigate affordances and changes in personal space during the covin-19. Investigate behavioral restrictions and affordance changes during the covin-19. As a result of the experiment of seat selection in the train by a questionnaire using the presence or absence of a mask, it was found that people's behavior choices changed depending on the presence or absence of a mask. Secondly, we investigate whether there was a difference in the distance between the waiting positions in the station yard of a person depending on the presence or absence of a mask. As a result, there was not much difference between the position of the person standing behind the person without the mask and the wearing the mask. The cause may be that the presence or absence of the mask is not recognized. Finally, we conducted a post-epidemic personal space survey of the new coronavirus with and without masks. There was no big difference in personal space However, the value of personal distance changed to the value of social distance due to the influence of covin-19.

Keywords: Personal-Space, Affordance, mask

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[J] Oral | H (Human Geosciences) | H-TT Technology & Techniques

[H-TT19] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanaka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), W. Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazuhiko W. Nakamura(The University of Tokyo)
Sun. Jun 6, 2021 10:45 AM - 12:15 PM Ch.14 (Zoom Room 14)
This session discusses various methods which acquire, store, analyze and visualize geospatial data, and presents the outcomes of empirical studies using GIS or mapping methods. The session also deals with applications of digital data, GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in Japanese.

11:45 AM - 12:15 PM

[HTT19-11]Discussion

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.15 Zoom Room 15

[H-CG26] Adaptation to climate change and its social implementation

convener:Hiroya Yamano(National Institute for Environmental Studies), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(University of Tsukuba), Makoto Tamura(Global and Local Environment Co-creation Institute, Ibaraki University), Chairperson:Hiroya Yamano(National Institute for Environmental Studies), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(University of Tsukuba), Makoto Tamura(Global and Local Environment Co-creation Institute, Ibaraki University)

The impacts of climate change will increase in the risks to societies through increased intensities of typhoons and torrential rains, changes in the distribution of organisms, deterioration in quality and yield in the agriculture, forestry and fisheries, etc. In response to this, Japan enforced "Climate Change Adaptation Act" in 2018, aiming to minimize or avoid the damage caused by climate change, and to build a sustainable society.
In this session, toward planning adaptation to climate change and enhancing its social implementation based on scientific knowledge, we will discuss about generation of climate change projection data, assessment of the impacts and risks of climate change in various fields, as well as social implementation of adaptation plans by co-creation with stakeholders and/or by local climate change adaptation acts.

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

[HCG26-01] Enhancing resilience of atoll islands against sea level rise

★Invited Papers

*Hajime Kayanne[1], Masafumi Fujita[2], Nori Fujita[1], Takashi Hosono[3], Yoich Ide[4], Yuji Kuwahara[2], Fumiko Matsudate[13], Satoru Mimura[5], Nobuko Nakamura[6], Susumu Onaka[7], Daisaku Sato[8], Tomoko Takeda[9], Koji Yamada[10], Toru Yamaguchi[11], Hiroya Yamano[12], Hiromune Yokoki[2] (1.the University of Tokyo, 2.Ibaraki Univ., 3.JAMSTEC, 4.Oceanic Planning Corp., 5.JICA, 6.Sasakawa Peace Foundation, Ocean Policy Res. Inst., 7.Nippon Koei, 8.Setsunan Univ., 9.IGES, 10.Japan Construction Information Center Found., 11.Keio Univ., 12.National Inst. Environmental Studies, 13.Heart Biz)

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

[HCG26-02] Developments of future climate scenario selection method for impact and adaptation studies

*Hideo Shiogama[1], Noriko N. Ishizaki[1], Naota Hanasaki[1], Kiyoshi Takahashi[1], Seita Emori[1], Rui Ito[2,3], Toshiyuki Nakaegawa[3], Izuru Takayabu[3], Yasuaki Hijioka[1], Yukari N. Takayabu[4], Ryosuke Shibuya[4] (1.National Institute for Environmental Studies, 2.Japan Meteorological Business Support Center, 3.Meteorological Research Institute, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[HCG26-03] Added values of regional multi-ensemble statistical downscaling approach in CORDEX Asia

*KOJI DAIRAKU[1] (1.University of Tsukuba)

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

[HCG26-04] Temperature rises and extreme rainfall intensity derived from observations and d4PDF in Japan

*Sayaka Yoshikawa[1,3], Megumi Watanabe[2], Shinjiro Kanae[3] (1.Ibaraki university, 2.The university Tokyo, 3.Tokyo institute of technology)

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

[HCG26-05] Adaptation measures based on future projections of corals and macroalgae, use/conservation status on the southwest coast of Shikoku

*Hiroya Abe[1], Haruka Suzuki[1], Yuko F Kitano[1], Naoki H Kumagai[1], Satomi Mitsui[1], Hiroya Yamano[1] (1.National Institute for Environmental Studies)

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

[HCG26-06] Workshop on Disaster Prevention Training to Improve Disaster Preparedness of Local Governments and Staff: As Part of Social Implementation of Disaster Prevention Policy for Climate Change Adaptation

*kouhei yoshimura[1,2], Seigo Nasu[2], Shingen Horiuchi[3] (1.Nippon Koei, 2.Kochi University of Technology, 3.Kochi City)

Enhancing resilience of atoll islands against sea level rise

*Hajime Kayanne[1], Masafumi Fujita[2], Nori Fujita[1], Takashi Hosono[3], Yoich Ide[4], Yuji Kuwahara[2], Fumiko Matsudate[13], Satoru Mimura[5], Nobuko Nakamura[6], Susumu Onaka[7], Daisaku Sato[8], Tomoko Takeda[9], Koji Yamada[10], Toru Yamaguchi[11], Hiroya Yamano[12], Hiromune Yokoki[2]

1. the University of Tokyo, 2. Ibaraki Univ., 3. JAMSTEC, 4. Oceanic Planning Corp., 5. JICA, 6. Sasakawa Peace Foundation, Ocean Policy Res. Inst., 7. Nippon Koei, 8. Setsunan Univ., 9. IGES, 10. Japan Construction Information Center Found., 11. Keio Univ., 12. National Inst. Environmental Studies, 13. Heart Biz

In the course of global warming, the sea level is projected to rise by 0.3 to 1.1 meters in this century, and by more than 5 meters in three centuries in the worst-case scenario. Atolls consist of low-lying land with an elevation of 1 to 4 meters, and are under threat of being submerged by rising sea levels. There are about 500 atolls globally, and about 400 of them are distributed in the Pacific Ocean. Tuvalu, Kiribati, and the Republic of the Marshall Islands in the Pacific Ocean, and the Maldives in the Indian Ocean are all atolls. These countries are in a critical situation due to global warming caused by CO_2, which they themselves emit little of. Therefore, they are appealing to the international community to join with other small island states to reduce global warming and support adaptation measures against sea level rise (Alliance of Small Island States). In response to this appeal, international support such as the Green Climate Fund (GCF) is being planned for adaptation to climate change. Atoll nations are anticipating sea walls and land reclamation as effective measures against sea level rise.

Atoll islands are formed by calcium carbonate skeletons of coral and foraminifera, which were washed up on the platform of coral reefs created by corals. The coral reefs were established 4,000 years ago, when sea level rise during the postglacial period stabilized, and atoll islands were constructed and inhabited as sea level fell by 1-2 m from 2,000 years ago (Yamaguchi et al., 2007; Kayanne et al., 2011). In atoll countries such as the Republic of the Marshall Islands and Tuvalu, the concentration of populations in the capital islands has led to the expansion of residential areas into low marshes and storm ridges, which are particularly vulnerable in atoll island landforms (Yamano et al., 2007). In addition, domestic wastewater from increasing population has created a reductive environment on the coast, degrading coral reef ecosystems and replacing coral communities with algae, thus reducing the resilience of the atoll islands against sea level rise (Fujita et al., 2013; Nakamura et al., 2020). Construction of causeways and dredge of shipping channels, piers, vertical seawalls by piling up stones also inhibit sand drift and accumulation.

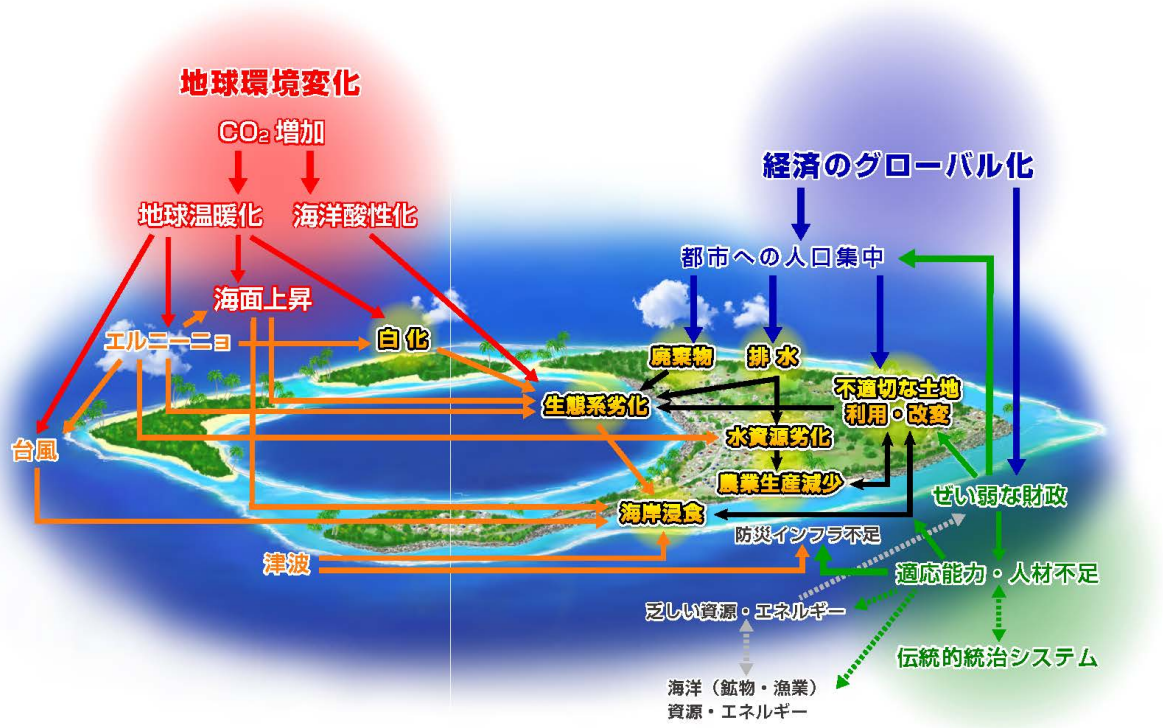
The problem of atolls is not as simple as submergence by sea level rise, but a complex problem caused by the expansion of inhabitable areas into vulnerable areas, the degradation of ecosystems due to environmental deterioration, and the diminishing restoration potential of the beach due to artificial coastal structures. In order to maintain atolls against future sea level rise, global warming and sea level rise must be suppressed as much as possible, and the resilience of the land must be rehabilitated through ecosystem restoration. The restoration of ecosystems will also contribute to the improvement of the basic environment of the atoll countries. From this perspective, Tuvalu implemented a beach reclamation project on Fongafale Island in Funafuti Atoll, the capital of Tuvalu, in 2015 with the technical cooperation of JICA (Onaka et al., 2017). Beach reclamation is a practical example of green infrastructure that does not interfere with the natural sand deposition process on the island.

However, Tuvalu has since planned a large-scale land reclamation project with the support of the GCF. Tuvalu's desire for short-term, tangible measures that will lead to the expansion of its small land area is

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understandable. Green infrastructure as an ideal cannot be forced on them that do not yet have sufficient gray infrastructure. However, it is necessary to evaluate the stability of reclaimed land against external forces and the danger that reclamation will lead to environmental degradation in the long run, which is not sustainable and will inhibit the formation of atoll islands. The application of the best mix of green infrastructure and gray infrastructure such as seawalls and landfills, under a long-term perspective, must be based on the demands of the local government and residents, and an approach to gaining local understanding is essential for this purpose.

Keywords: atoll islands, sea level rise, resilience, Tuvalu



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Developments of future climate scenario selection method for impact and adaptation studies

*Hideo Shiogama[1], Noriko N. Ishizaki[1], Naota Hanasaki[1], Kiyoshi Takahashi[1], Seita Emori[1], Rui Ito[2,3], Toshiyuki Nakaegawa[3], Izuru Takayabu[3], Yasuaki Hijioka[1], Yukari N. Takayabu[4], Ryosuke Shibuya[4]

1. National Institute for Environmental Studies, 2. Japan Meteorological Business Support Center, 3. Meteorological Research Institute, 4. Atmosphere and Ocean Research Institute, The University of Tokyo

Climate change impact assessment studies often use future projections of only a few global climate models (GCMs) due to limited research resources. Here we develop a novel method to select a small subset of GCMs that widely capture the uncertainty range of large ensemble. By applying this method, we select a subset of five GCM projections from the Coupled Model Intercomparison Project Phase 6 (CMIP6) ensemble for impact and adaptation studies in Japan. At first, we omit GCMs whose global warming projections have been evaluated to be overestimated in the recent literature. Then, we select a subset of five GCMs that widely captures the uncertainty ranges for 8 climate variables and have good performances in present-climate simulations. These selected GCM simulations will be used to provide better climate scenarios for impact and adaptation studies than those in the previous impact assessment project.

Keywords: Climate change, Adaptation, Climate scenarios

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Added values of regional multi-ensemble statistical downscaling approach in CORDEX Asia

*KOJI DAIRAKU[1]

1. University of Tsukuba

To develop reliable regional climate information for climate change adaptation measures, we assess added values of regional multi-ensemble dynamical and statistical downscaling in collaboration with researchers of geoscience, social science and humanities, and officials of local governments in Japan and CORDEX Asia.

Though we have conducted dynamical downscaling experiments with horizontal grid spacing of 5km and 2km to reproduce regional climate information using database for Policy Decision making for Future climate change (d4PDF) to detect the climate change impact in this region, it is not enough to investigate its uncertainty caused by the structural differences in models.

Multi-model large ensemble regional climate scenarios over Japan and CORDEX Asia are developed by using CMIP5 GCMs and two statistical downscaling approaches (Bias Corrected Spatial Disaggregation (BCSD) and Bias Correction and Constructed Analogs(BCCA)) to investigate uncertainty of projected change associated with structural differences of the GCMs for the periods of historical climate (1950-2005) and near future climate (2026-2050).

This research for uncertainty information of the regional climate scenarios is intended to provide end-users to make an informed selection and decision making.

Keywords: Downscaling, Multi-model ensemble, CORDEX, Asia

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Temperature rises and extreme rainfall intensity derived from observations and d4PDF in Japan

*Sayaka Yoshikawa[1,3], Megumi Watanabe[2], Shinjiro Kanae[3]

1. Ibaraki university, 2. The university Tokyo, 3. Tokyo institute of technology

The intensification of heavy rainfall in a warmer climate could follow the Clausius-Clapeyron (CC) relationship (7%/℃). Although there are studies which depict the intensification of heavy rainfall based on numerical climate model simulations, analyses based on observed records are limited in terms of whether the intensification eventually follows the CC relationship. In this study, we try to analyze whether the CC scaling can be applied to the intensification of heavy rainfall over Japan using observation data and a large-ensemble climate simulation database, namely d4PDF. We clarified the following three things. First, the intensification rate of sub-daily extremes is higher than that of daily extremes. Second, the intensification rate of rainfall extremes derived from climate models with a multiple ensemble coincides with that derived from observations. Third, the intensification rate of rainfall extremes under huge amounts of simulation results derived from climate models from the past to the future periods are less than those of the CC relationship. Although a large ensemble of climate simulations is a powerful tool for estimating extreme rainfall under climate change in the future, intensification rate of rainfall extremes derived from climate models in the future periods could be underestimated compared with those in the past periods.

Keywords: Clausius-Clapeyron, extreme rainfall, observations, climate model, warmer climate

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Adaptation measures based on future projections of corals and macroalgae, use/conservation status on the southwest coast of Shikoku

*Hiroya Abe[1], Haruka Suzuki[1], Yuko F Kitano[1], Naoki H Kumagai[1], Satomi Mitsui[1], Hiroya Yamano[1]

1. National Institute for Environmental Studies

Range expansion of reef-building corals, a decline of macroalgal beds, and changes in constituent species for coral community and/or macroalgal beds have been reported in many temperate seas. Not only mitigation but also adaptation is important for the measures against climate change. Consideration of adaptation measures depending on local conditions such as the degree of environmental changes and industrial structure is necessary when the measures will be implemented. This study focused on the marine protected area (Ashizuri-Uwakai National Park) and its surrounding area on the southwest coast of Shikoku Island. This area is characterized by a very large north-south gradient in water temperature and the distribution of corals and macroalgae along with it. The main objective of this study was to consider what adaptation measures are desirable for each region and industry in response to the changes in coastal ecosystems (coral community and macroalgal bed). In order to achieve this objective, we assessed the underwater landscape with a focus on corals and macroalgae that dominates the study area and evaluated how these biological resources are used and conserved in the local tourism and fishery industries. The potential distribution of reef-building coral (*Acropora solitaryensis* complex, *A. hyacinthus* complex, *Pocillopora damicornis*), macroalgae (kelps: *Ecklonia cava kurome*, temperate *Sargassum S. hemiphyllum*, tropical *Sargassum S. ilicifolium*), and their predators (coral-eating seastars *Acanthaster* cf. *solaris* and herbivorous fish *Siganus fuscescens*) in the 2090s under the RCP2.6 and RCP8.5 scenarios were projected using a simulated sea surface temperature dataset with high-spatial-resolution (FORP-JPN02 by SI-CAT). After projecting the coastal ecosystem changes and organizing the current use/conservation of coastal ecosystems, we gave examples of what specific adaptation measures should be taken in each area for three fields, i.e., biodiversity conservation, fisheries, and tourism. Assuming the 2090s, though drastic changes in the coastal ecosystem are not projected compared to the present state under the RCP2.6 scenario, as coral distribution moves north, feeding damage by coral-eating seastars is projected to become a problem. Therefore, the expansion of protected areas and the promotion of conservation activities are a major task for coral ecosystem conservation. In municipalities where coral monitoring and conservation activities are not currently being carried out, it is necessary to establish a system for such activities. Also, the challenge is to utilize them as a new tourism resource and to develop tourism facilities in areas where corals are increasing. On the other hand, under the RCP8.5 scenario in the 2090s, it is important to take appropriate conservation measures for macroalgae and grazing pressure on macroalgae will be increased due to extremely elevated water temperature. Moreover, since coral growth becomes difficult to achieve, the creation of alternate or new tourism resources must be needed. Any of the emission scenarios may cause changes in vegetation, and adaptation measures such as changing the target species of fish catches in coastal fisheries and enhancing aquaculture of fish species tolerant to high water temperature may be necessary. This research could represent coastal ecosystem changes in the future with high spatial resolution and adaptation measures based on the changes for each municipality. In the future, we plan to improve methods for projecting the future distribution of corals and macroalgae, clarify connectivity, and identify areas that are less susceptible to climate change. This study was conducted as a part of “Regional Adaptation Consortium Project” by the Ministry of the

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Environment, Japan.

Keywords: coral community, macroalgal bed, climate change, adaptation, utilization, conservation

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Workshop on Disaster Prevention Training to Improve Disaster Preparedness of Local Governments and Staff: As Part of Social Implementation of Disaster Prevention Policy for Climate Change Adaptation

*kouhei yoshimura[1,2], Seigo Nasu[2], Shingen Horiuchi[3]

1. Nippon Koei, 2. Kochi University of Technology, 3. Kochi City

Disaster prevention policies as climate change adaptation are important. The government has modified laws to reflect climate change. Local governments that actually implement disaster prevention policies to protect citizens are now required to prepare for the largest flood events. However, it is difficult to protect against floods that will expand due to climate change.

Therefore, government-led soft measures, such as the provision of information through hazard maps in advance and evacuation guidance at the time of a disaster, will be the main solution.

Local governments are under pressure to cope with floods, which are expected to change more drastically than in the past, and are obliged to save lives, including those of the elderly and other vulnerable people. However, it is difficult for disaster management departments to conduct specialized simulations that take into account the effects of climate change.

Kochi University of Technology (KUT) and Kochi City Office have established a cooperative system as part of the SI-CAT, and cooperated to conduct a disaster prevention workshop style drill conducted by the Disaster Prevention Policy Division. This Division conducted a more practical drill using data on inundation analysis provided by KUT.

Under the current situation, staff members consider and implement countermeasures only after the damage is reported. Therefore, there was a time lag between the occurrence of damage and the implementation of countermeasures to demonstrate their effectiveness. If damage forecasts were shared and countermeasures were implemented in advance, the time lag would be reduced and evacuation orders and post-flood recovery activities can be carried out smoothly according to damage reports and damage expansion forecasts. In the discussions between KUT and division supervisor, we were able to find that this flow is the ideal image to aim for in disaster response.

In Kochi City, heavy rainfall is difficult to predict meteorologically, and it takes only a few hours for floodwaters to reach urban areas after heavy rains occur. Therefore, the government needs to protect the lives of citizens and respond quickly.

The purpose of the "Disaster Countermeasures Headquarters Workshop Training" is to improve disaster response capabilities as senior officials through imagining the damage and countermeasures. The two main points of the training were to "estimate future response items based on the situation at the time of the disaster" and "understand the necessity to start considering disaster response as early as possible. In February, as a test case, a trial drill was conducted with several groups of senior officials.

As a prologue, the recent torrential rain disasters were explained. Furthermore, as a common scenario,

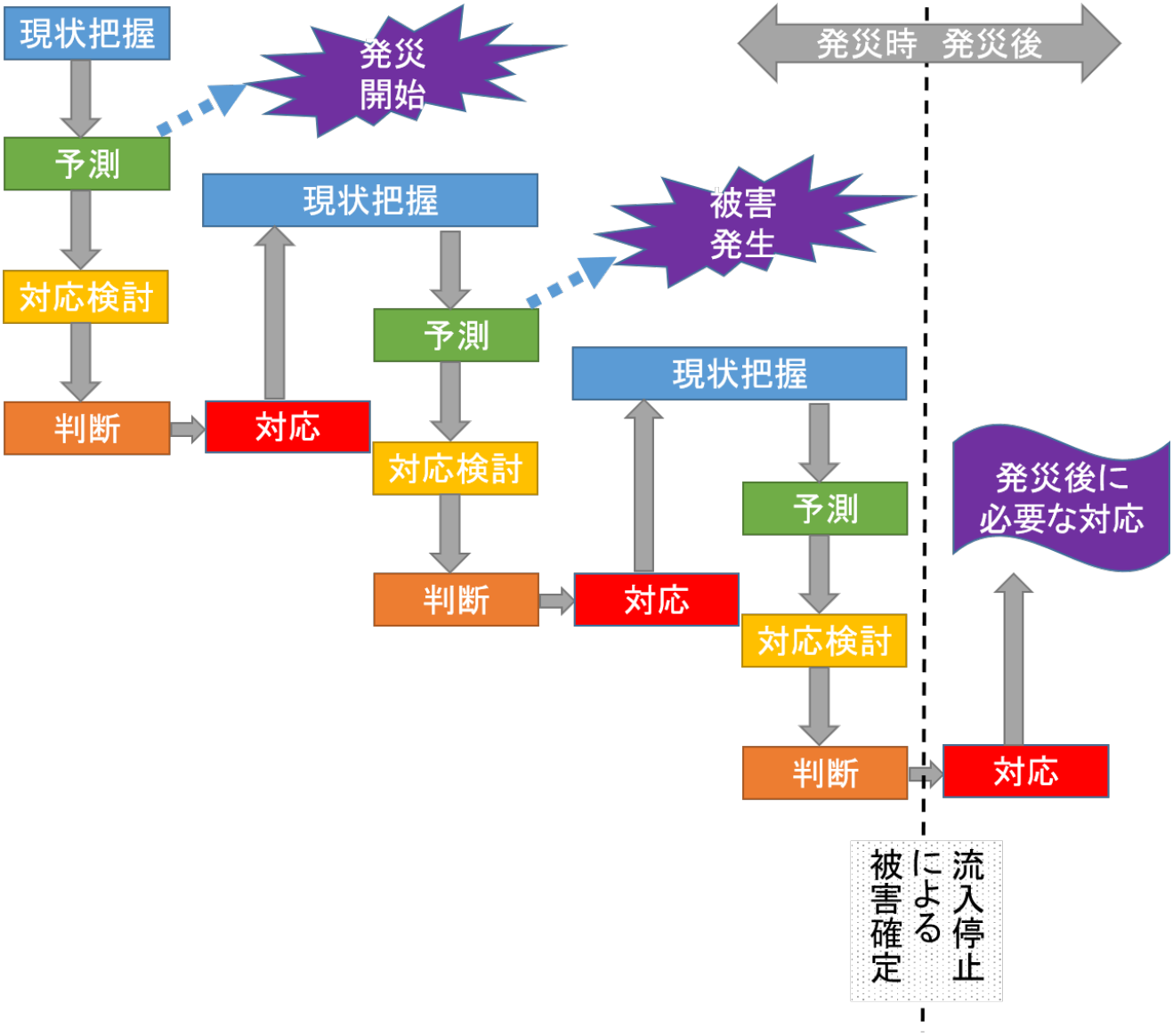
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administrative responses such as the opening of evacuation centers, weather information such as typhoons, and data on flooding and the number of evacuees after the floods were presented.

Next, individual participants wrote down their responses from the first day to the third day and up to one week later. Next, each group did group work to organize and summarize their responses. In the final stage, the results were presented to each other.

The participants were able to experience and understand their roles in the time line. In addition, they were able to infer the phenomena that will occur in the future and come up with early responses. It is expected that the participating executives will expand their experience in their own departments.
We plan to develop the questions to reflect the change climate change, and to present the spread of inundation, the number of evacuees, and disaster waste in a way that participants cannot predict. In addition, we will continue to deepen operation process in the next year and beyond.

Keywords: climate change, adaptation, Regional disaster prevention, Flood analysis, River engineering, DIG



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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.15 Zoom Room 15

[H-CG29] Advanced life support systems with closed bio-ecosystems and thier applications

convener:Masanori Shinohara(Teikyo University of Science), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Shunta Kimura(Institute of Space and Astronautical Science / Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency), Midori Ong(University of Tsukuba), Chairperson:Midori Ong(University of Tsukuba), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Masanori Shinohara(Teikyo University of Science)

In this session, since 2011, we and invited researchers have been introducing and discussing about practical and useful life-support systems in closed bio-ecosystems for inhabitation on extraterrestrial environments. Not only biological studies but also engineering ones
including broad research fields are our target. And also, we assume that it is indispensable to discuss about these interdisciplinary fields beyond the generation for inheriting to our next generation and for developing our field. Theme from old and basic to current and applicative from senior to youth including undergraduate are welcomed.

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

[HCG29-01] Introduction

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

[HCG29-02] Recent Trends of Advanced and Closed Ecological Life Support System.

*Masanori Shinohara[1], Tamiyasu Shimamiya[2] (1.Teikyo University of Science, 2.Japan Manned Space Systems Corporation)

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

[HCG29-03] Establishment of food self-sufficiency system for functional space foods to support manned space activities

★Invited Papers

*Takeshi Nikawa[1] (1.Institute of Nutrition, Tokushima University Graduate School)

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

[HCG29-04] Searching for gene related to environments adaptation

*Hiroshi Katoh[1] (1.Mie University)

10:00 AM - 10:25 AM JST | 1:00 AM - 1:25 AM UTC

[HCG29-05] Current status of planetary protection and its importance in closed eco-systems

★Invited Papers

*Shunta Kimura[1,2], Shino Suzuki[1,2], Yuko Inatomi[1,2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency)

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

[HCG29-06] Discussion

[J] Oral | H (Human Geosciences) | H-CG Complex & General

[H-CG29] Advanced life support systems with closed bio-ecosystems and thier applications

convener:Masanori Shinohara(Teikyo University of Science), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Shunta Kimura(Institute of Space and Astronautical Science / Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency), Midori Ong(University of Tsukuba), Chairperson:Midori Ong(University of Tsukuba), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Masanori Shinohara(Teikyo University of Science)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.15 (Zoom Room 15)

In this session, since 2011, we and invited researchers have been introducing and discussing about practical and useful life-support systems in closed bio-ecosystems for inhabitation on extraterrestrial environments. Not only biological studies but also engineering ones
including broad research fields are our target. And also, we assume that it is indispensable to discuss about these interdisciplinary fields beyond the generation for inheriting to our next generation and for developing our field. Theme from old and basic to current and applicative from senior to youth including undergraduate are welcomed.

9:00 AM - 9:05 AM

[HCG29-01]Introduction

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Recent Trends of Advanced and Closed Ecological Life Support System.

*Masanori Shinohara[1], Tamiyasu Shimamiya[2]

1. Teikyo University of Science, 2. Japan Manned Space Systems Corporation

Recent trends of bioregenerative LSS will be reviewed. Especially, results and lessons learned from Lunar Palace 365 project at Beihang University will be reported.

Keywords: LSS

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Establishment of food self-sufficiency system for functional space foods to support manned space activities

*Takeshi Nikawa[1]

1. Institute of Nutrition, Tokushima University Graduate School

Nowaday, humankind is entering the Age of Discovery in the 21st century. The space environment causes various physical changes. One of the changes is muscle atrophy (sarcopenia). We aim to elucidate the mechanism of this weightless muscle atrophy and devise a nutritional treatment for it.

Previous studies have shown that ubiquitin ligase Cbl-b, of which expression is increased by microgravity, induced IRS-1 ubiquitination and degradation, resulting in impaired IGF-1 signal and muscular atrophy. However, it remains unclear how cells sense weightless stress and enhance Cbl-b expression. Therefore, to clarify the mechanism of gravity sensing by these cells, we conducted “Myolab” and “Cell Mechanosensing” space experiments, and 3D-Clinorotation, which is a simulated microgravity culture device on the ground. First, in the Myolab space experiment, we performed metabolome analysis of space samples cultured under microgravity conditions for a week. Then we found that microgravity accumulated oxidative stress in cells and changed the expression of proteins localized in mitochondria related to energy metabolism. It was also found that the oxidative stress regulates the expression of ubiquitin ligase Cbl-b via Egr1 / 2 and ERK1 / 2 pathways.

Therefore, we considered ubiquitin ligase Cbl-b and oxidative stress as targets for functional foods that can prevent muscle atrophy due to weightlessness.

1) Soy protein (anti-ubiquitinating effect)

We discovered a DG (p) YMP peptide (named Cblin peptide) that has an inhibitory activity on the binding of IRS-1, which is the target molecule of ubiquitin ligase Cbl-b. Furthermore, it was found that the soy protein glycinin has a similar sequence. These suppressed the ubiquitination of IRS-1 by Cbl-b and increased muscle mass in *in vitro* and *in vivo* experiments. In addition, the soy protein-added diet was also effective in suppressing muscle weakness in bedridden patients.

2) Polyphenol (antioxidant effect)

Polyphenols are attracting attention as a dietary ingredient that can reduce antioxidant stress. Antioxidant nutrients such as soy isoflavone and quercetin have been shown to suppress muscular atrophy due to tail suspension.

Because of the usefulness of these functional ingredients of soybeans for such muscle atrophy, we are advocating the construction of a plant factory that can make soybeans self-sufficient in the space environment.

Keywords: Functional Space Foods, Disuse muscle atrophy, Plant factory

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Searching for gene related to environments adaptation

*Hiroshi Katoh[1]

1. Mie University

Living organisms are adapted to various environments. Previously, the author has been trying to search environmental adapted genes in cyanobacteria. In this presentation, the author will show to search result of environmental adapted gene in various living organisms.

Keywords: adaptation, environment, gene

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Current status of planetary protection and its importance in closed eco-systems

*Shunta Kimura[1,2], Shino Suzuki[1,2], Yuko Inatomi[1,2]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency

In space missions, we have to avoid both forward and backward contamination. The Committee on Space Research (COSPAR) develop, maintain, and promote the Planetary Protection (PP) Policy. Space organizations of each country observe PP in their space missions. Japan Aerospace Exploration Agency (JAXA) has started the organizational PP activity. It is also necessary to confirm this issue in closed eco-systems for human habitation missions. Here, we review the current status of PP, and we want to discuss future plans.

Keywords: planetary protection, closed eco-systems

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[J] Oral | H (Human Geosciences) | H-CG Complex & General

[H-CG29] Advanced life support systems with closed bio-ecosystems and thier applications

convener:Masanori Shinohara(Teikyo University of Science), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Shunta Kimura(Institute of Space and Astronautical Science / Space Exploration Innovation Hub Center, Japan Aerospace Exploration Agency), Midori Ong(University of Tsukuba), Chairperson:Midori Ong(University of Tsukuba), Hiroshi Katoh(Division of Plant Functional Genomics, Advanced Science Research Promotion Center, Organization for the Promotion of Regional Innovation, Mie University), Masanori Shinohara(Teikyo University of Science)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.15 (Zoom Room 15)

In this session, since 2011, we and invited researchers have been introducing and discussing about practical and useful life-support systems in closed bio-ecosystems for inhabitation on extraterrestrial environments. Not only biological studies but also engineering ones
including broad research fields are our target. And also, we assume that it is indispensable to discuss about these interdisciplinary fields beyond the generation for inheriting to our next generation and for developing our field. Theme from old and basic to current and applicative from senior to youth including undergraduate are welcomed.

10:25 AM - 10:30 AM

[HCG29-06]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.18 Zoom Room 18

[S-SS11] Strong Ground Motion and Earthquake Disaster

convener:Kazuhiro Somei(Geo-Research Institute), Yasuhiro Matsumoto(Kozo Keikaku Engineering), Chairperson:Kenichi Tsuda(Institute of Technology, Shimizu Corporation), Asako Iwaki(National Research Institute for Earth Science and Disaster Prevention)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

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

[SSS11-07] Development of data-driven strong motion model and common integrated database

*Hiroyuki Fujiwara[1], Nobuyuki Morikawa[1], Asako Iwaki[1], Takahiro Maeda[1], Shinichi Akiyama[1], Kenichi Kato[2], Toshiaki Sato[3], Takayuki Hayashi[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.KOBORI RESEARCH COMPLEX INC., 3.Ohsaki Research Institute, Inc., 4.Tokio Marine & Nichido Risk Consulting Co., Ltd.)

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

[SSS11-08] Consideration of Uncertainty in Seismic Hazard Assessment Based on Strong Motion Observation Record Database

*Nobuyuki Morikawa[1], Hiroyuki Fujiwara[1], Asako Iwaki[1], Takahiro Maeda[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS11-09] On applicabiltiy of ground-motion simulation data to data-driven ground-motion prediction model

*Asako Iwaki[1], Hiroyuki Fujiwara[1], Nobuyuki Morikawa[1], Takahiro Maeda[1] (1.National Research Institute for Earth Science and Disaster Prevention)

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

[SSS11-10] Spatial complexity characteristics of faut parameters based on self-similar models - Comparison of earthquake slip of Japan and all over the world-

*Fumino Suzuki[1], Kenichi Kato[1], Tetsushi Watanabe[1] (1.KOBORI RESEARCH COMPLEX INC.)

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

[SSS11-11] A scaling relation of crustal earthquakes assuming constant stress drop - in a case when fault width is used as a parameter -

*Kazuhito Hikima[1], Akihiro Shimmura[1] (1.Tokyo Electric Power Company Holdings, Inc.)

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

[SSS11-12] Correlation of Kinematic Source Parameters from Rupture Models Simulated by the Full Dynamic Earthquake Cycles

*Anatoly Petukhin[1], Percy Galvez[2,3], Paul Somerville[4], Ken Miyakoshi[1], Kojiro Irikura[5] (1.Geo-Research Institute, 2.ETH Zurich, Earth Science, 3.KAUST University, 4.AECOM, Los Angeles, 5.Aichi Institute of Technology)

Development of data-driven strong motion model and common integrated database

*Hiroyuki Fujiwara[1], Nobuyuki Morikawa[1], Asako Iwaki[1], Takahiro Maeda[1], Shinichi Akiyama[1], Kenichi Kato[2], Toshiaki Sato[3], Takayuki Hayashi[4]

1. National Research Institute for Earth Science and Disaster Resilience, 2. KOBORI RESEARCH COMPLEX INC., 3. Ohsaki Research Institute, Inc., 4. Tokio Marine & Nichido Risk Consulting Co., Ltd.

Strong motion observations in Japan have a history of nearly 70 years. In particular, due to the strengthening of the strong motion observation system after the Great Hanshin-Awaji Earthquake Disaster in 1995, a huge amount of strong motion observation data have been collected by many institutions and private companies, including more than 800,000 records by the strong motion observation networks K-NET and KiK-net of NIED. Information on underground structure exploration has been accumulated, and the construction of a nationwide subsurface velocity structure model for strong motion calculation is in progress. Strong motion prediction models (GMPEs) based on regression analysis of observation records have been developed and have contributed to the progress of seismic hazard assessment. The problem with strong motion prediction by GMPE is that the ability to predict rare and inexperienced events such as very large earthquakes is not guaranteed by observation records. In order to overcome these problems, a strong motion prediction method by physics-based simulation (PBS) using an advanced subsurface velocity structure model has also been developed. It is becoming possible to supplement the lack of observation records with simulation data based on theoretical models. In this study, we try to construct strong motion big data including inexperienced events by fusing observation data and PBS data based on theoretical model. We aim to develop strong motion prediction models that have high predictive performance and meet the needs of the practical side by using data-driven analysis that utilizes a common integrated strong motion database.

Seismic hazard and risk assessment are indispensable for ensuring safety and security against earthquake disasters. In seismic hazard assessment, there is "uncertainty" due to the natural variability of earthquakes and the limits of our human perception due to infrequent events. It is important for society to properly consider the “uncertainty” of seismic hazards to function risk management in preparation for earthquake disasters. Probabilistic seismic hazard analysis (PSHA) is one of the methods for such seismic hazard analysis. From the PSHA point of view, GMPE is currently the most practical strong motion prediction model in the world. In the United States, a unified observation database for the development of GMPE has been constructed, and based on this, multiple GMPEs are studied under the same conditions by multiple developers. Differences among multiple GMPEs are treated as epistemic uncertainty in PSHA and weighted according to the performance of each GMPE. On the other hand, GMPEs in Japan are developed by each developer under their own data set and conditions. Therefore, inadequate performance comparison and insufficient evaluation of epistemic uncertainty among multiple GMPEs have become a practical problem. It has also been pointed out that regression analysis based only on specific datasets has low prediction performance for events not included in the dataset. These are partly due to the lack of a unified strong motion database for the development of strong motion prediction models in Japan. To solve these problems, we have held a strong motion DB working group for the purpose of constructing an observation DB for the development of highly practical GMPE, and have been proceeding with trial production of the observation DB and formulation of GMPE specifications. The working group consists of GMPE researchers in Japan, NGA participants in the United States, and corporate researchers involved in structural design and risk assessment.

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GMPE is a model secured by observation facts, but rare events that should be predicted have not yet been observed. In order to deal with this simple and fundamental problem, this research aims to construct "strong motion big data" by fusing observation data and PBS data. The goal of this study is to propose multiple new strong motion prediction models (GMM) with high prediction performance by analyzing strong motion big data based on various methods including machine learning by multiple teams with different specialties, and extracting the information hidden behind the data beyond the knowledge of strong motion research so far. Specifically, formulation of GMM requirement specifications from the viewpoint of utilization, development of fusion method of observation data and PBS data, GMM development by various methods, quantitative evaluation of GMM variation, area prediction by spatial interpolation, evaluation of GMM performance and epistemic uncertainty. In this presentation, we will introduce the current status of our research.

Keywords: strong ground motion, GMPE, GMM, database, simulation, machine learning

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Consideration of Uncertainty in Seismic Hazard Assessment Based on Strong Motion Observation Record Database

*Nobuyuki Morikawa[1], Hiroyuki Fujiwara[1], Asako Iwaki[1], Takahiro Maeda[1]

1. National Research Institute for Earth Science and Disaster Resilience

In order to properly consider the epistemic uncertainties related to ground motion equations (GMPEs) in seismic hazard assessment, GMPEs based on various ideas for application of observation records to extrapolated regions. It is necessary to construct a framework for deriving the above and evaluating the performance of those models. Morikawa et al. (2020; JpGU) have prototyped a strong motion observation record database, which is the basis for this.

In order to evaluate the performance of GMPEs, it is necessary not only to use a common database in deriving the models, but also to be able to calculate ground motions under common conditions for earthquakes and site. In this study, from the viewpoint of applying to the seismic hazard assessment in Japan, the applicable conditions that can be the target of performance evaluation of the GMPE were determined as a tentative "specifications." It includes the condition that it is applied to the site very near source fault where the fault distance is within 1 km and to a mega-earthquake of magnitude 9. The analyst’ s concept regarding the modeling of extrapolation for which these observation records are not sufficiently obtained is clarified. Based on this prototype strong motion database and tentative specifications, we start to construct multiple GMPEs, including improvements to existing ones.

On the other hand, it is quite hard to verify the strong motion prediction results for a mega-earthquake along the Nankai Trough or near the source fault based on observation records. As the first step in the study to evaluate the reliability of such strong motion prediction results, we investigated strong motion intensity distribution for discretized magnitude-fault distance space in the strong motion observation record database. In the case with many records, it is close to the lognormal distribution. In the case with few records, however, it is close to the uniform distribution. We plan to further analyze the temporal changes in the distribution due to the accumulation of records. Such characteristic analysis of the database itself not only present the insufficiency of observation records, but also aims to formulate a method for evaluating the reliability of the added simulation data by changes in the distribution.

Keywords: Seismic Hazard Assessment, Uncertainty, Strong Motion Database, Ground Motion Prediction Equation (GMPE)

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On applicabiltiy of ground-motion simulation data to data-driven ground-motion prediction model

*Asako Iwaki[1], Hiroyuki Fujiwara[1], Nobuyuki Morikawa[1], Takahiro Maeda[1]

1. National Research Institute for Earth Science and Disaster Prevention

Ground-motion simulation based on fault and wave-propagation models, often called physics-based simulation (PBS), has become a powerful tool for ground-motion prediction that can consider the effects of rupture propagation and wave propagation through complicated tectonics. On the other hand, ground-motion prediction equation (GMPE aka. GMM) is the most practical tool in probabilistic seismic hazard assessment (PSHA).

Our group has started a project to construct strong-motion database and data-driven GMPEs (Fujiwara et al. and Morikawa et al., 2021, this meeting), aiming to consider uncertainties in GMPEs to improve current PSHA in Japan. It has been pointed out that current GMPEs are not sufficient accurate at predicting ground motion with low probability, such as near-fault ground motion and ground motion from mega-earthquakes.

In this study, we attempt to merge PBS data with observation data in order to make up for the deficiency of the observation database especially in short distances and large magnitudes. We generated PBS data for scenario active fault earthquakes in Kanto area and performed statistical analysis to ensure the PBS data provide stable ground motion level and appropriate variability of ground motion.

Keywords: strong-motion prediction, seismic hazard assessment, ground-motion prediction equation, ground-motion simulation

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Spatial complexity characteristics of faut parameters based on self-similar models -Comparison of earthquake slip of Japan and all over the world-

*Fumino Suzuki[1], Kenichi Kato[1], Tetsushi Watanabe[1]

1. KOBORI RESEARCH COMPLEX INC.

1. Introduction

Earthquake source parameters such as slip and stress drop on fault planes have spatially variable distributions. One of the models considered the complexity of the fault parameters is the self-similar model in which the spatially inhomogeneous distribution is characterized in the wavenumber domain (Hanks, 1979). As for the self-similar model, it was shown theoretically and numerically that the far field displacements follow the ω^{-2} decay assuming the "k-square" model in which the slip spectrum decays as k^{-2} beyond the corner wavenumber (Andrews, 1980, 1981; Herrero and Bernard, 1994). The slip complexities of past earthquakes around the world were characterized using the wavenumber spectra (Somerville et al. 1999; Mai and Beroza, 2002). The characterized complexities were utilized for strong motion simulations and validated by comparison with observation records of earthquakes around the world, such as in the SCEC BBP project. However, only four earthquakes in Japan were used for their evaluations, and validations of the complexities on Japan earthquakes are insufficient. In this study, the slip complexities are evaluated using the self-similar model for many earthquakes in Japan.

2. Methods

Targets are 38 earthquakes in Japan occurred from 1923 to 2016, and we used 61 fault slip models published on SRCMOD (http://equake-rc.info/srcmod/). One-segment fault models are used, since our targets are two-dimensional spatial distributions. In this study, 23 crustal earthquakes, 13 interplate earthquakes, and 2 intraplate earthquakes are used respectively.

The complexity evaluation method is similar to Mai and Beroza (2002). 2-D Fourier transform are applied to the fault slips to obtain 2-D wavenumber spectra. Then their spectra are fitted to the von Karman autocorrelation functions using grid-search, and the correlation distances and the Hurst exponents are estimated. Specifically, the correlation distances a_r and the Hurst exponents H are estimated from circular-averaged spectra. Next, the correlation distances a_x and a_y are estimated from along-strike spectra and downdip spectra respectively under conditions where H estimated from the circular-averaged spectra are fixed. These H, a_x, and a_y of earthquakes in Japan are compared with previous studies of earthquakes around the world. Differences between source types are also examined.

3. Results

Figure 1 shows the wavenumber spectra of all models.

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Hurst exponents H estimated by circular-averaged spectra are independent of moment magnitude M_W, and differences between source types are small. The median of H is 0.77 and close to $H = 0.75$ by Mai and Beroza (2002). Next, Correlation distances a_x estimated by along-strike spectra have positive correlation with M_W, and differences between source types are small. Linear regression results of $\log(a_x)$ on M_W for all earthquakes, crustal earthquakes, and interplate earthquakes respectively are almost the same as those of Mai and Beroza (2002). Therefore, the difference of H and a_x characteristics between Japan and the world tends to be small.

Correlation distances a_y estimated by downdip spectra have positive correlation with M_W like a_x. On the other hand, there are differences between source types, and the a_y of interplate earthquakes are larger than that of crustal earthquakes. In addition, a_y tends to be constant for M_W 6 class or higher crustal earthquakes. The same tendency is also acknowledged for M_W 8 class or higher interplate earthquakes. These may indicate the saturation of the fault width due to the thickness of the seismogenic layer. Based on these trends, a_y are regressed for each source types with two segments of the following equation,

$\log(a_y) = bM_W + c \ (M_W <= M_{WC})$

$\log(a_y) = bM_{WC} + c \ (M_W > M_{WC})$.

As a result, M_{WC}, which is a break point, is 6.6 for crustal earthquakes and 8.4 for interplate earthquakes. These are consistent with the boundary between the 1st stage and the 2nd stage of 3-stage scaling relations by Irikura and Miyake (2001) and Tajima et al. (2013).

Keywords: self-similar, spatial complexity, fault slip, wavenumber domain

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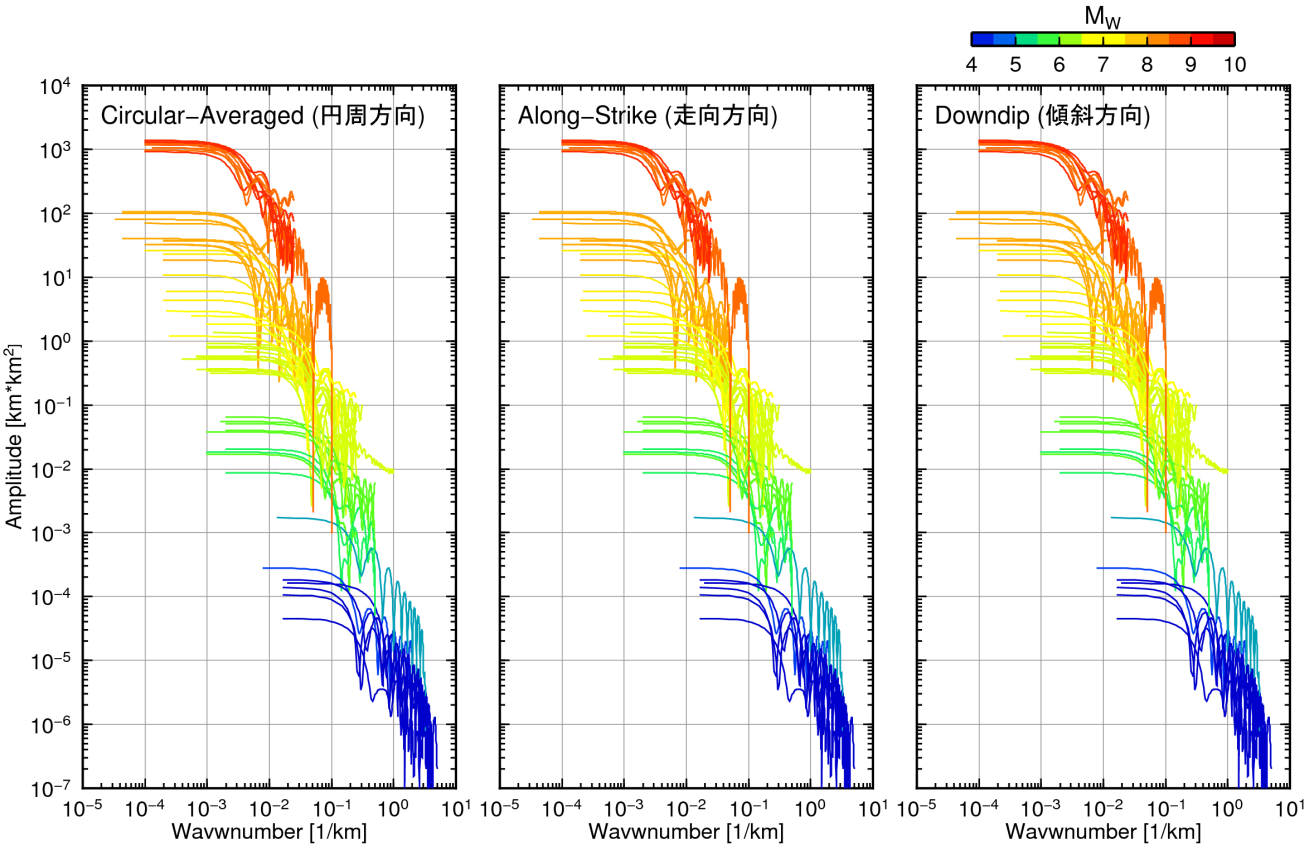


図1　すべり分布の全モデルの波数スペクトル

Figure 1 Wavenumber spectra for all models of fault slip

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A scaling relation of crustal earthquakes assuming constant stress drop - in a case when fault width is used as a parameter -

*Kazuhito Hikima[1], Akihiro Shimmura[1]

1. Tokyo Electric Power Company Holdings, Inc.

- Outline -

In Japan, the Irikura and Miyake formula (Irikura and Miyake, 2001) and 3 stage model (Murotani *et al*, 2015) are the key of the “recipe for the strong motion prediction”. Those formulas take into account the limitation of crustal thickness and are basically considered physically reasonable. However, some defects are pointed out especially for long fault. In our previous study (Hikima and Shimmura, 2020; BSSA), we proposed the similar M_0-S scaling relation, which realizes constant stress drop from small to large fault models. Although the relation was consistent with existing parameters, it was necessary to examine using newly analyzed data.

In recent studies, fault parameters are estimated by inversion analyses, which are performed mostly assuming larger fault model than true slip area. Therefore, we have to extract major fault area from the inversion results. Somerville *et al*. (1999) proposed a method in that marginal rows and columns having relatively small slips are trimmed and rectangular main area is extracted. However, it seems that the physically clear criteria are not proposed and it is difficult automatically select the main target. Therefore, we proposed a procedure to extract an effective rectangular area based on wavenumber spectra of slip distribution (Hikima and Shimmura, 2020; JpGU).

In this study, we shortly explain the proposed trimming method again, because the explanation at the time of presentation was somewhat different from the published abstract. Then, we discuss scaling relations using the determined source parameters.

- Trimming method -

First, a slip distribution at 1 or 2 km intervals for length (X-direction) and for width (Y-direction) is made from an original slip model. Then, zero values are added outside of the fault area, and amplitude wavenumber spectra of these data are calculated using two-dimensional FFT. For these spectra, we consider that the spectrum at k_y=0 (k_y: wavenumber for Y-direction) is in length direction and the spectrum at k_x=0 (k_x: wavenumber for X-direction) is in width direction, respectively.

On the side, Fourier transform of a rectangular function having width as L is $f(\nu)=L\sin(\pi L\nu)/(\pi L\nu)$ [$\nu=1/\lambda$; λ: wavelength]. This sinc function crosses with zero line at $\nu=n/L$ [n=1, 2, …], and these correspond to trough of the spectrum in the case of amplitude spectrum.

We adopted following criteria to extract almost equal fault areas as those using Somerville *et al*. (1999). We focused on lower part than first trough (it corresponds to n=1) of sinc function, and we determined maximum L length not to exceed observed spectra from lower wavenumber side. We applied the same process to the spectrum of width direction. In the previous presentation, we confirmed that the determined fault areas are almost same as those by Somerville’s procedure.

- Scaling relation for crustal earthquakes -

We applied these analyses for the fault models in the SRCMOD (Mai and Thingbaijam, 2014) in last year. Following discussions are based on determined parameters.

First, we checked the relation between the fault length and the fault width (Fig. 1). Conventionally, it has been recognized that the width saturates for long faults. Although such a trend can be seen among the data, it is also observed that the fault width increased in the long fault. Such a tendency is particularly remarkable for longitudinal slip faults. On the other hand, when the stress drop was calculated considering the formulas of the rectangular fault, there was no obvious correlation between the

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earthquake size and the stress drop (Fig. 2).
Considering these relations, we thought that the data could be explained more appropriately by treating the stress drop as a constant value and the fault width as a parameter. In Fig. 3, the fault widths of each earthquake are denoted according to the color table, and the curves show the M_O-S relations, assuming a constant stress drop of 2.5 MPa and with four saturation fault widths (W_{max}). The observed fault width becomes larger in larger earthquakes, and they are consistent with the relation with larger W_{max}.
These results may be affected by uniform treatment without considering various tectonic conditions in the world. However, it is shown that the relation for the crustal earthquakes can be basically scaled with constant stress drop condition. In addition, such as the area around Japan, where the tectonic environment is clear, W_{max} can be considered as almost constant in areas. Therefore, it may become possible to consider scaling with a single formula.
<Acknowledgment> We appreciate the SRCMOD and its related parties.

Keywords: Crustal earthquake, Scaling relation, Stress drop, Fault size, Fault width

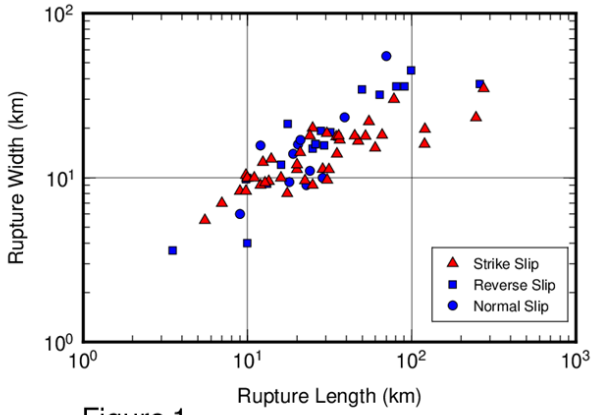


Figure 1

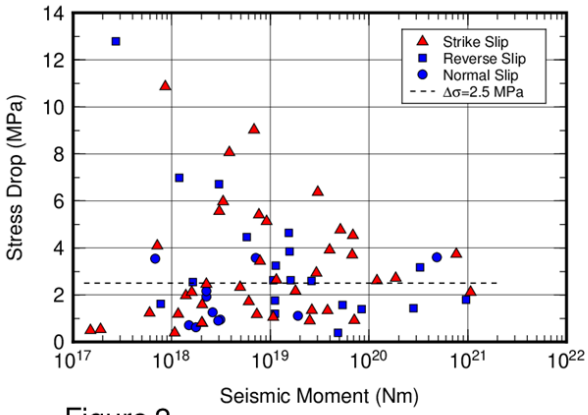


Figure 2

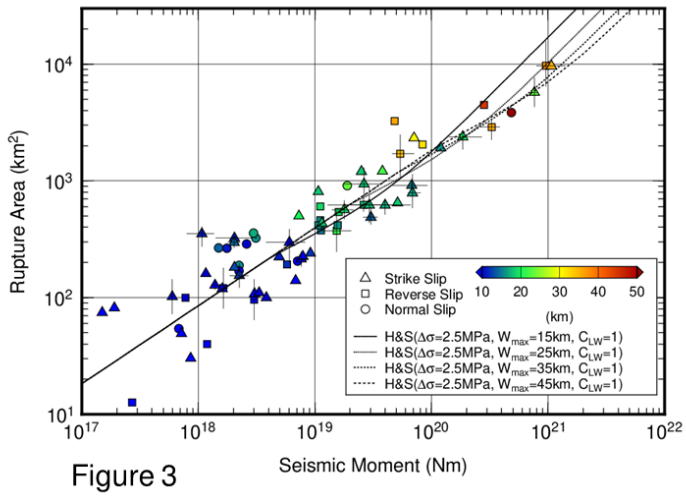


Figure 3

Fig. 1 Relation between rupture length and width.
Fig. 2 Relation between seismic moment and static stress drop. Stress drop values are calculated using formulae for rectangular faults.
Fig. 3 Scaling relation between seismic moment and rupture area. Color of each symbol indicates its fault width. Curves are scaling relations assuming constant stress drop by Hikima and Shimmura (2020), whose values are set as 2.5 MPa.
Fault models which have multiple slip models were plotted using averaged value. In figure 3, the bars indicate the corresponding ranges.

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Correlation of Kinematic Source Parameters from Rupture Models Simulated by the Full Dynamic Earthquake Cycles

*Anatoly Petukhin[1], Percy Galvez[2,3], Paul Somerville[4], Ken Miyakoshi[1], Kojiro Irikura[5]

1. Geo-Research Institute, 2. ETH Zurich, Earth Science, 3. KAUST University, 4. AECOM, Los Angeles, 5. Aichi Institute of Technology

Realistic dynamic rupture modelling validated by observed earthquakes is necessary for estimating parameters, such as stress drop, rupture velocity and slip rate function, that are poorly resolved by seismic source inversion. Source inversions using forward dynamic modelling are frequently used to obtain rupture models. Alternatively, in this study, we use set of a hundred spontaneous physically self-consistent rupture models, whose rupture process is consistent with the spatio-temporal heterogeneity of previous earthquakes on the same fault, as the result of multicycle simulations under the rate-and-state friction law on strike-slip fault (Galvez et al., 2021). The magnitude range of the ruptures is *Mw*5.5-7.4. Models are validated by comparison with: (1) source scaling relations from seismic inversions, (2) ground motion preduction models, and (3) observed fault displacements.

From the heterogeneous rupture models, we analyzed distributions of *Slip*, peak slip rate (*PSR*), static stress drop (Ds), rupture velocity (*Vr*), parameters of the source time function (STF), as well as the rate-and-state critical distance *Dc*, the only initial heterogeneity parameter in the multicycle modeling. The dynamic rupture static stress drop tracks the evolution of stress during the rupture process. It is computed as the difference of final stress and initial stress at the rupture initiation moment. Dynamic STFs are well approximated by the regularized Yoffe function. This Kostrov-type STF is described by two parameters: smoothing time *Ts*, which is approximately equivalent to the peak delay time, and rise time *Tr* . Examples of parameter distributions are shown on the figure below. It seems that there are spatial correlations between parameters: high *PSR* areas correlate with areas of small *Dc*, large rupture velocity and small *Ts*-time, and areas of large *Tr* correlate with areas of small peak slip rate (*PSR)* and small Ds, although there can be a spatial offset in some cases.

On a 1x1 km mesh we studied one-point correlations between parameters. Additionally, we studied two-point cross-correlations considering possible spatial offset. The main findings are:

1. Strong positive correlations (correlation coef. > 0.4) are confirmed in the following pairs: Ds −*Slip*, *PSR* −*Vr*, *PSR* −1/*Ts*, *PSR* −Ds, *Ts* −*Dc*.

2. Minor positive correlations (correlation coef. < 0.4) are confirmed in the following pairs: *Tr* - *Slip*, *PSR* −1/*Dc*, *Vr* −1/*Dc*.

3. There is spatial correlation between *PSR* and *Slip*. However, where there is strong rupture directivity, high slip-rate areas are located on the outer edge of the large slip areas. Due to this effect, we could not confirm this correlation by the one-point method.

4. Spatial correlations between *PSR* and other parameters: 1/*Dc*, *Vr* and 1/*Ts*, have no spatial offset.

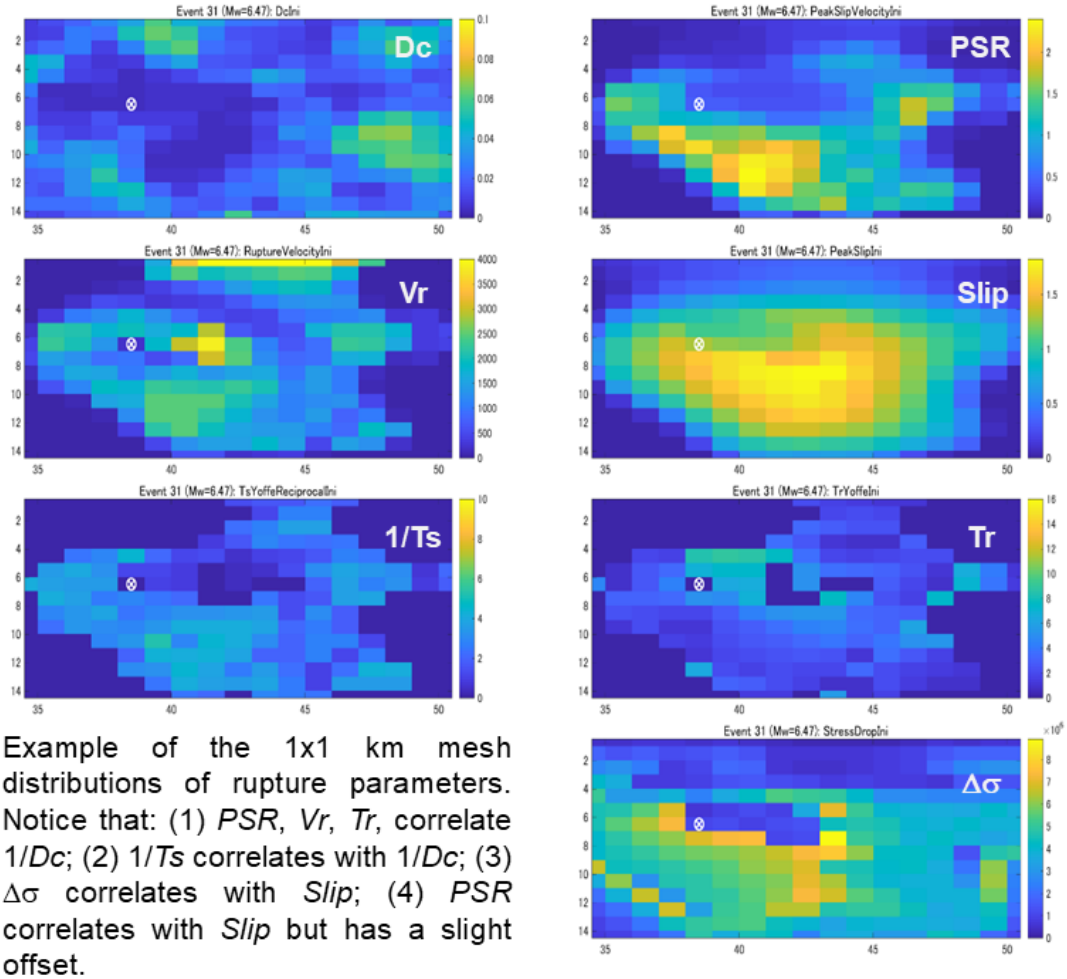
Although many of these correlations are as expected theoretically, it is important to confirm them by physics-based dynamic rupture simulations.

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Acknowledgements. This study is based on the 2018 research project 'Examination for uncertainty strong ground motion prediction for inland earthquakes' by the Secretariat of Nuclear Regulation Authority (NRA), Japan.

Reference. Galvez, P., et al. (2021). Multi-cycle earthquake modeling for source scaling and near-source ground motion validation, *Bull.Seismol.Soc.Am.*, submitted.

Keywords: earthquake rupture dynamics, earthquake cycle simulation, source characterization, strong ground motion prediction



Example of the 1x1 km mesh distributions of rupture parameters. Notice that: (1) *PSR*, *Vr*, *Tr*, correlate 1/*Dc*; (2) 1/*Ts* correlates with 1/*Dc*; (3) $\Delta\sigma$ correlates with *Slip*; (4) *PSR* correlates with *Slip* but has a slight offset.

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.18 Zoom Room 18

[S-SS11] Strong Ground Motion and Earthquake Disaster

convener:Kazuhiro Somei(Geo-Research Institute), Yasuhiro Matsumoto(Kozo Keikaku Engineering), Chairperson:Hisahiko Kubo(National Research Institute for Earth Science and Disaster Resilience), Hongjun Si(Seismological Research Institute Inc.)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

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

[SSS11-13] Long-period incident waves to the Echigo basin during the 2011 off the Pacific coast of Tohoku Earthquake

*Tomiichi Uetake[1] (1.R&D Department, TEPCO research Institute, Tokyo Electric Power Company)

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

[SSS11-14] On the attenuation characteristics of peak ground motion from three M_W7 class intraplate earthquakes along the Japan Trench

*Hongjun Si[1] (1.Seismological Research Institute Inc.)

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

[SSS11-15] Comparison of seismic wave fields from the earthquakes off Fukushima prefecture, northeastern Japan

*Yasumaro Kakehi[1] (1.Department of Planetology, Graduate School of Science, Kobe University)

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

[SSS11-16] ESTIMATE TIME AND SPATIAL EVOLUTION OF THE RUPTURE PROCESS OF THE 2021 OFF-FUKUSHIMA BASED ON THE FINITE-FAULT SOURCE INVERSION

*Kenichi Tsuda[1], Chen Ji[3], Ralph J Archuleta[3,4], Toshiaki Sato[2] (1.Institute of Technology, Shimizu Corporation, 2.Ohsaki Research Institute, Inc., 3.University of California, Santa Barbara, 4.RJA Ground Motion Analysis, Inc.)

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

[SSS11-17] Source process of the 2021 off Fukushima, Japan, intraslab earthquake derived from strong motion data

*Hisahiko Kubo[1], Wataru Suzuki[1], Shin Aoi[1], Haruko Sekiguchi[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SSS11-18] Strong motion characteristics at MYGH10 (KiK-net), Yamamoto, during the Off Fukushima pref. earthquake of 13th Feb., 2021

*Tomotaka Iwata[1] (1.Disaster Prevention Research Institute, Kyoto University)

Long-period incident waves to the Echigo basin during the 2011 off the Pacific coast of Tohoku Earthquake

*Tomiichi Uetake[1]

1. R&D Department, TEPCO research Institute, Tokyo Electric Power Company

During the 2011 off the Pacific coast of Tohoku Earthquake, the long-period ground motion was observed in the Echigo basin, Japan, and Rayleigh waves were predominant in periodic zones with a period of about 10 seconds or more [Uetake et al. (2016).)]. To know the characteristics of the incident wave are essential to consider the response of the basin structure. This report confirms whether the Rayleigh wave was predominant in the incident wave during the 2011 off the Pacific coast of Tohoku Earthquake.
To examine the incident wavefield to the Echigo basin, we selected 23 strong motion observation stations from the eastern part of Fukushima prefecture facing the Pacific Ocean to the Chuetsu region of Niigata prefecture. All of them are the observation stations of K-NET and KiK-net of the National Institute for Earth Science and Disaster Resilience and are lined up from east to west within the epicenter distance of the 2011 event in the range of 174 km to 347 km.
First, the Fourier spectrum characteristics of acceleration data were investigated. The spectral amplitude of the high-frequency band changes significantly due to the influence of ground characteristics, and at the observation point located west of the volcanic front, the spectral amplitude sharply decreases as the frequency increases. On the other hand, no significant change was observed at low frequencies below 0.1 Hz. Also, similarities were found in the spectral shapes of UD and EW in this frequency band.
Velocity waveforms were created by integrating the acceleration waveforms with a bandpass filter with a frequency of 0.05 to 0.2 Hz. Two wave groups propagating from east to west were observed in the EW- and the UD-component, continuous with the wave groups found in the Echigo Basin records. The apparent velocities of these two wave groups were approximately 3.4 km/s. When the particle locus was drawn with the EW- and the UD-component at observation stations other than the eastern part of Fukushima Prefecture, both wave groups have retrograde rotations characteristic of Rayleigh waves. The waveform of the NS component is different from that of the EW- and the UD-component. Next, the distance attenuation characteristics of the maximum value (PGV) of the velocity waveform concerning the epicenter distance (r) were investigated. For the UD-and EW-components, the attenuation curve of PGV shows the surface wave's attenuation characteristics. For the NS-component, the attenuation curve shows the body wave's attenuation characteristics.
Coherence analysis between the components was performed for each observation station. The coherence was calculated for 300 seconds from the head of the data. Focusing on the frequency of 0.05 to 0.1 Hz, the coherence between the UD-component and the EW- component was the highest, and the phase shift was about 90 degrees at many observation points. Also, coherence analysis was performed for 80 seconds from the start of recording and for the next 80 seconds, taking into account the two wave groups' appearance times confirmed in the velocity waveform, and similar results were obtained. Different results were obtained at the observation stations in the eastern part of Fukushima Prefecture.
It is considered that the Rayleigh wave component was predominant in the seismic motion with a period of 10 seconds or more that was incident on the Echigo Plain during the 2011 off the Pacific coast of Tohoku Earthquake. At least the seismic motions of the UD and EW components should be considered as Rayleigh waves propagating westward. The NS component is considered to be mainly body waves from the viewpoint of distance attenuation.

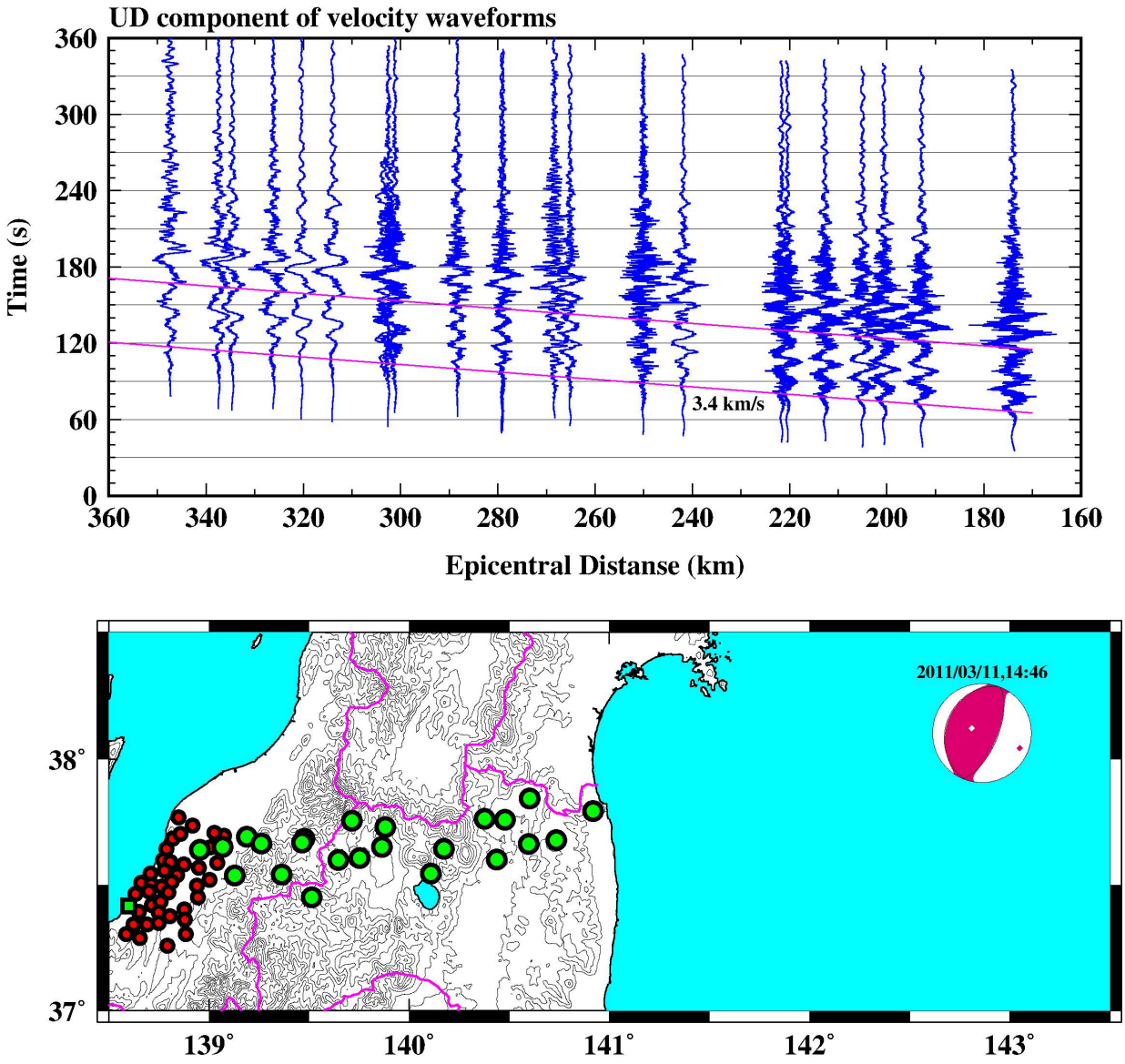
Acknowledgments: We used the strong motion data from K-NET and KiK-net of the National Research

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Institute for Earth Science and Disaster Prevention.

Keywords: Rayleigh wave, Coherence analysis, Attenuation curve

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Location of observation stations (green circles) and velocity waveforms

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On the attenuation characteristics of peak ground motion from three M_w7 class intraplate earthquakes along the Japan Trench

*Hongjun Si[1]

1. Seismological Research Institute Inc.

Including the February 13, 2021 M_w 7.1 Fukushima-oki earthquake, there are three well recorded M_w 7 class intraplate earthquake that occurred along the Japan Trench. The other two earthquakes are the 2003 M_w 7.0 Miyagi-ken-oki earthquake and the 2011 M_w 7.1 Miyagi-ken-oki earthquake. In this study, we’ ll compare the attenuation characteristics of peak ground motions recorded during the three earthquakes and discuss the differences among them.

The data used in this study for all the three earthquakes are derived by K-NET and KiK-net. All the waveform data are processed by a bandpass filter with a lower cut off frequency at 0.1 Hz and higher one at 10 Hz. The acceleration waveforms are integrated to velocity waveforms. PGA and PGV are defined as the larger one between the two horizontal components. The closest distance from the seismic fault to the observation station is defined as the source distance. The source models used for the calculation of source distances are those proposed by Aoi et al. (2003), Harada and Kamae (2011) and the Kubo et al.(2021), respectively. M_w is adopted from the online catalog by the Global CMT Project. The source depth used here are 70km, 59km and 52km for the 2003 M_w 7.0 Miyagi-ken-oki earthquake, the 2011 M_w 7.1 Miyagi-ken-oki earthquake and the 2021 M_w 7.1 Fukushima-oki earthquake, respectively.
We compared the PGAs and PGVs observed during the 2021 M_w 7.1 Fukushima-oki earthquake with the 2003 M_w 7.0 Miyagi-ken-oki earthquake (shown in Figure 1), and with the 2011 M_w 7.1 Miyagi-ken-oki earthquake (shown in Figure 2). As a reference, in the figures, the values calculated by the GMPE proposed by Si and Midorikawa (1999) are also plotted. The figures show that, (1) the data for the 2021 Mw7.1 Fukushima-oki earthquake are generally similar to those for the 2003 M_w 7.0 Miyagi-ken-oki earthquake, but relatively weaker than those for the 2011 M_w 7.1 Miyagi-ken-oki earthquake at distances shorter than about 200 km; (2) the observations at distances farther than about 150 km are generally consistence with the prediction by GMPE, but stronger than GMPE at shorter distances; (3) higher attenuation for stations at far distances reported for the 2011 Geiyo earthquake are not significantly observed for all the three earthquakes in this study.

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Acknowledgements

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The author thanks NIED to provide recordings by K-NET and KiK-net.

Keywords: Peak ground motion, Attenuation characteristics, Intraplate earthquake, 2021 Mw7.1 Fukushima-oki earthquake, Ground motion prediction equation (GMPE)

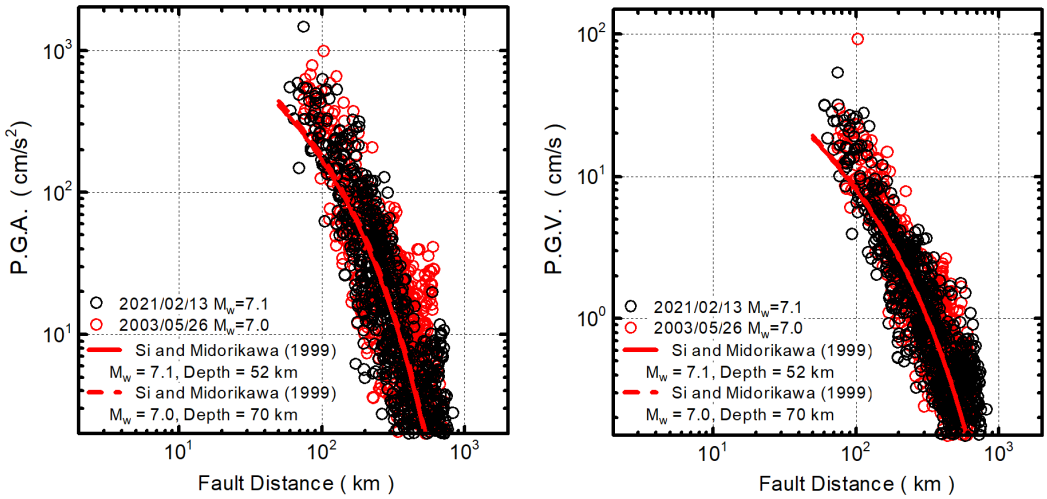


Fig.1.Comparison of peak ground motion for the 2021 Fukushima-oki earthquake (black open circle) and the 2003 Miyagiken-oki earthquake (red open circle)

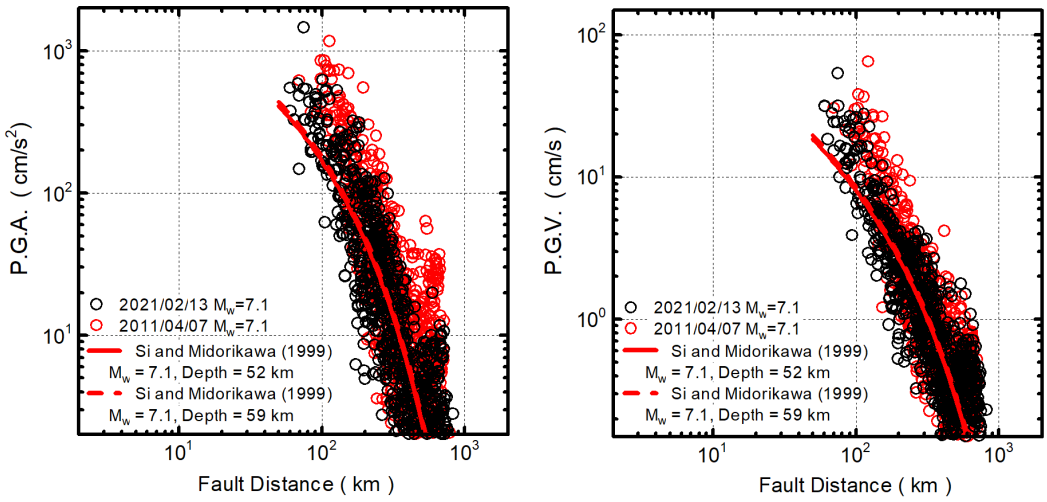


Fig.2.Comparison of peak ground motion for the 2021 Fukushima-oki earthquake (black open circle) and the 2011 Miyagiken-oki earthquake (red open circle)

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Comparison of seismic wave fields from the earthquakes off Fukushima prefecture, northeastern Japan

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An M_W 7.1 earthquake occurred off Fukushima prefecture in northeastern Japan on Feb. 13, 2021. This (called event SU1 hereafter) is a down-dip compression type intraslab earthquake occurring on the upper plane of the double seismic zone, and its focal depth is 55km. The PGA (Peak Ground Acceleration) distribution based on NIED K-NET and KiK-net observation networks shows singular distribution, apart from concentric distribution, where high-frequency seismic wave amplitudes decay rapidly in the backarc side of the island arc, while large amplitudes of high-frequency seismic waves are observed in the forearc side. This phenomenon is a reflection of the attenuation structure with low-Q medium in the backarc side specific to island arc, and it comes from attenuation of high-frequency waves during propagation through the low-Q medium in the backarc side (Kakehi, 2015). In order to investigate the difference of seismic wave fields due to focal depths, strong ground motion data from following three M5 class earthquakes that have epicenters close to that of SU1 and various focal depths are analyzed: an interplate earthquake on Oct. 2, 2001 (M_W 5.5, 40.8km depth, event P hereafter), an intraslab (upper plane) earthquake on Aug. 4, 2013 (M_W 5.9, 58.0km depth, event SU2 hereafter), and an intraslab earthquake (lower plane) on Mar. 13, 2010 (M_W 5.5, 77.7km depth, event SL hereafter). The epicentral location and focal depth of SU2 are almost same as those of SU1. From the comparison of the PGA spatial distributions from these three earthquakes, a common feature that a clear contrast is seen between the forearc and backarc sides, where high-frequency seismic wave amplitudes decay rapidly in the backarc side, is observed among them, similar to the SU1 case. Although the focal depths of the three events have difference of about 20km among them, the incident angles of the seismic rays from the sources to the stations are commonly high angles, since the 40km depth of the shallowest P is sufficiently deep and the epicenter is close to the land area. Therefore, significant difference is not seen in the attenuation of high-frequency waves in the backarc side among the three events. On the other hand, a remarkable difference is seen between the shallowest event P and the deeper events of SU2 and SL, with regard to the absolute amplitude of overall PGA distribution. The amplitude level of the large acceleration area close to the epicenter of P is clearly lower than those of the deeper SU2 and SL. Additionally, while the spatial extents of the observed accelerations reach Hokkaido prefecture (= the accelerometers are triggered) in case of the deeper SU2 and SL, that of the shallowest P reaches only the southern part of Aomori prefecture at farthest. This indicates the overall acceleration level brought by the shallow P is lower than those by deeper SU2 and SL. This is an reflection of the finding by Kasatani and Kakehi (2014) based on the spectral inversion of strong ground motions of interplate and intraslab earthquakes in northeastern Japan: "high-frequency levers of source effects depend not on the tectonic environments but simply on the focal depths and the events with deeper focal depths have higher high-frequency levels."

Keywords: island arc, interplate earthquake, intraslab earthquake, attenuation

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ESTIMATE TIME AND SPATIAL EVOLUTION OF THE RUPTURE PROCESS OF THE 2021 OFF-FUKUSHIMA BASED ON THE FINITE-FAULT SOURCE INVERSION

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1. Institute of Technology, Shimizu Corporation, 2. Ohsaki Research Institute, Inc., 3. University of California, Santa Barbara, 4. RJA Ground Motion Analysis, Inc.

The rupture process of large earthquakes is very essential to understand the physic of faulting process as well as to mitigate the seismic hazard for the future events. Furthermore, if such earthquake occurs on the ocean, the risk for generating tsunami needs to be considered. Usually, right after the occurrence of large earthquakes, many dislocation models to understand the rupture process have been released based on the analysis of various kinds of observed data, such as the seismic waveform including on the regional, near-field and the far-field data, the geodetic such as GPS and the geological field data. On other hand, these models are dependent on the assumption about how the fault ruptures, then, the choice of slip-rate functions that specify how fault ruptures is very important.
In this study, we have developed the source model of the mainshock of the 2021 Off-Fukushima earthquake (Mw 7.1) based on the finite-fault inversion method developed by Ji *et al.* (2002). We constructed the 1D velocity structure representing the source area of this event with consideration to the results by the seismic tomography (Matsubara *et al.,* 2019). We have used the waveform data at close stations by K-NET and KiK-net with the range of 0.05-0.2 Hz. Our preliminary results of the inversion show that the rupture extend to the southern side of the hypocenter.

Keywords: 2021 Off-Fukushima Earthquake, Finite-Fault-Inversion

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Source process of the 2021 off Fukushima, Japan, intraslab earthquake derived from strong motion data

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1. National Research Institute for Earth Science and Disaster Resilience, 2. Disaster Prevention Research Institute, Kyoto University

The 2021 off Fukushima earthquake (Mjma 7.3) struck Tohoku and Kanto regions in Japan on February 13, 2021 (JST). This earthquake caused strong ground motions over a wide area with a maximum seismic intensity of 6+ on the JMA scale and a maximum PGA of approximately 1400 cm/s^2. The moment tensor solution of F-net and the spatial distribution of the mainshock and its aftershocks indicate that this event was an intraslab reverse-fault-type earthquake. In this study, we estimate the source process of this earthquake using strong motion waveforms.

We use velocity waveforms at 12 stations of K-NET and KiK-net of NIED. The waveforms are band-pass filtered between 0.05 and 0.5 Hz, resampled to 5 Hz, and windowed from 2 s before S-wave arrival for 30 s.

We assume a 32 km ×24 km rectangular fault model that has a strike of 24˚ and a dip of 34˚ based on the F-net moment tensor solution. The rupture starting point is set at 37.729˚N, 141.698˚E, and a depth of 55.4 km, which is the hypocenter determined by JMA.

The rupture process is spatially and temporally discretized following the multiple-time-window linear waveform inversion scheme (Olson and Apsel 1982; Hartzell and Heaton 1983; Sekiguchi et al. 2000). For the spatial discretization, the fault plane is divided into 8 subfaults along the strike direction and 6 subfaults along the dip direction, with a size of 4 km ×4 km each. For temporal discretization, the moment rate function of each subfault is represented by 4 smoothed-ramp functions (time windows) progressively delayed by 0.8 s and having a duration of 1.6 s each. The triggering velocity of first time window is set to 2.4 km/s to minimize the data-fit residual. Two orthogonal slips of each time window at each subfault are derived by minimizing the difference between the observed and synthetic waveforms using the non-negative least-squares scheme (Lawson and Hanson 1974). The slip angle is allowed to vary centered at 108˚, which is the rake angle of the F-net analysis. We impose a spatiotemporal smoothing constraint on slips (Sekiguchi et al. 2000).

Green's functions are calculated using the discrete wavenumber method (Bouchon 1981) and the reflection/transmission matrix method (Kennett and Kerry 1979) assuming 1-D velocity structure models. The structure models are obtained for each station from the 3-D structure model (Fujiwara et al. 2009). Logging information is also used for the KiK-net station. To consider the rupture propagation effect, 25 point-sources are uniformly distributed over each subfault in the calculation of Green’ s functions.

In the estimated source model, large slips are found south-west of the hypocenter and partly overlap the active-aftershock area. In the first 5 s, the rupture slowly grew around the hypocenter with small slips. Then, the rupture developed with the large moment release between 5 s and 10 s in the large slip area.

Keywords: The 2021 off Fukushima earthquake, Source process, Strong motion, Intraslab earthquake

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Strong motion characteristics at MYGH10 (KiK-net), Yamamoto, during the Off Fukushima pref. earthquake of 13th Feb., 2021

*Tomotaka Iwata[1]

1. Disaster Prevention Research Institute, Kyoto University

We estimate ground motion characteristics of MYGH10 (KiK-net Yamamoto), south of Miyagi pref., during the 2021 Feb. 13th Off Fukushima Pref. earthquake (MJ7.3). The JMA seismic intensity of 6+ was estimated at this site. As this site is a KiK-net site, they have geological and velocity profile up to the downhole station whose depth is 208m. The superficial layer above the engineering bedrock is a cray one with 3.5m thickness and whose average S-wave velocity is about 150m/s. The predominant frequency of the observed horizontal accelerations at the surface station and those of the spectral ratio between the surface and the downhole is about 10Hz, during the weak motions, which is consistent with the predominant frequency of the superficial layer.

Nakano et al. (2019) separated the source, propagation-path, and site effects from strong motion data set and the predominant frequency of MYGH10 is about 10Hz for the weak motion S-waves. That is consistent to our results. On the contrary, during the mainshock, as the peak acceleration was 1,492cm/s/s (three comp. vectorial summation), the predominant frequency was about 4Hz. This would indicate the non-linear behavior of the superficial layer during the strong shaking. Those characteristics are similar to those at Nagomi site (Iwata et al., 2019).

Noguchi et al. (2016) analyzed the soil response recovery process at this site between 2007 and 2013 event data and pointed out that this kind of non-linear behavior occurs repeatedly during strong shakings and after the strong shaking the weak responses were stable. This paper will discuss the effect of non-linear response of the superficial layer on seismic intensity.

Acknowledgements

I used KiK-net strong motion data (NIED, 2019; doi:10.17598/NIED.0004).

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Keywords: the Off Fukushima pref. earthquake of 13th Feb., 2021, non-linear response of the superficial layer, KiK-net

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.21 Zoom Room 21

[S-EM13] Geomagnetism, paleomagnetism and rock magnetism

convener:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Chairperson:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Yutaka Yoshimura(Faculty of Social and Cultural Studies, Kyushu University)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and other planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the SEDI-Japan community. The presentations and discussions will be made in Japanese or English in this session.

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

[SEM13-01] Revised magnetostratigraphy and eruption timing of Afro-Arabian Large Igneous Province using new $^{40}Ar/^{39}Ar$ ages

*Yutaka Yoshimura[1], Osamu Ishizuka[2], Toshitsugu Yamazaki[1], Yuhji Yamamoto[3], Hyeon-Seon Ahn[3], Tesfaye Kidane[4], Yo-ichiro Otofuji[5,6] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3.Center for Advanced Marine Core Research, Kochi University, 4.School of Agricultural, Earth, and Environmental Sciences, University of KwaZulu Natal, 5.Institute of GeoHistory, 6.Kobe University)

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

[SEM13-02] Palaeomagnetism of ca. 3-4 Ma lavas from Borgarfjordur, Iceland - magnetostratigraphy and paleosecular variation of direction

Maxwell Christopher Brown[1,2], *Yuhji Yamamoto[3], Hiroyuki Hoshi[4], Masaru Kono[5], Hidefumi Tanaka[3], Takehiro Koyaguchi[6], Brian Jicha[7], Kohei Masaoka[3,8], Vivian Sinnen[2], Justin Tonti-Filippini[2,9], Hiroto Ishikawa[3], Richard Bono[10] (1.University of Minnesota, 2. University of Iceland, 3.Kochi University, 4.Aichi University of Education, 5.Tokyo Institute of Technology, 6.University of Tokyo, 7.University of Wisconsin-Madison, 8.Kyushu University, 9.Ludwig Maximilian University of Munich, 10.University of Liverpool)

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

[SEM13-03] Archeointensity variation for the past millennium from Reunion Island

*Koji Fukuma[1], Hisatoshi Ito[2] (1.Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2.Central Research Institute for Electric Power Industry)

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

[SEM13-04] Analyzing the early 19th century's geographical points in latitude and longitude of 0.2 second level and geomagnetic declination through Japan from Tadataka Inoh's magnetic survey azimuth ledger simultaneously.

*Motohiro Tsujimoto[1] (1.none)

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

[SEM13-05] Effects of cooling from the CMB on geodynamo with different Rayleigh numbers and inner core radii

*Yuki Nishida[1], Yuto Katoh[1], Hiroaki Matsui[2], Masaki Matsushima[3], Takumi Kera[1], Atsushi Kumamoto[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Dept. of Earth and Planetary Sciences, University of California, Davis, 3.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

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

[SEM13-06] An attempt to detect a stratified layer at the core surface from a geomagnetic field model

*Masaki Matsushima[1] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

Revised magnetostratigraphy and eruption timing of Afro-Arabian Large Igneous Province using new $^{40}Ar/^{39}Ar$ ages

*Yutaka Yoshimura[1], Osamu Ishizuka[2], Toshitsugu Yamazaki[1], Yuhji Yamamoto[3], Hyeon-Seon Ahn[3], Tesfaye Kidane[4], Yo-ichiro Otofuji[5,6]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3. Center for Advanced Marine Core Research, Kochi University, 4. School of Agricultural, Earth, and Environmental Sciences, University of KwaZulu Natal, 5. Institute of GeoHistory, 6. Kobe University

We report four new $^{40}Ar/^{39}Ar$ ages on fresh groundmass grains of basalts from the 2 km thick Lima-Limo section in Ethiopia to construct magnetostratigraphy of the Afro-Arabian Large Igneous Province (AALIP). A succession of seven magnetozones (R4-N3-R3-N2-R2-N1-R1, from top to base) were identified by Ahn et al. (in press), which were tentatively correlated to Chron C11n.1r (29.477-29.527 Ma) (R4) - C11n.2n (29.527-29.970 Ma) (N3 to N2) - C11r (29.970-30.591 Ma) (R2 to R1) of the geomagnetic polarity time scale 2016 (GPTS 2016; Ogg et al., 2016).

New ages were obtained from the R4, N3, and N1 magnetozones. They have ~40 % higher precision than the previously reported ages (Coulie et al., 2003; Hofmann et al., 1997), and they are concordant with stratigraphy. We calibrated our ages using the FCs standard from Kuiper et al. (2008) and the ^{40}K decay constant of Min et al. (2000), which were used in GPTS 2016. We compared our calibrated ages and their uncertainties with GPTS 2016 and the revised GPTS model proposed by Sahy et al. (2017). The difference of the two ages obtained from the R4 magnetozone is 0.39 Myr. This supports that the R4 magnetozone belongs to Chron C11r rather than Chron C11n.1r; the former duration is 0.621 Myr and the latter 0.05 Myr (Ogg et al., 2016). The magnetozones from N1 to N3 are correlated to Chron C12n (31.23 to 30.41 Ma), which constrain that the R1 magnetozone is correlated to Chron C12r (33.09 to 31.23 Ma) (ages are based on Sahy et al., 2017).

From the duration of 0.5 Myr for C11r according to the GPTS model of Sahy et al. (2017) and the area of ~600,000 km^2 (Mohr, 1983), the average eruption rate within the R4 magnetozone is estimated to be 1.1 km^3/yr, which is about one third of the rate of the Siberian LIP (Pavlov et al., 2019). On the other hand, AALIP has large successive silicic components in the N3 magnetozone. Touchard et al. (2003) correlated them with tephra layers in ODP sediment cores of the Indian Ocean using magnetostratigraphy and geochemistry of volcanic glass, and suggested a linkage with the Oi-2 cooling event. However, based on our age determination, the tephra layers are not coeval with the AALIP silicic eruptions, and there was no tephra layer in the cores that could be correlated to the silicic eruptions (Touchard et al., 2003). This mismatch suggests that the AALIP silicic eruptions would not have caused the climate change.

Keywords: Afro-Arabian Large Igneous Province, magnetostratigraphy, 40Ar/39Ar dating, geomagnetic polarity time scale

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Palaeomagnetism of ca. 3-4 Ma lavas from Borgarfjordur, Iceland - magnetostratigraphy and paleosecular variation of direction

Maxwell Christopher Brown[1,2], *Yuhji Yamamoto[3], Hiroyuki Hoshi[4], Masaru Kono[5], Hidefumi Tanaka[3], Takehiro Koyaguchi[6], Brian Jicha[7], Kohei Masaoka[3,8], Vivian Sinnen[2], Justin Tonti-Filippini[2,9], Hiroto Ishikawa[3], Richard Bono[10]

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Iceland is a unique location for palaeomagnetism. Glacially and fluvially eroded valleys expose sequences of hundreds of easily accessible lavas that dip gently towards rift zones: ideal candidates for reconstructing past variations in Earth’ s magnetic field. In this study we present new palaeomagnetic directions from lavas spanning approximately 3.1-4.3 Ma from the Lundarreykjardalur valley in the Borgarfjörður region of western Iceland. In total ~1600 specimens from ~250 lavas spanning 14 sections along an 18 km transect of the Lundarháls ridge have been measured for palaeodirectional analysis. This provides one of the most detailed records of field changes recorded by lavas for this time.

This study is the culmination of two phases of field work and laboratory measurements. The first phase began in 1994 with the sampling and analysis of nine sections comprising the older half of the magnetostratigraphy. The second phase began in 2016, with an additional five sections expanding the magnetostratigraphy to younger ages. Through a combination of pilot K-Ar ages carried out in the 1990s and new $^{40}Ar/^{39}Ar$ ages we assigned a series of reversed and normal polarity lavas to chrons within the geomagnetic polarity time scale (GPTS) spanning approximately 4.3 to 3.1 Ma. $^{40}Ar/^{39}Ar$ ages confirm that the composite lava section records the reversal boundaries of C3n.1r/Cochiti (GPTS age, 4.300 Ma), Cochiti/C2Ar (4.187 Ma), C2Ar/C2An.3n (Gilbert/Gauss, 3.596 Ma) and C2An.2n/Kaena (3.116 Ma), but misses the Mammoth subchron.

Detailed variations in Earth's magnetic field can relate to changes in the geodynamo. We look at the distribution of virtual geomagnetic poles (VGPs), as well as their dispersion. Our analysis suggests the field recorded in the Lundarháls lavas is consistent with the geocentric axial dipole assumption, but that VGP dispersion may differ between chrons. This has implications for our understanding of the long-term variability of the field.

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Archeointensity variation for the past millennium from Reunion Island

*Koji Fukuma[1], Hisatoshi Ito[2]

1. Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2. Central Research Institute for Electric Power Industry

Archeointensity variation for past one thousand years was obtained from volcanic rocks of Reunion Island in South Indian Ocean. Several geomagnetic field models such as gufm1 or cals-?k series have provided comprehensive global pictures of the geomagnetic field change for the past millennia. Although direct measurements for recent centuries form the basis of these models, for the more distant past archeomagnetic data are indispensable to construct the models. However, archeointensity data rely heavily on restricted regions and materials like archeological artifacts in Europe. This time we obtained reliable archeointensity data from lava flows of Piton de la Fournaise in Reunion Island. Hand samples of upper and lower clinkers were collected on twelve lava flows of archeomagnetic directional studies by Tanguy et al (2011). Emplacement ages are known based on historical records, 14C and archeomagnetic dating. An automated spinner magnetometer with thermal demagnetizer TSpin was utilized for Thellier measurements. Even strict selection criteria of TTA and curvature limit applied for the Thellier results still yielded paleointensity data for 64% samples and averaged paleointensities for 10/12 sites. Lava flows of recent centuries gave consistent archeointensity values with the presumed linear decay of gufm1. Reported lower g10 for 18th century seem restricted to Triaxe data on archeological artifacts. Older lava flows showed a monotonic decay of virtual dipole moment beginning at 1000 CE. Therefore the observed dipole moment decay after 1840 CE could have continued for the past millennium.

Keywords: archeointensity, Thellier method, geomagnetic field model

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Analyzing the early 19th century's geographical points in latitude and longitude of 0.2 second level and geomagnetic declination through Japan from Tadataka Inoh's magnetic survey azimuth ledger simultaneously.

*Motohiro Tsujimoto[1]

1. none

The Santou-Houi-Ki is a national tresure of Japan recorded by cartographer Tadataka Inoh in 1800 to 1816 consist of 67 volumes magnetic survey azimuth ledger of Japan. In the Santou-Hou-Ki estimate 200,000 magnetic compass survey azimuth data by acculacy of 0 degree 05 minute unit were recrded with name or short description of magnetic compass survey excution reference point and target points . Inoh carried out the survey did not aplly the correction of magnetic declination<in Edo(ToKyo) was nearlyzero. It is able to calculte backward the precise position of survey excution reference point,where the value of geomagnetic declination,subtracting the magnetic survey azimuth from the true azimythto any target points are similar or approximate by using exce formula. Check the sourse books or maps of local history,and adjust the precise detail position. We must excute interdisciplinary and simultaneous analysis. This time,I will mention the transition of the geomagnetic declination in Nagasaki in the first half of the 19th century.

Keywords: Tadaataka Inoh, geomagnetic declination, inter disciplinary analysis

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Effects of cooling from the CMB on geodynamo with different Rayleigh numbers and inner core radii

*Yuki Nishida[1], Yuto Katoh[1], Hiroaki Matsui[2], Masaki Matsushima[3], Takumi Kera[1], Atsushi Kumamoto[1]

1. Department of Geophysics, Graduate School of Science, Tohoku University, 2. Dept. of Earth and Planetary Sciences, University of California, Davis, 3. Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology

The geomagnetic field has been sustained for at least 3.5 billion years as revealed by paleomagnetic observations (Biggin et al., 2015; Tarduno et al., 2015). It is generated and maintained by dynamo action driven by convective motions of liquid iron alloy in the outer core. Studies of the thermochemical evolution of the Earth's core suggest that the solid inner core has been growing up for approximately on the last one billion years (Labrosse et al., 2001; Gubbins et al., 2004). Consequently, heat flow in the core has also been changing through the Earth's history (Driscoll and Bercovici, 2014; Patocka et al., 2020). While it is reported that sustained dynamos are dipolar-dominated in cooling from the core-mantle boundary (CMB) with an inner core smaller than the present in numerical dynamo simulations (Hori et al., 2010; Heimpel and Evans, 2013), a question remains how heat flux with relation to different inner core sizes have effects on properties of dynamo. Answers to the question are important to understand a physical state of the past Earth.

In the present study, using a numerical dynamo code Calypso (Matsui et al., 2014), we investigate the effects of cooling from the CMB on numerical dynamos with two inner core sizes. We fix the Ekman, Prandtl, and magnetic Prandtl numbers to be $E = 10^{-3}$, $Pr = 1$, and $Pm = 5$, respectively, and change the Rayleigh number (Ra) and the radius ratio of the inner core to the outer core, r_i/r_o, to be 0.25 and 0.35. To represent cooling from the CMB, fixed heat flux boundaries are set as different heat flow ratios: Q_i/Q_o = 0.5, 0.75, and 1, where Q_i and Q_o are the heat flow at the inner-core boundary (ICB) and CMB, respectively.

First, we perform numerical simulations of non-magnetic thermal convection to determine the critical Rayleigh number (Ra_{crit}), which represents the Rayleigh number for the onset of thermal convection, by the same method as Al-Shamali et al. (2004). While critical flux Rayleigh number based on the heat flux at the CMB increases with smaller Q_i/Q_o because of the decreasing the incoming heat flux at the ICB, the conventional critical Rayleigh number, which is based on the temperature difference between the ICB and CMB, is almost the same in various Q_i/Q_o. Property of onset of thermal convection can be understood in the same way regardless of different heat flow ratios in the range of $Q_i/Q_o \geqq 0.5$ by using the Ra based on the temperature.

Next, we perform dynamo simulations with the three heat flow ratios with changing the flux Ra. We find that kinetic and magnetic energy densities can be lined up based on Ra/Ra_{crit}. The parameter ranges are $2.4 \leqq Ra/Ra_{crit} \leqq 11.0$ at $r_i/r_o = 0.25$ and $2.5 \leqq Ra/Ra_{crit} \leqq 10.5$ at $r_i/r_o = 0.35$. The kinetic energy basically increases with increasing Ra/Ra_{crit}.The simulation results reveal that the change of the generated magnetic energy by Ra/Ra_{crit} is similar to the cases in the range of $Q_i/Q_o \geqq 0.5$. The change of the dipolar dominance by the Ra/Ra_{crit} is also the same as the behavior that we found in numerical dynamos in the fixed temperature boundary cases at $r_i/r_o = 0.25$ and 0.35, as we reported at JpGU Meeting 2019. Based on the simulation results and related discussion, in the range of $Q_i/Q_o \geqq 0.5$, we conclude that the

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dynamo regime is determined by Ra/Ra_{crit} regardless of different heat flow ratios.

Keywords: geodynamo, the Rayleigh number, the inner core size, cooling

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An attempt to detect a stratified layer at the core surface from a geomagnetic field model

*Masaki Matsushima[1]

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A stably stratified layer at the top of the Earth's outer core can be present as suggested by recent seismic studies. If it is the case, upwelling and downwelling flows would not be present just below the core-mantle boundary (CMB); that is, only toroidal flows contribute to temporal changes in the geomagnetic field. Such fluid flows near the CMB can be estimated from a geomagnetic field model which provides information on the spatial distribution of the geomagnetic field and its temporal variation at the Earth's surface. The information at the CMB can be obtained through downward continuation of the geomagnetic potential field on the assumption that the mantle is an electrical insulator. Most of core flow models are estimated on the basis of the frozen-flux hypothesis. If a viscous boundary layer with finite thickness is present below the CMB, not only the motional induction but also the magnetic diffusion inside the boundary layer should cause temporal variations of the geomagnetic field. Hence core surface flows near the CMB can be estimated from a geomagnetic field model as follows; the magnetic diffusion contributing to temporal variations of the geomagnetic field is neglected below the boundary layer as in the frozen-flux approximation, whereas the magnetic diffusion is assumed to cause the temporal variations inside the boundary layer. Core surface flows below the boundary layer are assumed to be in the tangentially magnetostrophic state.

In this method to estimate a core surface flow, depths from the core surface are provided as parameters; one (ξ_1) is taken to be less than the thickness of the boundary layer, and the other (ξ_2) be larger than the thickness of the boundary layer. Hence, it might be possible to investigate the existence of a stably stratified layer at the top of the core in the following way. In case 1, only the toroidal flow is allowed inside the stratified layer, while in case 2, both the toroidal and poloidal flows are permitted there. Correlation coefficients and misfits between a temporal variation of the magnetic field obtained from a geomagnetic field model and that due to core surface flows in case 1 are calculated. Also correlation coefficients and misfits in case 2 are calculated. Then correlation coefficients and misfits thus obtained are compared with each other. The result provides information on the stratified layer at the top of the outer core.

Keywords: core surface flow, geomagnetic field, stratified layer

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.21 Zoom Room 21

[S-EM13] Geomagnetism, paleomagnetism and rock magnetism

convener:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Chairperson:Chie Kato(Faculty of Social and Cultural Studies, Kyushu University), Tetsuro Sato(Earthquake Research Institute, The University of Tokyo), Yutaka Yoshimura(Faculty of Social and Cultural Studies, Kyushu University)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and other planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the SEDI-Japan community. The presentations and discussions will be made in Japanese or English in this session.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SEM13-07] Unmixing complex sedimentary magnetic mineral assemblages

★Invited Papers

*Andrew P Roberts[1], Jinhua Li[2,3,4,5], Yan Liu[2,3,4,5], Shuangchi Liu[2,5], Hongmiao Pan[4,6], Tian Xiao[4,6], Yongxin Pan[2,3,4,5] (1.Research School of Earth Sciences, Australian National University, Canberra, ACT 2601, Australia, 2.Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Innovation Academy for Earth Sciences, Chinese Academy of Sciences, Beijing 100029, China, 3.Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266061, China, 4.International Associated Laboratory of Evolution and Development of Magnetotactic Multicellular Organisms (LIA-MagMC), CNRS-CAS, Beijing 100029, China, 5.College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing 100049, China, 6.Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China)

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

[SEM13-08] Examination of the properties of remanent magnetization carried by magnetotactic bacteria in the early stages of sediment formation; example of mixed system with magnetic particles of inorganic origin

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[3], Yuhji Yamamoto[3], Masao Ohno[1] (1.Kyushu University, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 3.Kochi University)

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

[SEM13-09] Analysis of magnetic mineral composition of a sediment core taken from the Ontong-Java Plateau and its implications to relative paleointensity estimations

*Jiaxi Li [1], Toshitsugu Yamazaki[1], Yoichi Usui[2], Takuya Sagawa[3], Junichiro Kuroda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kanazawa University)

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

[SEM13-10] Environmental magnetic study of a Holocene sediment core from the Yeongsan Estuary, Southwest Korea

*Hyeon-Seon Ahn[1], Jaesoo Lim[2] (1.Kochi University, 2.Korea Institute of Geoscience and Mineral Resources)

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

[SEM13-11] **Relationship between the abundance of the exsolved magnetite and the valence state of iron in single plagioclase crystal separated from Doshi gabbro**

*Yujiro Tamura[1], Masahiko Sato[2], Ryoichi Nakada[3], Chie Kato[4], Shinji Yamamoto[1] (1.Yokohama National University, 2.The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Kyushu University)

Unmixing complex sedimentary magnetic mineral assemblages

*Andrew P Roberts[1], Jinhua Li[2,3,4,5], Yan Liu[2,3,4,5], Shuangchi Liu[2,5], Hongmiao Pan[4,6], Tian Xiao[4,6], Yongxin Pan[2,3,4,5]

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Magnetic unmixing is an important part of environmental magnetic and sedimentary paleomagnetic studies because unambiguous magnetic mineral identification is usually a prerequisite for reconstructing magnetic signals of interest. Unmixing is an inverse problem that can have an infinite number of solutions, so magnetic studies tend to focus on identifying constituent magnetic minerals and their relative grain size variations through a series of magnetic measurements to minimize ambiguities by “supervised” unmixing. Supervised unmixing is normally achieved using bulk magnetic measurements that are used to indirectly interpret magnetic mineral components. Direct magnetic mineral observation using electron microscopy is a valuable addition to such studies, although it often raises questions about the representativeness of observed particles in relation to measured bulk magnetic properties. Challenges associated with magnetic unmixing are illustrated here from a detailed magnetic and electron microscopy study of a deep-sea surface sediment sample from the central Pacific Ocean. Magnetic analyses are interpreted to reveal the presence of 2-4 magnetic components depending on the type of mathematical functions used for fitting and whether the unmixing is unsupervised or supervised, while comprehensive electron microscope observations indicate the presence of 8 (titano-)magnetite particle types. Magnetite magnetofossils are also identified with extensive searching by transmission electron microscopy, but their contribution to the sediment magnetic properties is small. Combined results indicate that two particle types dominate the magnetic properties. This work illustrates the potential magnetic complexity of sediments and the need for detailed supervision of unmixing. Our results demonstrate the value of electron microscope observations in sedimentary magnetic studies and illustrate the potential magnetic complexity of sediments, which needs to be recognized to arrive at meaningful interpretations of conventional bulk magnetic data.

Keywords: Magnetic unmixing, Environmental magnetism, Paleomagnetism

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Examination of the properties of remanent magnetization carried by magnetotactic bacteria in the early stages of sediment formation; example of mixed system with magnetic particles of inorganic origin

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[3], Yuhji Yamamoto[3], Masao Ohno[1]

1. Kyushu University, 2. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 3. Kochi University

Variation of the past geomagnetic field is recorded in marine sediments as a fossil magnetization, called natural remanent magnetization (NRM). The carrier of the NRM is not only detrital magnetic grains but also biogenic magnetic grains originated from magnetotactic bacteria. To investigate characters of NRM carried by biogenic magnetic grains we have cultured the magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1 (here under, MS-1) in laboratory. We made samples using them for remanent magnetization measurements to simulate the very early process of sediment formation.
Properties of the remanent magnetization carried by the samples used only MS-1 cells have been presented in Masaoka et al (2020JpGU). However, there is a difference from actual sediments containing magnetic particles of inorganic origin, and it is not possible to make a simple comparison. Various experiments and magnetic analysis were performed to fill this difference: we have made two types of samples containing reagent magnetite and MS-1 cells, and MS-1 cells crushed by ultrasonic. We will report and discuss the results.

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Analysis of magnetic mineral composition of a sediment core taken from the Ontong-Java Plateau and its implications to relative paleointensity estimations

*Jiaxi Li [1], Toshitsugu Yamazaki[1], Yoichi Usui[2], Takuya Sagawa[3], Junichiro Kuroda[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology, 3. Kanazawa University

Marine sediments contain considerable amounts and different types of magnetic mineral particles. Magnetic minerals may be statistically aligned to the direction of the ambient geomagnetic field so that potentially preserve geomagnetic intensity records in the past. However, different types of magnetic minerals should preserve the remanent magnetization in different manners. And the compositional variation of magnetic mineral assemblages in marine sediments may hinder us from extracting reliable geomagnetic paleointensity records.

We studied a sediment core taken from the Ontong-Java plateau and managed to extract the geomagnetic paleointensity variation from it. The magnetic mineral assemblages of the sediment core are principally a two-component mixture of terrigenous and biogenic magnetite with changing amounts of carbonates. So it provides an opportunity to assess influence that compositional variations in marine sediments could bring to relative paleointensity (RPI) estimations and thus to distinguish different contributions of the biogenic and terrigenous components to paleointensity signal recording in marine sediments.

RPI obtained by normalizing natural remanent magnetization (NRM) with anhysteretic remanent magnetization (ARM) shows downcore decreases, and it has an inverse correlation with the ratio of ARM susceptibility (k_{ARM}) to saturation isothermal remanent magnetization (SIRM) (k_{ARM}/SIRM). This indicates that the RPI signal became apparently weaker with increasing proportion of biogenic to terrigenous magnetic minerals. Moreover, NRM-ARM demagnetization diagrams show curvature, which indicates that the coercivity distributions of NRM and ARM are different. Therefore, we tried to distinguish the different contributions of the biogenic and terrigenous components to the RPI record by recalculating NRM-ARM demagnetization slopes in relatively higher and lower coercivity intervals. If we assume that the magnetization of the higher coercivity interval is carried by biogenic magnetite while that of the lower coercivity interval is carried by the terrigenous component, RPI recording efficiency of the biogenic component may be lower than that of the terrigenous component. The validity of this assumption was investigated by first-order reversal curve (FORC) measurements, transmission electron microscope (TEM) observations, low-temperature measurements, and extraction of silicate-hosted magnetic inclusion from the sediments, and the results proved that NRM of the higher coercivity interval is carried mainly by biogenic magnetite. But our conclusion contradicts with the previous studies using a similar method; some previous studies suggested higher RPI recording efficiency of the biogenic magnetic component than the terrigenous component. Different concentrations of silicate-hosted magnetic inclusions due to different sedimentary environments might be a possible reason for the contradiction; the contribution of silicate-hosted magnetic inclusions to NRM is minor in our sediments. However, this contradiction remains to be studied further. The goal of our research is to figure out the mechanism how magnetic minerals derived from different sources contribute to remanent magnetizations of sediments. Then, it is expected that influences on RPI estimations brought by compositional variations of magnetic mineral assemblages in marine sediments will be able to be known.

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Keywords: geomagnetic paleointensity, silicate-hosted magnetic mineral inclusion, biogenic magnetite, Ontong-Java plateau

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Environmental magnetic study of a Holocene sediment core from the Yeongsan Estuary, Southwest Korea

*Hyeon-Seon Ahn[1], Jaesoo Lim[2]

1. Kochi University, 2. Korea Institute of Geoscience and Mineral Resources

The sensitivity of magnetic properties to environmental processes may provide useful information on paleoenvironmental changes in estuarine environments. Magnetic property studies of estuaries are less common than other environments. Owing to the west coast of South Korea having an abundance of estuaries, it can provide a good place to study these processes in estuarine environments. We analyzed a variety of magnetic properties based on magnetic susceptibility, hysteresis parameters, progressive acquisition of isothermal remanent magnetization (IRM), and first-order reversal curve data, in addition to electron microscopic observations of magnetic minerals, from a Holocene muddy sediment core recovered from the Yeongsan Estuary on the west coast of South Korea. The age of the studied sediment core was well constrained based on radiocarbon dates. We examined diagenetic effects on magnetic properties and tested their availability as proxies of paleoenvironmental change. The presence of generally low magnetic susceptibilities, ubiquitous authigenic magnetic components such as pyrite and greigite suggested that the analyzed sediments had undergone considerable early diagenetic alteration. Our results confirm that the use of initial bulk susceptibility as a stand-alone environmental change proxy is not recommended unless it is supported by additional magnetic analyses. We recognized the existence of ferromagnetic-based variabilities related to something besides the adverse diagenetic effects, and examined possible relationships with sea-level and some of major climate changes during the Holocene. The most remarkable finding of this study is the two distinct intervals with high values in magnetic coercivity (B_c), coercivity of remanence (B_{cr}), and ratio of remanent saturation moment to saturation moment (M_{rs}/M_s) that were well coincident with the respective abrupt decelerations in the rate of sea-level rise occurred at around 8.2 and 7 thousand years ago. Furthermore, it is inferred that such condition with abrupt drop in sea-level rise rate would be favorable for the abrupt modification of grain size distribution of ferromagnetic minerals toward more single-domain-like content.

Keywords: Holocene sediments, magnetic properties, estuary, paleoenvironments, diagenesis

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Relationship between the abundance of the exsolved magnetite and the valence state of iron in single plagioclase crystal separated from Doshi gabbro

*Yujiro Tamura[1], Masahiko Sato[2], Ryoichi Nakada[3], Chie Kato[4], Shinji Yamamoto[1]

1. Yokohama National University, 2. The University of Tokyo, 3. Japan Agency for Marine-Earth Science and Technology, 4. Kyushu University

Paleomagnetic measurements using single silicate crystals such as quartz (Tarduno et al., 2010), zircon (Sato et al., 2015), and plagioclase (Kato et al., 2018) play a key role on the geomagnetic field study. Among them, the plagioclase crystal sometimes contains fine-grained and rod-shaped magnetite as exsolution lamellae, and the paleomagnetic record of exsolved magnetite likely provides reliable paleomagnetic information for a long era. However, the exsolved magnetite does not commonly exist in plagioclase crystals of various rock samples, and its formation mechanism has not been understood. It is expected that the formation of magnetite exsolution lamellae is caused by the decrease of maximum solubility of iron in plagioclase crystals during the cooling process of rocks under subsolidus conditions. Additionally, important factors controlling the exsolution of magnetite are the cooling speed of crystal, iron concentration, and valence state of iron in plagioclase should be important factors controlling the exsolution of magnetite. Then, to understand the exsolution mechanism, investigations of iron valence state and abundance of exsolved magnetite within a single plagioclase crystal are suitable because these factors are not significantly different in a single crystal. This study investigated the plagioclase crystal from the Doshi gabbro, northwest of the Tanzawa tonalitic complex, for microscopic observation and measurements of iron valence state. Thin sections with double-side polished were made for the observation by polarizing microscope and electron microscope. Subsequently, we analyzed the composition of plagioclase by Electron probe Micro-Analyzer and the valence state of iron within plagioclase by K-edge X-ray absorption fine structure analysis. The abundance of exsolved magnetite has estimated from backscattered electron images in the image analysis using the Image J software. The plagioclase crystal shows the clear zonal structure of exsolved magnetite parallel with the chemical zoning structure. In order to investigate the formation mechanism of magnetite exsolution, we compared the iron valence within plagioclase with the abundance of exsolved magnetite and iron concentration around the measured spot. The iron valence of plagioclase in each spot was approximately 2.5 to 2.6, and there is no clear relationship between the iron valence of plagioclase and the abundance of exsolved magnetite. We additionally estimated the iron valence state in plagioclase crystal before the magnetite exsolution from iron valence measurement and the abundance of exsolved magnetite. As a result, it was suggested that exsolved magnetite tends to form in the areas that originally had a high iron valence. The causes of the differences in iron valence in plagioclase will also be discussed.

Keywords: magnetite exsolution, plagioclase, iron valence

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.20 Zoom Room 20

[S-MP25] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

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

[SMP25-01] Prolonged subduction metamorphism and deep forearc accumulation of Sanbagawa Complex: an example from Okawara district, southern Japanese Alps

*Kazuhiro Miyazaki[1], Yoshihiro Nakamura[1], Hiroshi Makimoto[1] (1.Institute of Geology and Geoinformation, Geological Survey of Japan/National Institute of Advanced Industrial Science and Technology)

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

[SMP25-02] High mobility of Sr and Ba in subduction-related metamorphism: Application of Machine-learning mass transfer analyses to mafic shists, the Sanbagawa belt

*Matsuno Satoshi[1], Masaoki Uno[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies Tohoku University)

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

[SMP25-03] U–Pb garnet dating of HP marble from the Eastern Iratsu body, Sanbagawa metamorphic terrane: decoupled isotopic signature and compositional zoning

*Sota Niki[1], Kenta Yoshida[2], Hikaru Sawada[2], Ryosuke Oyanagi[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

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

[SMP25-04] **Crystal size distribution of garnet formed by two-stage growth in the Kotsu eclogite, Sanbagawa belt**

*OTGONBAYAR DANDAR[1], Atsushi Okamoto[1], Masaoki Uno[1] (1.Graduate School of Environmental Studies, Tohoku University)

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

[SMP25-05] A shape change model of isolated K-feldspar inclusions within a micro-shear zone developed in Teshima granite, the Ryoke metamorphic belt

*Tae-Hoon Uhmb[1], Katsuyoshi Michibayashi[1] (1.Department of Earth and Planetary Sciences, Research group of Petrology and Mineralogy, Nagoya University)

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

[SMP25-06] C-O-H fluid was present during garnet-forming partial melting reaction in a pelitic migmatite from the Ryoke belt, Japan

*Natsumi Yoshimoto[1], Tetsuo Kawakami[1] (1.Kyoto University)

Prolonged subduction metamorphism and deep forearc accumulation of Sanbagawa Complex: an example from Okawara district, southern Japanese Alps

*Kazuhiro Miyazaki[1], Yoshihiro Nakamura[1], Hiroshi Makimoto[1]

1. Institute of Geology and Geoinformation, Geological Survey of Japan/National Institute of Advanced Industrial Science and Technology

Sanbagawa and Chichibu complexes are distributed between the north-south trending MTL and BTL in the Okawara district, southern Japanese Alps. Both complexes were fragmented by some north-south trending vertical faults. Except for near MTL , dips of main schistosities ara gentle. Nearly horizontal structures are preserved within fault-bounded blocks. The Okawara district possesses about 2000 m difference of elevation, therefore this area is adequate for revealing geological architecture of the Sanbagawa Complex . The Sanbagawa Complex consists of Kurokawasawa (mainly pelitic schist), Kamasawa (mainly pelitic schist with small amount of marble), Mikabu (mainly ultramafic to mafic metamorphic rocks), and Terasawa units (mainly pelitic phyllite and metachert), in order from bottom to top with referring to the gentle-dipping main schistosity. The Mibugawa unit (mainly mixed rock, chert and basalt) of the Chichibu complex tectonically overlaps the Sanbagawa Complex.
Boundaries between Mikabu and Kurokamasawa units and between Kamaswa and Terasawa units are almost identical to 325 ˚C and 315 ˚C isotherms, restpectively. These planes were used as references. Using the references, lithological distribution, main schistosity, and RSCM isotherms, many geological cross sections generated by QGIS plug-in, mineral assemblages, solid solution composition of minerals, , bulk compositions, Gibbs free energy minimum modeling, and MCMC maximum likelihood estimation and information criterion of the youngest age component with detrital zircon U-Pb ages, we reconstruct geological architecture of the Sanbagawa Complex. The results show that thickness measured in the direction perpendicular to the main schistosity, peak temperatures and pressures, the youngest age components of detrital zircon are as follows; the Kurokawasawa unit: 1400 m, 325-400 ˚C, 6-8 kbar, 72.3 ±0.7 Ma (lower part), 96.3 ±2.8 Ma (middle part), 104.0 ±1.1 Ma (upper part); Kamasawa unit: 1200 m, 285-325 ˚C, 5.0-6.5 kbar, 105.7 ±1.2 Ma and 109.8 ±1.9 Ma; Mikabu unit: 285-325 ˚C, 5.0-6.5 kbar; Terasawa unit: 800 m, 135.8 ±1.8 Ma; Mibugawa unit: 1000 m, 280-305 ˚C, 4-5 kbar, 171.3 ±2.2 Ma. Using these values, we also estimate thermal gradient perpendicular to the main schistosity as follows; Kurokawasawa unit: 55 ˚C/km; Kamasawa unit: 40 ˚C/km; Mibugawa unit: 33 ˚C/km. These high values are possible in inverted thermal structure in subduction channel with descending cold slab. However, downward increases of temperatures in our case are opposite to what one expected for the inverted thermal structure. Assuming crustal density of 2.9 g/cm^3, our geological estimation of total thickness from the Kurokawasawa to Mibugawa units is about one third of the petrological estimation of pressure differences. This large discrepancy suggest large amount of crustal thinning took place with formation of main schistosity during exhumation.
P-T conditions from the Kurokawasawa to lower part of the Mibugawa units show linear array on P-T diagram, and are resemblant to those along subduction channel with shear heating (e.g. Ishii and Wallis, 2020). Metamorphic phengite K-Ar ages from bottom and top of the Kurokawasawa unit yield ca. 65 Ma (Shibata and Takagi, 1988) and 105 Ma (Watanabe et al., 1982), respectively. These metamorphic ages suggest at least 40 Myr duration of the Sanbagawa metamorphism. Our geological, petrological and geochronological results lead to the following formational picture for the Sanbagawa Complex; 1) steady-state P-T conditions observed by the Sanbagawa Complex was maintained along subduction

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channel for at least 40 Myr duration, 2) protolith of the Sanbagawa Complex was continuously subducted to the subduction channel and suffered the Sanbagawa metamorphism, 3) metamorphic rocks were successively exhumed with thinning and formation of main schistosity, and 4) the exhumed metamorphic rocks accumulated from bottom at deeper depths of forearc in arc-trench system.

Keywords: Sanbagawa, Subduction zone, Metamorphism

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High mobility of Sr and Ba in subduction-related metamorphism: Application of Machine-learning mass transfer analyses to mafic shists, the Sanbagawa belt

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Regional mass transfer in subduction-related metamorphic rocks records fluid activities in subduction zones and serves as a key to understand fluid-related processes such as seismic activity (e.g., Hacker et al., 2003) and magma generation in island arcs (e.g., Pearce et al., 2005). Although geophysical observations suggest that such fluid distributions are in regional scales (i.e., 1–10km), the scales of quantitative mass transfer analyses are usually limited to outcrop scales. Mass transfer analysis on the regional scale has been investigated as chemical trends (e.g., John et al., 2004; Bebout 2007; Masters and Ague 2005); however, protolith heterogeneity hinders quantitative analyses of mass transfer in scales larger than outcrops (i.e., >100 m; e.g., Moss et al., 1995; Bebout 2007; Uno et al., 2014). To understand regional scale metamorphic mass transfer, it is required to determine protolith composition from metamorphic rock sample by sample.

To evaluate metamorphic mass transfer, we have developed protolith compositional estimation models using machine learning. The models were built by learning protolith basalt compositional dataset (Ocean Island basalt, Mid-ocean ridge basalt, and Island arc basalt), and designed to estimate trace element compositions from limited numbers of input trace element concentrations (i.e., 2–9 elements). Gradient Boosting Decision Tree was used as a machine learning algorithm, and models were evaluated by the Root Mean Squared Error in the log unit. With Zr, Th, Ti, and Nb as input elements and Rb, Ba, U, K, La, Ce, Pb, Sr, Nd, Y, Yb, and Lu as output elements, the developed models can reproduce protolith basalt compositions within errors of 10%–25% (i.e., <0.1 in log10 unit). As Zr, Th, Ti, and Nb are the most immobile element in typical regional metamorphism (e.g., Ague et al., 2017), these elements are adopted as input elements. It is noted that models with other input elements are also available. These models were applied to seafloor altered basalt for validation. Compositions of fresh glass remained in the seafloor altered basalt are compared to the estimated protolith compositions, which ensured the model reliability.

The protolith compositional estimation models were applied to the Sanbagawa metamorphic belt, SW Japan. Samples were collected from Asemigawa-river, Central Shikoku, where it crosses chlorite zone (CHZ), garnet zone (GTZ), albite-biotite zone (ABZ), and oligoclase-biotite (OBZ), with increasing metamorphic grade. Mafic rocks are exposed as lenticular bodies or layers, and are collected at each grade for mass transfer analyses. It has been revealed that mafic rocks in CHZ are N-MORB-like compositions, and those in GTZ and OBZ are E-MORB-like compositions (Uno et al., 2014), and such protolith heterogeneity inhibited direct comparisons of trace element compositions among metamorphic grades. To enable direct comparisons of mass transfer among metamorphic grades, the protolith compositional estimation models were applied to the mafic rock samples. It is revealed that both enrichment and depletion had occurred for Rb, K, Sr, and Y compared to their protoliths; Ba is depleted for most of the samples; Not a significant mass transfer was detected for La, Ce, and Nd. Although the degree of mass transfer varies within a metamorphic grade, maximum depletion of Ba and Sr at each grade correlates with metamorphic grades: Ba has been depleted more than 90% at the maximum, Sr has been enriched more than 200% at the maximum, while some samples have been depleted 50% at the

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minimum. These results provide unique insights into elemental budgets and fluid activities in subduction zones.

Keywords: Mass transfer, Metamorphism, Regional scale, Machine-learning, Subduction zone

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U–Pb garnet dating of HP marble from the Eastern Iratsu body, Sanbagawa metamorphic terrane: decoupled isotopic signature and compositional zoning

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Generally, geochronological studies on metamorphic rocks have been dependent on the occurrence of specific minerals (e.g. mica and zircon). For these minerals, the relationships between the timing of mineral growth and metamorphic stages are often unclear [1, 2]. For the accurate reconstruction of the pressure-temperature-time (*P-T-t)* paths, geochronological data from in-situ dating while differentiating textures inside mineral grains should be linked to *P-T* conditions determined by co-existing inclusion minerals near the spots measured by in-situ dating methods.

Among metamorphic mineral species, grossular (Grs)-andradite (Adr) series garnet is a potential candidate to define both U–Pb ages and *P-T* conditions. The U–Pb isotopic system of garnet is robust against thermal events because of the high closure temperature (>800 ˚C [3]). The *P-T* conditions of garnet can also be deduced from the co-existing inclusion minerals.

In this study, U–Pb dating of metamorphic Grs garnet was first conducted using a laser ablation-ICP-mass spectrometry. The in-situ spot ages were linked to the *P-T* conditions deduced from the garnet itself. The garnet sample was collected from the eastern margin of the Eastern Iratsu body in the eclogite-unit of the Sanbagawa metamorphic terrane. Prior to the U–Pb isotopic analysis, the zoning texture inside the garnet sample was observed using backscattered electron images. The Grs grain showed a patchy texture with an almost pure Grs core ($Grs_{98}Adr_2$) and an Adr-rich rim ($Grs_{91}Adr_8Alm_{<2}$). The presence of aragonite in the core indicates formation during the eclogite-facies metamorphism while the rim was formed under the *P-T* conditions of the juxtaposition of the exhuming eclogite-unit and surrounding schists [4].

For U–Pb isotopic analysis, the 13 spots for the core and 13 spots for the rim were carefully selected. The obtained U–Pb isotopic results formed a regression line on the Tera and Wasserburg Concordia Diagram. The mean square weighted deviation (MSWD) of the regression line was greater than 2 (2.5 for core and 4.1 for rim). Since titanite in this sample recorded ages of an older stage (ca. 200 Ma [5]), the large MSWD can be attributed to the remnant of such old U–Pb isotopic signatures. By rejecting these “old” U–Pb isotopic data, the obtained age of the core was 95.8±8.9 (2 σ) with a MSWD = 0.70 and the obtained age of the rim was 95.3±8.3 (2 σ) with a MSWD =1.0.

The resulting U–Pb ages of the core were in good agreement with the timing of the eclogite-facies stage, such as 92.6±8.8 Ma of zircon U–Pb ages [6] and 88.8±0.6 Ma of garnet Lu–Hf isochron ages [7]. The core and rim were indistinguishable despite the obvious zoning texture inside the garnet and the difference in metamorphic *P-T* conditions constrained from co-existing inclusion minerals. The agreement of the U–Pb ages between the core and rim can be explained by two reasons. Firstly, the chemical compositions and the U–Pb isotopic system were decoupled because of coupled dissolution-reprecipitation processes [8]. The rim of Grs was produced through the series of dissolution-reprecipitation reactions among the Grs grains while the U–Pb isotopic system remains

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unperturbed and partly preserved old (96 Ma) signature. Secondly, the time difference between core and rim formations was too small to detect by present analytical precision. The timing of the rim formation can be earlier than the peak (or cooling) ages of the surrounding schists, i.e. 90-85 Ma [7, 9]. This time period overlapped with the obtained ages in this study within the analytical errors.

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Keywords: garnet, U–Pb geochronology, Sanbagawa metamorphic terrane, LA-ICP-MS

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Crystal size distribution of garnet formed by two-stage growth in the Kotsu eclogite, Sanbagawa belt

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The nucleation and growth history of crystals during metamorphism are recorded both as crystal size distribution (CSD) and compositional zoning from core to rim. In particular, the crystal size distribution of garnet has been investigated and modeled by relative rate of nucleation and growth, and coupled with diffusion. As garnet is commonly formed during prograde metamorphism, the incremental amount of the garnet growth at individual P-T conditions is essential information to elucidate the water release at the subduction interfaces. Conventionally, there are two types of model on crystal size distribution; one is the nucleation and growth rates are defined as a function of time (e.g., Spillar and Dolejs 2013), and the other one is growth rate is defined as the size (e.g., Eberl et al., 1998). However, it is still uncertain which model is more appropriate, as the data aquations of CSD from thin sections and the composition of “true” core are very difficult due to the cut effects. In this contribution, we showed the detailed data showing the relationship between crystal size distribution and compositional zoning of garnet in the Kotsu eclogite in the Sanbagawa metamorphic belt, Japan. This eclogite sample is suitable to this trial, because garnet grains show euhedral shape and record two-stage growth history composed of the core containing abundant mineral inclusions (epidote, plagioclase, chlorite, carbonate, titanite, quartz, and omphacite) and poor-rim.

The detailed analyses were performed in the following steps. (1) We crashed the ~120 grams of eclogite samples by the system of high voltage pulse fragmentation (Selfrag), and picked up all garnet grains (n>4342). (2) We sieved the grains into five classes (>2 mm, >1 mm, >0.5 mm, >0.25 mm, and <0.25 mm). (3) In each class, garnet grains are embedded in epoxy resin, and we took the X-ray CT images for getting the crystal size distribution. (4) After taking X-ray CT, we polished the sample to section the real cores. (5) The two-stage growth is obtained based on the back-scattered images and get the compositional zoning from core to rim.
Combining the results of the crystal sizes taken from the X-ray CT images in all classes, we reveal that the garnet population shows pseudo-lognormal CSDs, which has a small shoulder at the medium grain size (~0.75 mm). The crystal growth is divided into two stages. The garnet grains are euhedral grains composed of the inclusion-rich core (stage 1) and poor-rim (stage 2). The core shows prograde zoning, characterized by decreases of X_{Mn} (0.025 to 0.005) and increase of X_{Mg} (0.06 to 0.12) from core to rim, and almost constant X_{Fe} (0.55-0.65) and X_{Ca} (0.27-0.35). The smaller grains have lower Mn and higher Mg contents, suggesting that nucleation at the later retrograde stages. All grains have an inclusion-poor rim showing Mn increase. One of the interesting observations is a positive relationship between the diameter of the inclusion-rich core and the growth width of the inclusion-poor rim, meaning that the growth rate is proportional to the grain size. We will construct the nucleation and growth model to reproduce the CSD and the trend of growth zoning, and discuss the mechanism and water production history.

Keywords: Garnet, Crystal size distribution, nucleation, growth, Kotsu eclogite

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A shape change model of isolated K-feldspar inclusions within a micro-shear zone developed in Teshima granite, the Ryoke metamorphic belt

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The isolated mineral inclusions possess many kinds of important information for geological history of natural rocks. Especially, shape change patterns (i.e. size versus aspect ratio pattern of the inclusion) of the inclusions were used as a tool to estimate deformation time and deformation conditions in some of previous studies. Toriumi [1981, 1987] firstly proposed mathematical equation representing shape change patterns of the isolated mineral inclusions. More recently, Okamoto and Michibayashi [2005] evaluated deformation time and deformation conditions of natural rock deformed in uniaxial deformation by modeling shape change patterns of garnet inclusions based on the mathematical equation. In this study, we present a numerical model explaining shape change of isolated K-feldspar inclusions within quartz host grain in micro-shear zone developed in Teshima granite, the Ryoke metamorphic belt based on the mathematical equation proposed by Toriumi [1987]. Moreover, we estimated deformation time and shear strain of the micro-shear zone on the basis of modeling and observing data of the K-feldspar inclusions.

To calculate shape change pattern according to various deformation conditions from the model, we estimated deformation temperature (~500-600 ˚C) and paleo-stress (156 MPa) based on deformed quartz microstructures within the micro-shear zone. Shape change patterns were obtained by calculating the model at the estimated temperature ranges from 500 to 600 ˚C with 25 ˚C of interval and at the estimated paleo-stress. Subsequently, the shape change patterns were corrected through combining shape change patterns in zero stress condition to compensate post-deformational annealing effects during exhumation stage of the micro-shear zone. Deformation time was measured by finding out the best-matched shape change pattern calculated by the model in comparison with a shape change pattern observed in the micro-shear zone and by cooling rate of the Ryoke belt proposed by Okudaira et al. [2001]. As a result, deformation time in the micro-shear zone is calculated as 2250-4000 yr under conditions of T = 540-550 ˚C, σ = 156 MPa. Shear strain in the micro-shear zone is 34-45.

Keywords: Micro-shear zone, Numerical modeling, K-feldspar inclusion, Deformation time

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C-O-H fluid was present during garnet-forming partial melting reaction in a pelitic migmatite from the Ryoke belt, Japan

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1. Kyoto University

Partial melting of the crustal rocks has long been discussed based on the scheme of two end member concepts of vapor-present melting vs dehydration melting. Common textural characteristic of the incongruent melting is a coexistence of peritectic mineral(s) and leucosome, and this has long been considered as an evidence of dehydration melting. Existence of primary melt inclusions such as nanogranites in peritectic mineral(s) is also good evidence of incongruent melting. Recently, however, coexistence of melt inclusions and fluid inclusions are found from peritectic garnet in partially molten rocks (e.g., Carvalho et al., 2019), evidencing that fluid phase coexisted with partial melts when the peritectic garnet was formed. In order to investigate the presence/absence of such fluid phase during partial melting of the middle to lower crust beneath a volcanic arc, we carried out petrographic observation of pelitic migmatites from the Cretaceous Ryoke metamorphic belt (Aoyama area, SW Japan).

The sample used in this study is a pelitic diatexite that occur in the metatexite-dominant area of the Grt-Crd zone of the Aoyama area. The sample mainly consists of biotite + garnet + plagioclase + quartz, and minor K-feldspar and muscovite are also present in the matrix. The garnet is almost homogeneous in terms of major elements except for the grain margin in contact with biotite. Therefore, we utilized discontinuous zonings in terms of P and Y to define the isochronous surface within the garnet during its growth. As a result, garnet is divided into inner core, outer core, mantle, inner rim and outer rim. Inner and outer cores show higher Y concentration compared to other domains, and prograde xenotime is included in the outer core. In the mantle and the inner rim, sillimanite needles are included. Muscovite, plagioclase, K-feldspar are included in the vicinity of the sillimanite in the inner rim. The outer rim has abundant ilmenite inclusions and rare euhedral plagioclase inclusion indicative of partial melting. Fluid inclusions are seen throughout the garnet grain except for the inner rim. These fluid inclusions are composed of both fluid and solid phases. The fluid phase is mainly composed of CH_4 or CO_2 + CH_4, and the solid phases are siderite, chlorite, and clay minerals. Such a mode of occurrence of CH_4-bearing COH fluid inclusions is interpreted as a result of post-entrapment reaction between original COH fluid inclusion and host garnet that resulted in the formation of secondary daughter minerals (Carvalho et al., 2019).

Based on pieces of observation described above, the garnet-forming process is explained as follows. (1) High Y concentration and presence of prograde xenotime inclusion and COH fluid inclusion in the outer core of the garnet suggests that the garnet core grew at around 530-570°C (Kawakami et al., 2019) in the presence of COH fluid. (2) Sillimanite, muscovite, plagioclase and K-feldspar in the inner rim suggests that the inner rim grew at around the muscovite breakdown reaction Ms + Ab + Qtz = Sil + Kfs + melt. (3) The COH fluid inclusions, abundant ilmenite and rare euhedral plagioclase enclosed in the outer rim of garnet indicate that the biotite breakdown melting in the presence of COH fluid was responsible for the formation of the outer rim of garnet. Therefore, this study revealed that COH fluid was present during the biotite breakdown melting reaction to form garnet in the middle crust of the upper-amphibolite to granulite facies Ryoke metamorphic belt. Presence of fluid phase can be common even during the partial melting of graphite-bearing pelitic lithology that produces peritectic mineral(s).

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Keywords: metamorphism, partial melting, crustal fluid

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.20 Zoom Room 20

[S-MP25] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

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

[SMP25-07] Rheological and metamorphic evolutions of high-grade Shimanto accretionary complex in Kerama islands, Ryukyu

*Ippei Yamamoto[1], Yoshihiro Nakamura[2], Yumiko Harigane[2], Yui Kouketsu[3], Kenichiro Tani[4], Asuka Yamaguchi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Institute of Advanced Industrial Science and Technology, 3.Nagoya University, 4.National Museum of Nature and Science)

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

[SMP25-08] Rheological Properties of Ductile Shear Zone Developed in Mado Megamullion, Shikoku Basin, Philippine Sea

*Kohei Nimura[1], Katsuyoshi Michibayashi[2], Yumiko Harigane[3], Yasuhiko Ohara[4,5] (1.Department of Earth and Planetary Science, Faculty of Science, Nagoya University , 2.Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 3.Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 4.Hydrographic and Oceanographic Department of Japan, 5.JAMSTEC)

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

[SMP25-09] Possibility of CPO development during diffusion creep of the lower crustal minerals

*Bunrin Natsui[1], Kosuke Yabe[1], Takehiko Hiraga[1] (1.Earthquake Research Institute, University of Tokyo)

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

[SMP25-10] The effect of fluid compositions on pore formation during plagioclase replacement under supercritical conditions

*Astin Nurdiana[1], Atsushi Okamoto[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1] (1.Tohoku University)

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

[SMP25-11] Garnet–aluminosilicate–spinel–plagioclase geobarometer

*Toshiaki Shimura[1], Yuki Harada[1,2], Geoffrey L. Fraser[3], Noriyoshi Tsuchiya[4] (1.Yamaguchi University, 2.i-SHOT Inc., 3.Geoscience Australia, 4.Tohoku University)

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

[SMP25-12] Porosity wave and mineral banding in the metamorphism

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

Rheological and metamorphic evolutions of high-grade Shimanto accretionary complex in Kerama islands, Ryukyu

*Ippei Yamamoto[1], Yoshihiro Nakamura[2], Yumiko Harigane[2], Yui Kouketsu[3], Kenichiro Tani[4], Asuka Yamaguchi[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. National Institute of Advanced Industrial Science and Technology, 3. Nagoya University, 4. National Museum of Nature and Science

The Kerama Formation in the Ryukyu Arc is located at the southwestern edge of the Shimanto Belt, made up of repetition of greenstone, metasandstone, and pelitic schist. Sedimentation and metamorphic ages were estimated to be ca. 105 and ca. 91 Ma, respectively, based on zircon U-Pb and muscovite K-Ar ages (Yamamoto et al, submitted). Occurrence of terrigenous metasediment and N-MORB type greenstone contacts are intrusive in most places, suggesting ocean floor spreading occurred near the trench (Chinen et al., 2004; Yamamoto et al., submitted).

Although metamorphic mineral assemblage of greenstone (epidote + actinolite; Hashimoto, 1978) and the existence of mylonite originated from conglomerate (containing quartz, plagioclase, K-feldspar, muscovite and chlorite; Yamamoto et al., submitted) suggest metamorphism and deformation occurred at high temperature conditions, there have been few reports on the detailed metamorphic temperature estimations and deformation microstructures of the Kerara Formation before. In this study, we present results of Raman spectroscopy of carbonaceous material (RSCM) thermometry and electron backscatter diffraction (EBSD) analyses of the rocks of the Kerama Formation to constrain peak metamorphic temperature and rheological condition related to subduction of spreading center.

RSCM analyses were performed using a Raman spectrometer with a 532 nm Nd-YAG laser (system installed at Nagoya University). Peak metamorphic temperature of pelitic schist and conglomerate mylonite (originated from gravel sandstone) was estimated to be 470–525˚C, which is consistent with the temperature range of metamorphic facies proposed in the greenstone.

Measurement of grain size and crystallographic preferred orientations (CPO) in quartz were conducted by SEM-EBSD-EDS system in GSJ-Lab (HITACHI SU3500 SEM mounted with Oxford EBSD detector). Recrystallized quartz region from a sample of conglomerate mylonite shows type II crossed girdle CPO. According to the quartz c-axis fabric opening-angle thermometer of Faleiros et al (2017), it is suggested that the recrystallized quartz region from the sample of conglomerate mylonite was deformed under ~530˚C, which corresponds to the peak metamorphic temperature estimated from RSCM thermometry. The mean grain size of quartz in the mylonite is ~80 μm, which suggests the differential stress magnitudes of ~30 MPa (Cross et al. 2017).

In contrast to common occurrence of mylonite along fossil fault zones in continental lithosphere, mylonite in subduction setting is rare: no mylonite has reported from the Shimanto Belt so far. The geology of Kerama islands would be a strong constrain for rheology of subduction plate interface at high temperature condition.

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Rheological Properties of Ductile Shear Zone Developed in Mado Megamullion, Shikoku Basin, Philippine Sea

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Oceanic core complexes (OCCs) are domal bathymetric features that are found along intermediate-to ultraslow-spreading ridge (<55 mm/yr) and are characterized by exposed lower crust and mantle material. These domal bathymetric features are interpreted to be exposed on the seafloor over several million years by detachment faulting, but few studies have examined their properties from a rheological point of view. In this study, we investigate the kinematic features of detachment faulting in the Mado Megamullion, one of the OCCs in the Shikoku Basin of the Phillipine Sea, based on the deformation microstructure and crystallographic orientation fabric of the deformed gabbroic rocks.
Microstructural observations, crystallographic-preferred orientation (CPO) analysis and major element composition analysis of plagioclases and amphibole from 3 deformed gabbroic rocks (R10, R19a and R20) were studied among 10 rocks collected from the Mado Megamullion. The deformation mechanism was estimated based on the results of microstructural and CPO analyses. In addition, the deformation temperature was estimated by applying the chemical composition obtained from the major element composition analysis to the amphibole–plagioclase geothermometer.
Both plagioclase and the secondary amphibole show evidence of intracrystalline plastic deformation and were dynamically recrystallized. The CPOs of plagioclase and amphibole show a strong concentration of (001)[100] and (100)[001] patterns, respectively. The chemical compositions of plagioclase and amphibole are diverse, ranging from An_{41}–An_{76} and Hornblende–Pargasite, respectively. However, the equilibrium temperatures obtained for 3 samples were in the same temperature range (870–690˚C). Equilibrium temperatures of 690–610˚C were obtained from felsic veins penetrating the gabbros.
Based on microstructural observations and CPO analyses, the deformation mechanism of plagioclase and amphibole is assumed to be dislocation creep. Assuming that the equilibrium temperature is the temperature range during deformation, the analyzed gabbros were plastically deformed at 870–690˚C (granulite-facies) because the crystallographic slip planes of plagioclase and amphibole are the same.
In order to clarify the characteristics of the ductile shear zone, deformation mechanism maps of plagioclase deformed by dislocation creep were constructed from the dynamic recrystallized grain size, the equilibrium temperature and the flow law of plagioclase. The shear strain rate of the ductile shear zone of the Mado Megamullion was estimated to be more than 10^{-9} s^{-1} and its thickness to be about 20 cm. The values of shear strain rate and shear zone thickness estimated in this study mean that there are localized regions of high shear strain rate in the ductile shear zone. In other words, it suggests strain localization due to grain size reduction and fluid infiltration. We compared the deformation temperatures and shear strain rates obteined in this study with data from Godzilla Megamullion, the world's largest OCC in the Parece Vela Basin. The properties of the ductile shear zones of Mado Megamullion and Godzilla Megamullion show similarities. This suggests that there is a common feature in the formation process of Mado Megamullion and Godzilla Megamullion.

Keywords: Oceanic Core Complex, Ductile shear zone, Back-arc basin, lower oceanic crust, gabbro, flow law

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Possibility of CPO development during diffusion creep of the lower crustal minerals

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Olivine is a major constituent minerals of the upper mantle and is known for its crystal preferred orientations (CPO), where the crystal axis is oriented in a specific direction. CPO has been thought to develop only during dislocation creep, but recently the CPO development during diffusion creep and its mechanism have been experimentally demonstrated (Miyazaki et al., 2013; Maruyama and Hiraga, 2017). However, it is not clear that the similar CPO development process occurs in minerals other than olivine.

The CPO development of plagioclase in lower crustal rocks is well known. In this study, the mechanism of CPO development during deformation of plagioclase which is responsible for the lower crustal flow was investigated by pure shear deformation experiments at high temperatures. Polycrystalline anorthite ($CaAl_2Si_2O_8$), the Ca-rich end member of plagioclase, with an average grain size of ~2 μm and porosity of <0.01 vol% was synthesized using vacuum sintering technique. This polycrystalline material was placed in a carbon guide and deformed at atmospheric pressure, temperature of 1242℃ and stresses of 40~75 MPa. Microstructural analysis of the deformed samples revealed CPO development, and the stress-strain rate relationship during the deformation indicated the mechanism of diffusion creep. We discuss the possibility of CPO development during diffusion creep in the lower crust.

Keywords: diffusion creep, CPO, lower crust, anorthite

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The effect of fluid compositions on pore formation during plagioclase replacement under supercritical conditions

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Multistage feldspar replacement by Na-K rich fluid is frequently found in mid-crustal depth (e.g. Plümper et al., 2009; Yuguchi et al., 2019) at which micro- to nano- pores fluid pathways developed intensively. Such feldspar replacement was also found in mafic schist from Kinkasan Island, NE Japan, as a part of the South Kitakami Belt. Multiple plagioclase replacement by infiltration of Na-rich and K-rich fluid was recorded. In the K-rich fluid alteration, plagioclase (An35-60) was altered to Kfs (An0Ab1Or99) and albite (An4Ab94Or2) intergrowth along with pores development that increases bulk rock porosity up to 1.34± 0.14%. The replacement was induced by pegmatite-related Na-K-rich fluid and took place at 400-570˚C at 0.3–0.45 GPa. That shows that Na-K-rich fluid may induce multiple secondary feldspar and micro- to nano- pores generations. However, the role of these fluids governs the replacement process is still poorly understood.

We conduct feldspar replacement by Na-K rich fluids to see if the Na-K ratio may induce the secondary product and pore formations to compare to natural sample in Kinkasan. We carried out plagioclase replacement by aqueous 2M KCl and/or NaCl under 600˚C & 150 MPa for 4-8 days. Plagioclase starting materials are anorthite (An; An96Ab4), labradorite (Lab; An66Ab33Or1), and albite (Ab; An1Ab99) that each of them reacted with the fluid with and without silica presence to progress feldspar replacement. Reaction results show the dissolution-reprecipitation process with a sharp reaction front and induced pores formation up to ~7%. That micro-size pores are unlikely to always relate to the grain boundaries. Reactions of KCl-feldspar in undersaturated silica show a faster reaction rate and varied porosity properties compare to NaCl and/or KCl fluid with feldspar in silica saturated conditions. Labradorite-KCl reaction shows the most intense pore formations and alkali feldspar product which is the closest texture of plagioclase replacement by K-rich fluid in Kinkasan sample.

That result indicates the role of Na-K rich fluid ratio and silica saturation toward feldspar replacement. The reaction of feldspar with the higher K ratio fluid and limited silica leads to intense pore generations as the main fluid channel. The different ratios of Na-K and silica presence brought the feldspar replacement into different pore properties.

Keywords: Na-K rich fluid, feldspar replacement, fluid transport, hydrothermal experiment, Kinkasan

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Garnet–aluminosilicate–spinel–plagioclase geobarometer

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Spinel series mineral, (Mg, Fe, Zn, Mn) Al_2O_4 solid solution is one of the rock-forming minerals in pelitic metamorphic rocks. It mainly occurs in the sillimanite field, but also occurs in the kyanite field and andalusite field. Many authors studied spinel-forming reactions of pelitic metamorphic rocks. Some of these were solved as net-transfer reactions, geobarometers. Many geobarometers have been proposed for spinel-bearing pelitic metamorphic rocks (e.g. Harris, 1981; Perchuk et al., 1989; Nichols et al., 1992). For example, such net-transfer reactions are;

(1) Grt + 2Als = Spl + Crd,
(2) Crd = 2Spl + 5Qz,
(3) Grt + 2Als = 3Spl + 5Qz.

The reaction (1) means that the product minerals are spinel and cordierite. As a result, the spinel must be in contact with cordierite. Such textures are well-known in the Hidaka metamorphic belt and Ryoke metamorphic belt. On the other hand, the reactions (2) and (3) mean that the product minerals are spinel and quartz. As a result, the spinel must be in contact with quartz directly. This mineral assemblage is one of the diagnostic UHT metamorphic mineral assemblages (e.g. Waters, 1991; Harley, 1998; Ganguly et al., 2017). Therefore, net-transfer reactions (2) and (3) geobarometers can be used only for the UHT conditions. Generally, almost all pelitic metamorphic rocks contain quartz. However, spinel does not occur in contact with quartz in the amphibolite facies and/or in the granulite facies (lower than the UHT) conditions. Geobarometers (2) and (3) cannot be used for such metamorphic conditions.

Spinel + plagioclase symplectites in pelitic metamorphic rocks have been reported from many localities. We report occurrence of such texture, from Lützow–Holm Complex (LHC), East Antarctica, Hidaka Metamorphic Belt, Japan, Uetsu area, Japan, and Ryoke Metamorphic Belt, Japan. For example, Tenmondai Rock of LHC lies approximately mid-way along the amphibolite- to granulite-facies progression (Shiraishi et al., 1984). In this example, spinel occurs in a garnet-sillimanite gneiss. It is mainly composed of garnet, spinel, biotite, sillimanite, plagioclase, K-feldspar, quartz, ilmenite, and rutile. Dark green spinel (hercynite) occurs as spinel + plagioclase symplectite. Spinel and quartz are always bounded by plagioclase and spinel is not in direct contact with quartz. Garnet near this texture is enveloped by plagioclase. These textures are produced by the following metamorphic reaction; garnet + sillimanite = spinel + plagioclase. This can be described as the following two net-transfer reactions;

For CFAS-system: 5Grs + Alm + 12Als = 3Hc + 15An, and
For CMAS-system: 5Grs + Prp + 12Als = 3Spl + 15An.

We employed thermodynamic data from Holland and Powell (2011) for these reactions. Consequently, we propose the following geobarometers:

$P_{[CFAS,\ sillimanite]} = (-155761 + 587.4\ T + RT \ln K_{Fe}) / 29.378$, and
$P_{[CMAS,\ sillimanite]} = (-132541 + 564.2\ T + RT \ln K_{Mg}) / 29.299$.

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Where P is in bar, T is in K. The equilibrium constant K_{eq} is,

$K_{Fe} = (a_{Grs}^{5}\, a_{Alm}) / (a_{Hc}^{3}\, a_{An}^{15})$, and
$K_{Mg} = (a_{Grs}^{5}\, a_{Prp}) / (a_{Spl}^{3}\, a_{An}^{15})$.

Additionally, we will propose for kyanite and andalusite equations. Our proposed geobarometers are free from quartz, corundum, orthopyroxene, and cordierite within these equations. These are useful to analyze pressure conditions for spinel-bearing pelitic metamorphic rocks within a wide pressure–temperature range (andalusite, kyanite, and sillimanite fields).

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Keywords: spinel, geobarometer, aluminosilicate, spinel + plagioclase symplectite

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Porosity wave and mineral banding in the metamorphism

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Metamorphic and metasomatic banding are very common in the regional and contact metamorphic rocks. Mineral bands are composed mainly of retrograde assemblages of albite, chlorite, epidote, calcite and quartz in basic schists and quartz, albite, chlorite, calcite in pelitic schists of the low grade zones, although in the medium grade zones, albite, epidote, garnet, and amphiboles are common in basic schists. In many cases, bands both pelitic and basic schists together with low grade and medium grade metamorphic rocks exhibit monomineralic to bimineralic coarse grained texture compared with matrix. Besides, there is a significant difference in crystallographic orientation in matrix and bands. For examples, tabular grains of epidote occurs commonly perpendicular to the band boundary, suggesting the geometrical growth in the bands from the band wall.

By the way, in metamorphic bands abundant pores coated by oxides and hydroxide minerals appear in the central zone of the band. Those are considered to have been fluid filling pores but not pore after dissociation of carbonates, because of common existence of druse mineral of euhedral acicular quartz. Considering the periodic and parallel distribution of these metamorphic bands, it seems that there is a layered structure of fluid filling pore distribution during the retrograde metamorphism. Besides, such pores are surely considered to be the paths of metamorphic fluid. The pores in these bands also are thought to be derived from dissolution of constituent minerals.

In this paper, the author would like to proposes a theoretical model of banding distribution of the fluid filling pores during the metamorphism and metasomatism. It suggests that the banding distribution of these pores in the metamorphic rocks may result in the strain instability forming shear localization and large scale faults in the plate boundary metamorphic rocks.

Keywords: pore wave, mineral banding, metamorphism

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.20 Zoom Room 20

[S-MP25] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

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

[SMP25-13] Different entrapment timings of melt inclusions in garnet and quartz in an UH *T* granulite from Rundvågshetta

*Kota Suzuki[1], Tetsuo Kawakami[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

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

[SMP25-14] **Effect of syn-metamorphic fluids on HP-LT chloritoid-bearing assemblages: a study case from the Monti Romani (Italy)**

*Samuele Papeschi[1], Alessio Pontesilli[2], Claudia Romano[3], Federico Rossetti[3] (1.Kochi (X-Star), JAMSTEC, Japan, 2.INGV, Roma, Italy, 3.University Roma Tre, Italy)

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

[SMP25-15] **Newly discovered eclogite in the Khungui zone, Zavkhan terrane, Western Mongolia: P-T evolution and tectonic implication**

*Manzshir Bayarbold[1], Atsushi Okamoto[1], OTGONBAYAR DANDAR[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

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

[SMP25-16] Serpentinization and Carbonation processes of Ultramafic rocks in Manlay Ophiolite, Southern Mongolia

*Nomuulin Amarbayar[1], Atsushi Okamoto[1], Masaoki Uno[1], OTGONBAYAR DANDAR[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

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

[SMP25-17] Petrological characteristics of the slab-mantle interface during incipient subduction: insights from Dalrympole Amphibolite, Palawan, Philippines

*Gabriel Theophilus Vinalay Valera[1], Tetsuo Kawakami[1], Betchaida Duetes Payot[2] (1.Graduate School of Science, Kyoto University, 2.National Institute of Geological Sciences, University of the Philippines)

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

[SMP25-18] New deformation proxy for alkaline felsic rocks: Na-K zoning of alkali feldspar in syenites from the Wadi Dib alkaline ring complex, Eastern Desert, Egypt

*Kazuhito Ozawa[1], Eman Saad Hassan[2], Hideto Yoshida[1], Ali Abdel-Kader Khudeir[2] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Geology Department, Assiut University)

Different entrapment timings of melt inclusions in garnet and quartz in an UH*T* granulite from Rundvågshetta

*Kota Suzuki[1], Tetsuo Kawakami[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

The presence of melt during anatexis is considered to have profound effects on the rheology of middle to lower crustal rocks and thus the exhumation mechanisms of them (e.g., Jamieson et al., 2011). Therefore, precisely constraining the timings when melts coexisted in the pressure-temperature-time (*P-T-t*) evolutions of high-grade metamorphic rocks is important (e.g., Barich et al., 2014).
In this study, we report two types of melt inclusions (MI-g and MI-q) and discuss their entrapment timings in a clock-wise *P-T* evolution of an ultrahigh-*T* (UH*T*) granulite (sample TK2003010309) from Rundvå gshetta (Lützow-Holm Complex, East Antarctica). MI-g are enclosed in garnet porphyroblasts, while MI-q are in quartz grains in the matrix.
The occurrences of MI-g have been already reported by previous studies (e.g., Hiroi et al., 2019). They commonly consist of Qtz + Kfs + Pl + Bt. We recently reported that MI-g occur exclusively in the P-poor cores of garnet (Suzuki and Kawakami, 2020). In addition to MI-g, the P-poor cores of garnet commonly include biotite, sillimanite, quartz, rutile, and zircon monomineralic inclusions. Therefore, the P-poor cores of garnet and MI-g were probably formed by the following dehydration melting reaction; Bt + Sil + Qtz = Grt + Kfs + melt (e.g., Spear et al., 1999). By applying the Zr-in-rutile geothermometer (Tomkins et al., 2007) to rutile grains enclosed in the P-poor cores of garnet, the entrapment *P-T* condition of MI-g was constrained to be 892 ±11 ˚C/8.5 kbar to 914 ±10 ˚C/12.2 kbar in the sillimanite stability field. This corresponds to the prograde stage in the clock-wise *P-T* evolution of the UH*T* granulite. The peak metamorphic condition of 1026 °C/14.6 kbar was obtained by applying the same method to inclusion minerals enclosed in the P-rich mantles of garnet.
We newly found MI enclosed in quartz grains in the intervening matrix between garnet and sillimanite porphyroblasts. These MI-q are not aligned in the host quartz grains. Therefore, we interpret that they are primary ones. They commonly consist of Qtz +Kfs + Pl + Ms, without any mafic minerals. Some internal porosities were observed in MI-q, which were probably formed due to the increase of density during the melt crystallization in a constant cavity volume (e.g., Cesare et al., 2009). Quartz grains in MI-q are less luminescent under cathodoluminescence (CL) images compared to the host quartz grains. This might reflect the differences of Ti content in quartz and thus the crystallization *T* condition (e.g., Hiroi et al., 2020). However, there still exist some other possible factors that cause CL emissions of quartz (e.g., Okumura, 2005), and thus further analyses are needed to understand the cause.
It should be noted that in order to trap MI, host minerals must grow in the presence of melt. This can occur in two ways; (I) growth during melt-producing process and (II) melt-consuming process (e.g., Bartoli et al., 2013). As discussed above, MI-g were formed with the peritectic P-poor cores of garnet during the prograde dehydration melting reaction (I). On the other hand, MI-q and the host quartz grains in the matrix is not likely to be formed during process (I). This is because quartz is always consumed as a reactant mineral and its modal amount decreases during the prograde melt-producing process (e.g., Weinberg and Hasalová, 2015). Therefore, the host quartz grains in the matrix can grow and trap MI-q only during the retrograde melt-consuming process (II).
These results may indicate that melts coexisted from prograde into retrograde metamorphic stages and their composition might have changed to less mafic one during fractional crystallization. The melts coexisted in the prograde and retrograde stages of UH*T* metamorphism probably played an important role in weakening the metamorphic rocks (e.g., Rosenberg and Handy, 2005), and might have triggered and

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promoted their exhumation, respectively (e.g., Jamieson et al., 2011).

Keywords: partial melting, melt inclusion, nanogranitoid, nanogranite inclusion, ultrahigh-temperature metamorphism

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Effect of syn-metamorphic fluids on HP-LT chloritoid-bearing assemblages: a study case from the Monti Romani (Italy)

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The Monti Romani Complex (Central Italy) exposes metapelitic –metapsammitic rocks that were metamorphosed during the Alpine Orogeny. HP-LT metamorphism is generally cryptic within these rocks, showing graphite-bearing white mica ±paragonite parageneses, where no Fe-Mg-silicate is evident. Only a handful of samples, collected in correspondence of quartz veins, lack graphite and contain chlorite or zoned chloritoid associated with hematite. Chloritoid zoning, in particular, ranges dramatically from XMg = 0.10-0.14 to XMg = 0.27. Raman Spectroscopy on Carbonaceous Material constraints the thermal peak to 340 –420 ˚C, excluding a possible contribution of temperature increase for chloritoid zoning.

Thermodynamic modelling in the system $MnO–Na_2O–K_2O–FeO–MgO–Al_2O_3–SiO_2–H_2O–TiO_2–O$ (MnNKFMASHTO) fails to reproduce the observed mineral chemistry, if all iron is considered as divalent. The introduction of ferric iron via P–T–X(Fe_2O_3) phase equilibria modelling reproduces the observed equilibria, mineral chemistry, and modes for values of X(Fe*) = Fe_2O_3/Fe_{TOT} ranging from 0.1 to 0.7. Chloritoid zoning can be explained by a change in the oxidation state of Fe at diminishing pressure and constant temperature, consistent with isothermal exhumation from P = 1.1–1.2 GPa to P = 0.6–0.7 GPa.

Our study suggests that the introduction of an oxidizing aqueous fluid in graphite-bearing metapelite deeply modified mineral stability, catalyzing the growth of Mg-Fe chloritoid and chlorite. This study highlights that the Fe_2O_3 content has a profound influence on the mineral assemblages that are stable in metapelites. The use of P–T–X(Fe_2O_3) phase equilibria diagrams is therefore fundamental to derive reliable P–T estimates from the analysis of greenschist- to blueschist-facies parageneses in metasedimentary rocks.

Keywords: HP/LT metamorphism, chloritoid, fluid/rock interaction, ferric iron, RSCM thermometry, pseudosection modelling

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Newly discovered eclogite in the Khungui zone, Zavkhan terrane, Western Mongolia: P-T evolution and tectonic implication

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The Central Asian Orogenic belt (CAOB) is a significant site to understand the Paleo-subduction system (Neoproterozoic-Permian). The CAOB can be divided into southern and northern parts based on the distribution of ultrahigh-pressure and high-pressure rocks. Although the Paleo-subduction system in the south part of the CAOB has been studied in detail, the Paleo-subduction system in the northern part of the CAOB is not fully understood. A few details study has an occurrence of HP rock in the northern part of CAOB such as Chandman (Štípská et al., 2010), Gorny-Altai (Ota et al., 2007), and Kokecthav (Y et al., 2001). In this study, we present the P-T condition evolution, tectonic implication, and garnet micro-texture of the newly discovered Khungui eclogite from the Zavkhan terrane in western Mongolia, the northern part of the CAOB, and discuss its significance to the northern part of the CAOB. The geological character and metamorphic age of Khungui eclogite described by Naemure et al. (2020).

The seven eclogites collected from the Khungui zone, the Zavkhan terrane, western Mongolia were examined in detail. The geochemical signatures of eclogites manifest basaltic composition with a signature of continental arc basalt (Nb/La vs. La/Yb ratios). The eclogites are composed of garnet, omphacite, amphibole, Ti-rich phases (rutile, ilmenite, and sphene), phengite, quartz, epidote, plagioclase, and a small amount of zircon, chlorite, and feldspar. According to the modal abundance of minerals, the eclogites show two evident layers: Ti-rich phase-dominant and epidote-dominant layers. In Ti-rich phase-dominant layers, garnet occurs as the aggregates (>500 μm) composed of a large number of individual garnet grains (10-250 μm in size and xenomorphic shape), which are separated by high angle boundaries. In epidote-dominant layers, garnet appears as a euhedral crystal (>100 μm). In the Ti-rich phase-dominant layers, the individual garnet boundary is not controlled by compositional zoning. The garnet aggregate rim (bordered with the Ti-rich phase) is enriched in Mn. Garnet aggregate shows zoning core to rim: $Alm_{0.62\text{-}0.57}$, $Grs_{0.30\text{-}0.31}$, $Prp_{0.06\text{-}0.11}$, $Sps_{0.02\text{-}0.01}$ in the Ti-rich phase-dominant layers. The single euhedral garnet shows zoning core to rim: $Alm_{0.71\text{-}0.59}$, $Grs_{0.10\text{-}0.31}$, $Prp_{0.16\text{-}0.09}$, $Sps_{0.03\text{-}0.01}$ in the epidote-dominant layers. Jadeite content of the omphacite varies Xjd=0.32-0.38 in the matrix of the layers and Xjd=0.34-0.44 in the rim of garnets. The Si content of phengite is homogenous (3.23 - 3.49 a.p.f.u.) in a matrix of the layers and rim of garnets. Amphibole occurs as barroisite to taramite (core to rim) in the matrix of layers, hornblende in symplectite, and barroisite coexisted with the rim of garnets. Mineralogy of the eclogite suggests pre-peak (garnet core), peak (garnet rim), and retrograde (symplectite of hornblende + plagioclase) stages. The peak assemblage –garnet rim, omphacite, rutile, phengite, epidote, and barroisite, corresponds to T=445-610 ˚C and P=20-21 kbar. Taramite (barroisite rim), and the symplectite are interpreted as retrograde stages formed at T=541-615 ˚C and P=5-15 kbar.

The compositional and textural differences of garnets in the two layers suggest the aggregate formation of small garnets and heterogeneity of compositional zoning could be related to Ti- and Si-rich fluid. Garnet aggregate texture is not commonly observed in other northern parts of HP rocks of CAOB. Pressure-Temperature path based on mineralogy of the eclogites indicates clockwise metamorphism, which is similar to other HP rock in CAOB. The signature of continental arc basalt for eclogites in the Khungui zone (associated with orthogneisses) contrasts with other eclogite bodies (commonly related to

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meta-ophiolite or ophiolite sequences) signatures (MORB type) in the CAOB. Outstanding microtexture, P-T path, protolith, and the surrounding rock of the eclogites in the Khungui zone imply the Paleo-collision type which is contrary to the eclogite bodies recording paleo-subduction system in the northern part of the CAOB.

Keywords: Eclogite, Metamorphic evolution , the Khungui zone, the CAOB

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Serpentinization and Carbonation processes of Ultramafic rocks in Manlay Ophiolite, Southern Mongolia

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1. Graduate School of Environmental Studies, Tohoku University

Carbonation is a natural carbon-capturing process that silicate and hydroxide minerals of mafic and ultramafic rock react with CO_2 to form carbonate minerals such as magnesite, dolomite, and calcite as long-term carbon sequestration. One of the highly reactive materials for sequestering CO_2 is serpentinite formed by the hydration of olivine-rich ultramafic rocks. An ophiolite is a primary focus for studying carbonation and serpentinization, which is interpreted as remnants of oceanic crust and upper mantle suites of ultramafic, mafic, and felsic rocks. Numerous ophiolites are situated in the Central Asian orogenic belt (CAOB), which is one of the largest orogenic belts in the world. However, metamorphic processes of ophiolites in the CAOB have been insufficiently studied. This study aims to understand the mechanism of multi-stage alteration of ultramafic rock in the Manlay Ophiolite, southern Mongolia, which is located at the central part of the CAOB, in order to understand serpentinization and carbonation processes.

The mineral assemblage of collected samples suggests that ultramafic rocks from the Manlay ophiolite are divided into three types; (1) serpentinized ultramafic rock composed of the low-temperature serpentine phase of lizardite (mesh) and chrysotile (mesh, bastite, and vein) with calcite veins and a small amount of magnetite and spinel. Based on X-ray elemental mapping, mesh lizardite shows low Al content which could indicate that firstly it replaced the olivine, and Al and Fe rich chrysotiles were precipitated later. (2) The partially carbonated serpentinite (lizardite and chrysotile >50%) that replaced by calcite and cut by calcite and dolomite veins with a small amount of diopside, magnetite, and spinel, (3) completely carbonated serpentinite that entirely replaced by calcite and quartz, and contains a small amount of dolomite, magnetite and spinel. The completely carbonated sample includes quartz, calcite and dolomite that show zonal texture as dolomite inside the calcite and surrounded by quartz, as well as the remained mesh texture of serpentine is found which was replaced by quartz in the core and magnetite in the rim.

The relation of microtextures demonstrates three stages. The first stage, protolithic ultramafic rock consisted of olivine and orthopyroxene with a small amount of clinopyroxene and spinel. Secondly, the hydration of ultramafic rock produced serpentinite. The last stage is determined as the carbonation of serpentinites. The reactions of olivine to serpentine and serpentine to calcite and dolomite ±quartz suggest that ultramafic rock was hydrated with Si-rich fluid to form serpentine without brucite, and serpentinite was reacted with Ca and CO_2-rich fluid, and partially or completely carbonated by calcite and dolomite ±quartz. We are assuming that silica has dissolved during the continuous carbonation process, and pores have appeared due to volume change. After the serpentinite was completely carbonated, silica could precipitate in the pores which developed an uncommon texture. Therefore, the presence of carbonation in the Manlay ophiolite indicates that serpentinized ultramafic rocks could effectively capture and store CO2, and is an attractive occurrence to study calcium carbonate, especially calcite, dolomite and quartz assemblage.

Keywords: Serpentinization, Carbonation, Manlay Ophiolite, South Mongolia

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Petrological characteristics of the slab-mantle interface during incipient subduction: insights from Dalrympole Amphibolite, Palawan, Philippines

*Gabriel Theophilus Vinalay Valera[1], Tetsuo Kawakami[1], Betchaida Duetes Payot[2]

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The slab-mantle interface in the earliest stages of subduction are preserved in some ophiolites as thin slivers of amphibolite to granulite-facies rocks collectively referred to as metamorphic soles. Observation of most metamorphic soles reveal that they are composed of relatively coherent slices which preserve high geothermal gradients (~25 ˚C/ km) (e.g. Agard et al. 2018). The boundary between the subducting slab and the overlying mantle in a mature subduction zone on the other hand, is typically composed of eclogite-blueschist blocks surrounded by serpentine and/or chlorite- rich matrix (e.g. Bebout and Penniston-Dorland, 2016). The cooler gradients (4-10 ˚C/ km; Guillot et al., 2009) and fluid-rich nature of this setting, allows the extensive mixing of crustal and mantle components resulting in a hybridized matrix composition (e.g. Bebout and Penniston-Dorland, 2016).

In this study, we present the petrological characteristics and *P-T* history of the Dalrympole Amphibolite which correspond to the slab-mantle interface of an Eocene subduction zone in its infancy (Encarnacion et al., 1995). This unit underlies the residual mantle peridotites of the Palawan Ophiolite composed of harzburgite-dunite interlayers. Similar to other metamorphic soles (e.g. Oman), the Dalrympole amphibolite is predominantly composed of high grade metamafic blocks (i.e. amphibolites ±Grt, Ep) with only minor metasedimentary units. Unlike most soles which are preserved as coherent sheets however, the Dalrympole Amphibolites is a melange complex with 1-2 m blocks surrounded by a highly sheared matrix. The matrix apparently represents a hybridized composition (Ky-Hbl-Bt-Ilm±Grt) resulting from the mixing of sedimentary and mafic components derived from the downgoing slab.

Grt porphyroblasts in the garnet amphibolite block 214-TK9, preserves prograde zonation marked by a Mn-rich, Mg-poor core (= $Alm_{46-51}Prp_{10-19}Grs_{15-20}Sps_{15-25}$) and a Mn-poor, Mg-rich rim (= $Alm_{38-41}Prp_{30-35}Grs_{13-15}Sps_{13-17}$). Applying Zr-in-Rt thermometry (Tomkins et al., 2007) and Qz-in-Grt barometry (Angel et al., 2017) to Rt and Qz inclusions respectively, in the core and rim of the garnet porphyroblasts consistently reflect prograde metamorphism from the core (~625˚C, 11.5 kbar) towards the rim (~700˚C, 13 kbar). The same thermobarometric techniques were applied to the matrix sample 214-TK2 in order to constrain the *P-T* conditions leading to the formation of the matrix. Rutile inclusions in Ky, and Qz hosted in Grt which are in turn included in Ky were used. The Grt (=$Alm_{35-36}Prp_{28-32}Grs_{16-19}Sps_{16-19}$) in this sample are fine grained and do not preserve clear zonation. *P-T* conditions preserved in the matrix (~700˚C, 13 kbar) are comparable to the rim stage of the metamafic blocks.

The similar peak metamorphic conditions constrained in the matrix and the metamafic blocks in Dalrympole Amphibolite suggests that the matrix-forming deformation possibly started en route towards depths of around ~45 km (Jagoutz and Behn, 2013). Furthermore, the paleogeothermal gradient preserved in the Dalrympole Amphibolite (~16 ˚C/km) and its block-and-matrix structure are atypical of metamorphic soles but are also warmer than commonly observed for a developed subduction channel in a mature arc. These characteristics are more comparable to early high *T* melanges (e.g. Agard et al. 2018)

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suggesting that the Dalrympole Amphibolite may correspond to the slab-mantle interface of a young subduction complex already transitioning from the much warmer conditions when subduction was first initiated.

Keywords: Slab-mantle interface, melange, Dalrympole amphibolite, Thermobarometry

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New deformation proxy for alkaline felsic rocks: Na-K zoning of alkali feldspar in syenites from the Wadi Dib alkaline ring complex, Eastern Desert, Egypt

*Kazuhito Ozawa[1], Eman Saad Hassan[2], Hideto Yoshida[1], Ali Abdel-Kader Khudeir[2]

1. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2. Geology Department, Assiut University

Deformation of rocks gives rise to diversities not only in microstructures but also chemical heterogeneity on various scales. These records in deformed rocks will conversely provide rich information on deformation conditions, such as strain, stress, and strain rate. Ozawa (1989) shows that Cr-Al zoning in spinel in deformed mantle peridotites formed by a diffusion creep driven by stress (kinetic demixing: Dimos and Kohlstedt 1987). The zoning is characterized by maxima of both Al and Cr on the grain surface and an intermediate value at the grain center. The shape of spinel and the strain predicted from diffusion creep is consistent: the Al maxima are found in the elongate direction and Cr on the shortest direction. The conditions for development of such zoning and morphology are: (1) notably smaller diffusivity of Cr than Al (Suzuki et al., 2008), (2) Cr and Al diffusion controls rate of deformation for given conditions of grain size and temperatures (Suzuki et al., 2008), (3) proper deformation conditions such as temperature, pressure, stress, and strain rate, and (4) deformation took place under lowering temperature to freeze the zoning pattern. If these conditions are fulfilled in other minerals and chemical components, similar chemical zoning in naturally deformed rocks may be expected. There are, however, no indisputable reports so far. We found such chemical zoning in intermediate alkali feldspar in terms of Na and K in fine-grained porphyritic trachyte and syenite from the 580Ma Wadi Dib alkaline ring complex, Eastern Desert, Egypt (Frisch and Abdel-Rahman, 1999). Deformation induced chemical zonings of feldspars have long been reported (e.g., White, 1975; Kramer and Seifert, 1991), but they mostly require involvement of open reaction processes and do not belong to kinetic demixing. The rocks from the Wadi Dib complex are composed dominantly of intermediate alkali feldspar, which underwent recrystallization by pyrometamorphism and deformation to grain size smaller than 200 microns. The above conditions (1) are satisfied because of a large difference in K and Na diffusivity in alkali feldspar by more than two orders of magnitude (Cherniak, 2010). The conditions of (2) - (4) might also be fulfilled because of high temperature and small grain size (Farver and Yund, 1995). In this talk, we will report microstructure and Na-K zoning in alkali feldspar to show that they formed by deformation, and we propose that the zoning may be a useful proxy of deformation.

Keywords: stress, chemical zoning, alkali feldspar, Na-K zoning

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Sun. Jun 6, 2021 10:45 AM - 11:50 AM JST | Sun. Jun 6, 2021 1:45 AM - 2:50 AM UTC | Ch.23 Zoom Room 23

[S-MP26] Physics and Chemistry of Minerals

convener:Masahiro KAYAMA(Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Itaru Ohira(Department of Chemistry, Faculty of Science, Gakushuin University), Chairperson:Masahiro KAYAMA(Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Itaru Ohira(Department of Chemistry, Faculty of Science, Gakushuin University)

Minerals are important constituent materials of the Earth and planetary bodies.
New results and findings of the physics and chemistry of minerals (including crystal, amorphous and melts) obtained from various analytical approaches, experimental methods (e.g, electron microscope, X-ray diffraction, FT-IR, and Raman spectroscopy), and computer simulations) will be discussed here.

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

[SMP26-01] **Skew-normal peak fitting of cathodoluminescence on shocked quartz: a statistical model for impact pressure estimation**

Yu Chang[2], Shintaro Kadoya[3], *Keisuke Yano[1], Masahiro KAYAMA[2], Eiichi Tajika[2], Yasuhito Sekine[4], Toshimori Sekine[5], Hirotsugu Nishido[6], Takamichi Kobayashi[7] (1.The Institute of Statistical Mathematics, 2.The University of Tokyo, 3.University of Washington , 4.Tokyo Institute of Technology, Earth-Life Science Institute (ELSI), 5.Osaka University, 6.Okayama University of Science, 7.National Institute for Materials Science)

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

[SMP26-02] Magnetite oxidation investigated by synchrotron X-ray diffraction and X-ray absorption spectroscopy

*Atsushi Kyono[1], Ibuki Kinebuchi[1] (1.Division of Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba)

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

[SMP26-03] *P-T* dependence of hydrogen-bond geometry of β-CrOOD

Chikara Shito[1], *Hiroyuki Kagi[1], Asami Sano-Furukawa[2,3], Sho Kakizawa[4], Kazuki Komatsu[1], Riko Iizuka-Oku[1], Katsutoshi Aoki[1], Jun Abe[5], Shinichi Machida[5], Takashi Saito[3], Takashi Kamiyama[3], Noboru Furukawa[6], Akio Suzuki[7] (1.Graduate School of Science, University of Tokyo, 2.Japan Atomic Energy Agency, 3.High Energy Accelerator Research Organization, 4.Graduate School of Advanced Science and Engineering, Hiroshima University, 5.Comprehensive Research Organization for Science and Society, 6.Graduate School of Science, Chiba University, 7.Graduate School of Science, Tohoku University)

11:30 AM - 11:50 AM JST | 2:30 AM - 2:50 AM UTC

[SMP26-04] Discussion

Skew-normal peak fitting of cathodoluminescence on shocked quartz: a statistical model for impact pressure estimation

Yu Chang[2], Shintaro Kadoya[3], *Keisuke Yano[1], Masahiro KAYAMA[2], Eiichi Tajika[2], Yasuhito Sekine[4], Toshimori Sekine[5], Hirotsugu Nishido[6], Takamichi Kobayashi[7]

1. The Institute of Statistical Mathematics, 2. The University of Tokyo, 3. University of Washington , 4. Tokyo Institute of Technology, Earth-Life Science Institute (ELSI), 5. Osaka University, 6. Okayama University of Science, 7. National Institute for Materials Science

Impact pressure is a key parameter to understand an impact cratering on celestial body, one of the ubiquitous processes on terrestrial planets, satellite and asteroidal bodies. Recent studies qualitatively revealed that cathodoluminescence (CL) spectra of shocked quartz depend on impact pressure [1, 2] as also found in alkali feldspar [3]. However, since CL spectra of shocked quartz have broad and skewed peaks, it has been difficult to obtain a quantitative relation between CL spectra and impact pressure by using spectral deconvolution.

In this study, we propose a statistical model that decomposes CL spectra of experimentally shocked quartz at various impact pressures into several peaks by utilizing skew-normal distributions, instead of normal distributions. The samples of shock-induced quartz were obtained by shock experiments done in Chang et al. (in prep). According to the experiments, the peak pressures of the samples reach 0 GPa to 40 GPa in 5 GPa increments. Also, the CL spectra of the samples were analyzed with SEM (JEOL: JSM-5410) combined with a grating monochromator (Oxford: Mono CL2) at the Okayama University of Science. The obtained CL spectra were corrected by standard lamp. Using Monte-Carlo sampling and Akaike information criterion, we estimate the number of skew-normal peaks and four parameters for each peak, i.e., location, scale, shape, and weight. A mixture of skew–normal distributions provides a better fitting model for CL spectrum of shocked quartz than a mixture of normal distributions. Moreover, it is statistically revealed that among the four parameters of a skew-normal distribution, weights of peaks change with impact pressure.

We also demonstrate that the quantitative relation between weights of CL peaks and impact pressure can be utilized for an estimate of impact pressure based on CL spectra of shocked quartz. Here, we divide the CL data of shocked quartz into two data sets, i.e., training and validation data sets. Then, we calculate a posterior probability of impact pressure of the validation data set by comparing posterior distributions of CL weights of the validation data sets with those of the training data sets. As a result, the actual pressure of the validation data set tends to have the highest posterior probability. The proposed method is as precise as a conventional impact pressure estimation via Planar Deformation Features (PDFs) while the dynamic range would be wider than the conventional method. Additionally, The proposed method is more convenient than the other. The improvement in the efficiency in estimation of paleo impact pressure would drive investigations of impact cratering processes. Also, a fitting via skew-normal distribution could contribute to deconvolution of spectra other than CL spectrum of shocked quartz.

[1] Chang et al., (2016) JpGU Meeting, PSS11-P21.

[2] Chang et al. (in prep)

[3] Kayama et al. (2012) JGR Planets 117 (E9).

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Keywords: cathodoluminescence, impact, spectral deconvolution, Bayesian statistics

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Magnetite oxidation investigated by synchrotron X-ray diffraction and X-ray absorption spectroscopy

*Atsushi Kyono[1], Ibuki Kinebuchi[1]

1. Division of Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba

The oxidation process from magnetite to hematite through maghemite was investigated by synchrotron X-ray diffraction and X-ray absorption spectroscopic analyses. The XRD pattern of magnetite heated at 100 °C showed a small peak corresponding to maghemite with partial Fe vacancy disorder structure (space group $P4_132$.) Diffraction peaks of hematite occurred from magnetite heated at 250 °C, in which maghemite and hematite coexisted with magnetite. Diffraction peaks of magnetite subsequently disappeared at 300 °C. Instead, maghemite and hematite dominated the XRD pattern, but the amount of maghemite reduced from 300 °C. Maghemite completely disappeared at 500 °C, and hematite finally dominated the XRD pattern. Rietveld fitting results clearly showed that the site occupancy of Fe at the octahedral sites in the oxidized magnetite continuously decreased from 1.000 to 0.3992(4) at the temperature range between 25 °C and 300 °C. The XANES result showed that the $Fe^{3+}/\Sigma Fe$ increased up to 300 °C and remained constant until 500 °C, indicating that the Fe^{2+} in magnetite was completely oxidized to Fe^{3+} at 300 °C. Furthermore, peaks derived from octahedrally coordinated Fe continuously reduced up to 300 °C. The fitting results of the first shells indicated that the coordination number and site occupancy factor at the octahedral site were continuously decreased at the temperature range between 25 °C and 300 °C, which were approximately consistent with those of Rietveld fitting analysis. It is therefore clearly confirmed that during oxidation from magnetite to maghemite Fe is continuously removed from the octahedral sites with keeping degree of vacancy ordering in the space group $P4_132$.

Keywords: magnetite, maghemite, oxidization, XRD, XANES

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P-T dependence of hydrogen-bond geometry of β-CrOOD

Chikara Shito[1], *Hiroyuki Kagi[1], Asami Sano-Furukawa[2,3], Sho Kakizawa[4], Kazuki Komatsu[1], Riko Iizuka-Oku[1], Katsutoshi Aoki[1], Jun Abe[5], Shinichi Machida[5], Takashi Saito[3], Takashi Kamiyama[3], Noboru Furukawa[6], Akio Suzuki[7]

1. Graduate School of Science, University of Tokyo, 2. Japan Atomic Energy Agency, 3. High Energy Accelerator Research Organization, 4. Graduate School of Advanced Science and Engineering, Hiroshima University, 5. Comprehensive Research Organization for Science and Society, 6. Graduate School of Science, Chiba University, 7. Graduate School of Science, Tohoku University

The Earth's mantle contains a certain amount of high-pressure hydrous minerals. However, behaviors of hydrogen bonding and physical properties of such hydrous minerals at high-*PT* conditions have not been clarified. We focused on hydrogen-bond geometry and compression behavior of guyanaite (β-CrOOH). β-CrOOH is a distorted rutile-type hydrous mineral and isostructural to δ-AlOOH, one of the most promising hydrous phases for transporting hydrogen to the core–mantle boundary. In this study, X-ray and neutron diffraction experiments on β-CrOOD were carried out at various *P-T* conditions to clarify the *P-T* dependence of hydrogen-bond geometry in β-CrOOD. Crystal structure was refined using the Rietveld method.

The space group of β-CrOOD was determined to be $P2_1/c$, indicating that the hydrogen atoms are partially disordered at ambient condition. Above 450 K, however, the hydrogen atoms were fully disordered, and the space group was *Pnnm*. Thermal expansion anomaly was observed at temperature range of 300–500 K, where the phase transition ($P2_1/c$ – *Pnnm*) occurred. In high-pressure experiments, changes in compression behavior caused by phase transition from $P2_1/c$ to *Pnnm* were observed at about 3 GPa and 4.5 GPa at 300 K and 250 K, respectively. However, no significant change in compression behavior was observed at 450 K. Therefore, d*P*/d*T* of the phase boundary would have a negative slope. Assuming that the phase boundary of δ-AlOOH ($P2_1nm$–*Pnnm*) has the same tendency as that of β-CrOOD, δ-AlOOH would have a *Pnnm* structure in the Earth's mantle and would have higher seismic velocity than the major minerals in the mantle transition zone.

Keywords: neutron diffraction, hydrous mienerals, high pressure, hydrogen bonds

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[J] Oral | S (Solid Earth Sciences) | S-MP Mineralogy & Petrology

[S-MP26] Physics and Chemistry of Minerals

convener:Masahiro KAYAMA(Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Itaru Ohira(Department of Chemistry, Faculty of Science, Gakushuin University), Chairperson:Masahiro KAYAMA(Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Itaru Ohira(Department of Chemistry, Faculty of Science, Gakushuin University)

Sun. Jun 6, 2021 10:45 AM - 11:50 AM Ch.23 (Zoom Room 23)

Minerals are important constituent materials of the Earth and planetary bodies.
New results and findings of the physics and chemistry of minerals (including crystal, amorphous and melts) obtained from various analytical approaches, experimental methods (e.g, electron microscope, X-ray diffraction, FT-IR, and Raman spectroscopy), and computer simulations) will be discussed here.

11:30 AM - 11:50 AM

[SMP26-04]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.25 Zoom Room 25

[S-VC27] Mitigation of volcanic disasters - basic and applied researches

convener:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government), Tatsuro Chiba(Asia Air Survey Co., Ltd.), Yousuke Miyagi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government)

Volcanic disasters are caused by wide range of volcanic phenomena including ash fall, pyroclastic flow, debris avalanche, lahar, and lava flow. To mitigate volcanic disasters, wide range of technologies including simulation, data processing on GIS, and communication techniques are required. Researches on volcanic hazards mapping, eruption scenarios, estimation of tephra falls, and probabilistic eruption assessments are getting important. This session invites presentations and broad reviews related to these topics. Contributions on database technology, case studies of social and school educations, the Next Generation Volcano Research, and specific examples of eruption crisis events are also encouraged.

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

[SVC27-01] Ash Fall Hazard Map using Newly Developed Simulation Model

*Tsuyoshi Nakatani[1], Toshiyuki Asano[1] (1.The Research and Education Center for Natural Hazards, Kagoshima University)

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

[SVC27-02] On the Effects of the Inertial Forces of the Falling Volcano Ash on the Ash absorption by an External Unit of Building Air Conditioning

*Kiyotoshi Otsuka[1], Arihide Nobata[1], Hitoshi Suwa[1], Tomohiro Kubo[2], Yosuke Miyagi[3], Masamitsu Miyamura[3] (1.Obayashi Corporation, 2.Mount Fuji Research Institute, Yamanashi Prefectural Government , 3.National Research Institute for Earth Science and Disaster Resilience)

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

[SVC27-03] Experimental Study on Safety of Wooden Building Roofs Against Impact of Ballistic Ejecta

*Kohei Tateyama[1], Hiroyuki Yamada[2], Ryo Honda[3], Tomohiro Kubo[3], Mitsuhiro Yoshimoto[3] (1.Ritsumeikan University, 2.National Defense Academy, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[SVC27-04] **A trajectory analysis of a rockfall on a steep slope at Mt. Fuji to determine the possible source area of the falling rock**

*Taishi Sakurada[1], Ryodo Hemmi[2], Yasuhiro Ishimine[3], Hideaki Miyamoto[1] (1.The University of Tokyo, 2.The University Museum, The University of Tokyo, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[SVC27-05] Improvement of Proto-type Educational Web Contents for the Municipalities' Disaster Response Staff.

*Tomohiro Kubo[1], Mitsuhiro Yoshimoto[1], Yosuke Miyagi[2], Ryo Honda[1], Yasuhiro Ishimine[1] (1. Mount Fuji Research Institute, 2.National Research Institute for Earth Science and Disaster Resilience)

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

[SVC27-06] Training of the human resource development for volcanic disaster management officers at Mt Fuji

*Mitsuhiro Yoshimoto[1], Tomohiro Kubo[1], Ryo Honda[1], Yasuhiro Ishimine[1], Kenji Niihori[2], Makoto Kanano[2] (1.Mount Fuji Research Institute, Yamanashi Prefectural Government, 2.Organization of Volcanic Disaster Mitigation, NPO.)

Ash Fall Hazard Map using Newly Developed Simulation Model

*Tsuyoshi Nakatani[1], Toshiyuki Asano[1]

1. The Research and Education Center for Natural Hazards, Kagoshima University

In 2020, Sakurajima volcano has recorded 432 times eruptions by counting cases of which column heights are more than 1000m, according to Kagoshima Local Meteorological Observatory. It should be noted that such an active volcano is located at just 6km west of the central city of Kagoshima having 600,000 population. In recent years, accumulation of magma in the underground pool is observed to be comparable to the 1914 Taisho eruption volume, and therefore, we are highly conscious of the precaution against large scale eruption in near future.

Not limited to large scale eruptions, smaller but more frequent eruptions may cause serious damages against infrastructure. In May and August 2020, 10 and 20 flights connecting to Kagoshima Airport respectively, were reported to be canceled due to ash fall from the eruptions. The Kagoshima Airport has many domestic flights to connect remote islands; some of them are also volcanic islands. Thus, it is important in this area to ensure the safety of aviation from the impact of ash fall.

The Research and Education Center for Natural Hazards, Kagoshima University, has been studying methodology for predicting ash fall transport in real time, and evaluating expected disaster risks to improve the resilience in Kagoshima area. In this presentation, ash fall hazard map using newly developed simulation model will be reported.

The simulation model was based on a two-dimensional convection-diffusion equation including a settling transport term of pyroclastic material, and a source term. The eruption column acts as the source term, where we adopted Suzuki(1983) model to describe the vertical mass distribution. The particle size distribution was assumed to be comprised of 11 classes ranging from -5 to 5 on the Φscale, which was equivalent to 32mm to 0.03125mm.
In the numerical algorithm, the advection term and the diffusion term were solved by the upwind difference scheme and the central difference scheme, respectively. The computational domain was taken horizontally about 150km square which covers the entire mainland of Kagoshima prefecture and taken vertically from 1500m to 20000m in the altitude. The number of computational grids was 169×169×38, which is about 1 million points totally. To reduce the computation time, non-equidistant grids were applied for the horizontal plane. As the results, the horizontal grid spacing around Sakurajima became 500m, meanwhile the spacing near the edge of the domain was 1330m. In the vertical direction, a constant grid spacing of 500m was taken, and the volume of ash fall passing through the grid of 1500m altitude was assumed to be accumulated on the ground.

The ash fall hazard map was made by the following scenarios.
1) The same magnitude of Taisho eruption is assumed to occur at 9 am every day in 2020.
2) The temporal variation of eruption column height is given as the same as Taisho eruption case. The eruption lasts for 39 hours.
3) The total amount of eruption volume is given as 600million m^3 equal to the Taisho case. The total amount is distributed to the instantaneous amount by referring the above assumed temporal variation.
4) Kagoshima Aerological Observatory has conducted observations on wind velocity and direction daily at 9am and 9pm. Using these data, the spatially interpolated dataset on the wind speeds of the east-west

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and north-south components at every 500m altitude is constructed.
5) The simulation is carried out while updating the eruption height every hour, and the wind speed every 12 hours. The computational duration of one case simulation is set as 48 hours.
6) Computations are performed for 366 days from January 1 to December 31, 2020. For each calculation point, the maximum depth of ash deposition in one year period is analyzed.

The ash fall hazard map 2020 reveals that there are several vulnerable areas such as the coastal area of central Kagoshima city, where the deposition depths exceed 1m.

Keywords: Ash Fall Simulation, Hazard Map, Taisho Eruption, Sakurajima volcano



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On the Effects of the Inertial Forces of the Falling Volcano Ash on the Ash absorption by an External Unit of Building Air Conditioning

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Explosive eruption of volcanos can affect infrastructures of the cities in many ways, even if they are situated far from the volcanos, say, more than 100km. Degradation of performances of the building air conditioning due to ashfall events is among such volcano impacts. In this context, we carried out experiments on ashfall influences on the operation of an open type cooling tower[1)], where the amount of the ashfall leading to the abnormal operation of it was investigated, showing the deviation from the normal operation of the cooling tower begins to be recognized when the cumulative ashfall depth exceeded around 20 to 30mm, mainly due to the intrusion of ash into the piping of the cooling water circulation. In their study, the amount of the ash absorbed into the cooling tower was related to the ashfall depth by assuming that the rate of the ash absorption at the air intake is expressed by the product of the air intake velocity and the airborne ash concentration which is directly related to ash fall rate when it is multiplied by bulk terminal fall velocities of ash particles. It is noted that ash particles falling in the vertical direction are assumed to quickly respond to the, usually horizontal, suctioning force of the air intake of the air conditioning system, which is usually set on the side walls of the devices or building walls. However, in reality, the inertia of the ash particles will more or less retard the response of the particle motion to the suctioning force near the air intakes, so it is possible that the relationships between the absorbed ash amount and the ash fall depth derived in our previous study will become somewhat different when the above mentioned inertia effects are taken into account.

In the present study, the effects of the inertia forces of the falling ash particles on the ash absorption rate at the air intake are investigated numerically. In reference to the method of the multi-phase flow simulations, the equations of motion of the ash concentration, which takes into account particle sizes and non-sphericities, are numerically integrated and the deviation of the ash flow from the air flow near the air intake due to inertia force are investigated for the simple cases where a rectangular exterior unit of the air conditioning device is placed at the bottom of the rectangular computational domain with ashfall from the ceiling of the domain. The air flow obtained from mass-consistent flow simulations with an incompressible continuity restriction condition is used to represent the air flow on which ash particles are laden. The results of the numerical calculation show that the inclusion of inertia effect tends, in general, to lessen the ash absorption rate at the air intake, and this tendency is more apparent for heavy particles than the light ones, and, in addition, for the particles with the same weight, the tendency is more of the case for the particles with small non-sphericity than with low non-sphericity. These results suggest the possibility of the ashfall depth at which the air conditioning begins to deviate from normal operation shift to somewhat larger side than the one indicated in our previous study.

Keywords: Ashfall, Functional Damage, Concentration, Inertial Force, Building Air Conditioning

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Experimental Study on Safety of Wooden Building Roofs Against Impact of Ballistic Ejecta

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Damages and destruction of the wooden buildings caused by volcanic activities are due to various factors. Especially, at the phreatic eruption of Mt. Ontake on September 27, 2014, most of the damages were caused by the impact of the ballistic ejecta.

In order to mitigation this damage, it is suggested that evacuation to a mountain hut is effective. Thus, evaluation of safety for wooden buildings (e.g. mountain huts) against ballistic ejecta impact is necessary. Previously, we reported the penetration boundary energy for the unreinforced 15 mm and 18 mm thick wooden building roof. In addition, it was found that by superimposing the cedar boards, impact absorption properties can be improved simply. In this study, we focused on the effect of pumice that are often installed on roofs in many mountain huts and investigated their impact absorption characteristics.

An impact test was carried out at the velocity of 10 to 90 m/s using a large-scale launching system. In this system, a projectile was accelerated by compressed air and then collided with the target. The projectile velocity was measured using two lasers and light receiving parts.

In case of normal phreatic eruptions, the ballistic ejecta with a diameter of approximately ϕ100 mm are scattered. Therefore, cylindrical abrasive materials similar to the common ballistic ejecta (density: 2400 kg/m^3, diameter: 90 mm, length: 170 mm, mass: 2.66 kg) was used as the projectile. A typical wooden roof structure (e.g., cedar boards, waterproof sheet, galvalume steel plate and cedar rafter) was used for the target. The thickness of the cedar board, waterproof sheet and galvalume steel plate were 18 mm, 1 mm and 0.4 mm, respectively. The components were fixed with nails and its spacing was approximately 150 mm. The dimensions of the specimen were 600 mm ×600 mm.

For the impact experiment, artificial pumice (hereafter referred to as pumice) in sandbags was placed in front of the specimen. The pumice with composition and specific gravity similar to natural pumice were used. The sandbag bag containing pumice is approximately 180 mm thick. The pumice used in this study was an inorganic porous material made from 96 % waste glass. Its particle size was approximately 2 to 75 mm and its shape was irregular. The density in oven-dry conditions was between 300 and 600 kg/m^3.

In previous study, it was known that the boundary between penetrating and non-penetrating impact energy was taken to be near 1.2 kJ in the unreinforced 15 mm thick wooden building roof.

As a result of the impact test, due to the installation of pumice on the roof structure, the boundary between penetrating and non-penetrating impact energy was taken to be near 3.7 kJ. Therefore, the impact absorption energy of pumice used in this study can be calculated as approximately 2.5 kJ.

Keywords: Ballistic ejecta, Wooden buildings roof , Artificial pumice

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A trajectory analysis of a rockfall on a steep slope at Mt. Fuji to determine the possible source area of the falling rock

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Rockfalls are among the most active geologic events found on Earth, Mars, and the Moon. A newly detached mass of rock falling from a steep-slope often rolls down a slope until its break. It occurs most frequently in mountains or steep areas, especially crater and valley walls on Mars and the Moon (Bickel et al., 2020; Senthil Kumar et al., 2019). It is a kind of the fastest type of landslide often initiated by repeated freezing and thawing on Earth, while most extraterrestrial ones are likely caused by shaking induced by impacts (Bickel et al., 2020; Brown & Roberts, 2019). Complete monitoring of the phenomena is usually challenging, so the incidents are often recognized by the newly-formed tracks or debris fragments along the slope.
On September 9th, 2019, a rockfall occurred on the north-eastern flank of Mt. Fuji. No fatality or injured is involved with minor damage to a building reported. A notable characteristic of this incident is the clear boulder tracks along the rockfall route, which shows significant similarities to those found on Mars and the Moon. Thus, we studied the scale, distributions, and the possible route of the rockfall based on the field images obtained by Yoshikage Inoue (manager of Taishikan hut) and his observations, drone-based images, satellite images, as well as numerical modeling with a digital elevation model.
Our preliminary study shows that a boulder of a couple of meters in size may have detached from a region higher than 3,600 meters altitude and fall to the area of altitudes between 3,250-3400 meters, resulting in leaving 11 to 14 boulder tracks of about 30m intervals before it hit the other boulder, which would make the falling rock jump and fly more than 300m with a velocity of no less than about 50m/s. We find that the initial location of the boulder is essential in determining the exact route of a high-velocity boulder, which may imply that the boulder track analysis can be a useful method to determine the source area or the velocity of the boulder of a rockfall event.

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Keywords: Mt.Fuji, rockfall, Discrete Element Method, boulder track

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Improvement of Proto-type Educational Web Contents for the Municipalities' Disaster Response Staff.

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We develop the educational web contents which is funded by the D3 of the Integrated Program for Next Generation Volcano Research and Human Resource Development of MEXT. We conducted an interview survey on the proto-type educational web contents developed last year, against the municipalities' disaster response staff, we report on the result.

In the interview survey, we interviewed them the following issues.

1) The contents for their self-education

2) The contents and needs for public awareness activities to residents

3) How to use observation information in the event of a volcanic disaster

As a result, we found that they need the video education contents for about 15 minutes and the simulation contents, the semi-real-time photo data from volcano surveillance camera for observation. In addition, we report that we improved the educational web contents based on the above results.

Keywords: Web contents, Municipalities' disaster response staff, Volcano disaster mitigation

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Training of the human resource development for volcanic disaster management officers at Mt Fuji

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Since disaster prevention measures for active volcanoes differ for every volcano, it is difficult to imitate other volcanoes' disaster prevention plans and measures. On the other hand, disaster prevention officers will be changed every two to three years. As a result, knowledge and experience of volcanic disasters have not been accumulated, and disaster prevention measures have not progress.
In order to solve these problems, Yamanashi Prefecture has been considering an effective training program for volcano disaster prevention officers since 2017. In Yamanashi Prefecture, the Yamanashi Core Group Meeting of the Mt. Fuji Volcano Disaster Prevention Council is held about six times a year (four times in FY2020), and training is conducted once or twice a year using the framework of this meeting. The training was carried out five times before FY2020. In FY2020, the lecture about the volcanic disaster was held on July 22, 2020, and the tabletop exercise was held on January 20, 2021. In the FY 2020 tabletop exercise, each municipality's specific evacuation plan was examined based on new simulation results. If an eruption occurs, residents around Mt. Fuji must evacuate within the area or over a wide area, depending on the scale of the eruption. This exercise was conducted on the assumption that people would evacuate to neighboring municipalities. Eruption scenarios were prepared by experts belonging to the Volcano Disaster Prevention Council, and drills were conducted without distributing scenarios in advance.
In this exercise, we were able to extract problems that would occur by using realistic eruption scenarios and making realistic assumptions. It also revealed problems with the existing evacuation plan. In the future, it will be possible to improve the volcano disaster prevention officer's skills by conducting training in various patterns, changing the location of the crater, and other factors.

Keywords: Training, human resource development , volcanic disaster management officer, Mt Fuji

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.25 Zoom Room 25

[S-VC29] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology)

There is a diversity of hydrothermal systems between magmas and the ground surface in various geoscientific environments. Understanding of the hydrothermal systems contributes to understanding of the earth systems, and is essential for utilization of geothermal energy and prediction of volcanic eruption. In this session, we will discuss the topics on subsurface structures and heat and fluid flows of "hydrothermal systems of volcanoes" from the perspectives of geophysics, geochemistry, geology and geothermal reservoir engineering. Any research approaches, theoretical, observational and experimental, are welcome.

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

[SVC29-01] Compositional variability of rare earth elements in spring waters around Aso Volcano

*Hitomi Nakamura[1], Noritoshi Morikawa[1], Hikaru Iwamori[2], Shuhei Sakata[2], Qing Chang[3] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology)

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

[SVC29-02] Deep-seated fluid supply around Kusatsu-Shirane volcano revealed by helium and carbon isotope ratios

*Hirochika Sumino[1], Takiguchi Takahiro[2], Tomoya Obase[1], Kotaro Toyama[3], Akihiko Terada[4] (1.Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo, 2.Department of Integrated Science, College of Arts and Science, The University of Tokyo, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Volcanic Fluid Research Center, Tokyo Institute of Technology)

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

[SVC29-03] Evolution of the magmatic-hydrothermal system of Mendeleev volcano (Kunashir Island)

*Alexey Andreevich Kotov[1], Sergey Zakharovich Smirnov[2], Noriyoshi Tsuchiya[1], Masaoki Uno[1] (1.Graduate School of Environmental Studies, Tohoku University, 2.Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia)

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

[SVC29-04] Volcanic unrests after the 2015 phreatic eruption of Hakone volcano and its hydrothermal system

*Kazutaka Mannen[1], Yuki Abe[1], Ryosuke Doke[1], Yohei Yukutake[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

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

[SVC29-05] Structure of the shallow hydrothermal system in Hakone volcano inferred from InSAR analysis

*Ryosuke Doke[1], Kazutaka Mannen[1], Kazuhiro Itadera[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

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

[SVC29-06] Ground deformations at Kuju volcano, Japan, revealed by PALSAR-2 InSAR

*Shohei Narita[1], Takahiro Ohkura[1] (1.Aso Volcanological Laboratory, Institute for Geothermal Science, Graduate School of Science, Kyoto University)

Compositional variability of rare earth elements in spring waters around Aso Volcano

*Hitomi Nakamura[1], Noritoshi Morikawa[1], Hikaru Iwamori[2], Shuhei Sakata[2], Qing Chang[3]

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Rare earth elements in spring waters may provide information on the origin and/or processes during water circulation; e.g., material and generation process at the source, interaction during the fluid migration through a crack or a vein with host rocks, mixing with meteoric water in a shallow aquifer. A large-scale circulation processes, including the dehydration from the subducted Philippine Sea slab and the subsequent interactions with surrounding basement rocks and meteoric waters, were distinguished by the rare earth element compositions of the spring waters in the Arima and the Kii areas, southwest Japan (Nakamura et al., 2015; 2016), with the aid of statistical analyses (Iwamori et al., 2020). To understand the origin and the upwelling processes, we have analyzed rare earth element composition of groundwaters including hot springs, river waters around the Aso volcano in Kyushu, Japan.

The Aso volcano has a caldera structure formed with four gigantic eruptions and numerous small eruptions (e.g., Kaneko et al., 2007). After the caldera formation, the central cone named Naka-dake has been and is active. The activity of Naka-dake and the related magma supply system have been studied by geophysical and petrological methods (e.g., Hata et al., 2018; Abe et al., 2017; AIST, 2016)). The northward-dipping conductive anomaly toward Naka-dake cone and several anomalies interpreted as an aqueous fluid flow have been detected by electromagnetic study (Hata et al., 2018). Both basaltic and dacitic magmas are thought to be involved in the magma supply system by petrological study, and the magma seems to have evolved during four gigantic eruptions (AIST, 2016). Alternatively, geochemical studies of groundwaters were performed to identify a magma related fluid (e.g., Kazahaya et al., 2019, Morikawa et al., 2019), and of which major solute elements are comprehensively analyzed by using statistical method (Iwamori et al., 2021). Statistical study has been revealed a spatial distribution of major solute elements which clearly decreases toward outside of caldera as a concentric structure (Iwamori et al., 2021).

In this study, we have classified the rare earth element compositions of groundwaters based on the result of statistical analysis of major solute elements, and newly found that the behavior of rare earth element is partly decoupled from major solute elements. Therefore, the dataset of rare earth elements would be expected to include unique information during fluid generation and upwelling. Combining geophysical, petrological, and geochemical studies, we aim to reveal the fluid circulation and the spatial extent of magmatic component at the Aso volcano.

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Deep-seated fluid supply around Kusatsu-Shirane volcano revealed by helium and carbon isotope ratios

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In January 2018, a phreatic eruption occurred at Motoshirane, one of the three pyroclastic cones of Kusatsu-Shirane volcano. From September to December of the same year, a swarm of earthquakes was observed in Takayama Village, Nagano Prefecture, west of the volcano (Terada et al., JpGU-AGU Joint Meeting 2020). Both of these phenomena were caused not by magma itself but by deep hydrothermal fluids involving volatile components separated from magma. Therefore, it is important from the viewpoint of disaster prevention to obtain knowledge of the origin and migration path of deep-seated hydrothermal fluid in and around Kusatsu-Shirane volcano. In this study, we collected fumaroles, hot spring water, well water, and hot spring gas in the area, and measured the helium and carbon isotope ratios.

The $^{3}He/^{4}He$ ratio (defined as 1 Ra in the atmosphere and corrected for atmospheric contamination using the $^{4}He/^{20}Ne$ ratio) shows a decreasing trend with distance from the crater at the top of Shirane cone, where all documented (after 1882) phreatic eruptions have occurred until the 2018 eruption at Motoshirane cone. This suggests that the contribution of magmatic helium with a high $^{3}He/^{4}He$ ratio of about 8 Ra is diluted by the crustal helium with a low $^{3}He/^{4}He$ ratio during migration of the fluids. Based on the decreasing trend, degree of the dilution is more significant in the west than in the east. However, hot springs with almost constant $^{3}He/^{4}He$ ratios (4-5 Ra) are widely distributed from 9 to 15 km away from the volcano to the west. It is unlikely that fluids from the hydrothermal system beneath the volcano (e.g. Matsunaga et al., JVGR 2020) are supplied to the groundwater system in this region with a constant mixing ratio with crustal helium. The distribution of the $^{3}He/^{4}He$ ratio almost overlaps with the source distribution of the 2018 swarm of earthquakes, suggesting that deep hydrothermal fluid may have been efficiently supplied through the fault that may have been the epicenter. A higher $^{3}He/^{4}He$ ratio (6.1 Ra) was observed in the hot spring gas at a sampling site 26 km to the west, which is located near an active fault system on the western margin of the Nagano Basin, suggesting that deep-seated fluids are also supplied through this fault.

The carbon isotope ratios ($\delta^{13}C_{PDB}$) within 10 km from the crater were in the range of -1 to -8‰, but tended to become lower as the distance from the crater increased. At the farthest site in the west, a very low value of -76‰ was observed. The carbon in this hot spring gas is derived from methane, and since the Green Tuff is distributed in this area, there is a possibility that the natural gas reservoir in Green Tuff, which is reported to contain mantle-derived helium (Sakata, Sekiyu Gakkaishi 1997), is supplied from deep within the basin through the active fault system at the western margin of the Nagano Basin.

Keywords: helium isotope ratio, Kusatsu-Shirane volcano, hydrothermal fluids, carbon isotope ratio

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Evolution of the magmatic-hydrothermal system of Mendeleev volcano (Kunashir Island)

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Caldera eruption of Mendeleev volcano occurred about 39 thousand years ago on Kunashir Island. The volume of pyroclastic material is estimated at 60 km^3, which makes this eruption one of the largest eruptions of the Upper Pleistocene in the southern Kuril Islands. The pumice stones of the caldera eruption are dacitic. The proportion of porphyry phenocrysts in pumice is not higher than 20 vol. %. Phenocrysts are represented by plagioclase, augite, hypersthene, quartz, magnetite, and ilmenite, which are immersed in a glassy groundmass. Pumice stones do not contain amphibole phenocrysts; however, it was found in the form of crystalline inclusions in pyroxenes. Amphibole is Mg-Fe^{3+} hornblende (Al_2O_3 7-11 wt. %). To estimate pressures, we used an amphibole geobarometer (Ridolfi et al., 2010). We argue that the amphibole is a relic of a mineral association that formed during the partial melting of crustal metabasites of Kunashir Island. Thus, the estimates of the PT parameters correspond to the process of generation of the melt that participated in the formation of the upper crustal magmatic chamber. The maximum estimates of the PT parameters were about 3 kbar and 920˚C. Most of the compositions of amphibole correspond to 1-2 kbar and temperatures of 780 - 890˚C. Melts were formed at high fO_2 corresponding to the NNO +0.1-1.9 buffer.

Pumice phenocrysts often contain primary glassy melt inclusions (MI). Sometimes these MI’s contain empty shrinkage bubbles. The composition of MI corresponds to low-K_2O dacite-rhyodacite. MI’s differ from the bulk rocks by a higher SiO_2 content and do not differ in alkali content. The most important part of this study is to determine the content of volatile components in the melts that participated in the caldera eruption. By combining the methods of Raman spectroscopy and the measurement of oxygen by the EPMA EDS, we found that MI’s contain from 4.2 to 7.4 wt. % H_2O. At the same time, the water content in the glass of the groundmass does not exceed 4.5 wt% H_2O, which indicates significant losses of volatile melts during a caldera eruption. Comparison of the content of volatile components in glasses of the groundmass and in melt inclusions allows us to estimate the amount of volatile components emitted into the atmosphere during a caldera eruption.

Phenocrysts of plagioclase and clinopyroxene also contain primary and pseudo-secondary fluid inclusions (FI). The features of the composition and location of FI’s show that during the evolution the melt degassed. And this degassing is not associated with the final large eruption, as indicated by the presence of pseudo-secondary FI. Also, combined melt inclusions were found. They are represented by melt, trapped non-daughter crystals, and two-phase fluid segregations (liquid H_2O and gaseous CO_2). These inclusions indicate that the fluid pressure in the chamber could have exceeded the lithostatic one. An additional drop in lithostatic pressure (for example, due to the rise of magma) allowed additional portions of fluid to migrate from the glass of the melt inclusion into these segregations. The data obtained make it possible to accurately describe the evolution of magma from Mendeleev volcano before the caldera eruption and to compare it with other Pleistocene-Holocene calderas of the Southern Kuriles.

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Keywords: Caldera eruptions, Water content, Dacite pumice

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Volcanic unrests after the 2015 phreatic eruption of Hakone volcano and its hydrothermal system

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Since the beginning of the 21st century, volcanic unrests detected as increase of seismic activity, increase of baseline length across the edifice, and frequent deep low-frequency earthquakes have been observed at Hakone volcano every few years. The most intensive volcanic unrest culminated in a small phreatic eruption in 2015 as the first eruption in the history of observation. Even after the eruption, volcanic unrests have been observed in 2017 and 2019. In this presentation, we compare the pre- and post-eruptive unrests, and discuss the status of the hydrothermal system just below the eruption center.

Volcanic unrests of Hakone volcano start with a deep inflation (6-10 km) and deep low-frequency events around 20 km below the surface, followed by volcano tectonic earthquakes (< 6 km below the sea level). At the same time, the component ratio of magmatic to hydrothermal in the fumarole such as CO2/H2S and He/ H2S increases. In addition, abnormal steam emission from steam production wells in Owakudani can be observed. In fact, Volcano Alert Level 2 for Hakone Volcano is defined are crustal movement, seismic activity, and fumarolic anomalies that exceed the specified level. This series of changes can be interpreted as the supply of magma or magmatic fluids to the deep inflation source, which increase pore pressure of the hydrothermal system.

The post eruptive volcanic unrests occurred in 2017 and 2019 also accompanied deep inflation, volcanic tectonic earthquakes, changes in volcanic gas ratios, and deep low-frequency earthquakes. However, the frequency of volcano tectonic earthquake during the post-eruptive unrests was significantly lower especially in the shallow immediately beneath Owakudani. Also rise of magmatic/hydrothermal gas ratio was less significant during the post-eruptive unrest. In this presentation, we attribute these phenomena to the 2015 eruption, which ruptured the hydrothermal system near the surface (cap-rock) and at the bottom (sealing zone near the brittle-ductile boundary).

Recent magnetotelluric surveys showed that volcano tectonic earthquakes at Hakone Volcano occur within the hydrothermal system, and seismic activity during the unrests was interpreted as intrusion of fluid and the pore pressure rise within the hydrothermal system. The decrease in seismic activity observed in the post-eruptive unrest beneath Owakudani may be due to the destruction of the caprock by the 2015 eruption which allows no significant pressure rise within the hydrothermal system. If so, the future volcanic unrests may not be accompanied by the significant increase in seismic activity and local uplift seen in 2015 near Owakudani, until the healing of the caprock.

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Temperature profile beneath Owakudani can be constrained from the mineral assemblage of bore hole samples and the bottoming of seismicity. Assuming the temperature profile and isoenthalpy of pore water through the hydrothermal system, vapor static pore pressure beneath the bottom of the caprock can be inferred. In a liquid-dominated system, unload of surface deposit can cause explosion of hydrothermal water near the boiling temperature just beneath the surface and eject surrounding material. This ejection causes further unload and explosion progresses downward (8). The fact that the 2015 eruption resulted in a very small magnitude with the explosion source only around 100 m deep may be attributed to the pressure profile described above. In addition, paucity of volcanic tremors and low-frequency earthquakes at Hakone volcano can be attributed to the vapor dominated hydrothermal system.

Assuming healing of caprock in progress and the steam-dominated hydrothermal system, risk of phreatic eruption near Owakudani may be low at present, and phreatic eruption larger than that of 2015 can be highly unlikely. On the other hand, since the deep inflation has continued even after the eruption, magmatic fluid can accumulate in deep and its release may cause major phreatic eruption in future as observed at Ontake volcano.

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Keywords: Hakone volcano, hydrothermal system, volcanic unrest, phreatic eruption, pore pressure, caprock

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Structure of the shallow hydrothermal system in Hakone volcano inferred from InSAR analysis

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During the 2015 unrest at Hakone volcano, satellite-based SAR observations captured surface deformation before, during, and after the phreatic eruption. Moreover, recent magnetotelluric surveys reveal the subsurface resistivity structure of the volcano. In this presentation, we introduce the surface displacement, which was considered to be related to activities of hydrothermal fluids, detected by InSAR analysis and these models. Furthermore, we will discuss the structure of the shallow hydrothermal system of Hakone volcano.

1. Surface Displacement at the Owakudani Fumarole Area during the 2015 Unrest

During the 2015 unrest, an abnormal blowout occurred at a steam production well (473 m deep) in Owakudani from May 3, and ALOS-2/PALSAR-2 repeatedly observed very local uplift (~200 m diameter) at Owakudani (Kobayashi et al., 2018; Doke et al. 2018). This surface displacement is explained by a Mogi source at an elevation of about 900 m (about 100 m deep). A magnetotelluric survey also confirms the existence of a small resistive body, which was interpreted as a vapor pocket locating almost at the Mogi source (Mannen et al., 2019).

2. Surface Displacement during the 2015 Phreatic Eruption and Intrusion of Fluid Crack

Observation of ALOS-2/PALSAR-2 before and after the phreatic eruption at Owakudani from June 29 to July 1, 2015, detected a surface displacement in an area about 1 km southeast of Owakudani (Doke et al., 2018). This displacement was explained by an NW-SE-trending crack opening and closing of a sill beneath the crack. The estimated crack location corresponds to a pre-existing fissure vent, suggesting that the crack was opened using the pre-existing structure. Moreover, a crater, which was considered the eruption center of a phreatic eruption that occurred in the past (Kobayashi et al., 2006; Kobayashi, 2008), is located on the estimated crack, and the opening of the crack is thought to have caused repeated phreatic eruptions. In the central cone of Hakone volcano, several crater chains with NW-SE strikes are distributed, suggesting the existence of similar cracks beneath the crater chains.

3. Surface Displacement during 2006-2011 by ALOS/PALSAR

The InSAR time series analysis (SBAS method) of ALOS/PALSAR showed steady subsidence on the west side of Owakudani (Doke et al., 2020), with a subsidence rate of 25 mm/yr estimated from the results of 2.5D analysis. This subsidence is explained by the contraction of a Mogi source at an elevation of 700 m (depth of 300 m), with about 10,000 m^3/yr. The existence of such contraction suggests that there is a similar vapor pocket to the 2015 unrest, although they differ in depth and behavior.

These results suggest that the hydrothermal system in the shallow part of Hakone volcano is characterized by plural NW-SE to WNW-ESE striking crack-like fluid supply paths and pocket-like fluid reservoirs distributed at depths of several hundred meters.

Acknowledgments

ALOS/PALSAR and ALOS-2/PALSAR-2 data were provided by JAXA via the Coordinating Committee for the Prediction of Volcanic Eruption as part of the project, “ALOS Domestic Demonstration on Disaster

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Management Application," of the Volcano Working Group. The original ALOS/PALSAR data belong to JAXA and METI, and the original ALOS-2/PALSAR-2 data belong to JAXA.

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Keywords: Hakone volcano, hydrothermal system, phreatic eruption, InSAR, surface displacement

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Ground deformations at Kuju volcano, Japan, revealed by PALSAR-2 InSAR

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Kuju volcano is located in the western part of Oita prefecture in Kyushu Island, Japan. The latest eruption occurred in 1995 at Iwoyama, which is the most active area in Kuju volcano and has numerous active fumarolic vents. Post-eruptive ground deflation accompanying significant heat discharge started immediately after the eruption (Nakaboh et al., 2003), and continued until, at least, 2002 (Saito et al., 2003). From 2012, a continuous GNSS observation network installed in 2001 by Japan Metrological Agency (JMA), has recorded increases in the baseline length indicating ground inflation, which suggests a possibility of on-going magma intrusion or fluid migration into a shallow part of Kuju volcano.

To clarify the spatiotemporal evolution of this deformation in more detail, we analyzed PALSAR-2 data, which is L-band Interferometric Synthetic Aperture Radar (InSAR), operated by Japan Aerospace Exploration Agency (JAXA). We used two-track data; right-looking ascending and right-looking descending orbits, acquired from August 2014 to November 2019. We performed SAR interferometry using RINC software (Ozawa et al., 2016) and time series analysis using SBAS (Small Baseline Subset; Berardino et al., 2002) method implemented with GIAnT software (Agram et al., 2013).

SBAS results of both tracks show spatial patterns indicating ground deflation in Iwoyama and geothermal power plants of Hattyobaru and Otake (hereafter, Hattyobaru and Otake), which are located on the west side of Kuju volcano. The spatial extent of the deformation is less than 1 km at Iwoyama, while it is about 4 km in Hattyobaru and Otake. Quasi-eastward and vertical deformation maps show different spatial characteristics. At Iwoyama, there is a rather incomprehensible pattern; a combination of subsidence (1.4 cm/yr) and only eastward displacement (1.4 cm/yr), which is not likely to be modeled by only a simple deflation source. On the other hand, in Hattyobaru and Otake, a simple pattern indicating ground deflation can be recognized, and the maximum subsidence velocity is about 1.2 cm/yr at Hattyobaru and 0.4 cm/yr at Otake. These deformation characteristics are consistent with those of ALOS-derived deformation around Hattyobaru and Otake during 2007-2010 (Ishitsuka et al., 2016), suggesting that a common deflation source, such as the deflated geothermal reservoir just beneath Hattyobaru at 750-m depth (Nishijima et al., 2005), has consistently caused the deformation during 2007-2019.

Source modeling for the deformation at Iwoyama shows that a combination of a spherical deflation source and a right strike-slip fault with slight normal faulting better fits the observed deformation than only a single deflation source. The deflation source during 2014-2019, of which depth is 200-300 m, is clearly shallower than the deflation source during 1995-2002 at a depth of 500-600 m. On the other hand, the 2014-2019 deflation source is probably overlapped with the position of a demagnetized source from 2014, suggesting coeval progress of deflation and demagnetization. The combination of deflation and demagnetization is an unusual phenomenon because, in other volcanoes, only cases of coeval inflation-demagnetization and deflation-magnetization have frequently been reported (Hashimoto et al., 2019).

The ground deflation of Iwoyama observed in this study is opposed to the deformation observed by the GNSS network, i.e. ground inflation. In addition, GNSS baseline lengths (4-5 km) are longer than the

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spatial scale of the Iwoyama deformation (less than 1 km), which suggests the existence of a deeper inflation source. To disclose the real nature of the ground inflation observed from 2012, it is necessary to further investigate GNSS data; remove several non-volcanic factors, such as post-seismic deformation of the Kumamoto earthquake and subsidence of Hattyobaru and Otake geothermal power plants.

Keywords: Interferometric Synthetic Aperture Radar, Kuju volcano, volcanic deformation, Hattyobaru geothermal power plant

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.25 Zoom Room 25

[S-VC29] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University)

There is a diversity of hydrothermal systems between magmas and the ground surface in various geoscientific environments. Understanding of the hydrothermal systems contributes to understanding of the earth systems, and is essential for utilization of geothermal energy and prediction of volcanic eruption. In this session, we will discuss the topics on subsurface structures and heat and fluid flows of "hydrothermal systems of volcanoes" from the perspectives of geophysics, geochemistry, geology and geothermal reservoir engineering. Any research approaches, theoretical, observational and experimental, are welcome.

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

[SVC29-07] The plumbing system of a Miyakejima volcano: insights into magmatic-hydrothermal interactions

*Marceau Gresse[1], Makoto Uyeshima[1], Takao Koyama[1], Hideaki Hase[2], Koki Aizawa[3], Yusuke Yamaya[4], Yuichi Morita[1], Derek Weller[1], Tawat Rung-Arunwan[5], Takayuki Kaneko[1], Yoichi Sasai[6], Jacques Zlotnicki[7], Tsuneo Ishido[8], Hideki Ueda[9], Maki Hata[1] (1.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 2.Geothermal Energy Research & Development Co., Ltd., Tokyo, Japan, 3.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, Fukuoka, Japan, 4.National Institute of Advanced Industrial Science and Technology (AIST), Renewable Energy Research Center, Fukushima, Japan, 5.Curl-E Geophysics Co., Ltd., Thailand, 6.Earthquake Prediction Research Center, Tokai University, Shizuoka, Japan, 7.CNRS, EMSEV, OPGC-UMR6524, Aubière, France, 8.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 9.National Research Institute for Earth Science and Disaster Resilience (NIED), Tsukuba, Japan)

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

[SVC29-08] Ability of the magnetotelluric method to image a deep conductor: Exploration of a supercritical geothermal system

*Keiichi Ishizu[1], Yasuo Ogawa[1], Toru Mogi[1], Yusuke Yamaya[2], Toshihiro Uchida[2] (1.Tokyo Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[SVC29-09] Analysis and interpretation of DAS-seismic results obtained at the Ohnuma geothermal field in the Hachimantai volcanic region, in Japan

*Junzo Kasahara[1,2], Yoko Hasada[1,3], Kuzume Haruyasu[1] (1.ENAA, 2.Shizuoka University, 3.Daiwa Exploration and Consulting Co. Ltd.)

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

[SVC29-10] Thermal property measurements by drilling cuttings obtained from a geothermal well in the Hachimantai area and thermal structure analysis

*Haruto Sugamoto[1], Kazuya Ishitsuka[1], Weiren Lin[1], Takemi Sakai[2] (1. Graduate School of Engineering, Kyoto University, 2.Geothermal Engineering Co., Ltd.)

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

[SVC29-11] Characteristics of eruption periodicity observed at Shikabe geyser and estimation of the factor of long term periodicity change

*Ayuta Tsuge[1], Hiroshi Aoyama[2] (1.Institute of Seismology and Volcanology, Graduate School of Sciences, Hokkaido University, 2.Institute of Seismology and Volcanology, Fuculty of Science, Hokkaido University)

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

[SVC29-12] Modeling of multidisciplinary observations during an inter-eruptive period by using a hydrothermal simulation with post-processors

*Ryo Tanaka[1], Takeshi Hashimoto[1], Shohei Narita[2] (1.Hokkaido University,Institute of Seismology and Volcanology, 2.Kyoto University, Graduate School of Science, Institute for Geothermal Sciences, Aso Volcanological Laboratory)

The plumbing system of a Miyakejima volcano: insights into magmatic-hydrothermal interactions

*Marceau Gresse[1], Makoto Uyeshima[1], Takao Koyama[1], Hideaki Hase[2], Koki Aizawa[3], Yusuke Yamaya[4], Yuichi Morita[1], Derek Weller[1], Tawat Rung-Arunwan[5], Takayuki Kaneko[1], Yoichi Sasai[6], Jacques Zlotnicki[7], Tsuneo Ishido[8], Hideki Ueda[9], Maki Hata[1]

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Phreatic and phreatomagmatic eruptions are difficult to predict with accuracy on volcanoes due to complex interactions at depth between heat, water, and magmatic fluids. To better understand such multifaceted interactions, we present here a multidisciplinary geophysical approach performed on Miyakejima, a 10-km wide stratovolcano in the Izu Bonin arc. Its plumbing system was highlighted by combining four geophysical methods: magnetotellurics, seismicity (hypocenters), self-potential, and thermal image (remote sensing). We thus propose the first large-scale interpretation of the volcanic structure in terms of rock properties, temperature, fluid content, and fluid flow. Our findings indicate that hot volatiles released from a *deep* magmatic reservoir (> 350 ˚C, 2.5–4.5 km depth) rise through a narrow permeable path, interact with the conductive hydrothermal system beneath the 2000 A.D. caldera (<250 ˚C, 0–2 km depth). This mixture of fluid is finally released in the fumarolic area in the southern part of the caldera at 181˚C. This combined approach allow us to: 1) delineate the water table of the volcano (300–700 m depth), 2) determine the general fluid flow circulation beneath the island, 3) characterize seismic signatures of long-period and volcano-tectonic events, and 4) elucidate the origin of the high water content of fumaroles developed since the last eruption in A.D. 2000.

Keywords: hydrothermal system, magnetotellurics, electrical resistivity, seismicity, self-potential, remote-sensing

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Ability of the magnetotelluric method to image a deep conductor: Exploration of a supercritical geothermal system

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Fluids trapped under supercritical conditions are attractive unconventional geothermal resources that can yield much higher well-productivity. The magnetotelluric (MT) method can image supercritical fluids as deep conductors. However, MT imaging of a deep conductor strongly depends on the conductor geometries and overlying clay layers. The MT ability to image a deep conductor should be clarified to understand the MT usefulness for exploring supercritical fluids and correctly relate the imaged conductor to supercritical fluids. Therefore, this study investigated the MT ability to image a deep conductor of supercritical fluids using numerical tests. The numerical tests used a conceptual resistivity model of a promising supercritical geothermal system in the Kakkonda area, northeast Japan. The test results prove that the MT method is useful for revealing the deep conductor of promising supercritical fluids. The results also showed that the MT ability to image deep conductors strongly depends on the size and depth of the target conductor and the thickness of overlying clay layers. The findings from the test results help to relate deep conductors imaged by the MT method to supercritical geothermal systems.

Keywords: Resistivity, Electromagnetic survey, Geothermal energy, supercritical geothermal system, Kakkonda

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Analysis and interpretation of DAS-seismic results obtained at the Ohnuma geothermal field in the Hachimantai volcanic region, in Japan

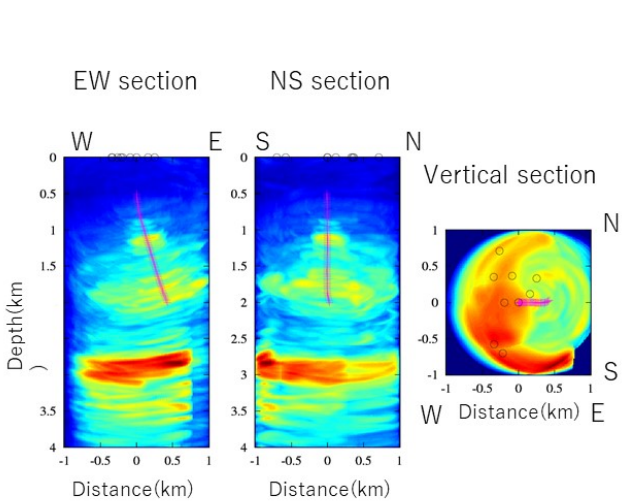
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1. ENAA, 2. Shizuoka University, 3. Daiwa Exploration and Consulting Co. Ltd.

We report seismic data analysis and preliminary interpretation for the distributed acoustic sensor (DAS)-seismic survey obtained at Ohunuma geothermal field in 2020. The New Energy and Industrial Technology Development Organization (NEDO) in Japan has promoted the use of supercritical water for geothermal power generation under a project called Research and Development of Supercritical Geothermal Resources. In September, we carried out a seismic survey as a part of this NEDO project using the DAS-seismic method using an optical fiber system. We deployed the optical fiber in the O-13R geothermal borehole at the Ohnuma power plant owned by Mitsubishi Materials Corporation. The Ohnuma geothermal filed is in Hachimantai volcanic region in the north-eastern part of Japan. We used a middle size active source at nine locations for the survey. In Ohnuma geothermal borehole, the optical fiber extended to 2,037 m-long along the borehole casing (vertical depth = c.a. 1,971 m). The DTS (distributed temperature sensor) temperature in the borehole obtained by the same optical fiber was 235 degree C at around 1,100m-depth. To enhance the signal to noise ratio (S/N) we applied the stacking of the DAS records by 480 times after the removal of outliners and source signature compensation. We separated the DAS records to down-going phases (direct arrivals) and up-going phases (reflected arrivals). We migrated the upgoing arrivals and made a composite migrated image of nine source locations in 3-D space (Fig. 1). We recognized several distinct reflection arrivals. The reflections occur at around 1.1 km, 1.5 km, 2 km and 2.8-3.0 km-depths. The amplitudes of reflected PP arrivals from the 2.8-3.0 km-depth is half of amplitude of direct P arrivals at C8 source location (~700 m distance in the south of O-13R wellhead). The depth of 1.1 km corresponds to the lithological boundary of the dacite welded tuff and the altered andesite, and the depth of 1.5 km does to another lithological boundary of the altered andesite and the silicious shale. The depth of the geothermal production of Ohnuma geothermal power plan is between approximately 1,200 m and 1,700 m depths. The migrated images have similarities to this production zone. We correlated fracture zones obtained by the drilling and logging data of geothermal boreholes (unpublished data of Mitsubishi Materials Co.) and the DAS seismic data, and some of reflections occur around the fracture zones. Because all geothermal boreholes in the Ohnuma geothermal power plant is down to 2,100 m, the distinct reflections from 2.8-3.0 km depth is not resolved by the lithological data of boreholes. One of interpretations for the reflections from the 2.8-3.0 km-depth is presence of hot fluids in fractures of granitic intrusive rock like Sumikawa geothermal field.
Acknowledgements This study was supported by the New Energy and Industrial Technology Development Organization (NEDO). We greatly appreciate Mitsubishi Materials Corporation for their kind permission for fieldwork in their power plant.We also express our great thanks to Mr. Iwasaki and his colleagues of Mitsubishi Materials Techno Corporation for their aggressive discussions.

Keywords: Geothermal exploration, supercritical water, DAS, seismic reflection, migration imaging, geothermal reservoir

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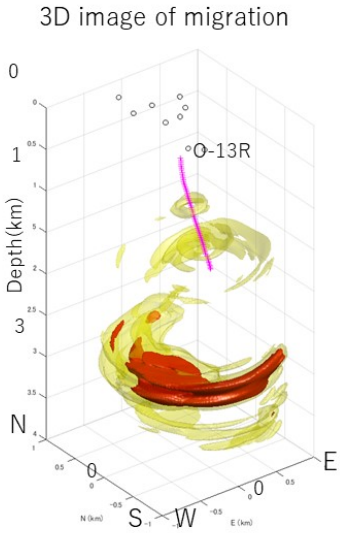


Fig. 1: Migrated image of reflection arrivals obtained by DAS-seismic survey in the O-13R geothermal borehole at the Ohnuma geothermal power plant

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Thermal property measurements by drilling cuttings obtained from a geothermal well in the Hachimantai area and thermal structure analysis

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It is important to identify the factors that influence the temperature depth profile of a well in order to investigate the presence of heat convection. Especially, the thermal conductivity of rocks of a well is a vital property for quantitatively analyzing temperature logs. In general, the thermal properties of rocks can be obtained by measuring core samples. However, rock cores are often not retrieved and only drilling cuttings are collected, thus thermal conductivity measurements of drilling cuttings are required. In this study, we measured the thermal conductivities by the drilling cuttings obtained in the N19-HA-1 well in the Hachimantai area, Japan, using a transient plane heat source method. We further estimated the core-equivalent thermal conductivities from the measurements of the drilling cuttings based on a thermal conduction mixing model, and the temperature profile was quantitatively examined from the viewpoint of heat conduction.

Firstly, to validate the method of estimating the core-equivalent thermal conductivity from the cuttings, we prepared cuttings by artificially grinding andesite cores in laboratory, and compared the thermal conductivities of the cuttings and the core sample. To select the best mixing model to convert measured thermal conductivity of cuttings to core-equivalent thermal conductivity, we tested five thermal conduction mixing models (i.e., arithmetic mean, harmonic mean, geometric mean, square root mean, and effective medium theory mean). After the validation, we applied the method to 18 cuttings samples of andesite and dacitic tuff in the Hachimantai area (5 samples from depth range of 120-220 m, 4 samples from 305-385 m, and 9 samples from 925-1165 m, respectively). The estimated core-equivalent thermal conductivities were used to examine the temperature log based on Fourier's law ($j = \lambda \, \mathrm{grad} T$, where j is the heat flux, λ is the thermal conductivity, and $\mathrm{grad} T$ is the temperature gradient). This analysis of temperature profile was performed under the assumption that the heat conduction is dominant in one dimension along the well and the heat flux is constant along the analyzed depth interval. In this analysis, the average thermal conductivity of each depth zone was obtained by taking the harmonic mean of the thermal conductivities at each depth, and the heat flux was calculated from the gradient of the temperature log data.

As a result of the validation using the andesite core and cuttings, we found that difference of the thermal conductivities between the core and cuttings was minimal (1.8%) when we applied the square root mean model. In conclusion of this validation, the core-equivalent thermal conductivity could be obtained using the square root mean model. We subsequently estimated the core-equivalent thermal conductivity from the cuttings samples in the Hachimantai area by using the square root mean model and calculated the conductive temperature profile using Fourier's law. The calculated temperature profile was then compared with the observed temperature log. As the result of this analysis, we found that the heat conduction is dominant between the 120-220 m depth range. In the case of the 305-385 m depth range, the measured temperature also agrees well with the estimated conductive profile especially below the depth of 330 m, indicating that the temperature pattern is determined mainly by heat conduction. In contrast, the temperature profile of some sections between 925 m and 1165 m could not be reproduced

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from the present analysis. The fact that the temperature structure was not reproduced from the present analysis based on heat conduction may suggest the presence of heat convection in the depth intervals.

Keywords: Hachimantai area, Drilling cuttings, Thermal conductivity, Transient plane heat source method, Temperature profile

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Characteristics of eruption periodicity observed at Shikabe geyser and estimation of the factor of long term periodicity change

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The eruption periodicity of a geyser is not always regular but sometimes shows bimodal distribution or acts chaotically. Also, the eruption periodicity changes from short to long time scales. For example, the eruption periodicity at Old Faithful Geyser in Yellowstone National park was regular distribution in the 1800s, but gradually became bimodal distribution (Rinehart, 1969). Hurwitz *et al.* (2008) suggested that some geysers in Yellowstone National park may change their eruption periodicity due to the river discharge and precipitation. However, the mechanism of periodicity change has been discussed mainly statistically, so the physical parameters (hydraulic head, for example) controlling the eruption periodicity are not understood quantitatively.

In this study, we implemented observation at Shikabe geyser in southern Hokkaido to understand the mechanism of periodicity change of geyser, from November 26th, 2019 to February 24th, 2020 (first half) and from July 8th, 2020 to November 4th, 2020 (latter half). The intermittent cycle of the Shikabe geyser consists of the quiescence period—hot spring water does not discharge from the vent, the overflowing period—hot spring water overflows from the vent, and the eruption period. We measured the periodicity as the interval between the time of onset of overflow (IBO: Interval Between Overflow) from the temperature change of the Pt resistance thermometer attached at the vent. Then, we classified the periodicity into the quiescence time, overflowing time, and eruption time based on the acoustic pressure data which reflect onset and termination of eruption well, and investigated temporal change and the relative relationship of these times.

In the first half, IBO extended from approximately 12.5 min to 14.3 min, and the extending rate gradually decreased. We can find two distinctive modes of the periodicity: the stable mode distributing around the mean IBO, and the unstable mode fluctuating several minutes from the mean IBO. In particular, the unstable mode has a series of patterns in which once a long eruption occurs, the following quiescence time and the overflowing time are certainly extended, and the next quiescence time will be shortened. In the latter half, unlike the first half, the mean IBO decreased to approximately 11 min and changed to a double cycle. The quiescence time, overflowing time, and eruption time in the double cycle exhibit a pendulum-like behavior alternating back and forth around the mean IBO.

To understand the factor of the increase in mean IBO in the first half, we investigated the temporal change of the quiescence time, overflowing time and eruption time and found that the IBO extension is affected by the increase in both the quiescence time and overflowing time. Therefore, we made a hypothesis that the decrease in supply rate of the hot spring water to the geyser reservoir; the decrease in the hydraulic

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head causes the decrease in mean IBO in the first half. We formulated the IBO change mathematically using the equation of water ascent in the well based on Darcy’ s law and calculated the hydraulic head change that explains the observed IBO change. As a result of the calculation, the IBO change in the first half can be explained by a decrease in the hydraulic head of about 0.7m. In the previous study, the pressure change in the aquifer was pointed out as one of the factors of periodicity change (Hurwitz *et al.*, 2008; Kiryukhin, 2016). The result of this study is quite significant in that the amount of change in aquifer pressure can be estimated from the model equation of the IBO.

The decrease in aquifer pressure suggested from the long-term IBO change may be affected locally by the increase in pumping at the nearby hot springs, or regionally by the decrease in aquifer pressure in the entire hot spring area or the seasonal changes. However, we only have data for about a year and have no information on nearby hot springs, so we have not yet been able to specifically distinguish these factors. Therefore, we should not only continue observing for several years, but also obtain information about the use of nearby hot springs and changes in the amount of spring discharge.

Keywords: geyser, eruption periodicity change

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Modeling of multidisciplinary observations during an inter-eruptive period by using a hydrothermal simulation with post-processors

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Recently, some volcanic unrest events in inter-eruptive periods have been observed with multidisciplinary monitoring (e.g. Tokachidake volcano, Kuchinoerabu-jima volcano, Kuju volcano). We focus on the simultaneous changes in ground deformation, total magnetic field, and thermal discharge rate, which are considered to be good indicators of subvolcanic hydrothermal activity. The ground deformation and total magnetic field mainly reflect the subsurface changes in pressure and temperature, respectively. Therefore, these observations are important to understand the activity of the hydrothermal system. In this study, we performed the simulation under several conditions to clarify the behavior of the hydrothermal system and the multidisciplinary observations by coupling the hydrothermal simulation with the post-processors which calculate a ground deformation and changes in the magnetic field.

The numerical simulation was carried out with the TOUGH2 geothermal simulator (Pruess et al. 1999). The calculation region was set axisymmetric 2D. A high permeability region (radius: 100 m, permeability: 1.0×10^{-12} m^2) was set near the symmetry axis to represent the fumarolic conduit. The rest of the calculation region represents the host rock and was set the permeability in two ways (1.0×10^{-14} m^2 and 5.0×10^{-15} m^2). For simplicity, the topography was assumed to be flat. In the subsequent simulations, the initial condition was obtained by simulating a constant injection of hydrothermal fluids (H_2O, 350 ºC, 1500 ton/day) from the bottom of the fumarolic conduit for 10k years, representing a quasi-steady state. After that, we imposed an elevated hydrothermal fluid input (3000 ton/day) from the bottom and/or a reduced permeability (1.0×10^{-14} m^2) at a particular depth in the middle of the conduit to monitor the subsequent changes.

The ground deformation was calculated by using the partial differential equation module of COMSOL Multiphysics (COMSOL, 2012). The ground deformation corresponding to changes in pressure and temperature was calculated following the extended Hooke’ s law (Jaeger et al., 2007), assuming the thermoporoelasticity. For the magnetic field changes, we take the thermomagnetic effect only and calculated the total magnetic field following the uniformly magnetized prism model (Bhattacharyya, 1964), where we assumed a temperature-dependence of the rock magnetization as 0.01 A/m/K. The heat discharge rate from the crater was calculated by summing up the heat discharge rate of the most upper cells of fumarolic conduit in the hydrothermal simulation.

When only an elevated injection rate was applied, the increase in the subsurface pressure and temperature resulted in the combination of inflation, demagnetizing field changes, and a larger heat discharge from the crater. In the case of a depleted permeability in the conduit, inflation, re-magnetizing field changes, and a reduced heat discharge was observed together. This combination was resulted from the simultaneous occurrence of cooling above the choked zone and pressurization below it. Subsequently, the cooled zone in the upper part of the conduit turned into heating and the continued pressurization below the choked point resulted in inflation, demagnetization, and recovery in the heat discharge.
As a next step, we will perform more calculations under various conditions to classify the simultaneous

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changes in ground deformation, total magnetic field, and thermal activity, in which it is necessary to examine the effects of a caprock and topography. It enables us a direct comparison between hydrothermal simulations and field observations to better understand the behavior of a subvolcanic hydrothermal system during an inter-eruptive period.

This work was supported by MEXT “Integrated Program for Next Generation Volcano Research and Human Resource Development”.

Keywords: hydrothermal system, hydrothermal simulation, unrest event

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.23 Zoom Room 23

[S-CG44] Petrology, Mineralogy & Resource Geology

convener:Koichi Momma(National Museum of Nature and Science), Yu Nishihara(Geodynamics Research Center Ehime University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Yu Nishihara(Geodynamics Research Center Ehime University), Koichi Momma(National Museum of Nature and Science), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

We widely invite presentations in the fields of petrology, mineralogy and resource geology. Especially description of minerals and rocks, investigation of their origin and evolution by field investigation and/or laboratory experiments, and development of new methods are accepted.

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

[SCG44-01] Consolidation anisotropy of Mio–Pleistocene sedimentary soft rocks in the eastern part of the Boso Peninsula, central Japan

*Nana Kamiya[1], Masahiro Miyazaki[1], Weiren Lin[1] (1.Graduate School of Engineering, Kyoto University)

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

[SCG44-02] Prograde and progressive metamorphism of low-pressure and high-temperature terrane in the Tenzan area, Saga prefecture, north Kyusyu, Southwest Japan

*Yusaku Tanaka[1], Masaaki Owada[1] (1.Yamaguchi University)

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

[SCG44-03] **ZIRCON U–Pb AGES AND GEOCHEMISTRY OF GRANITOIDS FROM SOUTHWEST MONGOLIA**

*Dolzodmaa Boldbaatar[1], Yasuhito Osanai[1], Nobuhiko Nakano[1], Tatsuro ADACHI[1], Ippei Kitano[1], Kundyz Syeryekhan[2] (1.Kyushu University, 2.Golden Hill LLC)

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

[SCG44-04] **Zircon U–Pb ages of plutonic rocks from Iwafune area, Ibaraki Prefecture**

*Haruki Yamazaki[1], Terumi Ejima[1], Yoshiaki Kon[2], Yuki Tsunazawa[2] (1.Shinshu University Faculty of Science Department of Geology, 2.National Institute of Advanced Industrial Science and Technology)

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

[SCG44-05] Petrogenetic study on the cretaceous granitoids on the Takanawa Peninsula, northwest Shikoku, southwest Japan

*Kazuya Shimooka[1], Satoshi SAITO[1], Kenichiro Tani[2], Toshiro Takahashi[3] (1.Graduate School of Science and Engineering, Ehime University, 2.Department of Geology and Paleontology, National Museum of Nature and Science, 3.Graduate School of Science and Technology, Niigata University)

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

[SCG44-06] The kinetics and heat conduction model of thermoluminescence of orthoclase

*Takahiro Sato[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1] (1.Tohoku University)

Consolidation anisotropy of Mio–Pleistocene sedimentary soft rocks in the eastern part of the Boso Peninsula, central Japan

*Nana Kamiya[1], Masahiro Miyazaki[1], Weiren Lin[1]

1. Graduate School of Engineering, Kyoto University

Consolidation generally progresses with an increase in the overburden by the thickness of the sediment. In tectonic stress field, such as a subduction zone, folding also progress with sedimentation, therefore it is necessary to consider the effects of tectonic stress on consolidation. In this study, consolidation tests were conducted using siltstone distributed on the Boso Peninsula, central Japan which is located at the subduction zone of the Sagami Trough to investigate the anisotropy of the consolidation.

The Boso Peninsula is located at the northern part of the Sagami Trough and had formed with the subduction of the Philippine Sea Plate. The Boso Peninsula is composed of the accretionary prisms, trench slope break, and forearc basin, in this study, siltstones were taken from the eastern part of the Boso forearc basin as samples for the consolidation tests. The Boso forearc basin is composed of the Miura Group (15-3 Ma) and the Kazusa Group (2.5-0.3 Ma) and the boundary of both groups is the Kurotaki Unconformity. The large scale folds are distributed in the Miura Group, but the Kazusa group is monocline to the north. In this study, siltstone block samples were taken from the eastern part of the Boso forearc basin composed of both groups to consider the characteristics of anisotropy of consolidation based on geological structure.

We made two types of specimens from a block sample: height direction is perpendicular or parallel to the bedding plane. Cylindrical specimens were put into a consolidation ring, loaded at a constant strain rate, and the consolidation yield stress (p_c) was obtained from the consolidation curve. As a result, the consolidation yield stress in the parallel direction was the same or larger than that in the perpendicular direction. K_{0pc} value which is the ratio of the stress of the parallel to the perpendicular was estimated as an indicator of the anisotropy of consolidation using the p_c of perpendicular and parallel directions. K_{0pc} of the Miura Group is approximately 1.1 and that of the Kazusa Group is approximately 1.2. Compared to the characteristics of anisotropy of consolidation between the two groups, there is no difference between the two groups. The K_0 value of sediment is generally 0.5-0.8 in the silence basin without tectonic stress. Therefore, considering the setting of the Boso forearc basin, it was suggested that the consolidation of the Boso forearc basin is affected by the tectonic compaction.

Keywords: Consolidation, Anisotropy, Sedimentary soft rock

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Prograde and progressive metamorphism of low-pressure and high-temperature terrane in the Tenzan area, Saga prefecture, north Kyusyu, Southwest Japan

*Yusaku Tanaka[1], Masaaki Owada[1]

1. Yamaguchi University

Low-pressure and high-temperature type metamorphic rocks are exposed as mega blocks in the Cretaceous north Kyushu batholiths. Adachi et al. (2012) reported 120—100 Ma monazite Th—U—Pb chemical age and 105 Ma LA—ICP—MS zircon U—Pb ages from pelitic granulites in the Ukidake area, Fukuoka prefecture. This report is addressed with the petrological characters of the metamorphosed mafic rocks from the Tenzan area, Saga prefecture, and discussed in their temporal and spatial changes on the metamorphic grade.

The Tenzan area is underlain by the metamorphic rocks including ultramafic rocks and the Cretaceous granites and gabbros. The metamorphic rocks are exposed in the area covering 20 km in the east to west and 8 km in the north to south. The main structural features in the study area generally show east-west in strikes and dipping 50 to 80 degrees to the south or north. In the eastern part of the Tenzan area, the metamorphic rocks occur apart in the two areas with distance about 3 km, the Hiko-dake area in the north and the Ogi area in the south. The Cretaceous granitic rocks intruding the metamorphosed mafic rocks are situated between two areas.

The metamorphosed rocks consist mainly of amphibolite that are classified into Amphibolite-I and Amphibolite-II in terms of lithofacies. Amphibolite-I shows fine-grained and well foliated structures, and locally intercalates thin calc-silicate layers. On the other hand, Amphibolite-II has coarse-grained without any thin calc-silicate layers. Both Amphibolites-I and -II geochemically resemble N-MORB based on some discrimination diagrams. Amphibolite-I has a nematoblastic structure and is composed mainly of hornblende and plagioclase with a small amount of quartz. The hornblende shows a zonal structure with light green in cores to greenish brown in rims. Opaque minerals and titanite are included as accessory minerals. In addition to these minerals, clinopyroxene and epidote appear in the calc-siliceous thin layers. Amphibolite-II consists mainly of hornblende and plagioclase with a small amount of biotite, potassium feldspar and quartz. Hornblende possesses greenish brown in cores with light-green thin rims, and locally includes plagioclase and quartz with poikilitic textures indicating originally intrusive rocks. Potassium feldspar is produced as antiperthite. Opaque minerals, apatite, zircon and titanite are included as accessory minerals. In addition, Amphibolites-I and -II show granoblastic textures near the contact area of the Cretaceous granites.

Hornblende in Amphibolite-I compositionally shows actinolite in core and magnesio-hornblende or edenite in mantle to rim, and locally has thin actinolite rim, whereas that of Amphibolite-II has wide ferro-edenite in core to rim with locally associated with thin actinolite rim. Plagioclase grains are of Anorthite contents (An) 35 to 43 for both Amphibolites-I and -II with few chemical zoning. Zonal structures of hornblende grains in Amphibolite-I would reflect the prograde metamorphism from greenschist to amphibolite facies metamorphism, then finally greenschist facies again at the retrograde stage. The prograde change in Amphibolite-I can be explained by the reaction of tremolite and albite to form edenite and quartz. Since plagioclase in Amphibolite-I is of andesine, it is inferred that the low An

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plagioclase stabled in the greenschist facies has been consumed by the above reaction. The estimated peak metamorphic temperatures of Amphibolite-I in the Ogi and Hiko-dake areas were 550—600℃ and 640—650℃, respectively. The results indicate that the metamorphic rocks in this area underwent the progressive metamorphism with increasing temperatures from south to north regardless of the distribution of granites. Overall, it is inferred that the metamorphism occurred at 100—105 Ma because of resembling its mode of occurrence and metamorphic features metamorphic style to those of the Ukidake area.

Keywords: Tenzan area, metamorphosed mafic rocks, MORB

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ZIRCON U–Pb AGES AND GEOCHEMISTRY OF GRANITOIDS FROM SOUTHWEST MONGOLIA

*Dolzodmaa Boldbaatar[1], Yasuhito Osanai[1], Nobuhiko Nakano[1], Tatsuro ADACHI[1], Ippei Kitano[1], Kundyz Syeryekhan[2]

1. Kyushu University, 2. Golden Hill LLC

We present new petrographic, geochemical and geochronological data for granitic rocks emplaced in the Altai (Mongolian Altai) terrane of southwest Mongolia. The data are used to constrain their evolution and to discuss the tectonic implications for the Altai terrane. The zircon U–Pb ages indicate that the magmatism can be divided into three stages: stage 1 (397–366 Ma), stage 2 (340-300 Ma) and stage 3 (208-200 Ma). The stage 1 granitic rocks are divided into two types: Bt–Hbl granites having I-type affinity with volcanic arc signature and Crd–Grt bearing Bt–Ms granites having S-type affinity. On the other hand, Stage 2 Qz–Bt syenite having shoshonitic affinity and stage 3 Kfs-porphyritic Bt granites having high-K calc-alkaline affinity with intraplate tectonic setting.

Keywords: I-, S-type granite, zircon U–Pb age, SW Mongolia

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Zircon U–Pb ages of plutonic rocks from Iwafune area, Ibaraki Prefecture

*Haruki Yamazaki[1], Terumi Ejima[1], Yoshiaki Kon[2], Yuki Tsunazawa[2]

1. Shinshu University Faculty of Science Department of Geology, 2. National Institute of Advanced Industrial Science and Technology

The Yamizo Mountains consist of Yamizo, Torinoko, Keisoku and Tsukuba Mountain Blocks. The Yamizo, Torinoko, and greater part of Keisoku Mountain Blocks consist of the Yamizo Group and several plutons. The diorites and gabbros of the plutons are of Early Cretaceous in age (109–102 Ma: Ejima et al., 2018; Ejima et al., 2019), and the granites of Late Cretaceous–Paleocene in age (69–63 Ma: Ejima et al., 2019). On the other hand, southern part of the Keisoku and Tsukuba Mountain Blocks mainly consist of plutonic rocks, such as granites and gabbros are of Late Cretaceous–Paleocene in age (66–61 Ma: Koike and Tsutsumi, 2017; Koike and Tsutsumi, 2018). The Iwafune pluton occurs in northern part of the Keisoku Mountain Block. The Iwafune pluton consists mainly of diorite with minor gabbroic diorite and granite which is distributed in southeast. Shibata et al. (1973) reported biotite K–Ar age of the Iwafune diorite is 64.5 ±2.5 Ma. However, the petrographic characteristics of the Iwafune diorite are similar to diorite of the Fukuroda pluton with about 100 Ma ages in the Torinoko Mountain Block.
Therefore, in order to reexamine age of igneous activity of the Iwafune pluton, U–Pb dating of zircons extracted from the Iwafune plutonic rocks was carried out using laser ablation inductively coupled plasma mass spectrometry combined with cathodoluminescence (CL) imaging on the zircons.
The CL images of zircons separated from diorite, gabbroic diorite and granite show that these zircons have oscillatory zoning and broad-banded zoning which are characteristic internal texture for magmatic zircon. The zircon U–Pb ages of the diorite, gabbroic diorite and granite are 64.4 ±0.6 Ma (n = 37), 64.5 ± 0.7 Ma (n = 24) and 64.6 ±0.8 Ma (n = 41), respectively. The diorite, gabbroic diorite and granite of the Iwafune pluton are same intrusive age, and there is no difference between these ages of the Iwafune pluton and the K–Ar age of previous study (Shibata et al.,1973). Moreover, the zircon U–Pb ages of the Iwafune pluton are same as those of granites in the Yamizo Mountain Block (69–63 Ma: Ejima et al., 2019), and granites and gabbros in the Tsukuba Mountain Block (66–61 Ma: Koike and Tsutsumi, 2017; Koike and Tsutsumi, 2018).

Keywords: U-Pb age of zircon, Iwafune pluton, Granite, Diorite, Gabbroic Diorite

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Petrogenetic study on the cretaceous granitoids on the Takanawa Peninsula, northwest Shikoku, southwest Japan

*Kazuya Shimooka[1], Satoshi SAITO[1], Kenichiro Tani[2], Toshiro Takahashi[3]

1. Graduate School of Science and Engineering, Ehime University, 2. Department of Geology and Paleontology, National Museum of Nature and Science, 3. Graduate School of Science and Technology, Niigata University

In recent years, felsic igneous activity during magmatic anomalies in volcanic arcs has attracted much attention as a key to understanding the formation and growth processes of continental crust. This period of anomalous magma generation is called "flare-up" (e.g., Paterson and Ducea, 2015), and is recognized on a global scale, from North and South America to the Pacific Rim of Eurasia.
Takanawa Peninsula in northwestern Shikoku is composed of plutonic rocks and related rocks including granitoids, mafic rocks, metamorphic rocks formed druing the Cretaceous flare-up event. The granitoids, which are the most widely exposed in the area, consist of several granitoid plutons with different petrological characteristics such as occurrence, mineral constituents and mineral modal ratio. The mantle-derived mafic rocks and metamorphic rocks of accretionary complex are distributed in the area, making the Takanawa Peninsula the best field to investigate thermal and chemical effects of mantle activity on the crust during the flare-ups. However, although wide range of studies including petrological studies by Ochi (1982), isotopic studies by Kagami et al. (1985; 1988), and geochronological studies by Yoshikura et al. (2004) and Shimooka et al. (2019) have been reported, no comprehensive petrogenetic studies on the granitoids have been conducted to elucidate the magmatic processes during the flare-ups in the Takanawa Peninsula.
In this study, I obtained new data including whole-rock and mineral chemical compositions, zircon U-Pb ages and Sr-Nd isotope ratios for the granitoids and related rocks to investigate the magma process of granitoids in the Takanawa Peninsula.
The results suggest that the granitoids in the Takanawa peninsula were formed from multiple pulsed magmas generated by partial melting of the mafic lower crust in 99 Ma, 96-93 Ma, and 89 Ma, which intruded, emplaced, and solidified in the middle crust. Based on the isotopic compositions, assimilation of the host metasedimentary rocks into the granitoid magmas is limited. The differences in the chemical compositions observed in the granitoid plutons are attributed to the degree of partial melting of the mafic lower crust and/or the degree of fractional crystallization of evolving magmas.

Keywords: Cretaceous Granitoids, Petrogenetic study, Flare-ups, Takanawa Peninsula

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The kinetics and heat conduction model of thermoluminescence of orthoclase

*Takahiro Sato[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1]

1. Tohoku University

One method of applying the thermoluminescence phenomenon of minerals such as quartz or feldspar to geothermal exploration is to estimate the underground temperature from the thermoluminescence intensity. In this study, we developed a model to relate the kinetics of thermoluminescence intensity to the heat conduction equation.
TL is a phenomenon in which the energy accumulated in a solid crystal due to the excitation and trapping of electrons by incident radiation is emitted as light by thermal stimulation. When the energy accumulation is caused by natural radiation, it is called natural TL (NTL), and when it is caused by artificial radiation, it is called artificial TL (ATL). A plot of TL intensity versus temperature is called a glow curve, and the Randall-Wilkins model exists as a simple model for drawing this glow curve (Randall and Wilkins., 1945). There is also a model that optimized Randall-Wilkins model using parameters obtained from experiments (Kitis et al., 1998). The integrated intensity of the glow curve is used to compare TL intensity. The kinetics of TL is expressed in terms of the decay of TL by thermal stimulation and the accumulation of TL by radiation. The decay term is described by a reaction rate equation and fitted to the results of isothermal heating experiments. We measured TL from a feldspar sample in a granitic pegmatite collected in Ishikawa-machi, Fukushima Prefecture, and separated several TL peak from glow curves using the Kitis model described above (hereinafter referred to as Peak). The glow curves of the samples whose TL was decayed by isothermal heating were also separated in the same way. The isothermal heating temperatures were 90, 125, and 150℃, and the heating times were 24, 168, 672, 1512, and 3360 hour. The results of the decay of TL intensity were plotted for each peak, and the curves drawn by the reaction rate equation with the frequency factor and reaction order as variables were fitted. The reaction was 2nd or 3rd order. The decay term in the kinetics of TL intensity was described by the reaction rate equation of the 2nd or 3rd order reaction. Next, To investigate the accumulation term, we performed ATL measurements. After artificially irradiating the feldspar samples with γ-rays, the ATL intensity was measured according to the radiation intensity, and the TL intensity per radiation intensity for each Peak was determined. The irradiation doses were 80, 500, 1000, and 2000 Gy. The annual dose received by the samples used was set to 15 mGy/year, and the annual accumulation intensity of each Peak was determined. From the above, the accumulation term could be expressed as a function of time with the annual accumulation intensity as a constant.
The temperature structure of a hypothetical heat source was set up using a heat conduction model, and the time variation of TL intensity was examined in a one-dimensional unsteady heat conduction model. The temperature at which the decay/accumulation of TL is switched is in the range of 20~30℃ at the lowest Peak, and the TL of the feldspar located far from the heat source is accumulated.

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Keywords: Thermoluminescence, feldspar, Heat conduction

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.23 Zoom Room 23

[S-CG44] Petrology, Mineralogy & Resource Geology

convener:Koichi Momma(National Museum of Nature and Science), Yu Nishihara(Geodynamics Research Center Ehime University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

We widely invite presentations in the fields of petrology, mineralogy and resource geology. Especially description of minerals and rocks, investigation of their origin and evolution by field investigation and/or laboratory experiments, and development of new methods are accepted.

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

[SCG44-07] Formation of bipyramidal quartz within the hydrothermal vents: inights from Kuroko samples and hydrothermal experiments

*Jumpei Sugioka[1], Atsushi Okamoto[1], Ryoichi Yamada[1] (1.Tohoku University)

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

[SCG44-08] Copper mobilization systems associated with the Neogene magmatism in the Northeast Japan arc

*Shota Satori[2,1], Yoshiaki Kon[2], Yasushi Watanabe[1], Takuya Echigo[1] (1.Graduate School of International Resource Sciences, Akita University, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[SCG44-09] Discussion

Formation of bipyramidal quartz within the hydrothermal vents: inights from Kuroko samples and hydrothermal experiments

*Jumpei Sugioka[1], Atsushi Okamoto[1], Ryoichi Yamada[1]

1. Tohoku University

Mineral precipitation from the hydrothermal vent fluids has been thought to occur in response to rapid cooling of hydrothermal fluids by mixing with cold seawater, but the mechanism of mineral precipitation still poorly understood. Kuroko is one of the typical massive sulfide deposits distributed along the western side of the central mountains of NE Japan, and formed at seafloor associated with rhyolitic magmatism. The Kuroko sample with the concentric structures represents the chimneys in submarine hydrothermal deposits (Shimazaki and Horikoshi, 1990). In addition to sulfides, bipyramidal quartz grains has been reported in such chimney-like structure, and is thought to be the key to understanding the physico-chemical conditions within chimneys. In this study, we analyzed the quartz-bearing Kuroko samples and conducted the hydrothermal flow-through experiments on silica precipitation. Comparing natural and experimental silica minerals, we discuss the formation and transport processes of quartz particles within the submarine hydrothermal vents.

We analyzed two Kuroko samples containing bipyramidal quartz grains collected from the Hanaoka mine (Doyashiki and Matsumine deposits) in the Hokuroku district, NE Japan. The samples show banded structure mainly composed of barite, galena, sphalerite, chalcopyrite, pyrite, and quartz. The quartz grains show euhedral bipyramidal shape with a long axial length of 0.07-0.45 mm and aspect ratio of 3-5. The bipyramidal quartz contains pyrite. The quartz contained fluid inclusions with size less than 5 micrometers, and showed homogenization temperature of 281-309℃. These features suggest that quartz crystals were formed from the high temperature fluids exceeding 300℃.

The silica precipitation experiments were conducted using the flow-through apparatus with vertical flow-path at constant pressure of 25 MPa with using high-silica aqueous solution (~300 mg/kgH_2O) by dissolution of granite. Within the cylindrical vessel, temperature increased from 350℃ to 430℃ along the flow-path, and silica minerals precipitation occur at around 390℃ within the inner tube in response to the drop of solubility of silica minerals. The silica precipitates were caught by 23 stainless steel nets placed at 10 mm intervals. We conducted two runs with flow rate of 0.1 ml/min and the different durations 1 h and 11 h, respectively. The precipitation of various silica minerals was observed along the flow-path. In the 1h run, amorphous silica occurred at 9-10 cm from the inlet of the alumina tube, cristobalite at 10-14 cm. In contrast, the 11h run, the precipitation of spherical amorphous silica were observed at 7 cm, and quartz particles at 8-10 cm. The quartz grained showed euhedral bipyramidal shape with size of 5.9-103 micrometers. These occurrences suggests that the silica nucleated as amorphous silica, in response to its low interfacial energy with water, and the silica particle grew and aggregated, and then transformed into more stable phases, such as cristobalite or quartz via heterogeneous nucleation on metastable silica phases (Okamoto et al., 2015). The Stokes' equation predict that the silica particles smaller than ~14 micrometers can move upward in ascending flow velocity of 0.01 m/s in the experiments, which is consistent with the particle size observed within the reaction vessel, suggesting that the bipyramidal quartz formation occurred in suspension. The bipyramidal quartz grains in the Kuroko samples were similar to that produced in the hydrothermal experiments. Because of the larger grain size of quartz grains, the fluid ascending velocity within the chimney was estimated to be 0.04-1.6 m/s, which is consistent with that inferred for the active submarine hydrothermal vents (Nozaki et al. 2016).

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Reports, 6, 22163.

Keywords: submarine hydrothermal vents, bipyramidal quartz, chimney, silica, kuroko, submarine hydrothermal deposits

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Copper mobilization systems associated with the Neogene magmatism in the Northeast Japan arc

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1. Graduate School of International Resource Sciences, Akita University, 2. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

A large number of Neogene vein-type copper deposits are distributed in the Northeast Japan arc, which is a volcanic arc associated with subduction of the oceanic plate but lacks porphyry-type copper deposits. Those vein-type copper deposits associated with neighboring Miocene and Pliocene intrusive rocks. The purpose of this study is to clarify how copper mobilized and concentrated as an ore deposit in the magma supply system. Felsic intrusive rocks and included enclaves (MME; mafic magmatic enclave / mafic microgranular enclave) in the Arakawa area, which have been clarified to be temporally and spatially related to the Arakawa copper deposit. In order to estimate the amount of copper released with the fluid during magma solidification, the copper content of the melt estimated using the partition coefficient was compared with the whole rock copper content.

The three felsic intrusive rocks in the Arakawa area consist of plagiorhyolite and amphibole rhyodacite stocks. The MME contained in felsic intrusive rocks is basaltic to dacite and is mainly classified into two types: clinopyroxene-bearing hornblende gabbro and hornblende dacite. All plagioclase in basaltic MME is lath-shape with An 36-89 % and Cu 2.8-35.7 ppm. Felsic intrusive rocks mainly contain tabular-shaped plagioclase with An 11-38 % and Cu 0.5-5.1 ppm. The lath-shaped plagioclase contained in basaltic MME and dacitic MME shows a negative correlation between the An value and Cu content. In the An value vs. Cu diagram, the plot is linearly continuous regardless of the type of MME. Tabular-shaped plagioclase has a small An value and Cu content as a whole, and shows a clear compositional difference from lath-shaped plagioclase. The Cu content of the whole rock is 1 ppm for felsic intrusive rocks, 2 ppm for dacitic MME, and 65-106 ppm for basaltic MME.

The copper content in the melt estimated using the partition coefficient between plagioclase and melt is about 9-24 ppm for felsic intrusive rocks and about 120-150 ppm for basaltic MME. The melts that crystallize lath-shaped plagioclase and tabular-shaped plagioclase in dacitic MME are 74-138 ppm and 8-36 ppm, respectively.

Thus, these analytical results suggest that the dacitic MME with an intermediate composition was generated by the magma mixing of the differentiated mafic magma that formed the basaltic MME and felsic magma. It is suggested that the difference between the estimated copper content of the magma that formed the felsic intrusive rocks and dacitic MME and the whole rock copper content was distributed to the fluid phase during degassing process to form the ore forming fluid.

Keywords: copper mobilization system, magma mixing / mingling, Northeast Japan arc

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[J] Oral | S (Solid Earth Sciences) | S-CG Complex & General

[S-CG44] Petrology, Mineralogy &Resource Geology

convener:Koichi Momma(National Museum of Nature and Science), Yu Nishihara(Geodynamics Research Center Ehime University), Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Tatsuo Nozaki(Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology)

Sun. Jun 6, 2021 3:30 PM - 5:00 PM Ch.23 (Zoom Room 23)

We widely invite presentations in the fields of petrology, mineralogy and resource geology. Especially description of minerals and rocks, investigation of their origin and evolution by field investigation and/or laboratory experiments, and development of new methods are accepted.

4:00 PM - 5:00 PM

[SCG44-09]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.18 Zoom Room 18

[S-CG53] Reducing risks from earthquakes, tsunamis & volcanoes: new applications of realtime geophysical data

convener:Masashi Ogiso(Meteorological Research Institute, Japan Meteorological Agency), Masumi Yamada(Disaster Prevention Research Institute, Kyoto University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), YAMAMOTO Naotaka CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

As the number of population centers grows in regions with earthquake, tsunami and volcano hazards, the importance of improving methods for rapid, realtime estimates of activity increases. Realtime monitoring, analysis, and prediction of seismic ground motion, crustal movement and tsunami will be powerful tools to contribute to earthquake and tsunami disaster preparedness/mitigation. Tsunami and Earthquake Early Warning systems exist today in many locations around the world. Now JMA has started to promptly provide Eruption Notices to inform people of impending and beginning volcanic eruptions. Large events like the 2011 Tohoku Earthquake (Mw9.0) have demonstrated some of the shortcomings of existing techniques. In this session, we invite presentations on new ideas, methods and applications of (near) realtime analysis of seismic, geodetic and tsunami data, to the problem of realtime prediction aimed at improving disaster preparedness/mitigation in the fields of earthquake, tsunami and volcano observation. Presentation is encouraged to bring together scientists, engineers, and practitioners from a broad range of backgrounds from around the world, and to promote collaborative communication at the leading edge of the science and technologies.

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

[SCG53-01] An advanced system for automatic strong gust detection and warning for railroads using deep learning

★Invited Papers

*Kusunoki Kenichi[1], Toru Adachi[1], Hanako Inoue[1], Osamu Suzuki[1], Naoki Ishitsu[2], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd., 3.East Japan Railway Company)

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

[SCG53-02] Tsunami observation and development of real-time tsunami detection by using ocean surface radar

★Invited Papers

*Ryotaro Fuji[1], Kohei Ogata[2], Hirofumi Hinata[3] (1.Kokusai Kogyo Co., Ltd., Ehime University, 2.Kokusai Kogyo Co., Ltd., 3.Ehime University)

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

[SCG53-03] Preliminary comparison of strong-motion parameters at the land & ocean bottom sites for the 2021 Mw 7.1 Off Fukushima Prefecture earthquake

*Yadab Prasad Dhakal[1], Wataru Suzuki[1], Takashi Kunugi[1], Takeshi Kimura[1], Shin Aoi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

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

[SCG53-04] Development of GNSS Real-time analysis including QZSS

*Satoshi ABE[1], Keitaro Ohno[1], Naofumi Takamatsu[1], MURAMATSU Hiroki[1], Tomoaki FURUYA[1], Yohei HIYAMA[1] (1.Geospatial Information Authority of Japan)

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

[SCG53-05] IPFx: extended integrated particle filter method for earthquake early warning and visualization of its results with social networking service

*Masumi Yamada[1], Koji Tamaribuchi[2], Stephen Wu[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Meteorological Research Institute, 3.Institute of Statistical Mathematics)

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

[SCG53-06] Near real-time estimation of hypocenter distribution from seismic amplitudes

*Masashi Ogiso[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

An advanced system for automatic strong gust detection and warning for railroads using deep learning

*Kusunoki Kenichi[1], Toru Adachi[1], Hanako Inoue[1], Osamu Suzuki[1], Naoki Ishitsu[2], 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 2007, the Meteorological Research Institute and the East Japan Railway company started a project to develop an automatic strong gust detection and warning system for railroads , which the decision to warn is based upon information from a single-Doppler radar at low elevation angles. Through over ten years of R&D, it had reached the stage of practical application with a reliable real-time performance and a comprehensive operational system has been implemented in some areas over the coast of the Sea of Japan (limited to Yamagata, Akita, and Niigata Prefectures) . In this presentation, we will introduce an overview of the project since the introduction of the operational system since 2017 and the recent progresses especially about the use of deep learning. Possibilities for further development of the sysytem and their application to other traffic systemss will be also discussed.

This study is partly supported by Cabinet Office, Government of Japan, Public/Private R&D Investment Strategic Expansion Program (PRISM).

Keywords: tornado, Doppler radar

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Tsunami observation and development of real-time tsunami detection by using ocean surface radar

*Ryotaro Fuji[1], Kohei Ogata[2], Hirofumi Hinata[3]

1. Kokusai Kogyo Co., Ltd., Ehime University, 2. Kokusai Kogyo Co., Ltd., 3. Ehime University

Ocean surface radar is a land-based remote sensing instrument that emits radio waves toward the ocean and receives radio waves backscattered by ocean waves to measure ocean surface currents from the frequency difference between the transmitted and received waves. The advantage of this radar is that it enables observation from the vicinity of the continental shelf edge to a harbor area with high resolution (spatial resolution 0.5 to 3 km, time resolution 2 minutes). Ocean surface radar first succeeded in observing the flow velocity of the tsunami generated by the 2011 Tohoku-Oki earthquake (e.g., Hinata et al., 2011). Since this success, real-time tsunami detection using ocean surface radar has been developed (e.g., Grilli et al., 2016).

On the other hand, tsunami detection accuracy with ocean radar depends on the SNR (ratio of the intensity of the received signal to external noise), so the detection performance should be statistically evaluated based on tsunami measurement data under various SNR conditions. However, the only tsunamis for which observation data have been acquired by ocean surface radar thus far are the 2012 tsunami in Indonesia and the meteotsunami in the US, and the data were insufficient for statistical evaluation. To solve this problem, a method called a virtual tsunami observation experiment has been proposed (Fuji and Hinata, 2017), and real-time tsunami detection has been developed based on this method (Ogata et al., 2018).

In this presentation, we will introduce the method of tsunami observation using ocean surface radar and the development of real-time tsunami detection, and discuss the utilization of ocean radar in tsunami disaster mitigation.

Keywords: Ocean surface radar, Tsunami, Tsunami mitigtation

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Preliminary comparison of strong-motion parameters at the land & ocean bottom sites for the 2021 Mw 7.1 Off Fukushima Prefecture earthquake

*Yadab Prasad Dhakal[1], Wataru Suzuki[1], Takashi Kunugi[1], Takeshi Kimura[1], Shin Aoi[1]

1. National Research Institute for Earth Science and Disaster Resilience

The 2021 Mw 7.1 Off Fukushima Prefecture earthquake is the largest magnitude earthquake in the Japan Trench area that was successfully recorded by all the 150 stations of S-net (Seafloor observation Network for Earthquake and Tsunami along the Japan Trench) after the start of the network. The Japan Meteorological Agency focal depth of the event was 55 km. The moment tensor solution of F-net (National Research Institute for Earth Science and Disaster Resilience, NIED) showed that the earthquake was a reverse fault event. The distribution of hypocenters of the aftershocks suggested that the event occurred inside the subducting Pacific Plate (NIED, 2021). This event was recorded by about 1060 strong-motion stations of MOWLAS acronym for Monitoring of Waves on Land and Seafloor operated by NIED, including the 150 stations of the S-net (Aoi et al. 2020). The largest peak ground acceleration (PGA) of approximately 1425 cm/s^2 was recorded at site MYGH10, located at the epicentral distance of about 70 km. This PGA value was larger than the PGA value of 1030 cm/s^2 recorded at the same site during the 2011 Mw 9.1 Tohoku-Oki earthquake. It is known that the cylindrical casings of S-net stations are prone to rotate during strong motions, adding artificial noises and offsets to the acceleration records. However, the X-component that is aligned along the long axis of the cylindrical casing is found to be generally less affected by the rotation of the cylindrical casing. The maximum X-component PGA of about 1100 cm/s^2 was recorded at the S-net S2N02 site at the epicentral distance of about 7 km. The X-component peak ground velocity (PGV) at the S2N02 site was about 50 cm/s, while the PGV at the MYGH10 was about 75 cm/s. We compared the X-component PGAs and PGVs from all the S-net sites with those on land recorded by K-NET and KiK-net of MOWLAS, operated by NIED, with respect to the ground motion prediction equation (GMPE) by Si and Midorikawa (1999). We found that the PGA values at the ocean bottom and land sites were, on average, similar within the hypocentral distance of 200 km. On the other hand, the X-component PGVs at the S-net sites were, on average, larger at the S-net sites. Dhakal et al. (2020) pointed out that the larger PGVs at the S-net sites were most probably due to the lower S-wave velocity of the subsea sediments. We also compared the absolute velocity response spectra (AVRS) in the period range of 1 to 10 s at the land and S-net sites with respect to the GMPE by Dhakal et al. (2015). The AVRS were computed from the two horizontal component records (see Dhakal et al. 2015 for details). We used the J-SHIS (Japan Seismic Hazard Information Station, Fujiwara et al. 2012) model to correct the deep soil amplification effect at both land and S-net sites. Similar to the case of PGVs, we found that the observed AVRS values at the S-net sites were, on average, larger than those at the land sites, and the root mean square errors (RMSE) for the S-net sites were slightly larger than those for the land sites. The RMSE values' differences are generally expected as the velocity model at the S-net sites is not well resolved compared with the velocity model on land. We are currently working on larger data set to understand the features of S-net strong-motion records for real-time application and report the results in future papers.

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Keywords: Ocean bottom seismographs, S-net, The 2021 Mw 7.1 off Fukushima Prefecture earthquake, MOWLAS, PGA, PGV, Long-period ground motions

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Development of GNSS Real-time analysis including QZSS

*Satoshi ABE[1], Keitaro Ohno[1], Naofumi Takamatsu[1], MURAMATSU Hiroki[1], Tomoaki FURUYA[1], Yohei HIYAMA[1]

1. Geospatial Information Authority of Japan

Displacement obtained by real-time GNSS positioning isn't saturate for large earthquakes, which directly measure the amount of ground deformation. The Geospatial Information Authority of Japan (GSI) operates REGARD (REal-time GEONET Analysis system for Rapid Deformation monitoring), which estimates a finite fault model based on a continuous GNSS observation network called GEONET.

REGARD conducts real-time kinematic (RTK) analysis using data from two observation points, but if one of the observation stops, the solution cannot be obtained. In particular, if the observation stops at a reference station, the effect will spread to results of all other stations. In addition, earthquakes that occur in the vicinity of a reference station have the weakness of making it appear as if crustal movement has occurred all over Japan. In order to overcome these weaknesses of relative positioning, we attempted to introduce Precise Point Positioning (PPP), which does not have the disadvantages of relative positioning because PPP can perform positioning alone. However, various kinds of correction information is required for accurate PPP.

In this study, we performed real-time PPP positioning by estimating satellite orbits and clocks in real time, including the Japanese positioning satellite MICHIBIKI (QZSS), and generating correction information. In this presentation, we present the results of our research and report the evaluation of the accuracy of real-time PPP, the comparison result with REGARD.

Keywords: REGARD, GEONET, PPP, QZSS

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IPFx: extended integrated particle filter method for earthquake early warning and visualization of its results with social networking service

*Masumi Yamada[1], Koji Tamaribuchi[2], Stephen Wu[3]

1. Disaster Prevention Research Institute, Kyoto University, 2. Meteorological Research Institute, 3. Institute of Statistical Mathematics

We improve the integrated particle filter (IPF) method, which is a new source determination algorithm recently incorporated into the Japanese earthquake early warning system. The problem of the current IPF method is that it uses specific trigger information as an input and is therefore applicable to only limited seismic networks. This study proposes the extended IPF (IPFx) method to deal with continuous waveforms and merge all Japanese real-time seismic networks into a single framework.

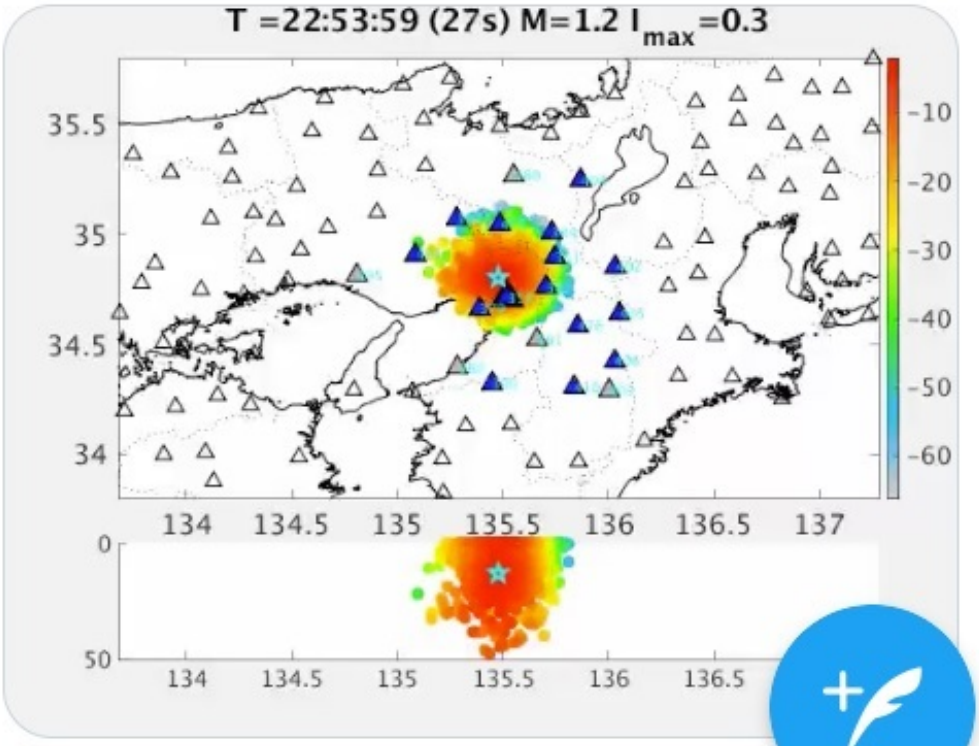
The new source determination algorithm processes seismic waveforms in two stages. The first stage (single-station processing) extracts trigger and amplitude information from continuous waveforms. The second stage (network processing) accumulates information from multiple stations and estimates the location and magnitude of ongoing earthquakes based on Bayesian inference. In a 10-month continuous online test, this method performed better than the JMA EEW method in detecting earthquakes with a maximum seismic intensity >=3 as per the JMA manual catalog. By merging multiple networks into a single method, both the P-wave detection and the event detection speeds were significantly improved compared to those of the current JMA EEW method.

We also developed an automatic processing system to visualize the results of the IPFx method in real-time. We use “Net::Twitter”, a perl interface to the Twitter API. The results of the IPFx method (time histories of the estimated source parameters, time histories of the trigger information, and waveforms aligned as a function of distance from the estimated location) are uploaded online a few minutes after the event detection. Currently, the tweets are protected by password and open for only limited users. The advantage of using twitter is that we can access the results anytime and anywhere. We can monitor the performance of the online IPFx system without accessing servers. The results will be uploaded automatically without human interactions. The tweets also work as a super-rapid earthquake report. The IPFx method can detect earthquakes as small as M=1 for inland, so we are able to monitor the seismicity of small earthquakes with only a few minutes latency.

Keywords: earthquake early warning, IPFx method, strong motion, source estimation

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2020/08/27,22:53:54.5_34.80_135.48_13.0km_M1.2_15/1/0_1



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Near real-time estimation of hypocenter distribution from seismic amplitudes

*Masashi Ogiso[1]

1. Meteorological Research Institute, Japan Meteorological Agency

Hypocenter distribution is important information for monitoring seismicity. In general, arrival times of seismic waves are used to determine hypocenters, but it is difficult to read arrival times when seismicity becomes active, resulting in a decrease in the numbers of hypocenters.

The amplitude source location (ASL) method uses seismic amplitudes to determine hypocenters. The ASL method does not require arrival times, but the precision of hypocenters is usually worse compared with that of arrival-time based hypocenters. Ogiso and Yomogida (2021, EPS) has proposed a method to estimate relative source locations of seismic events from seismic amplitude ratios. The relative source locations by their method show a good agreement with those estimated using phase arrival times. Hence, if the method of Ogiso and Yomogida (2021) could be applied in near real-time, the hypocenter distribution derived by the method would complement that derived by phase-arrival-time based automated hypocenter location method (e.g., Tamaribuchi, 2018, EPS), and the method would be useful for monitoring seismicities in real-time.

First, we applied the method to the continuous waveforms recorded on 29 September 2008 at Meakandake volcano. A volcanic tremor that occurred on 14:11 had activated seismicity at the volcano. The number of earthquakes that occurred from 14:00 to 16:00 was about 230 according to Sapporo District Meteorological Observatory, in which 34 earthquakes were estimated there hypocenters. We successfully estimated hypocenters of 103 earthquakes in that time window by applying the method.

Next, we conducted a synthetic test to investigate the applicability of the method in a wider region than in the case of volcanoes. The test was conducted in a focal region of the 2016 Kumamoto earthquake. At least an epicenter can be appropriately estimated for the earthquake about 26 km far from the reference event if we calculated amplitude at each station appropriately, that is, amplitude calculation considering the difference of arrival times between the reference and target events. This result implies that the method might be useful for hypocenter determination of aftershocks automatically after a large earthquake with an appropriate correction of arrival times when measuring the amplitude of each subevent at each station.

Keywords: seismic amplitude, hypocenter distribution, real-time analysis

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.17 Zoom Room 17

[S-CG54] Ten years from the 2011 Tohoku Earthquake: A milestone of Solid Earth Science

convener:Ryota Hino(Graduate School of Science, Tohoku University), Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Chairperson:Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

In the 2011 JpGU Meeting held immediately after the 2011 Tohoku-Oki Earthquake, an emergency session related to this earthquake was set up and 188 research results were reported. Not only was there a preliminary report of research and observations regarding this giant earthquake and tsunami, but also various important ideas indicating directions of subsequent solid-earth science researches were presented: the mechanism of earthquake generation including possible processes leading its large-scaled seismic rupture, the impact of the Tohoku-Oki earthquake on the inland crust, and limitations and effectiveness of early warning regarding earthquakes and tsunamis. Ten years after the 2011 JpGU, which was held just two months after the quake, how far has our understanding of these research themes progressed? In addition to the accumulation of 10 years of researches, our understanding of giant earthquakes and tsunamis has dramatically increased through the observations of post-Tohoku Earthquake phenomena of various kinds that have been progressing over a long period of time and through the newly developed observation networks in the offshore area. In this session, not only the researches on the Tohoku-Oki earthquake and tsunami itself, but also the research results in various solid-earth science fields that have clarified after this earthquake and tsunami will be brought together, to discuss the direction of research that should be aimed at in the future.

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

[SCG54-01] Introduction

9:05 AM - 9:30 AM JST | 12:05 AM - 12:30 AM UTC

[SCG54-02] **Modeling stress field and deformation associated with the Tohoku-Oki earthquake: Understanding the dynamics of the northeastern Japan islands arc-trench system**

★Invited Papers

*Bunichiro Shibazaki[1], Ryohei Sasajima[2] (1.International Institute of Seismology and Earthquake Engineering, Building Research Institute, 2.Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

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

[SCG54-03] Temporal evolution of seafloor crustal deformation obtained by the 10-year-long GNSS-A observations after the 2011 Tohoku-oki earthquake

*Shun-ichi Watanabe[1], Tadashi Ishikawa[1], Yuto Nakamura[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, University of Tokyo)

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

[SCG54-04] The slow earthquake spectrum in the Japan Trench illuminated by the S-net seafloor observatories

★Invited Papers

*Tomoaki Nishikawa[1], Takanori Matsuzawa[2], Kazuaki Ohta[2], Naoki Uchida[3], Takuya NISHIMURA[1], Satoshi Ide[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Graduate School of Science and International Research Institute of Disaster Science, Tohoku University, 4.Department of Earth and Planetary Science, University of Tokyo)

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

[SCG54-05] A Decade of Lessons Learned from the 2011 Tohoku-oki Earthquake

*Naoki Uchida[1], Roland Bürgmann[2] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2.Department of Earth and Planetary Science, University of California, Berkeley)

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

[SCG54-06] Temporal and spatial variations in background seismicity after the 2011 Tohoku-Oki earthquake estimated from HIST-ETAS model

*Taku Ueda[1], Aitaro Kato[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Oral | S (Solid Earth Sciences) | S-CG Complex & General

[S-CG54] Ten years from the 2011 Tohoku Earthquake: A milestone of Solid Earth Science

convener:Ryota Hino(Graduate School of Science, Tohoku University), Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Chairperson:Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.17 (Zoom Room 17)

In the 2011 JpGU Meeting held immediately after the 2011 Tohoku-Oki Earthquake, an emergency session related to this earthquake was set up and 188 research results were reported. Not only was there a preliminary report of research and observations regarding this giant earthquake and tsunami, but also various important ideas indicating directions of subsequent solid-earth science researches were presented: the mechanism of earthquake generation including possible processes leading its large-scaled seismic rupture, the impact of the Tohoku-Oki earthquake on the inland crust, and limitations and effectiveness of early warning regarding earthquakes and tsunamis. Ten years after the 2011 JpGU, which was held just two months after the quake, how far has our understanding of these research themes progressed? In addition to the accumulation of 10 years of researches, our understanding of giant earthquakes and tsunamis has dramatically increased through the observations of post-Tohoku Earthquake phenomena of various kinds that have been progressing over a long period of time and through the newly developed observation networks in the offshore area. In this session, not only the researches on the Tohoku-Oki earthquake and tsunami itself, but also the research results in various solid-earth science fields that have clarified after this earthquake and tsunami will be brought together, to discuss the direction of research that should be aimed at in the future.

9:00 AM - 9:05 AM

[SCG54-01]Introduction

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Modeling stress field and deformation associated with the Tohoku-Oki earthquake: Understanding the dynamics of the northeastern Japan islands arc-trench system

*Bunichiro Shibazaki[1], Ryohei Sasajima[2]

1. International Institute of Seismology and Earthquake Engineering, Building Research Institute, 2. Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University

After the 2011 earthquake off the Pacific coast of Tohoku (Mw9.0) (Tohoku-Oki earthquake) the dynamics of the northeastern Japan islands arc- trench system were investigated, and as a result, our understanding of it was dramatically improved. Important issues investigated include stress changes due to the Tohoku-Oki earthquake and postseismic deformation that occurred after the Tohoku-Oki earthquake. This presentation reviews the research on stress changes and postseismic deformation after the Tohoku-oki earthquake considering the heterogeneous rheological structure of the islands arc-trench system.

Before the Tohoku-Oki earthquake, east-west compression reverse fault-type earthquakes occurred sparsely under the forearc sea area, but after the Tohoku-Oki earthquake, normal fault-type earthquakes occurred frequently. Hasegawa et al. (2011) pointed out that the amount of compressive stress along the subduction zone was small, and the Tohoku-Oki earthquake released the absolute stress. The sources of the stress field in the arc upper plate are the tensile stress field affected by gravity from the topography and density structure, the compressive stress field affected by the frictional force acting on the plate boundary, the bending stress field caused by steady subduction (e.g., Fukahata and Matsu'ura, 2016), and stress fields associated with mantle wedge convection. Sasajima et al. (2018) considered the effects of four sources by subducting of the oceanic plate beneath Northeastern Japan for 100,000 years, considering a realistic nonlinear elasto-visco-plastic material with reference to the temperature, water content distribution, and serpentinization as simulated by Horiuchi and Iwamori (2016). When low frictional strength (5-11MPa) is applied to the shallow brittle region along the plate boundary, a normal fault stress field of east-west tension in the shallow part of the upper plate under the forearc sea is developed, and so is a reverse fault stress field of east-west compression near the plate boundary. The results suggest that the major changes in the main mechanism before and after the Tohoku-Oki earthquake are the suppression of normal fault activity and the promotion of reverse fault activity during inter-plate coupling between megathrust earthquakes. Then, normal fault activity is promoted and reverse fault activity is suppressed due to the stress change resulting from the Tohoku-Oki earthquake.

During the Tohoku-Oki earthquake, upward movement was observed in the east-southeast direction under the forearc sea area, but in the postseismic deformation, subsidence was observed in the west-northwest movement. Sun et al. (2014) showed that the west-northwest movement was due to the viscoelastic relaxation process of the mantle. Numerous detailed analyses of postseismic deformation after the Tohoku-Oki earthquake were performed (Yamagiwa et al., 2015; Muto et al., 2016; Hu et al., 2016; Iinuma et al., 2016; Suito, 2017; Freed et al., 2017; Noda et al., 2018). Agata et al. (2019) performed a large-scale numerical simulation of postseismic deformation, including afterslip and viscoelastic deformation processes, by applying the rate- and state-dependent friction laws to the plate boundary. They also considered the nonlinear flow law for the viscoelastic element in the Burgers model for the surrounding material. Large stress changes resulting from the Tohoku-Oki earthquake have caused the viscosity to drop sharply and rapid motion to occur due to the non-linear flow law in the asenospheres

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under the oceanic lithosphere and the forearc. The existence of a low-viscosity layer near the boundary between the oceanic lithosphere and the asenosphere has been pointed out in other studies (Sun et al., 2014), but its existence is inevitable when one considers the nonlinear flow law. In the presentation, we will also discuss the deformation processes during megathrust earthquake cycles.

Keywords: Tohoku-Oki earthquake, northeastern Japan islands arc-trench system, Geodynamics, Stress field, Postseismic deformation

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Temporal evolution of seafloor crustal deformation obtained by the 10-year-long GNSS-A observations after the 2011 Tohoku-oki earthquake

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On March 11, 2011, the Tohoku-oki earthquake occurred in the western side of the Japan Trench. Seafloor geodetic observation using the GNSS-A technique detected the trench-ward seafloor movements of several tens of meters (Sato et al., 2011 Science; Kido et al., 2011 GRL). Differential bathymetric measurements revealed that the coseismic rupture had reached the trench axis in the off-Miyagi region (Fujiwara et al., 2011 Science), where the seafloor geodetic network in 2011 had no resolution. Additionally, tsunami data suggested that the shallow coseismic rupture had spread in wider area from the off-Iwate to off-Fukushima regions than the geodetically derived distributions (Satake et al., 2013 BSSA).

The stress induced by the coseismic slip causes transitional rock deformation following the mainshock. In the time scale of months to years, afterslip and viscoelastic relaxation are dominant in the postseismic crustal deformation (e.g., Wang et al., 2012 Nature). Whereas the afterslip consistently causes trench-ward surface motion, the viscoelastic relaxation drives land-ward and trench-ward movements above the source region and its downdip side, respectively. The viscoelastic relaxation additionally causes significant subsidence on and around the downdip edge of the main rupture (e.g., Luo and Wang, 2021 Nat. Geo.).

Because both the afterslip and viscoelastic relaxation similarly cause the trench-ward motion in the onshore region, it is difficult to evaluate the contributions of these processes. In contrast, the seafloor geodetic observation is capable of extracting the dominant source rather than the terrestrial observations. The landward and downward movements were detected at the sites above the main rupture using the three-year-long GNSS-A seafloor observations, which provided the definitive evidence for the dominance of viscoelastic relaxation (e.g., Watanabe et al., 2014 GRL, Sun et al., 2014 Nature). The spatial distribution of GNSS-A observation was improved by the Tohoku University in mid-2012 (Kido et al., 2015 GENAH), which lead to detecting more detailed deformation pattern in and around the whole source region (Tomita et al., 2015 GRL; Tomita et al., 2017 Sci. Adv.; Honsho et al., 2019 JGR). Many researchers had proposed the postseismic models (e.g., Sun et al., 2014 Nature; Sun and Wang, 2014 JGR; Iinuma et al., 2016 Nat. Commun.; Freed et al., 2017 EPSL), and consensus has reached that the viscoelastic relaxation was dominant in the main rupture area and that the afterslip less likely occurred in the downdip side of main rupture in the off-Miyagi region. On the other hand, there remain difficulties in decomposing the postseismic deformation sources in the northern and southern regions, because the geodetic data including the early postseismic stage are insufficient. Moreover, the lower resolution of the shallow coseismic slip in these areas increased uncertainty in the viscoelastic relaxation modeling. Although many postseismic models used the geodetically-constrained coseismic model (e.g., Iinuma et al., 2012 JGR) as an input, tsunami data indicated wider shallow slip in the north-south extensions which will significantly affect the viscoelastic deformation in the marginal areas.

Based on the decade of GNSS-A data after the event, we investigated the temporal evolution of

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postseismic crustal deformation in this study especially in the northern and southern regions. Our results indicated (1) that the afterslip occurred on the rupture edges at depths near the epicenter, (2) that the northern afterslip had almost decayed in the first three years, and (3) that the shallow coseismic slip had taken place in the off-Fukushima region. We will present the decadal GNSS-A results and discuss the postseismic behaviors in the offshore region.

Keywords: GNSS-A, Seafloor geodetic observation, Postseismic deformation

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The slow earthquake spectrum in the Japan Trench illuminated by the S-net seafloor observatories

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Investigating slow earthquake activity in subduction zones provides insight into the slip behavior of megathrusts, which can provide important clues about the rupture extent of future great earthquakes. In the Japan Trench, which is a subduction zone located off the Pacific coast of eastern Japan, a pioneering study by Kawasaki et al. (1995) observed a M_w 7.3–7.7 aseismic slip transient accompanied by an earthquake swarm (seven M_j 6.0–6.9 events) far off the coast of Iwate Prefecture in July 1992. Furthermore, Kato et al. (2012) and Ito et al. (2013) revealed that one month before the March 2011 M_w 9.0 Tohoku-Oki earthquake, a slow slip event (SSE) accompanied by an earthquake swarm (four M_j 5.2–5.5 events) containing repeating earthquakes had occurred inside the Tohoku-Oki earthquake rupture area off Miyagi Prefecture. However, the distribution and activity of slow earthquakes across the entire Japan Trench have been unclear because the slow earthquakes occur far offshore and because ocean-bottom seismic or geodetic observations have been conducted only in limited areas and periods.

In 2016, the National Research Institute for Earth Science and Disaster Resilience (NIED) started the operation of the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net). The S-net consists of 150 seafloor observatories equipped with ocean-bottom seismometers and pressure gauges that are distributed over the Japan Trench and southern end of the Kuril Trench. Here, we used the S-net seismograms to map a detailed distribution of tectonic tremors from August 2016 to August 2018. The observed tremors coincided with very-low-frequency earthquakes (VLFEs) and an SSE. Compiling these and other related observations, including earthquake swarms containing repeating earthquakes, we found that the slow earthquake distribution is complementary to the Tohoku-Oki earthquake rupture. We then used our observations to divide the megathrust in the Japan Trench into three along-strike segments characterized by different slip behaviors: the northern (off Iwate Prefecture) and southern (off Ibaraki Prefecture) segments are characterized by a frequent occurrence of slow earthquakes, whereas the central (off Miyagi Prefecture) segment hosted the Tohoku-Oki earthquake and is characterized by a sparse distribution of slow earthquakes.

Very recently, there has been further progress in the study on the slow earthquake activity along the Japan Trench. Onshore seismic and geodetic observations have revealed the VLFE distribution across the entire Japan Trench (Baba et al., 2020) and the detailed SSE distribution in the southern segment (Nishimura, 2020) before and after the 2011 Tohoku-Oki earthquake. Moreover, Kubo & Nishikawa (2020) have pointed out the complementarity between the slow earthquake distribution and rupture areas of M_w -7-class interplate earthquakes that occurred before or after the 2011 Tohoku-Oki earthquake in the northern and southern segments.

Integrating the results of the S-net observations and these very recent studies, we suggest that the along-strike variation of the slow earthquake activity is a persistent feature that has existed since before the Tohoku-Oki earthquake. The VLFE distribution before the Tohoku-Oki earthquake well correlates with

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the tremor distribution after the Tohoku-Oki earthquake, with sparse VLFE and tremor distributions inside the largest coseismic slip area of the Tohoku-Oki earthquake. Slow earthquakes and rupture areas of large interplate earthquakes are distributed in a complementary manner, although the SSE one month before the Tohoku-Oki earthquake in the central segment is a notable exception. On the basis of these integrated observations, we propose that the slow-earthquake-prone areas impede the rupture propagation of great earthquakes along the Japan Trench and limit their sizes. This insight may help us better estimate the rupture extent of future great earthquakes along the Japan Trench.

Keywords: The 2011 Tohoku-Oki earthquake, Slow earthquake, Subduction zone, Megathrust earthquake, S-net, The Japan Trench

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A Decade of Lessons Learned from the 2011 Tohoku-oki Earthquake

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The moment magnitude Mw 9 Tohoku-oki earthquake was one of the most disastrous earthquakes in recent history. The large slip area and slip amount, including in the near-trench area, resulted in strong shaking and a huge tsunami that caused severe damage and casualties in Japan. In this presentation, we review the state of knowledge of the earthquake and tsunami potential of the Japan Trench before the earthquake, and the improved understanding after the earthquake. Pre-Tohoku-oki studies partly recognized the potential of Mw8 or larger earthquakes. However, the knowledge based on different types of observations was incomplete and the occurrence of such a great event was not considered in the governmental estimates of earthquake probabilities. The improved understanding of earthquake-cycle and rupture processes since the Tohoku-oki earthquake advanced the leading edge of efforts to characterize megathrust earthquake hazards. We can summarize the lessons as follows: 1) In addition to individual studies of a particular aspect of earthquakes, interdisciplinary research is essential to advance our understanding of the processes underlying the occurrence of earthquakes. 2) The recognition of earthquake potential informed by geologic evidence extending beyond available instrumental records is essential for assessing the largest possible earthquake in a subduction zone. 3) The development of advanced scientific infrastructure, especially near-source (ocean-bottom) observations is necessary to evaluate the locking state of subduction thrusts and to monitor dynamic megathrust fault-zone processes. 4) Although post-Tohoku-oki studies have better characterized the hazard and a number of possible precursors have been identified, the confident prediction of such events appears impossible in the near future.

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Temporal and spatial variations in background seismicity after the 2011 Tohoku-Oki earthquake estimated from HIST-ETAS model

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Epidemic Type Aftershock Sequence (ETAS) model (e.g., Ogata, 1988, 1998) represents seismicity rate as a summation of background seismicity rate and rate of aftershock. The HIerarchical Space-Time ETAS (HIST-ETAS) model (e.g., Ogata, 2004) represents the parameters as a function of space. Therefore, we can discuss the spatial variations in seismicity characteristics using this model. In addition, the removal of the contribution of aftershock using the HIST-ETAS model provides us the evolution in background seismicity rate.

In this study, we applied the HIST-ETAS model to the seismicity > M4 after the 2011 Tohoku-Oki earthquake to overview the decadal evolution of the aftershocks. We estimated the spatial variations in background seismicity rate μ, the parameters of the Omori-Utsu law (K, p), and the other parameters. Using the estimated parameters, we calculated the probability that each earthquake occurred as background seismicity and investigated the spatial and temporal changes in the background seismicity rate.

Immediately after the 2011 Tohoku-Oki earthquake, the background seismicity rate was higher around the large-slip zone of the 2011 Tohoku-Oki earthquake, which is consistent with the rapid increase in inter-plate earthquakes (Asano et al., 2011; Kato and Igarashi, 2012). The spatial variation in aftershock productivity K is strongly heterogeneous compared with the other parameters (α, p, q). As for temporal variation, the background seismicity has decreased with time (1/t). This result is consistent with the spatial and temporal changes of repeating earthquakes detected by Igarashi (2020) and may reflect aseismic slip associated with the afterslip driven by the Tohoku-Oki earthquake.

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.17 Zoom Room 17

[S-CG54] Ten years from the 2011 Tohoku Earthquake: A milestone of Solid Earth Science

convener:Ryota Hino(Graduate School of Science, Tohoku University), Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Toru Matsuzawa(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takeshi Iinuma(National Research and Development Agency Japan Agency for Marine-Earth Science and Technology), Chairperson:Shuichi Kodaira(Research Institute of Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Ryota Hino(Graduate School of Science, Tohoku University)

In the 2011 JpGU Meeting held immediately after the 2011 Tohoku-Oki Earthquake, an emergency session related to this earthquake was set up and 188 research results were reported. Not only was there a preliminary report of research and observations regarding this giant earthquake and tsunami, but also various important ideas indicating directions of subsequent solid-earth science researches were presented: the mechanism of earthquake generation including possible processes leading its large-scaled seismic rupture, the impact of the Tohoku-Oki earthquake on the inland crust, and limitations and effectiveness of early warning regarding earthquakes and tsunamis. Ten years after the 2011 JpGU, which was held just two months after the quake, how far has our understanding of these research themes progressed? In addition to the accumulation of 10 years of researches, our understanding of giant earthquakes and tsunamis has dramatically increased through the observations of post-Tohoku Earthquake phenomena of various kinds that have been progressing over a long period of time and through the newly developed observation networks in the offshore area. In this session, not only the researches on the Tohoku-Oki earthquake and tsunami itself, but also the research results in various solid-earth science fields that have clarified after this earthquake and tsunami will be brought together, to discuss the direction of research that should be aimed at in the future.

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

[SCG54-07] Seismic Imaging and Physical Properties of Underthrust Sediments at the Japan Trench Subduction Zone

*Ehsan Jamali Hondori[1], Jin-Oh Park[1] (1.The University of Tokyo, Atmosphere and Ocean Research Institute)

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

[SCG54-08] Inputs to the Japan Trench subduction zone and its implications for the subduction zone processes

★Invited Papers

*Gou Fujie[1], Shuichi Kodaira[1], Yasuyuki Nakamura[1], Seiichi Miura[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[SCG54-09] Frictional properties of incoming sediments and rocks at shallow conditions of the Japan Trench subduction zone

*Kyuichi Kanagawa[1], Sayumi Sagano[2], Takuma Hayashi[3], Junya Fujimori[2], Michiyo Sawai[1] (1.Graduate School of Science, Chiba University, 2.Graduate School of Science and Engineering, Chiba University, 3.Faculty of Science, Chiba University)

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

[SCG54-10] Earthquake faulting in the Japan Trench subduction zone: lessons learned from deep ocean drilling and the fault rocks in the exhumed accretionary complex

*Kohtaro Ujiie[1], Keisuke Ito[2], Ayaka Nagate[2], Hiroki Tabata[2] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Graduate School of Life and Environmental Sciences, University of Tsukuba)

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

[SCG54-11] Development of near-field tsunami forecasting method using ocean-bottom pressure sensor network (S-net)

*Yuichiro Tanioka[1] (1.Hokkaido University, Institute of Seismology and Volcanology)

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

[SCG54-12] Real-time Tsunami Inundation Forecast in Japan - Present and Future

*Shunichi Koshimura[1,5], Ryota Hino[2,5], Yusaku Ohta[2,5], Akihiro Musa[3,5], Takayuki Suzuki[5], Takashi Abe[1], Hiroaki Kobayashi[4,5] (1.International Research Institute of Disaster Science, Tohoku University, 2.Graduate School of Science, Tohoku University, 3.Cyberscience Center, Tohoku University, 4.Graduate School of Information Sciences, Tohoku University, 5.RTi-cast, Inc.)

Seismic Imaging and Physical Properties of Underthrust Sediments at the Japan Trench Subduction Zone

*Ehsan Jamali Hondori[1], Jin-Oh Park[1]

1. The University of Tokyo, Atmosphere and Ocean Research Institute

Although 10 years has passed since the 2011 Tohoku earthquake (M 9.0) occurred in the Japan Trench subduction zone, still the physical properties of the underthrust sediments and plate boundary are poorly known. The stress pattern at the decollement level plays a key role in the seismic behavior of the plate boundary fault and rupture propagation of the megathrust earthquakes. In order to investigate the detailed structure of the Japan Trench underthrust sediments, we have conducted pre-stack depth migration (PSDM) using multichannel seismic reflection data which was acquired along line D13 by research vessel Kairei offshore Miyagi in 2011. After developing a reliable seismic velocity model which could plausibly image the subsurface geological features, we calculated vertical effective stress by using existing empirical relations between P-wave velocity and porosity, and data-fitting approaches. Then we calculated pore-fluid pressure and fluid overpressure ratio for the underthrust sediments. We also calculated shear stress by applying a friction coefficient provided by previous studies. The PSDM depth section revealed a backstop interface with a reverse-polarity reflection, implying on a low velocity zone which extends upward from the plate-boundary fault at a depth of 11 km and a distance of 40 km landward from the trench axis. We specially focused on this area, where the huge shallow slip occurred during the 2011 Tohoku event.

Our results showed that the effective stress at the decollement level is significantly lower than the expected effective stress (under normal consolidation). The very low effective stress might have enabled the 2011 Tohoku earthquake (M 9.0) rupture, which was nucleated at greater depth, to propagate along the shallow decollement up to the trench. JFAST temperature sensors across the fault zone have previously shown that the slip-averaged shear stress and the apparent coefficient of friction estimated from the temperature anomaly at the plate-boundary thrust are 0.54 MPa and 0.08, respectively. By applying a friction coefficient of 0.08 to our vertical effective stress we obtained a shear stress of 0.543 MPa at a location 6km far from the Trench axis, i.e. relatively at the same distance from the Trench axis as the JFAST site. In addition, we calculated fluid overpressure ratio (λ^*), which corresponds to the ratio between fluid overpressure and overburden pressure. When $\lambda^*=1$, it reflects undrained conditions or total fluid retention (the media is impermeable) and when $\lambda^*=0$, it indicates optimal drainage conditions for fluid evacuation (the media is totally permeable). We noticed an area with a dramatically low λ^* located between 7km to 15 km from the Trench axis. The PSDM section shows that there are several faults in this area which provide a drainage path for the sediments and the pore fluid pressure becomes nearly equal to hydrostatic pressure. On the other hand, we found bucket sediments trapped in the subducting grabens with a reflection polarity alteration, indicating that these sediments are fluid-rich and a considerable amount of pore fluid is trapped right below the decollement. The relatively low permeability results in a very low shear stress value and a mechanically weak behavior of the underthrust sediments. Our seismic velocity model, which is built by a layer stripping method and tuned by several iterations of grid-based tomography, has an uncertainty of less than 5% for a depth of 10 km at a location 30 km far from the trench axis. The uncertainty of the velocity model increases downdip to 10% at a location 40 km far from the trench axis. The uncertainty of Vp-porosity transformation is also around 3.5%. A curve fitting approach is used to derive the consolidation curve of the incoming sediments and a

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normalized RMS error of 15% is estimated based on the goodness of the fitted curve to the data points. Since the propagated uncertainty of Vp model and Vp-porosity transform are already included in the data points prior to data fitting, we believe the 15% uncertainty is the maximum total uncertainty in our calculated stress values. The maximum vertical effective stress is around 63 MPa and the maximum expected effective stress is 114 MPa, which is almost 80% larger than effective stress. Compared to 80% of difference in the stress values, 15% of uncertainty is negligible.

Acknowledgments: The authors would like to thank JAMSTEC for providing the seismic reflection data. We also thank Paradigm/Emerson (http://www.pdgm.com) for providing seismic data processing software.

Keywords: Subduction, Japan Trench, Seismic Imaging, Stress, Pore Pressure

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Inputs to the Japan Trench subduction zone and its implications for the subduction zone processes

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The megathrust earthquakes in plate subduction zones, such as the 2011 Tohoku earthquake, occur along the boundary between the overriding plate and the subducting oceanic plate. Therefore, the nature of the incoming oceanic plate, such as surface topography, thermal state, lithology, and the water content, affects various processes in subduction zones.
However, the oceanic plate had been poorly studied before. One of the reasons was the difficulties in conducting extensive observations on the oceanic plate because the oceanic plate is generally far from land. However, with the advancement of the various studies in the plate subduction zone, the importance of revealing the nature of the incoming oceanic plate, as the inputs to the subduction zones, has been come to recognized.

Since 2009, We have conducted extensive controlled-source seismic surveys on the oceanic Pacific plate off northeastern Japan arc in order to reveal the nature and spatial variations of the inputs to the Japan Trench subduction zone. We have conducted eight 2-D wide-angle seismic reflection and refraction surveys using ocean bottom seismometers (OBSs) and a large volume airgun array of R/V Kairei and R/V Kaimei of JAMSTEC. The OBS spacing was basically 6-km and we have deployed about 400 OBSs in total. Along all the OBS survey lines, we have obtained multi-channel seismic (MCS) reflection data using a 6-km-long hydrophone streamer cable. In addition, we collected MCS data along more than a hundread of densely alighned short survey lines across the Japan Trench using a relatively small MCS reflection survey system.

Based on these large amount of seismic data, we have revealed systematic structural evolution of the oceanic plate prior to subduction due to the plate bending faulting. In addition, we found the oceanic plate is not laterally so uniform as previously thought. One of the notable spatial variations is the sediment thickness. In most area on the Pacific plate off northeastern Japan arc, the thickness of the sediments is roughly 400 meters. However, there are several areas with extremely thin sediment cover, e.g., ninety percent of the sediment seems to be missing. We investigated the detailed seismic structure beneath the thin sediment cover and found that the areas of thin sediments are heavily disturbed by recent magmatic activities related to the petit-spot.

Intriguingly, the along-trench variations in the sediment thickness on the incoming oceanic plate are well correlates with the extension of the large coseismic slip areas of the 2011 Tohoku earthquake. Therefore, we propose that post-spreading volcanic activities on the oceanic plate before subduction are factors controlling the size and the distribution of the interplate earthquakes after subduction through the disturbance and thermal metamorphism of the sediments.

Keywords: oceanic plate, Tohoku earthquake, petit-spot, seismic survey

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Frictional properties of incoming sediments and rocks at shallow conditions of the Japan Trench subduction zone

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In order to examine the frictional properties of incoming sediments and rocks at shallow conditions of the Japan Trench subduction zone, we conducted triaxial friction experiments on gouges of the following samples at a confining pressure of 150 MPa, a pore-water pressure of 50 MPa, temperatures of 25–200℃, and axial displacement rates V_{axial} changed stepwise among 0.1, 1 and 10 μm/s. We used hemipelagic and pelagic clay samples cored from the cover sediments on the Pacific plate off Sanriku, a chert sample cored from the footwall of the plate boundary thrust near the Japan Trench, and a basalt sample cored from the oceanic basement of the Philippine Sea plate off Kii Peninsula.

The results show that the steady-state friction coefficient μ_{ss} decreases with increasing content of clay minerals at a given temperature. Although μ_{ss} of a given sample does not change noticeably with increasing temperature up to 100℃, it increases with increasing temperature from 100℃ to 200℃, which is more pronounced for samples with higher contents of amorphous silica. 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}) decreases with increasing temperature. ($a-b$) values are positive for all samples at temperatures ≦50℃, while they are negative for all samples at 200℃, where all samples showed stick-slip. However, the temperature at which ($a-b$) value becomes negative increases with increasing content of clay minerals; 50–100℃ for the chert sample, ≈100℃ for the basalt sample, 100–150℃ for the hemipelagic clay sample and 150–200℃ for the pelagic clay sample. This implies that the temperature of transition from aseismic faulting with $a-b>0$ to potentially seismic faulting with $a-b<0$ is different among incoming sediments and rocks according to the content of clay minerals, suggesting that a heterogeneous distribution of seismicity at the Japan Trench subduction zone possibly reflects the heterogeneous distribution of fault-zone materials along the plate boundary megathrust.

Keywords: incoming sediments and rocks, frictional properties, shallow conditions of the Japan Trench subduction zone

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Earthquake faulting in the Japan Trench subduction zone: lessons learned from deep ocean drilling and the fault rocks in the exhumed accretionary complex

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Drilling into the shallow coseismic slip zone, which produced > 40 m of slip during the 2011 Tohoku-Oki earthquake, revealed that the earthquake faulting was localized along the smectite-rich pelagic clay. High-velocity friction experiments using the fault zone material demonstrated that large slip at the shallow portions of the Japan Trench subduction zone resulted from coseismic weakening of the fault due to the abundance of smectite and thermal pressurization. However, the actual conditions of earthquake faulting in the deeper portions of the Japan Trench subduction zone are largely unknown. The fault rocks in the Jurassic chert–clastic complex in central Japan provide windows to observe seismogenic processes in the deeper portions of the cold subduction zone, where pelagic sedimentary rocks were subducted at a temperature of ~220 ˚C. On the basis of structural and Raman spectroscopic analyses, we recognize the pseudotachylyte in the thrust fault branched from the plate-boundary décollement, which is marked by the preferential melting of illite, thermal erosion, wall-rock fracturing, and increased carbonization at temperatures higher than 900–1100 ˚C. The pseudotachylyte is derived from the frictional melting of black carbonaceous mudstone flanked with pelagic chert. The thermal modeling, the measurement of the fracture density in wall rocks, and the quartz-dominated mineral composition of the chert suggest that wall-rock fracturing is caused by thermal fracturing associated with the alpha–beta transition of quartz in chert. Such thermal fracturing tends to occur along the coseismic slip zone, flanked by rocks with high thermal diffusivities, and, thus, may be a characteristic process during seismic slip along the black carbonaceous mudstone flanked with chert. The thermal fracturing of wall rocks could lead to a dilatancy-induced fluid pressure drop in the coseismic slip zone and reduction in the stiffness of wall rocks, potentially contributing to the generation of frictional melt and acceleration of seismic slip. The seismic slip processes recorded in the Jurassic chert–clastic complex may be applicable to the deeper portions of the Japan Trench subduction zone, where pelagic clays are subducted with pelagic chert.

Keywords: Pelagic clay, JFAST, Accretionary complex, Pseudotachylyte, Thermal fracturing

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Development of near-field tsunami forecasting method using ocean-bottom pressure sensor network (S-net)

*Yuichiro Tanioka[1]

1. Hokkaido University, Institute of Seismology and Volcanology

The 2011 Tohoku-oki earthquake (Mw9.0) generated a large tsunami along the Pacific coast of northern Japan. Although the Japan Meteorological Agency (JMA) issued a major tsunami warning along the Pacific coast of Japan immediately after the earthquake, the tsunami caused a catastrophic disaster with approximately 19,000 casualties. After this event, the development of a more accurate and rapid tsunami warning system became a high-priority focus area in Japan. For this purpose, the Japanese government installed a dense cabled observation network, called the seafloor observation network for earthquakes and tsunami around the Japan Trench (S-net), in 2017. The network is operated by the National Research Institute for Earth Science and Disaster Resilience (NEID). In this network, 150 observation stations consisting of ocean-bottom pressure sensors and seismometers are connected by cables at the 30-km intervals.

Tsunami forecasting methods that use the data collected from the ocean floor sensors were recently developed. Tsushima et al. (2012) developed a method called tsunami Forecasting based on Inversion for initial sea Surface Height (tFISH) which estimates the initial sea surface deformation from tsunami waveforms observed at ocean-bottom pressure gauges. Moreover, new tsunami computation methods based on the assimilation of tsunami observations without the tsunami source information were developed by Maeda et al. (2015), Tanioka (2018), and Tanioka and Gusman (2018). Gusman et al. (2016) applied the method developed by Maeda et al. (2015) to the tsunami generated by the 2012 Haida Gwaii earthquake and computed the tsunami wave field successfully by assimilating data observed at ocean-bottom pressure sensors in Cascadia. However, it is difficult to apply this method with ocean-bottom pressure data within the source area. The near-field tsunami inundation forecasting method developed by Tanioka (2018) and Tanioka and Gusman (2018) uses the time derivative of the pressure waveforms observed at the ocean-bottom pressure sensors near the source area. Therefore, tsunami computation by assimilating data can be performed without any tsunami source information as soon as the earthquake or tsunami generation is completed. Tanioka and Gusman (2018) tested ocean-bottom pressure sensors equally distributed at 15 min intervals or approximately 30 km apart. In reality, the S-net ocean-bottom sensors are not installed at uniform intervals, particularly in the north–south direction, and have a lesser number than those tested by Tanioka and Gusman (2018). They finally concluded that it is necessary to improve their method using the exact locations of the S-net sensors for real-time tsunami inundation forecasts.

To overcome its limitation, we developed an interpolation method to generate the appropriate data at the equally spaced positions for the assimilation from the data observed at sensors in S-net. The method was numerically tested for two large underthrust fault models, a giant earthquake (Mw8.8) and the Nemuro-oki earthquake (Mw8.0) models. Those fault models off Hokkaido in Japan are expected to be ruptured in the future. The weighted interpolation method, in which weights of data are inversely proportional to the square of the distance, showed good results for the tsunami forecast method with the data assimilation. Furthermore, results indicated that the method is applicable to the actual observed data at the S-net stations. The only limitation of the weighted interpolation method is that the computed tsunami wavelengths tend to be longer than the actual tsunamis wavelength.

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Keywords: Tsunami, real-time forecast

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Real-time Tsunami Inundation Forecast in Japan - Present and Future

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The 2011 Great East Japan earthquake and tsunami disaster revealed many problems in Japan’s disaster management policies, and these have undergone reforms in the years since to promote initiatives for building national resilience in confronting any future disasters. One of the key challenges in the aftermath of tsunami disaster is identifying its impact and prioritizing disaster response and relief activities. Because of the widespread damage to infrastructure and communication networks, the impacted regions were hampered in addressing the overall damage, sometimes for months. This experience highlighted the need to develop technologies to forecast the regional impact of tsunamis. Recent advances in high-performance computing and large data sets comprising observations of tsunami emergence, propagation, and effects hold out the promise of dramatically improving our understanding of the whole picture of tsunami-affected areas in real-time.

Three approaches to real-time tsunami inundation forecast methods have been proposed in Japan. The first is the “Tsunami Scenario Database” approach: searching tsunami forecast data from pre-computed database connected with offshore tsunami observation. Once a tsunami is observed offshore, the pre-computed database starts searching for the best matching pair of offshore tsunami heights that fits the observations, then projects the tsunami inundation scenarios most likely to correctly forecast coastal tsunami heights.

The second is the “Data Assimilation” approach that assimilates tsunami wave field using dense offshore tsunami observation networks. This method estimates the tsunami wave field (tsunami height and tsunami velocity) in real-time by repeatedly assimilating dense tsunami observation data into a numerical simulation. Both are highly dependent on the configuration of offshore tsunami sensors.

The third is the “Real-time Forward Simulation” approach that runs simulations in real-time with estimation of tsunami source models based on seismic and geodetic observations. The real-time forward approach has the advantages in simulating tsunami inundation on land—if reliable tsunami source model information is obtained. None of the three methods was developed before the 2011 Great East Japan Earthquake. Some “Tsunami Scenario Database” methods are now being operated in some coastal areas, and the “Real-time Forward Simulation” method is now in operation as a part of the Japanese central government’s emergency response effort.

Throughout the case studies of modeling recent and potential tsunami events, we discuss advantages and drawbacks of those approaches with regard to applicabilities towards next generation tsunami inundation forecast system.

Keywords: Tsunami, Real-time Forecast, Disaster Response

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.19 Zoom Room 19

[S-CG55] Oceanic plate as inputs to subduction zone: from oceanic spreading ridge to subduction trench

convener:Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Takanori Kagoshima(University of Toyama), Chairperson:Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Takanori Kagoshima(University of Toyama)

As the inputs to subduction zone, the nature of the incoming oceanic plate, such as surface relief, thermal state, lithology, and the water content, affects various processes occurring in the subduction zone, including arc magmatism and interplate and intraplate seismic activities. The oceanic plate is formed in the oceanic spreading ridge and moves through the ocean basin for a long time and subducts from the oceanic trench. The nature of the incoming oceanic plate is determined by all the processes occurring from the spreading ridge to the subduction trench; e.g., hydrothermal circulation, sedimentation and diagenesis for more than millions years at the oceanic basin, and plate bending-related faulting near the subduction trench. Therefore, for studying the nature of the subduction inputs, it is essential to reveal the various evolution processes of the oceanic plate between the spreading ridge and the subduction trench.

We welcome contributions from a broad range of earth science (geophysics, geology, petrology, drilling science, and so on) discussing topics related to the inputs to subduction zones, such as tectonic process associated with the plate bending prior to subduction, post-spreading volcanic activities including large seamount formation and petit-spot volcanoes, and the nature of the "normal" or "typical" oceanic plate.

This session is supported by the focus group of hard rock drilling science.

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

[SCG55-01] The Earth recycle and verification of ocean extinction hypothesis - New development in ocean plate research

★Invited Papers

*Katsuyoshi Michibayashi[1] (1.Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University)

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

[SCG55-02] Prolonged mantle history recorded in zircons from the Horoman peridotite, Hokkaido, Japan

*Shinji Yamamoto[1], Yibing Li[2], Kiyoaki Niida[3], Shuhei Sakata[4], Takeshi Ohno[5] (1.Graduate School of Environment and Information Sciences, Yohohama National University, 2.Institute of Geology Chinese Academy of Geological Science, 3.Hokkaido University Museum, 4.Earthquake Research Institute, The University of Tokyo, 5.Gakushuin University)

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

[SCG55-03] Depth profile of hydration along the crust - mantle section of the Oman ophiolite: insights from holes CM1A and CM2B

*Kazuki Yoshida[1], Atsushi Okamoto[1], Ryosuke Oyanagi[2], Noriyoshi Tsuchiya[1], Oman Drilling Project Phase2 Science Party (1.Tohoku university, 2.Japan Agency for Marine-Earth Science and Technology)

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

[SCG55-04] The geochemical structure of pre-subducting oceanic lithosphere explored from petit-spot volcano

*Kazuto Mikuni[1], Naoto Hirano[1], Norikatsu Akizawa[2], Shiki Machida[3] (1.Tohoku University , 2.University of Tokyo, 3.Chiba Institute of Technology)

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

[SCG55-05] Rejuvenated extension of the Philippine Sea plate and its effect on subduction dynamics in the Nankai Trough

*Gaku Kimura[1], Yasuyuki Nakamura[2], Kazuya Shiraishi[2], Gou Fujie[2], Shuichi Kodaira[2], Asuka Yamaguchi[3], Rina Fukuchi[4], Yoshitaka Hashimoto[5] (1.Tokyo University of Marine Science and Technology, 2.JAMSTEC, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Dia Consultants Co., Ltd., 5.Kochi University)

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

[SCG55-06] Thermal structure of the Tohoku subduction zone: effects of plate cooling models

*Manabu Morishige[1] (1.Earthquake Research Institute, the University of Tokyo)

The Earth recycle and verification of ocean extinction hypothesis - New development in ocean plate research

*Katsuyoshi Michibayashi[1]

1. Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University

Planet Earth is the only planet in the solar system where the warm surface environment and oceans that harbor life are stabilized by the long-term circulation (global recycling) of various materials such as rocks, water, and organic matter over tens of millions of years. However, 4.6 billion years after its birth, the Earth is now at a major turning point in global recycling, and the hypothesis of the complete disappearance of the oceans as early as 100 million years has been predicted as a possible future scenario. The key to this future is the infiltration of seawater into the oceanic plates. In this research area, we focus on the hydrophilic properties and inundation processes of oceanic plates, which play a major role in global recycling, and conduct comprehensive research to verify and clarify the oceanic extinction hypothesis on multiple scales. The objectives of this research area are (1) to elucidate the effects of inundation of the oceanic plate on global recycling, especially on the Earth's surface environment and life on Earth, and (2) to test the ocean extinction hypothesis triggered by increased inundation of the oceanic plate and water transport to the Earth's depths. This research area is a fundamental study of natural science that will create a new dynamic model of global recycling by reviewing the oceanic plate from multiple perspectives. The new vision of the future of the Earth, including the oceanic annihilation hypothesis, will bring about new changes and turning points in the field of earth and planetary science, including the redefinition of the discipline responsible for the future of humanity.

Keywords: Earth, recycle, ocean distinction hypothesis, oceanic plate, inundation

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Prolonged mantle history recorded in zircons from the Horoman peridotite, Hokkaido, Japan

*Shinji Yamamoto[1], Yibing Li[2], Kiyoaki Niida[3], Shuhei Sakata[4], Takeshi Ohno[5]

1. Graduate School of Environment and Information Sciences, Yohohama National University, 2. Institute of Geology Chinese Academy of Geological Science, 3. Hokkaido University Museum, 4. Earthquake Research Institute, The University of Tokyo, 5. Gakushuin University

The Horoman peridotite complex, exposed at the southwestern end of the Hidaka metamorphic belt, is a well-preserved peridotite suites containing highly depleted spinel-harzburgite to fertile plagioclase-lherzolite with a large scale layered-structure coexisting with types of gabbro, pyroxenite and dunite (Niida, 2007). Geochemical studies have shown that the Horoman peridotite have complex and prolonged history from mid-ocean ridge (MOR) stage ca. 1.0 Ga (Yoshikawa and Nakamura, 2000; Ranaweera et al., 2018) to final stage of up-lifting from the mantle ca. 20 Ma (Yoshikawa et al., 1993; Kaneoka et al., 2001). We recovered sixteen zircon grains from lherzolite rock sample, and examined U-Pb age, trace elements and mineral inclusions in zircon to constraint their formation and age relationship previously reported. Rock samples of harzburgite and lherzolite were collected directly from quarry site of TOHO Olivine Industrial Company and cut them into plats on site, then transferred to the laboratory. To avoid any contaminations, all procedures mineral separation were conducted at newly built facilities in Yokohana National University.

Zircons are transparent or slightly pink in color and show subhedral to rounded shape. Analysis using Raman spectroscopy on zircon grains show relatively narrow and intense Raman peak indicating well-crystallinity, probably due to long annealing under the mantle conditions. Spot analyses with LA-IC-PMS, assisted by cathodoluminescence (CL) images gave a wide age range, from the early Miocene to the Mesoproterozoic (ca. 18–1055 Ma). Zircon CL images show unclear oscillatory zoning and relatively uniform and/or complex internal structure, and some grains have inherited old core (911 Ma) with younger rim (620 Ma). Zircons recovered often have mineral and or fluid inclusions within them. A young zircon with age of 18 Ma has Mg-hydrous silicate inclusion (phase not determined), which suggest that such zircons were formed by hydrous fluid/melt metasomatism at the mantle environment. It has been suggested that zircon U-Pb age retain under the mantle conditions (> 1000 ˚C) due to low Pb diffusion rate of host minerals such as orthopyroxene and olivine (Bea et al., 2020). The minimum ages of ca 18 Ma, plotted on the concordia curve, were consistent with the age of metasomatic event previously reported by Ar-Ar plateau age (20.6 ±0.5 Ma), and the maximum age of 1055 Ma in the study would correspond to that of MOR setting ca. 1.0 Ga.

Keywords: zircon, Horoman, peridotite, mantle metasomatism, recycling

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Depth profile of hydration along the crust - mantle section of the Oman ophiolite: insights from holes CM1A and CM2B

*Kazuki Yoshida[1], Atsushi Okamoto[1], Ryosuke Oyanagi[2], Noriyoshi Tsuchiya[1], Oman Drilling Project Phase2 Science Party

1. Tohoku university, 2. Japan Agency for Marine-Earth Science and Technology

The extent of serpentinization of the oceanic lithosphere is a key factor for evaluating the water content brought into the Earth’ s interior. However, the distribution of the serpentinized peridotites is still poorly constrained. The Oman ophiolite is one of the best places showing the complete sections from the upper crust to mantle of the oceanic lithosphere. In this study, we investigated the water content, vein structures and hydration structures of the continuous drilling cores from lower crust to transition zone to upper mantle taken from the Oman Drilling Project at CM1A (404 m) and CM2B (300 m) sites, based on thermogravimetry, Raman spectroscopy and electron microbe analyses. The main lithologies are gabbroic rocks at the lower crust, dunites in the crust-mantle transition zone (CMTZ), and harzburgites in upper mantle section.

All parts of CM1A and CM2B are extensively altered, and mainly characterized by serpentinization of olivine grains. The olivine grains in the gabbroic rocks are serpentinized ranging from 11 to 69 % to produce radial cracks at the surrounding plagioclase and pyroxene. Dunite is completely serpentinized with lizardite + brucite + magnetite, and cut by later antigorite vein networks. Harzburgite from upper mantle section are highly serpentinized (70–90%). The matrix part (lizardite + brucite + less magnetite) of the harzburgites are cut by tremolite veins. The TG analysis shows homogeneous serpentinization along the depth. The higher temperature veins (antigorite vein in the dunties, tremolite vein in the harzburgites) after pervasive lower temperature alteration (lizardite + brucite) suggest that the pervasive serpentinization before or during intra-oceanic overthrust of the Oman ophiolite. 300 m length of the crust-mantle transition zone to upper mantle section of the CM2B are almost completely serpentinized with average water content of 12 wt%.

Given that the gabbro has a low permeability as estimated by the intact sample ($k=10^{-22}$ m^2), 25 Myr of fluid-supply are required to complete the serpentinization observed in the CM1A & CM2B cores. This estimate contradicts with the interval of the igneous activity at ridge center of the Oman ophiolite and obduction of 1-2 Myr (Hacker, 1991). In contrast, the discrete element numerical simulations revealed that microcrack network formation by reaction induced stress during serpentinization could be important for enhancement of the permeability by more than several order of magnitude (Yoshida et al., 2020). In case of intact gabbro with enhanced permeability ($k=10^{-20}$ m^2), the duration for sepentinization is estimated to be ~0.25 Myr. These results suggest that abundant of water for the lower temperature serpentinization is possibly supplied during intra-oceanic overthrust of the ophiolite. The fluid flow triggered by intraoceanic thrusting is enhanced by later reaction-induced fracturing, which results in fluid penetration through the lower crust to the upper mantle. After the low-temperature alteration, hot fluids came from the subducting slab to form antigorite vein networks.

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Keywords: serpentinization, reaction-induced fracturing, hydrothermal alteration

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The geochemical structure of pre-subducting oceanic lithosphere explored from petit-spot volcano

*Kazuto Mikuni[1], Naoto Hirano[1], Norikatsu Akizawa[2], Shiki Machida[3]

1. Tohoku University , 2. University of Tokyo, 3. Chiba Institute of Technology

Chemical composition of the oceanic lithosphere has been represented previously by “abyssal peridotite” exposed along transform faults in the mid-ocean ridge. However, nobody has ever seen the lithospheric mantle of the oldest part of Pacific Plate. A subseafloor petit-spot (small conical knoll) cluster was recently discovered in the south of Minamitorishima (Marcus) Island, where the age of Pacific Plate is estimated as 160 Ma. Peridotite and pyroxenite xenoliths, and pyroxene xenocrysts transported to the ocean floor through the petit-spot volcanism could directly provide petrological and geochemical information of the oldest Pacific lithosphere. This study presents in-situ chemical compositions, determined using an electron micro-probe, of quenched glasses, xenoliths and xenocrysts in petit-spot basalts on the oldest part of Pacific Plate. The whole-rock chemical compositions were analyzed using an inductively coupled plasma-mass spectrometry. Eruption ages were estimated from thickness of palagonite, an altered quenched glass rind by the interaction with seawater.

The eruption ages of eight petit-spot volcanoes in this region were dated at 0.03–2.2 Ma, suggesting recent eruptions due to lithospheric flexure of the subducting Pacific Plate into the Mariana Trench. The petrographic and geochemical features of petit-spot basalts obtained in this study are similar to those of previously reported petit-spot basalts in the northwestern Pacific Plate.
Most of clinopyroxenes of peridotite and pyroxenite xenoliths are Ti-rich Al-augite, indicating compositional difference with the depleted abyssal peridotite. Ti-rich Al-augite is possibly originated from phenocryst crystallized at high pressure, cumulate from alkalic magma or metasomatic vein in lithospheric mantle. However, the petrographic characteristics of clinopyroxene in these xenoliths (e.g., lamellae) specify the presence of metasomatic veins in the lithospheric mantle. The estimated temperature and pressure of pyroxenite and peridotite xenoliths peculiarly fit on a geotherm younger than 160 Ma. These results imply that the oldest Pacific Plate has a high geothermal gradient due to multiple petit-spot magma injections as previously indicated in the northwestern Pacific Plate. If petit-spot volcanism is ubiquitous phenomenon, the nature of subducting oceanic plate must be revised drastically in previous recognition.

Keywords: Petit-spot, Lithosphere, Metasomatism, Mantle Xenolith, Pacific Plate

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Rejuvenated extension of the Philippine Sea plate and its effect on subduction dynamics in the Nankai Trough

*Gaku Kimura[1], Yasuyuki Nakamura[2], Kazuya Shiraishi[2], Gou Fujie[2], Shuichi Kodaira[2], Asuka Yamaguchi[3], Rina Fukuchi[4], Yoshitaka Hashimoto[5]

1. Tokyo University of Marine Science and Technology, 2. JAMSTEC, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Dia Consultants Co., Ltd., 5. Kochi University

The Nankai Trough, Japan, is a subduction zone characterized by the recurrence of disastrous earthquakes and tsunamis. Slow earthquakes and associated tremor also occur intermittently and locally in the Nankai Trough. The causal relationship between slow earthquakes and large earthquakes is important to understanding subduction zone dynamics. The Nankai Trough off Muroto, Shikoku, near the southeast margin of the rupture segment of the 1946 Nankai earthquake, is one of three regions where slow earthquakes and tremor cluster in the Nankai Trough. On the Philippine Sea plate, the rifting of the central domain of the Shikoku Basin was aborted at ~15 Ma and underthrust the Nankai forearc off Muroto. Here, the Tosa-Bae seamount and other high-relief features, which are northern extension of the Kinan Seamount chain, have collided with and indented the forearc wedge. In this study, we analyzed seismic reflection profiles around the deformation front of accretionary wedge and stratigraphically correlated them to drilling sites off Muroto. Our results show that the previously aborted horst-and-graben structures, which were formed around the spreading center of the Shikoku Basin at ~15 Ma, was rejuvenated at ~ 6 Ma to ~3.3 Ma and has remained active since. The reactivated normal faulting has enhanced seafloor roughness and appears to affect the locations of slow earthquakes and tremors. Rejuvenated normal faulting is not limited to areas near the Nankai Trough, and extends more than 200 km into the Shikoku Basin to the south. This extension might be due to extensional forces applied to the Philippine Sea plate, which appear to be driven by slab-pull in the Ryukyu and Philippine trenches along the western margin of the Philippine Sea plate.

Keywords: Nankai Trough, slow earthquake, seamount subduction, Philippine Sea plate, Tosa-Bae, subduction

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Thermal structure of the Tohoku subduction zone: effects of plate cooling models

*Manabu Morishige[1]

1. Earthquake Research Institute, the University of Tokyo

Recent studies have extensively investigated the effects of experimentally constrained thermal conductivity on the thermal structure of oceanic plates. However, little is known about how the updated cooling models affect the thermal structure of subduction zones. In this presentation I investigate the effects of plate cooling models on the thermal structure of the Tohoku subduction zone, with a particular focus on thermal conductivity. Three types of thermal conductivity were tested, including constant (Case 1), temperature-dependent (Case 2), and temperature- and material-dependent (Case 3) types. For each case, the parameters for the plate cooling models were inferred based on the observed variations in surface heat flow and seafloor depth with plate age using Bayes' theorem. It was found that the predicted locations of the blueschist-out boundaries in the oceanic crust and serpentinite-out boundaries in the slab mantle, which are possibly related to intermediate-depth earthquakes, can change by approximately 10 km depending on the assumed thermal conductivity. This may be significant when considering the causes of earthquakes. Therefore, it is desirable to take into account the variations in thermal conductivity when predicting the thermal structure of oceanic plates and subduction zones.

Keywords: Oceanic plate, Subduction zone, Thermal structure, Thermal conductivity

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.19 Zoom Room 19

[S-CG55] Oceanic plate as inputs to subduction zone: from oceanic spreading ridge to subduction trench

convener:Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Takanori Kagoshima(University of Toyama), Chairperson:Takanori Kagoshima(University of Toyama), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University)

As the inputs to subduction zone, the nature of the incoming oceanic plate, such as surface relief, thermal state, lithology, and the water content, affects various processes occurring in the subduction zone, including arc magmatism and interplate and intraplate seismic activities. The oceanic plate is formed in the oceanic spreading ridge and moves through the ocean basin for a long time and subducts from the oceanic trench. The nature of the incoming oceanic plate is determined by all the processes occurring from the spreading ridge to the subduction trench; e.g., hydrothermal circulation, sedimentation and diagenesis for more than millions years at the oceanic basin, and plate bending-related faulting near the subduction trench. Therefore, for studying the nature of the subduction inputs, it is essential to reveal the various evolution processes of the oceanic plate between the spreading ridge and the subduction trench.

We welcome contributions from a broad range of earth science (geophysics, geology, petrology, drilling science, and so on) discussing topics related to the inputs to subduction zones, such as tectonic process associated with the plate bending prior to subduction, post-spreading volcanic activities including large seamount formation and petit-spot volcanoes, and the nature of the "normal" or "typical" oceanic plate.

This session is supported by the focus group of hard rock drilling science.

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

[SCG55-07] Interpretation for variation in the incoming Pacific Plate structure around the Kuril Trench axial region by an OBS/MCS seismic survey

★Invited Papers

*Ryosuke Azuma[1], Shuichi Kodaira[2], Ryota Hino[1], Gou Fujie[2], Koichiro Obana[1], Fumiaki Tomita[2], Yusaku Ohta[1] (1.Recearch Center for Prediction of Earthquake and Volcanic Eruption, Graduate School of Science, Tohoku University, 2.Japan Agency for Marin-Earth Science and Technology)

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

[SCG55-08] **Characteristics of normal faults developing in the outer rise of the Japan Trench**

*YUE SUN[1], Ehsan Jamali Hondori[1], Jin-Oh Park[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[SCG55-09] Complicated fault geometry of outer-trench normal-faulting earthquakes based on the ocean bottom seismograph observations

*Koichiro Obana[1], Tsutomu Takahashi[1], Yojiro Yamamoto[1], Yasuyuki Nakamura[1], Gou Fujie[1], Seiichi Miura[1], Shuichi Kodaira[1] (1.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology)

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

[SCG55-10] Mantle-derived helium released through the Japan Trench bend-faults

★Invited Papers

*Jin-Oh Park[1], Naoto Takahata[1], Ehsan Jamali Hondori[1], Asuka Yamaguchi[1], Takanori Kagoshima[2], Tetsuro Tsuru[3], Gou Fujie[4], Yue Sun[1], Juichiro Ashi[1], Makoto Yamano[5], Yuji Sano[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Environmental Biology and Chemistry, University of Toyama, 3.Department of Marine Resources and Energy, Tokyo University of Marine Science and Technology, 4.Japan Agency for Marine-Earth Science and Technology, 5.Earthquake Research Institute, University of Tokyo)

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

[SCG55-11] Heat flow distribution seaward of the Japan and Kuril trenches: Implications for fluid circulation in the oceanic crust

*Makoto Yamano[1], Yoshifumi Kawada[2], Kouta Sasaki[3], Masataka Kinoshita[1] (1.Earthquake Research Institute, the University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kozo Keikaku Engineering Inc.)

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

[SCG55-12] Resistivity imaging around the Japan trench based on ocean bottom electromagnetic surveys

★Invited Papers

*Hiroshi Ichihara[1], Takafumi Kasaya[2], Tada-nori Goto[3], Kiyoshi Baba[4], Shinya Sato[5], Makoto Yamano[4] (1.Graduate school of environmental studies, Nagoya University, 2.JAMSTEC, 3.ERI, University of Tokyo, 4.University of Hyogo, 5.Graduate School of Engineering, Kyoto University)

Interpretation for variation in the incoming Pacific Plate structure around the Kuril Trench axial region by an OBS/MCS seismic survey

*Ryosuke Azuma[1], Shuichi Kodaira[2], Ryota Hino[1], Gou Fujie[2], Koichiro Obana[1], Fumiaki Tomita[2], Yusaku Ohta[1]

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The Pacific Plate subducting to the Japan and Kuril trenches is topographically characterized by bending-related faults, fracture zones, large seamounts, and therefore various heterogeneity seem to exist in the incoming plate. Previous seismic studies in these regions concluded that plate-bending faults at the trench outer slope is impactful for incoming plate hydration based on seismic velocity reduction. We have also analyzed an OBS seismic survey data newly collected in the Kuril Trench axial region to understand a state of the incoming plate development. Our previous model by first arrival and wide-angle PmP traveltime inversion proposed a low Vp (~7.5 km/s) mantle, expecting serpentinization of 40–50 %, quite larger than in the Japan and Kuril trenches (15–25 % serpentinization, Fujie et al., 2018), but similar to mantle Vp beneath the seamount (Kodaira et al., 2002; Nishizawa et al., 2009). Furthermore, a systematic difference in the estimated oceanic Moho depth was found between OBS and multi-channel seismic (MCS) data, meaning our model has the 8–10 km thick crustal-Vp (< 7 km/s) layer. We consider that this systematic difference can be explained by a presence of a zone with gradual increase of Vp beneath the MCS Moho; identified wide-angle phases seem to be not reflection but refraction in the corresponding zone. In this presentation, we quantitatively investigate the state of the low Vp anomaly around the Moho by an additional analysis based on traveltime data of the MCS profile in addition to OBS record sections.

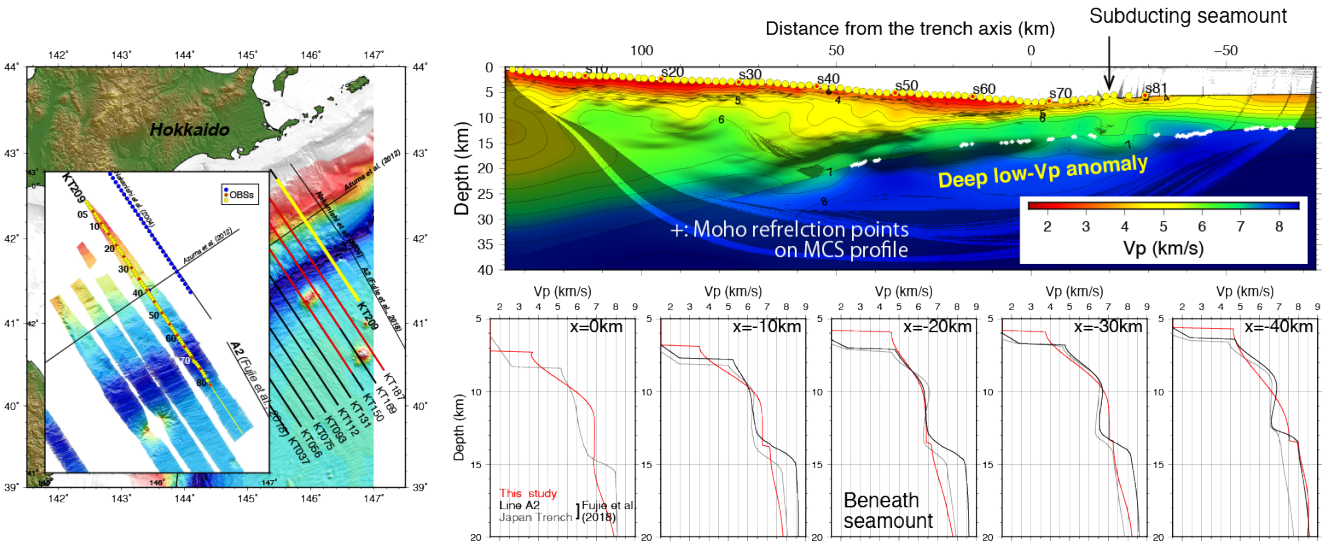
The survey was conducted by R/Vs Kairei and Yokosuka of JAMSTEC in 2019. A 208 km-length survey line KT209 runs from the land slope to the trench outer slope across bending-related faults and a seamount (call as the KT209 seamount). 80 of OBSs were deployed every ~2 km along the line. An airgun array with a total volume of 7,800 cu.in. was used as a controlled source and shoot every 200 m. Multi-channel seismic (MCS) reflection data was also collected by towing a 5.5 km-length multichannel hydrophone streamer cable. Observed first arrival traveltimes in OBS record sections and two-way-time of near-vertical oceanic Moho reflection were used for modeling P-wave velocity (Vp) structure by a 2-D traveltime tomographic inversion.

The revised Vp model is featured by a deep low-Vp anomaly in the incoming plate; the anomaly is less than 7 km/s and still reaches 10 kilometers depth from the seafloor same as the previous model. Because this anomaly expands beneath the oceanic Moho depth defined by the MCS profile, we interpret that the anomaly causes not in but beneath the crust. This anomaly is also significant and thickest beneath the KT209 seamount and continuously appears to at least 30 km landward from the trench. We understand above all features are close to crustal thickening beneath the Erimo and the Daiichi-Kashima Seamounts imaged from wide-angle data (Nishizawa et al., 2009). In addition, traveltimes of wide-angle PmP are projected along the bottom of low Vp anomaly in the revised model. We therefore interpret that low Vp anomaly beneath the oceanic crustal basement, that is the Moho, would be underplated magma material and wide-angle PmP seem to be reflections at the bottom of underplate layer. The age of the Erimo and Ryofu Seamounts near the KT209 are dated at ~100 Ma which are at least 20 Ma younger than surrounding seafloor, and produced by Cretaceous off-ridge volcanism (Takigami et al., 1989). Although an origin of the KT209 seamount is unknown, the fact of large seamounts distribution limitedly in the

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southmost Kuril Trench implies that the KT209 seamounts would belong to these Cretaceous volcanoes. Tens of small seamounts can be also recognized on the bathymetric topography in the northwest Pacific. We suggest that the Pacific Plate in this region subducts with a strong spatial heterogeneity.

Keywords: Incoming Pacific Plate, Outer rise in the Kuril Trench subduction zone, Seamount, Seismic survey



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Characteristics of normal faults developing in the outer rise of the Japan Trench

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There have been several large earthquakes occurred in the Japan Trench subduction zone and outer rise. Many previous studies have been conducted to elucidate the shallow crustal structure of the Japan Trench outer rise, but most of these studies depend on seafloor topographic maps and there are few studies focusing on the faults which cut the acoustic base in the Multi-Channel Seismic (MCS) survey profile. In order to investigate the characteristics of normal faults developing in the Japan Trench outer rise, the "Portable Multi-Channel Seismic Survey System" of the Atmosphere and Ocean Research Institute (AORI) of the University of Tokyo was mounted on the research vessel *Shinsei-maru*, for the survey KS-19-05 in April 2019 and survey KS-20-14 in September 2020, and a total number of 5 survey lines of MCS data were acquired. In this study, the data from three survey lines, KS19-05-1, KS19-05-5, and KS20-14-5 are used. Line KS19-05-5 of survey KS19-05 and line KS20-14-5 of survey KS20-14 generated strong noise due to bad sea conditions and poor equipment conditions. I succeeded in removing the noise by manually deleting the traces with spike noise and applying the Band-pass filter and FX deconvolution. Furthermore, the MCS data processing was performed with a Kirchhoff pre-stack depth migration (PSDM) and seismic depth sections were obtained. Three survey lines confirmed a clear Horst-Graben structure in the subducting Pacific plate. The results of investigating the normal faults, which are caused by plate bending and are imaged in the three survey lines, show that the normal faults of the survey line KS19-05-1 have a larger fault offset compared to the faults in the survey lines KS19-05-5 and KS20-14-5. However, the horizontal spatial distributions of these faults tend to be sparse. In addition, a number of young volcanic activities are observed near the trench axis in line KS19-05-1 and near the eastern side of line KS19-05-5 and line KS20-14-5. These young volcanic activities are referred to by Hirano et al. (2006) as petit spot volcanoes of site A and site C. In the PSDM section, petit spot volcanos and traces of magma intrusion were confirmed. In particular, on the line KS19-05-1, the reflection horizon of the chert layer is unclear within a range of 75 km from the trench axis to the seaside, and the existence of the chert layer cannot be confirmed. The sediment layer thickness was also clearly reduced in the petit spot volcanic area. I evaluated the formation time of the normal faults by calculating the difference between seafloor offset and the acoustic basement offset following the method of Ranero et al. (2003). In the line KS19-05-1, most of the normal faults are recent faults but in the line KS19-05-5 and the line KS20-14-5 both recent faults and older faults are seen on the seismic depth sections. Based on the above evaluations, the fault developing characteristics in the Japan Trench outer rise are organized into two models. In Model 1 the normal faults are not affected by the petit spot volcano, where older faults and recent faults are mixed and both are developing. In Model 2 the normal faults are affected by the petit spot volcano and only recent normal faults are developing. Model 1 applies to offshore Miyagi and model 2 applies to offshore Sanriku. The most important condition affecting the two models is the presence of the petit spot volcano.

Keywords: Japan Trench, Outer rise, Multi-Channel Seismic (MCS), Normal fault, Petit spot volcano

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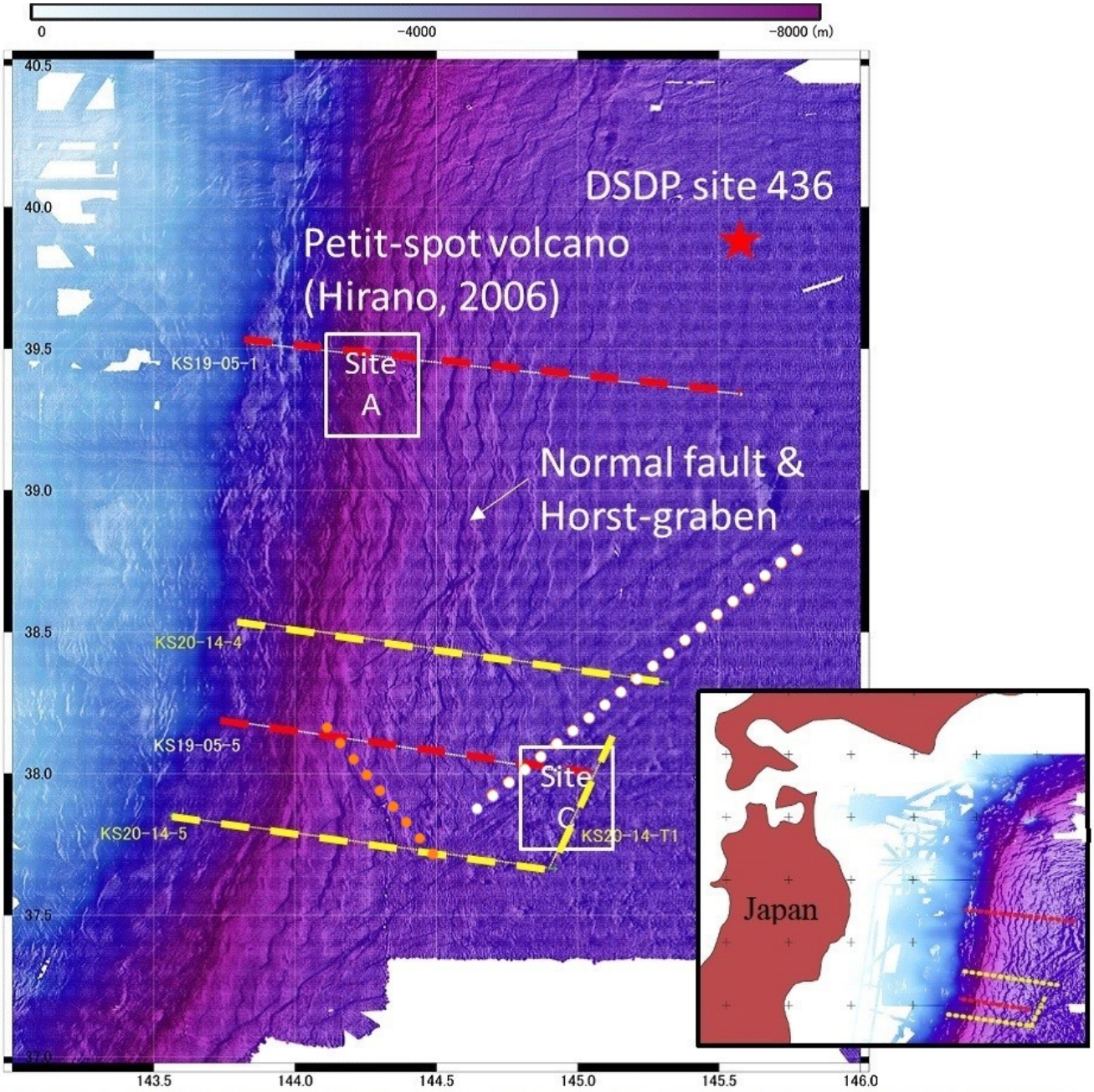


Fig.1 150m grid bathymetry map and seismic survey lines made from JCG & JAMSTEC (2011). Red dashed lines show two seismic survey lines of survey KS19-05 and yellow dashed lines show three seismic survey lies of survey of KS20-14. Two white squares show petit-spot volcanos site A and site C from Hirano (2006). The red star shows the location of DSDP (Deep Sea Drilling Project) Site 436. White dashed line shown faults that have different direction with trench axis. These faults parallel with paleomagnetic anomaly line. The orange dashed line perpendicular to the direction of the white line, shown the fracture zone direction. The lower right figure shows the relative position of study area and Japan.

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Complicated fault geometry of outer-trench normal-faulting earthquakes based on the ocean bottom seismograph observations

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After the 2011 Mw 9.0 Tohoku-oki earthquake, intra-plate normal-faulting earthquakes, including several M7-class earthquakes, have occurred in the trench-outer rise region along the Japan Trench and concern of large outer-rise earthquakes and related tsunamis have been raised. Based on the aftershock distribution, earthquake ruptures consisting of multiple faults are suggested for some large outer rise earthquakes. For 1933 Showa-Sanriku earthquake, rupture along two roughly parallel faults dipping toward opposite direction (westward dipping and eastward dipping) are proposed by Uchida et al. (2016). In addition, aftershock distribution along two conjugate faults were observed for two M7-class earthquakes in 2005 and 2011 in the trench-outer rise region along the Japan Trench (Hino et al. 2009, Obana et al.). The aftershock distribution used in these studies are based on the far-filed observations or observations conducted in a month to a few years later from the mainshock. During the OBS observations conducted in the trench-outer rise region of the central Japan Trench from September 2017 to July 2018, three M6-class outer-rise normal-faulting earthquakes (M6.3 on Sep. 21, 2017, M6.3 on Oct. 6, 2017, and M6.0 on Nov. 13, 2017) occurred around the OBS network. The results from the OBS observations succeeded to locate the rupture initiation of the mainshocks and aftershock activities including immediately after the mainshocks. The aftershocks of M6.3 earthquake on October 6 occurred along several inclined planes with different dipping angles and directions. Focal mechanisms indicate both normal-faulting and strike-slip aftershocks. In the trench-outer rise region, there are horst-and-graben structures formed by normal-faults cutting through the oceanic crust. The M6.3 earthquake on October 6 occurred at a joint of segments of the horst-graben-structures. Complicated distribution of the aftershocks with both normal-faulting and strike-slip suggests a possible compound rupture of multiple faults during the intra-plate normal-faulting earthquake. The other two M6-class earthquakes also show the complicated distribution of the aftershocks and suggest the relation to multiple faults both apparent and obscure from the bathymetry. Such complicated fault geometry should be considered as a possible fault of large intra-plate normal-faulting earthquakes and related tsunamis.

Keywords: Japan Trench, outer rise

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Mantle-derived helium released through the Japan Trench bend-faults <gdiv></gdiv>

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1. Atmosphere and Ocean Research Institute, University of Tokyo, 2. Department of Environmental Biology and Chemistry, University of Toyama, 3. Department of Marine Resources and Energy, Tokyo University of Marine Science and Technology, 4. Japan Agency for Marine-Earth Science and Technology, 5. Earthquake Research Institute, University of Tokyo

Plate bending-related normal faults (i.e. bend-faults) develop at the outer trench-slope of the oceanic plate incoming into the subduction zone. Numerous geophysical and numerical simulation studies suggest that bend-faults play a key role by providing pathways for seawater to flow into the oceanic crust and upper mantle, thereby promoting hydration of the oceanic plate. However, deep penetration of seawater along bend-faults remains controversial because fluids that have percolated down into the mantle are difficult to detect. In this talk we presents anomalously high helium isotope (3He/4He) ratios and seismic reflection data which support fluid infiltration into the mantle and subsequent outflow through bend-faults across the outer slope of the Japan Trench. Almost constant 3He/4He and 4He/20Ne ratios with depth at sites near trench bend-faults suggest local seawater inflow. Our findings provide the first reported evidence for a potentially large-scale active hydrothermal circulation system through bend-faults across the Moho (crust-mantle boundary) in and out of the oceanic lithospheric mantle. Mantle fluids expelled from the oceanic plate before subduction, if found to be pervasive across most of the ocean trench slope, would necessitate reconsideration of the water budget between Earth’s surface and its interior in terms of the global water cycle. As a future study, time-series geochemical observations at additional sites are required to clarify detailed fluid flux and the water circulation pattern. Ocean drilling of the bend-faults, which enables us to define mechanical and hydrological properties of the faults and to observe the mantle fluids at deeper depths, would be useful for more comprehensive understanding of the mantle fluid flow.<gdiv></gdiv><gdiv></gdiv><gdiv></gdiv>

Keywords: Mantle-derived helium, bend-faults, Japan Trench

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Heat flow distribution seaward of the Japan and Kuril trenches: Implications for fluid circulation in the oceanic crust

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Anomalous heat flow values, higher than that expected for the seafloor age of the incoming Pacific plate, are pervasively distributed on the outer rise of the Japan Trench. Overlapping the broad anomaly, local variations at a scale of several kilometers were detected through concentrated measurements along lines perpendicular to the trench. The broad high heat flow zone seaward of the trench can be attributed to pore fluid circulation in a permeable layer developed through fracturing of the oceanic crust due to plate bending, which efficiently pumps up heat from deeper part of the crust. Local variations may have arisen from heterogeneous development of fractures: higher surface heat flow is observed at sites where the crust has been fractured down to deeper part.

On the seaward slope of the Japan Trench, where normal faults are well developed, heat flow data has been rather sparse compared to dense data on the outer rise. We conducted heat flow measurements around faults with large surface displacement in the upper part of the seaward slope, on research cruises in 2015, 2016, and 2020. At around 39°N, heat flow values obtained at sites near faults are, on average, lower than the values on the outer rise, indicating that fluid circulation pattern in the oceanic crust may have changed associated with development of normal faults. Local heat flow variations were found in the vicinities of fault escarpments, possibly related to focused fluid flow along faults.

We also conducted heat flow measurements on the outer rise of the westernmost part of the Kuril Trench, adjacent to the Japan Trench, in 2018 and 2020. Most of the obtained values are normal for the seafloor age, in contrast to the high average heat flow on the Japan Trench outer rise. Local high heat flow anomalies were detected at two sites. One of them, at around 70 km from the trench axis, is rather broad, extending at least 5 km along a line perpendicular to the trench. We should make more measurements to delineate the shapes of local anomalies off the Kuril Trench for comparison with those off the Japan Trench.

These characteristics in the heat flow distribution provide information on fracturing process and fluid flow pattern in the oceanic crust. Nearly normal heat flow off the Kuril Trench may result from lower average permeability in less fractured crust, which suppresses development of large-scale fluid circulation. It is consistent with the observation that the anomaly in the seismic velocity structure is more significant off the Japan Trench than off the Kuril Trench. More detailed survey of the local anomalies would allow us to discuss heterogeneity in the oceanic crust and its regional variation along the trench.

Keywords: heat flow, oceanic crust, fluid circulation, heat transport, Japan Trench, Kuril Trench

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Resistivity imaging around the Japan trench based on ocean bottom electromagnetic surveys

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Electrical resistivity in the earth reflects amount, composition and connectivity of fluid, temperature, and lithology. Recent developments of seafloor observation instruments, data processing and inversion method allow us to obtain reliable images of resistivity distribution. Thus resistivity imaging is a powerful tool to discuss fluid and clay mineral distribution around the outer-rise (e.g. Naif et al., 2015) and subduction zone. In the Tohoku-oki area, Ocean Bottom Electro-magnetometers were deployed at 48 sites in order to obtain regional resistivity distribution based on magnetotelluric method. In the presentation, we introduce the OBEM surveys and resistivity models based on 2-D inversion procedures in the incoming plate zone and around the rupture zone of the 2011 Tohoku-oki earthquake (M9.0). Beneath the survey line along N39.4° across the incoming plate zone, the resistivity profile showed a conductive zone around a bending fault area. Sensitivity tests showed that the conductive zone may widely distributed near the Japan trench although depth range of the conductor were not constrained well. It implies hydration around the bending fualt. Beneath the survey line across rupture area of the 2011 Tohoku-oki earthquake (M9.0), the resistivity profile shows a low resistivity zone in the shallowest part of plate interface where huge fault slip over 80 m was reported (e.g. Iinuma et al., 2012; Fujiwara et al., 2011). On the other hand, resistivity is relatively high in the deeper plate interface that had been known as “asperity” and initial rupture zone was located. They indicate that the huge fault slip occurred in the pore fluid rich area that may affected by hydration in the incoming plate. However, especially in the incoming plate zone, MT impedances indicated strong three-dimensionality of resistivity structure and were not explained by a simple resistivity model including 3D bathymetry. It implies strong heterogeneity of the underground resistivity distribution and thus requires 3-D resistivity analyses.

Keywords: incoming plate, 2011 Tohoku-oki earthquake, OBEM, magnetotelluric

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[J] Oral | B (Biogeosciences)：B-PT Paleontology

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.26 Zoom Room 26

[B-PT02] Biotic History

convener:Isao Motoyama(Faculty of Science, Yamagata University), Takao Ubukata(Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University), Kazuyoshi Moriya(Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University), Chairperson:Isao Motoyama(Faculty of Science, Yamagata University), Takao Ubukata(Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University), Kazuyoshi Moriya(Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University)

The Biotic History session covers all aspects of ancient life and the history of biosphere through the geologic time. The study of ancient life is essential for unveiling mysteries of our planet earth. It also provides evidence for evolution of oceans, continents and island arcs. Modern progress in this field has been enhanced by interdisciplinary collaboration with allied sciences, such as paleoceanography and evolutionary biology. Our session intends to be a hub of communication amongst all earth scientists studying the biosphere; we welcome biological and biogeochemical approaches toward the understanding of the history of life.

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

[BPT02-01] Reconstruction of paleovegetation changes by pollen, palynomorph, and kerogen analyses of the Late Cretaceous sediments from the Kotanbetsu area, Hokkaido, Japan

*Maho Hayakawa[1], Ken Sawada[2], Masashi A. Ikeda[1], Reishi Takashima[3], Hiroshi Nishi[4] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.The Center for Academic Resources and Archives, The Tohoku University Museum, Tohoku University, 4.Institute of Dinosaur Research, Fukui Prefectural University)

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

[BPT02-02] Depth habitat of the late Eocene planktic foraminifers

*Kazuyoshi Moriya[1], Taku Oyama[2], Toyoho Ishimura[3] (1.Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.Major in Earth Sciences, Resources and Environmental Engineering, Graduate School of Creative Science and Engineering, 3.Department of Interdisciplinary Environment, Graduate School of Human and Environmental Studies, Kyoto University)

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

[BPT02-03] Micro sensory organs reveal the perception system and ecology of the Cretaceous cockroach

*Ryo Taniguchi[1], Yasuhiro Iba[1], Hiroshi Nishino[2], Hidehiro Watanabe[3], Kosuke Tateishi[3] (1.Faculty of Science, Hokkaido University, 2.Research Institute for Electronic Science, Hokkaido University, 3.Department of Earth System Science, Faculty of Science, Fukuoka University)

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

[BPT02-04] Computed tomography scanning reveals morphological development of a burrow produced by the tiger pistol shrimp *Alpheus bellulus*

*Miyu Umehara[1], Koji Seike[2], Seishiro Furuyama[1] (1.Tokyo University of Marine Science and Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[BPT02-05] Shell microstructure of extinct protobranch bivalves

*Kei Sato[1] (1.Faculty of Education and Integrated Arts and Sciences, Waseda University)

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

[BPT02-06] A unification of absolute growth, allometric, and theoretical morphologic models: a case of molluscan shells

*Takao Ubukata[1] (1.Department of Geology & Mineralogy, Division of Earth & Planetary Sciences, Kyoto University)

Reconstruction of paleovegetation changes by pollen, palynomorph, and kerogen analyses of the Late Cretaceous sediments from the Kotanbetsu area, Hokkaido, Japan

*Maho Hayakawa[1], Ken Sawada[2], Masashi A. Ikeda[1], Reishi Takashima[3], Hiroshi Nishi[4]

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The early Late Cretaceous (–Turonian) was characterized by one of the warmest paleoclimates, and subsequently the middle - late Late Cretaceous (Coniacian–Maastrichtian) is considered an interval of global cooling, possibly attributed by declining atmospheric CO_2concentration (e.g. Tabor et al., 2016). In the Cretaceous cooling condition, it is important to clarify the variation and evolution of paleovegetation adding angiosperm flora for understanding terrestrial paleoenvironment and paleoclimate. However, there have few reports for reconstructing long-time scale variation in paleovegetation during the Cretaceous. In the present study, we performed analyses of palynomorph including pollen and palynofacies (visual kerogen) of the sediments from the Upper Yezo Group (Hokkaido, Japan) to reconstruct the long-time scale variations in paleovegetation during the Late Cretaceous.

The mudstones of Saku Formation and Haborogawa Formation, Yezo Group, were sampled in the Kotanbetsu area, Hokkaido, Japan. In the Cretaceous Yezo Group, integrated bio- and carbon isotope stratigraphy have been well established in the studied section. We analyzed the Turonian–Santonian mudstone samples. We performed the treatments for separating pollen from sediments by 1) the common method for the Quaternary sediments, and 2) kerogen separation method. The palynomorphs including pollen and spore as well as kerogen were observed under transmitted and fluorescent light microscopes.

In the Coniacian–Santonian sediments, we identified trilete (fern origin), bisaccate (gymnosperm, especially Pinaceae), non-saccate gymnosperm pollen, and polyplicate (gymnosperm Ephedraceae). As angiosperm pollen, tricolpate, triporate, and tricolporate were ideintified. Interestingly, we found triprojectate, which is characteristically observed in the Late Cretaceous sediments from the Asia and North America. The angiosperm pollen/bisaccate ratios tended to decrease during the Coniacian, and subsequently increase during the Santonian. The bisaccate pollens are the most abundant, and could be divided to several types based on their sizes. The compositions of these bisaccate types varied, suggesting that the variations in coniferous vegetations can be reconstructed by using these bisaccate pollens. In addition, dinocysts were commonly observed. Microscopic observation of kerogen (palynofacies analysis) from sediments in the sediments from the Coniacian–Santonian Haborogawa Foramtion indicates that the kerogens mainly compose of wood and amorphous organic matter (AOM) such as fluorescent AOM (FA; plant cuticle origin) and non-fluorescent AOM (NFA; woody tissue origin), as well as sporomorphs (spore and pollen) and cuticle as minor component. The (Cuticle+FA)/(Wood+NFA) ratios, which is used as the proxy for herbaceous / woody vegetation ratios, tended to decrease from the early to middle Santonian, and slightly increased during late Santonian. However, the kerogen compositions by palynofacies analysis is thought to vary depending on sedimentological processes such as transport from land area, so that the sedimentological factors should be paid attention in the paleovegetation reconstruction by kerogen composition.

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Keywords: paleovegetation, Yezo Group, pollen, palynomorph, Cretaceous

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Depth habitat of the late Eocene planktic foraminifers

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Planktic foraminifers (Rhizaria) are widely distributed in modern ocean from equatorial to sub-polar oceans. Especially for surface dwelling species, distribution of those species is related to sea surface temperatures. For example, *Globigerinoides sacculifer* and *Neogloboquadrina pachyderma* predominantly inhabit tropical and polar oceans, respectively. In addition to this geographic variation, depth of habitat is also segregated from species to species. *Globigerinoides ruber* is well known as the shallowest dwelling species, *Globorotalia menardii* is deeper, and *Globorotalia truncatulinoides* is the deepest dwelling species. When calcifying their tests, oxygen isotope ratio (δ^{18}O) of their test carbonates records temperature of their habitat. Therefore, δ^{18}O of each species occurred from a given sample shows variation from positive to negative, hence, cooler to warmer. Using this temperature segregation, we can identify the depth of habitat of each species. This temperature/isotope segregation can be found in fossils species as well. Here, we report isotope segregation of the late Eocene planktic foraminifers in north Atlantic Ocean. We have determined δ^{13}C and δ^{18}O of 15 species at most within one sediment sample. The difference in δ^{18}O between species showing the most negative and positive δ^{18}O is approximately 3‰, corresponding to 12 degree C. *Turborotalia ampliapertura* show the most negative δ^{18}O, indicating surface dwelling nature of this species. On the other hand, the most positive δ^{18}O is recorded by *Globorotaloides quadrocameratus*.

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Micro sensory organs reveal the perception system and ecology of the Cretaceous cockroach

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1. Faculty of Science, Hokkaido University, 2. Research Institute for Electronic Science, Hokkaido University, 3. Department of Earth System Science, Faculty of Science, Fukuoka University

Sensory organs play essential roles for animals in detecting information of the surrounding environment. Insects are the most diverse group in Animalia, and their sensory organs have a notable ability to process complicated information despite the small size restriction. Among insects, cockroaches have maintained the body plan for a long time since they appeared on the earth, and they possess relatively small eyes and well-developed antennae reflecting the nocturnal ecology. Therefore, cockroaches can be considered model organisms on evolution and diversity of the remarkable insect sensors in paleontology. Fossils are the only direct evidence for paleontological research of these organs. Insect organs, however, are hardly fossilized owing to the smallness and fragility. Although they are exceptionally well preserved in amber, existing non-destructive analysis such as X-ray computed tomography does not achieve enough resolution to observe the fossil microstructure. Here, we focused on and visualized micro-sensors of an extinct male cockroach in Cretaceous Myanmar amber (*Huablattula hui* Qiu et al., 2019), combining destructive and non-destructive methods. Furthermore, we reconstructed the perception system and ecology of the cockroach in high-resolution.

We measured the surface area of the ommatidia and compound eyes based on the macro photographs and 3D-model constructed via X-ray CT. From these data, we estimated the number of ommatidia composing the compound eyes. We applied the thin-sectioning method used in mineralogy to observe antennal sensilla that are sensors of multiple information and too small for non-destructive methods to visualize. In this process, the amber piece containing the right antenna was cut off and ground down to 200 μm thick. We observed the thin section with a confocal laser scanning microscope.

The compound eyes of *H. hui* are large and round, and they consist of about 6,000 ommatidia. This number is 1.5 times larger than extant nocturnal species whose body sizes are five times as large as *H. hui* . Many sensilla are well preserved with surface microstructure on the antenna. We were able to classify them based on the morphology and estimate their function: mechanoreception and multiple olfactions. Compared to extant species living in dark environments, these sensilla are small against the body size, and mechanoreceptive sensilla are markedly fewer. These holistic characters of sensors indicate that *H. hui* relied on light stimulation rather than contact or odors to perceive environmental cues. *H. hui* was probably the diurnal insect adapted to bright habitats opposite to many modern cockroaches. We also revealed that the abundant sensillum type on the *H. hui* antenna is similar to extant male mantises. The abundance of particular sensilla in males results from using sex pheromones, and therefore *H. hui* may have used mantis-like intersexual communication. We show that detailed observation of micro sensory organs with destructive analysis enables reconstructing ecology and behavior of fossil insects in high-resolution.

Keywords: micro sensory organ, cockroach, amber, ecological reconstruction, destructive analysis, Cretaceous

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Computed tomography scanning reveals morphological development of a burrow produced by the tiger pistol shrimp *Alpheus bellulus*

*Miyu Umehara[1], Koji Seike[2], Seishiro Furuyama[1]

1. Tokyo University of Marine Science and Technology, 2. National Institute of Advanced Industrial Science and Technology

Trace fossils made by ancient animals provide information on the activities of their producers. However, improving our understanding of trace fossils requires the analysis of their modern analogs. In this study, we investigate morphology of a burrow produced by a modern benthic crustacean with computed tomography (CT) scanning to reveal its four-dimensional morphology. Because crustaceans are known to show a wide habitat range from shallow to deep sea and have lived since the Paleozoic era, they are suitable for burrow forming experiment as a modern analog of trace fossils.

The tiger pistol shrimp *Alpheus bellulus* used in this study was placed in each of the five tanks, and a light-shielding plate was set on the bottom to enable the shrimp to produce burrow easily. The CT images were taken at intervals of 10 to 30 minutes immediately after the start of burrowing by the shrimp. Then, morphological changes of the burrow were imaged with CT data processing, and we calculated surface area, volume, depth, diameter, and length of the burrow. Additionally, we calculated the growth rate of burrow surface area, volume, depth and length.

The surface area and volume of all burrows increased immediately after the start of the experiment, but the growth rates of them gradually decreased. The variation in the value of each diameter gradually got smaller. The depth sharply increased immediately after the start of the experiment and then moderately increased. The length of almost burrows significantly increased immediately after the start of, but then the growth rate gradually decreased. In addition, weak positive correlations were recognized between the carapace length and growth rates of the volume, depth, length, and surface area increase rate though there was almost no correlation between the carapace length and growth rates of the length.

The increase of the growth rate of surface area and volume immediately after the start of the experiment and no reactions by shrimp to food during burrowing indicate that a burrowing is high priority for shrimp. The increase of burrow depth growth rate immediately after the start of the experiment suggests that a hiding against predators is prioritized in the early stage of burrowing. Furthermore, the weak positive correlation between carapace length and volume indicates that larger shrimp produces larger burrow. Additionally, the growth rate of burrow to the shrimp size could be also positively correlated.

This study four-dimensionally observed burrow morphology of the tiger pistol shrimp *Alpheus bellulus*. The method used in this study can be applied to various burrowing organisms, and can contribute to further understandings of benthic ecology and paleoecology.

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Shell microstructure of extinct protobranch bivalves

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The shell microstructure is the micro-scale morphological trait of molluscan shells. It can be potentially preserved in fossils, and therefore is considered as a clue for inference on evolution and phylogeny of the past life. The presenter has described the shell microstructures of Recent protobranchs, the ancestral taxon of bivalve, using scanning electron microscopy. Furthermore, microstructural characters have been evaluated phylogenetically through molecular phylogenetic analysis using DNA sequences. Mapping of shell-microstructure characters on the phylogenetic tree confirmed that the composition of shell microstructures is conservative at the superfamily level and can be divided into three major groups; RESP (radially elongate simple prismatic structure), homogeneous, and nacreous groups. To assess the evolutional history of protobranch bivalves, the presenter newly described shell microstructures of fossil protobranchs mainly from the Mesozoic and revealed that several taxa changed their shell microstructural composition from homogeneous to nacreous group. This microstructural evolution can be one of the driving forces of their diversity modulation according to the paleobiological evidence.

Keywords: Shell microstructure, nacreous structure, bivalve, Protobranchia

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A unification of absolute growth, allometric, and theoretical morphologic models: a case of molluscan shells

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1. Department of Geology & Mineralogy, Division of Earth & Planetary Sciences, Kyoto University

Study on growth and form of past creatures is a fundamental part of paleobiology. There are three types of approaches: absolute growth analysis, allometry, and theoretical morphology. An absolute growth curve describing the pattern of growth with time provides information about the life history strategy of the animal. However, such information is often unavailable for fossil specimens, and paleontologists commonly focus on the relationship of relative growth rate between measurable morphological traits. Allometric equations are commonly used to describe the relative growth. However, allometric models do not fully represent the geometric characteristics of biological forms and abstraction of geometric information prevents us to perform an inversion analysis of the properties of absolute growth curves from morphological data. A theoretical morphologic model which mimics growth and form of an organism represents the relationship between elementary growth processes and geometric properties. However, theoretical morphology has developed independently from absolute and relative growth analyses in terms of methodology. In the present study, I introduce a new theoretical morphologic model of molluscan shell growth which combines absolute growth and allometric models. It allows us to estimate the properties of absolute growth curves based on an inversion analysis from morphological measurements. A pilot inversion analysis was carried out using artificial data sets to assess reliability of the estimation.
The theoretical morphologic model introduced herein is based on a logistic growth model represented by a sigmoid function of time. It is approximately exponential in the early growth stage, but shows a convex upward curve in the later growth stage, and finally approaches the upper bound of the curve. The logistic function can be defined by its initial value, the intrinsic growth rate, and the inflection point of the logistic curve. These parameters describe the rate and timing of growth processes that underlie shell geometries. The theoretical morphologic model is represented by growth of a helicospiral tube which consists of increases in length of the helicospiral, radius of the spiral, height of the helix, and radii of the elliptic cross-section of the tube. Anisomorphic shell growth can be represented by the theoretical morphologic model if growth of each dimension is approximated by a logistic growth function. A total of 14 dimensionless parameters uniquely define the ontogenetic trajectory of a computer-generated shell form. When intrinsic growth rate and the inflection point of the logistic curve are equal among dimensions, shell shape remains constant throughout ontogeny, even though growth rate changes during growth. If the timing of the inflection point of the logistic curve is nearly equal between a pair of dimensions and the intrinsic growth rate is not greatly different between them, the relative growth between the two dimensions can be approximated by an allometric model. Various patterns of ontogenetic variation in shell shape observed in actual mollusks were reproduced by the theoretical model.
The theoretical morphologic model was designed as a forward model for inversion of parameters of the logistic growth function that are ecologically and developmentally important. A computer-generated planispiral shell form with known parameter values which mimics anisomorphic shell growth of an ammonoid was used to generate data for a pilot inversion analysis. A grid search over the 11-dimensional parameter space revealed that the topography of the parameter hyper-space is not intractably complicated, although the global minimum corresponding to the true values of parameters is in a narrow spike.

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Keywords: theoretical morphology, absolute growth, allometry

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[J] Oral | G (General)：General

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.02 Zoom Room 02

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education), Tetsuhiko Asano(Senshu University Matsudo Junior High School High School), Chairperson:Shintaro Hayashi(Akita University Graduate School of Education), Tetsuhiko Asano(HunabashiKeimei High School), Jiro Komori(Teikyo Heisei University), Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education)

This session, slated for the 2021 convention, will mark the 10th time the meeting has been convened since the first public session was held a year after the Great East Japan Earthquake. We have consistently focused on how to provide disaster prevention education that is universally and continuously applicable. Almost every year since the first session has been marked by earthquakes and meteorological disasters, and each time we discovered defects in our preparatory measures to mitigate the effects of disasters. The accumulation of such bitter experiences must lead to the creation of new disaster prevention measures. For this purpose, it is necessary to share the experiences of regions right across the country. In particular, people involved in disaster prevention education must extract, from what has been learned in individual regions, those lessons that are universally applicable to any region, and pass them on to future generations. The year 2021 will mark the 10th anniversary of the Great East Japan Earthquake, which resulted in the death or loss of more than 18,000 people, and many more injuries, within the space of just a few hours. The last 10 years has revealed a number of issues to be addressed in disaster prevention education. We would like to review and discuss these issues.

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

[G01-01] Subjects on science education based on lower secondary school Students' cognition of triggers and first causes of natural disasters caused by flood and earthquake: A case of F City, Japan

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

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

[G01-02] School education of disaster prevention through stone monuments for historical natural disasters and SfM technique

*Wataru Tanikawa[1], Go-Ichiro Uramoto[2], Kazuhisa Iwaka[3], Group General Affairs Division[1] (1.Japan Agency for Marine-Earth Science and Technology, Kochi Instutute for Core Sample Research, 2.Kochi University, 3.Tokushima University)

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

[G01-03] A Teaching Material as an Education for Volcanic Disaster Prevention in No Active Volcanic Area
- Kikai-Akahoya Volcanic Ash at Tarumi-Hyuga Site in Kobe -

*Tatsuya KODA[1], Eiichi Sato[2] (1.Yanagi Gakuen Soukai Senior High School, 2.Hokkaido University of Education at Asahikawa)

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

[G01-04] Disaster prevention education on volcanic disasters
Development of Sakurajima version HUG

*Yuko Matsunari[1], Yasuhiro Ishimine[2], Tatsuo Takama[3], Hideaki Yoshihara[4], Tsuyoshi Nakatani[1], kaori Kaimoto[5], Keiko Imamura[1], Mitsuhito Sato[4], Naoyuki Hironiwa[6] (1.Kagoshima University, 2.Mount Fuji Research Institute, Yamanashi Prefectural Government, 3.Kagoshima prefecture Hospital , 4.Kagoshima City Hospital , 5.Kagoshima Women's College, 6.Minami-Nippon Shimbun)

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

[G01-05] The Necessity of Expanding Disaster Literacy toward the Era of "Society 5.0" "SDGs"

*Mamoru Hayashi[1] (1.University of TOYAMA)

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

[G01-06] Disaster prevention education through on-demand classes at universities

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

Subjects on science education based on lower secondary school Students' cognition of triggers and first causes of natural disasters caused by flood and earthquake: A case of F City, Japan

*Norihito Kawamura[1]

1. School of Regional Resource Management, Graduate School, University of Hyogo

The presenter review progress and subjects of study regarding natural hazards and disasters in scence education for elementary to upper secondary schools in Japan.

Keywords: flood disaster, earthquake disaster , questionnaire survey, elementary school, lower secondary school

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School education of disaster prevention through stone monuments for historical natural disasters and SfM technique

*Wataru Tanikawa[1], Go-Ichiro Uramoto[2], Kazuhisa Iwaka[3], Group General Affairs Division[1]

1. Japan Agency for Marine-Earth Science and Technology, Kochi Instutute for Core Sample Research, 2. Kochi University, 3. Tokushima University

Natural disaster monuments are used not only to preserve records of past natural disasters, but also as icons to warn people to be prepared for future natural disasters. However, due to the weathering of natural disaster monuments over the years, damage to the monuments and illegibility of the inscriptions has become a problem. Therefore, solutions using digital technology have been devised. On the other hand, the use of natural disaster monuments for disaster prevention education for citizens and students is not sufficient. In this study, as part of the "Hirameki Tokimeki Science" project funded by the Grants-in-Aid for Scientific Research, we conducted a project to deepen understanding of natural disasters by learning about the background of natural disaster monuments and the contents of their inscriptions through the 3D digital technology. This project was designed for elementary to high school students, with two points in mind: practicality and spontaneity. The project was conducted in Tosashimizu City, Kochi Prefecture, which has been hit by earthquakes many times in the past and has many monuments to earthquakes and tsunamis.

A survey of natural disaster monuments in Tosa-Shimizu City revealed that there are not only earthquake and tsunami monuments that tell of the damage caused by the Nankai earthquake, but also many stone monuments that tell of flood damage. Monuments to the 1707 Hōei earthquake, the 1854 Ansei Nankai earthquake, and the 1946 Showa Nankai earthquake were found to exist as monuments to the Nankai earthquake, while monuments to flood damage were erected as a memorial to the August 1920 flood and a monument to the September 2001 torrential rain disaster in southwest Kochi Prefecture. Therefore, it is possible to examine the characteristics of the stone monuments according to the natural disaster and the period of their construction. This project consisted of (1) a lecture on natural disasters and disaster monuments, (2) a visit to a natural disaster monument at the site and data acquisition for building a 3D model, and (3) the use of SfM Structure-from-Motion Multi-View Stereo Photogrammetry (3) construction of 3D models using SfM (Structure-from-Motion Multi-View Stereo Photogrammetry) and production of miniatures using 3D printers, and (4) examination of natural disaster monuments to be produced in the future. In (2) and (3), students learned (A) how to clarify inscriptions that are difficult to see in the field due to sunlight or shade, and (B) how to create 3D digital models of stone monuments. Each group visited five to six natural disaster monuments and conducted (A) and (B) for two monuments.For (4), the following task was given to each group to think of a stone monument they would like to produce. For (4), we gave each group the following task: "X years from now, the Nankai Trough Earthquake will hit your city, causing great damage. A huge tsunami came rushing in, and the port, bridges, and elementary schools were severely damaged. As soon as the quake hit, everyone rushed to evacuate to a nearby shelter, which saved their lives. Afterwards, you were assigned the role of conveying the experience of this great earthquake to future generations through the use of stone monuments. Afterwards, you were assigned the role of conveying the experience of this great earthquake to future generations through the use of stone monuments. What kind of stone monument will you build?".

As a result of this project, we once again felt the difficulty of reading and understanding the inscriptions in the field. During our visit to the natural disaster monument, we were also able to hear from the people who managed and preserved the stone monument and those who experienced the flood disaster. We realized the importance of passing on disaster records using stone monuments as well as hearing from

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people who were directly involved in the disasters and the monuments. The future stone monuments presented by students stood out by making it colorful, huge, and near the school. Since the SfM technology is not yet widely used, I felt that this technology could be used for educational activities other than learning about stone monuments.

Acknowledgements:
This program is funded by JSPS program (20HT0112).

Keywords: stone monuments for natural disasters, Nankai Earthquake, flood disaster, tradition, Structure from Motion, SfM

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2020年 雨天決行 11月15日(日)
9:30~15:40
参加費無料(昼食付き)

3Dデジタル技術で地震津波災害の記録を未来へ残そう!



わたしたちの祖先は、過去に起きた大地震や台風による災害を伝えるために、巨大な石に文字を彫って記録を残しました。しかしその碑は長年の風化でダメージを受けて、文字が読めなくなりつつあります。そこで、3Dデジタル技術を用いて、文字を読みやすくして蘇らせた碑を保存する試みが行われています。このプログラムでは、実際の碑から過去に発生した大災害を知り、災害の記録を未来へ残す最先端の取り組みを学習・体験します。

対　　象:小学校5、6年・中学生
定　　員:15名(先着順)
会　　場:竜串ビジターセンター「うみのわ」
集合場所:8:45 土佐清水市役所前(バス送迎)
または
9:00 会場「うみのわ」

<スケジュール>
9:00 - 9:30 受付(うみのわ)
9:30 - 9:40 開会式・オリエンテーション
9:50 -10:10 講義① 地震津波碑から南海トラフ地震を理解しよう
10:20 -12:20 実習① 自然災害碑の観察(散策)
12:20 -13:20 昼食・休憩
13:20 -13:35 講義② 3Dデジタル技術を体験しよう
13:35 -14:20 実習② 3Dモデルからミニチュアの作成
14:30 -15:30 実習③ 自然災害ロールプレイング
15:30 -15:40 終了式・解散
＊野外での散策可能な服装と靴でお越しください。

講師:谷川　亘(海洋研究開発機構 高知コア研究所・主任研究員)
協力:浦本 豪一郎(高知大学・特任助教)
　　:井若　和久(徳島大学・学術研究員)

主催:海洋研究開発機構 高知コア研究所
協力:土佐清水ジオパーク推進協議会
　　高知大学

申込方法:「ひらめき★ときめき サイエンス」HPまたはQRコードからお申し込みください。
申込締切:2020年11月9日(月) https://www.jsps.go.jp/hirameki/

本プログラムは感染症予防対策を徹底し、安全に配慮して実施いたします。

<お問合せ>海洋研究開発機構 高知コア研究所(管理課)　メール:kochicore@jamstec.go.jp　電話:088-864-6705

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A Teaching Material as an Education for Volcanic Disaster Prevention in No Active Volcanic Area
- Kikai-Akahoya Volcanic Ash at Tarumi-Hyuga Site in Kobe -

*Tatsuya KODA[1], Eiichi Sato[2]

1. Yanagi Gakuen Soukai Senior High School, 2. Hokkaido University of Education at Asahikawa

In recently many natural disasters happened for examples earthquake, typhoon, local heavy rain, volcanic eruption and so on. We asked to university students what do you think about the most worried disaster. As a result, the volcanic disaster was the most worried less than earthquake disaster and meteorological disaster. So we tried them to be anxious about the volcanic disaster in no active volcanic area such as Kobe and Osaka. We gave a lesson for volcanic disaster prevention observing the volcanic ash as a teaching material. This volcanic ash that is abundant in fresh volcanic glasses was collected at Kobe Tarumi-Hyuga site in 1997. The volcanic ash was identified as the widespread tephra named Kikai-Akahoya volcanic ash composed of bubble type glasses less than 1mm length. Consequently, most of university students changed their image of volcano and grew up their intension for the volcanic disaster by the lesson. The volcanic ash sample is quite able to be an effective teaching material as an education for volcanic disaster prevention in no active volcanic area

Keywords: Widespread tephra, Kikai-Akahoya volcanic ash, Tarumi-Hyuga site, Education for volcanic disaster prevention

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Disaster prevention education on volcanic disasters Development of Sakurajima version HUG

*Yuko Matsunari[1], Yasuhiro Ishimine[2], Tatsuo Takama[3], Hideaki Yoshihara[4], Tsuyoshi Nakatani[1], kaori Kaimoto[5], Keiko Imamura[1], Mitsuhito Sato[4], Naoyuki Hironiwa[6]

1. Kagoshima University, 2. Mount Fuji Research Institute, Yamanashi Prefectural Government, 3. Kagoshima prefecture Hospital , 4. Kagoshima City Hospital , 5. Kagoshima Women's College, 6. Minami-Nippon Shimbun

The purpose of this research is to develop the Sakurajima version of HUG (an acronym for *hinanzyo unei* game, a game for managing evacuation shelters) as a part of the educational program for disaster prevention related to Sakurajima’ s volcanic disasters. Residents will understand the need for self-help and mutual assistance in the event of a disaster by experiencing the Sakurajima version of the evacuation center management game. The aim is to take action to gain self-help in disasters and to strengthen disaster prevention and mitigation measures in the region. At the Earthquake and Volcano Disaster Prevention Center of Kagoshima University, a working group was established in 2018 and started its activities. It was predicted that it would have a great impact on people's lives and livelihoods. In a volcanic disaster, Kagoshima City would be isolated due to the effects of ash- fall. The effects of volcanic disaster would be prolonged. It was concluded that living in a shelter would be inevitable. Then, measures residents should take were examined. After some consideration, it was thought that it was necessary to expand disaster prevention and disaster mitigation awareness activities for residents by having them experience the evacuation center (HUG) game developed by Shizuoka Prefecture. Consequently, the Sakurajima version of the evacuation center management game was developed. This shelter game is a game that simulates how to respond to various events that occur in the shelter. Currently, a prototype version of this Sakurajima evacuation center management game has been completed. This prototype version allows people in local governments and related occupations involved in disasters to gain knowledge and ways to respond during volcanic disasters. However, since the ultimate goal of this research project is to improve disaster prevention literacy for volcanic disasters of local residents, further activities are needed. Therefore, in order to spread disaster prevention literacy to the general public, elementary school students, and the elderly, teaching material which can be grasped visually and intuitively are needed. Thus, a card game with commentary was developed, which when played and completed, can lead to disaster prevention awareness. A prototype version of the Sakurajima evacuation center management game has been completed. First, we asked general participants to play the game during the Sakurajima evacuation drill, which is held once a year. We also recruited elementary and junior high school students who are interested in disasters and disaster prevention. We also asked the children who applied to play the game and observe it. Then, we asked for opinions on whether there were any words that they did not understand or if they had any problems. We also asked the elementary and junior high school teachers for their opinions on possible problems. Thus, the content was revised and led to the completed version of the modified Sakurajima evacuation center management game. The elementary school students were able to enjoy playing games and to increase their level of interest in disasters. The junior high school students gained confidence in leadership skills by explaining the game and taking care of the elementary school students. There is a danger that Sakurajima may erupt on the same scale as that of the Taisho eruption. By using this game, information about disaster prevention and mitigation can be disseminated to local residents in cities and the prefecture. This will raise awareness not only in volcanic disasters but also in other kinds of disasters. This game has not been developed exclusively for Sakurajima but also for other volcanic disasters. For example, possibility of a volcanic disaster on Mt. Fuji is not zero. Thus, measures to prevent and mitigate volcanic disasters should be a topic priority in a volcanic country

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like Japan.

Keywords: Disaster prevention , education , volcano , shelter

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The Necessity of Expanding Disaster Literacy toward the Era of "Society 5.0" "SDGs"

*Mamoru Hayashi[1]

1. University of TOYAMA

The junior high school textbook with the highest adoption rate in Japan (Tokyo-shoseki Edition), contained the geological cross-section of Rokko Ikoma since 1981, and it was introduced as a typical example of earthquake and crustal movement. In 1970's, Kobe City asked the group of researchers of Osaka City University for active fault investigation, and the result covered 1 side of the local paper as "Kobe May Hit by Earthquake". In 1990's, in the decision of the regional disaster prevention plan, the seismic intensity of 5 which is unnecessary in the earthquake resistant fire cistern was chosen through the discussion on which seismic intensity of 6 or seismic intensity of 5 is assumed. The Han-Shin Awaji Earthquake disaster is a typical example of causing the earthquake disaster without being utilized even if there is a knowledge with high probability.

The Ishinomaki plain, Sendai plain and the coastal area of Fukushima Prefecture was left unprotected, because it was not taken in the countermeasure, though there was an experience of the giant history tsunami of Jogan and Keicho.The Manual for the Creation of Tsunami Storm Hazard Maps by the Cabinet Office (2004) established the principle of indicating a wide inundation area for the purpose of soft disaster prevention, which protects people's lives by evacuation, even if the hardware could not prevent tsunami attacks. However, it did not even specify the possibility of inundation damage such as making the Fukushima Nuclear Power Plant an inundation area. It is thought that behind this was political pressure from the electric power companies (The details are summarized in the serial of 'Science' "and the tsunami that was buried" by Kunihiko Shimazaki who experienced a member of the Earthquake Research Committee of the Headquarters for Earthquake Research Promotion, a chairman of the Long-term Evaluation Subcommittee of the Headquarters, and an acting chairman of the Nuclear Regulation Authority.).

The SDGs target of "leave no one behind" is set, and in the "Society 5.0" for the realization, it can be said that the innovation is not only the industrial technology development but also the solution of the public problem by the cooperation of civil society. I would like to establish a social framework that does not bring about "unexpected" such as the Great Hanshin-Awaji Earthquake and the Great East Japan Earthquake as one of the pillars of literacy for disaster prevention education. To achieve this goal, the government will examine the need for public education and democracy.

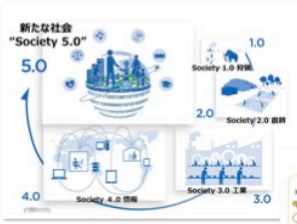
Keywords: Great Hanshin-Awaji Earthquake Disaster, Great East Japan Earthquake Disaster, soft disaster prevention, hazard map, Fukushima nuclear power plant, probability

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狭義の防災教育を越えた論点

- 新自由主義的な能力選抜のための学校教育だった側面（差がつくようにできた試験点数重視）
- 学力は個人では決まらないのに，いまだに個人で測定→学校格差社会化→動機づけが限定
- 「誰一人取り残さない」（SDGs）公教育に変われるかどうかが問われている。。
- 全体の奉仕者のまちがいを正す「市民社会の主権者」のための知識･教育の重要性（社会科教育だけの問題ではないが社会科に限界あり）
- その一例として，中学理科でもマグニチュードを→原理がわかるので知識定着も高いはず

Society 5.0やSDGsのためのとしてGIGAスクール構想が語られる現在



SDGs→「誰一人取り残さない」

イノベーション→産業技術発展ではなく，知識･情報の共有，連係による社会問題解決としてのイノベーション概念の強調

美辞麗句に終わらせないために



内閣府：Society 5.0とは
https://www8.cao.go.jp/cstp/society5_0/

「知識があっても生かされない」問題



直下地震が神戸に起きる可能性を報じた１９７４年６月２６日付の本紙

神戸新聞連載「想定を問う　不作為の連鎖　災害列島に生きる」（2012年1月14日付）ネット版掲載写真から

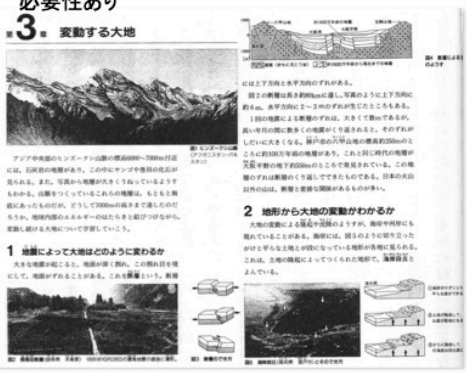


1996年4月刊

https://www.kobe-np.co.jp/rentoku/sinsai/17/rensai/201201/0005480235.shtml

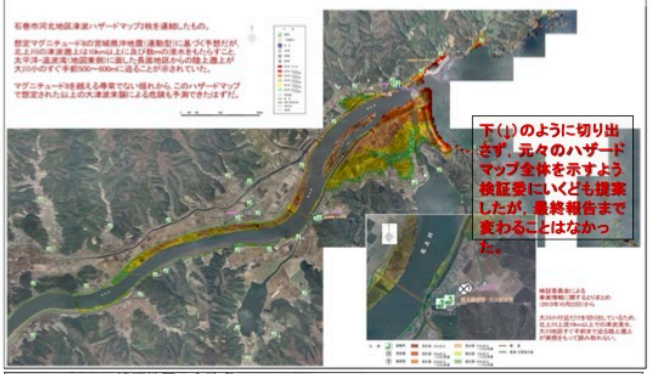


- 1981年から日本で一番採択率の高い東京書籍中学校理科の教科書に→“啓蒙”の最終段階？
- 主体性をうながすには，社会のしくみを問題にする必要性あり

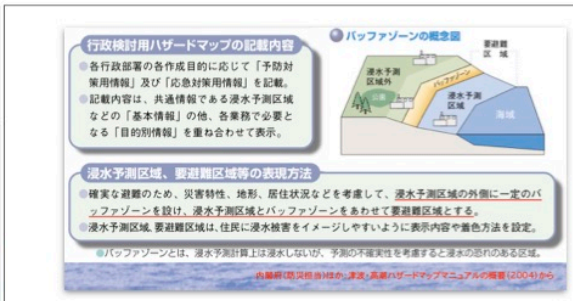


100万年で800m
1万年で8m
1250年で1m
600年で約50cm

3.5kmもの津波陸上遡上が予言マグニチュード8以上では明確に危険



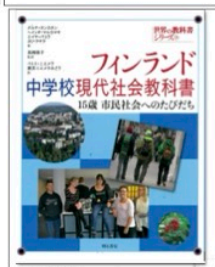
下（↓）のように切り出さず，元々のハザードマップ全体を示すよう検証委にいくども提案したが，最終報告まで変わることはなかった。



論点例その3：バッファゾーン明示義務の記録，検証は不要か。
ひとつの計算結果はひとつの結果にすぎず，ひとつの結果だけをもとに安全，危険を判断してはならないという認識は，防災研究者，政府の防災関係者らに2004年の段階で共有されていたといってよい。2004年の時点で，誤差や津波の多様性があるのを補うためにハザードマップにはバッファゾーン明示が求められていた。ところが，バッファゾーンが明示されないハザードマップが自治体によって繰り返し使われていた（右に続く）。

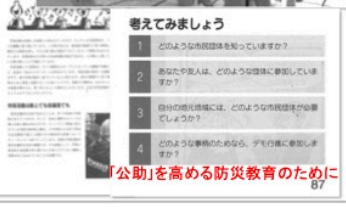


東北大学災害科学国際研究所展示
浪江町での津波堆積物はぎ取り標本。これら平野部への激しい浸水の証拠があったのに生かされなかったために東日本大震災の犠牲者数は倍加した。原発立地の影響があったのだろうか。









Cf.日本国憲法，フランス革命などの市民革命の説明から始まるのが日本の「公民」

「公助」を高める防災教育のために

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Disaster prevention education through on-demand classes at universities

*Shintaro Hayashi[1]

1. Akita University Graduate School of Education

1) COVID-19 and Akita University

On January 16, 2020, the first person infected with COVID-19 by the new coronavirus was found in Japan. Since then, COVID-19 has spread rapidly, and on April 16th, a state of emergency was issued to all prefectures in Japan. In response to this, classes were rapidly brought online at many universities.

At Akita University, to which the speaker belongs, classes using the online conference system and class system (Zoom and WebClass in the case of Akita University) began on May 11. Akita University's 2020 classes can be divided into three types: time-space shared face-to-face classes, space-non-shared time-shared online conferencing systems, and time-space non-shared on-demand classes. Of these, especially in on-demand lessons, teachers and students do not share time and space, so it is necessary to devise ways to interact with students.

2) On-demand "natural disaster and disaster prevention education"

The class of "Natural disaster and disaster prevention education" (Hayashi, 2020) in the latter half of 2021 was offered as an on-demand class that does not share time and space. The class consists of four parts, STEP1,2,3 & 4.

The short lecture (STEP 1) is a explanation of basic knowledge that conveys only the main points in a compact manner. In the exercises (STEP2), exercises related to the theme of the lesson were given. We performed tasks such as reading through the relevant page of the designated textbook, investigating on the Internet, and making the situation of the disaster site considered from the prediction data of earthquake damage. These tasks were used by slightly revising what was done in group work until last year. The mini test (STEP 3) is a quiz-style four-choice question for confirming knowledge. Ask about 5 questions to strengthen the knowledge gained in the lecture. In Reflection (STEP4), we looked back on the learning tasks and made them think about their use in disaster prevention education at school.

3) Interaction with students in on-demand lessons

Of course, the diligent response to students was done online. There are two main methods: a) commenting on the assignment submitted to the lesson system, and b)summary of sudent answers were presented at the short lecture. a) Add simple comments to exercises and reflections at the same time as scoring. Students have seen this comment quite a bit, so it functions as a reaction from the teacher. It's much easier to comment than a paper-based submission. Here, we took the action of "praising" as much as possible and controlled the students to be active in disaster prevention education. b) We selected

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excellent answers from the exercises and reflections submitted and introduced them at the beginning of the short lecture. Since group work cannot be used, the interaction between students had to rely on this part.

4) Class results

I will describe the impression that these classes were given (the lecture will give concrete examples of student reactions). Hayashi (2020) cited "knowledge about disaster factors," "knowledge about disasters," "quick judgment," "independent judgment," and "ability to respond before a disaster occurs" as the results of face-to-face lessons. Among these, I have the impression that they learned more about "quick judgment," "independent judgment," and "ability to respond before a disaster occurs" than in face-to-face lessons. In the final exam of this lecture, the question is how to act in a situation where a doctor who was hit by a direct earthquake calls for help from a collapsed house along the road on the way from his home to the clinic. It is a problem that must be solved in about 30 minutes, and of course there is no correct answer. In the student's answer, I could read the process of imagining the situation realistically, seriously imagining how to worry, and coming up with countermeasures. In the lecture, concrete examples of answers will be given for other problems.

Keywords: Disaster prevention education, On-demand class, Natural disaster, Online class, COVID-1

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[J] Oral | G (General)：General

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.03 Zoom Room 03

[G-02] Outreach and geoscience education

convener:Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Ken Tsukada(Hiratsuka City Museum), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies)

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[G02-01] The strategy and implementation of the Hayabusa2 outreach activities during the phase of the near asteroid operation

★Invited Papers

*Chisato Ikuta[1] (1.Japan Aerospace Exploration Agency)

9:30 AM - 10:00 AM JST | 12:30 AM - 1:00 AM UTC

[G02-02] How to activate discussion on on-line science cafe: Case study of "Science Agora 2020"

★Invited Papers

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3], Junya Terazono[4] (1.Kyoto City University of Arts, 2.Kyoto University, 3.University of Tokyo, 4.National Institute of Information and Communications Technology)

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

[G02-03] A practical report of virtual field activities with high-resolution panorama (GigaPans) at multiple scales and live broadcasting

*Norihito Kawamura[1], Takashi Sawaguchi[2], Jiro Komori[3] (1.School of Regional Resource Management, Graduate School, University of Hyogo, 2.Toyo Univ., 3.Teikyo Heisei Univ.)

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

[G02-04] Verification of demands for a location-based geological site interpretation service

*Keisuke Ito[1] (1.Geokatsu Inc.)

The strategy and implementation of the Hayabusa2 outreach activities during the phase of the near asteroid operation

*Chisato Ikuta[1]

1. Japan Aerospace Exploration Agency

The outreach activities for Hayabusa2 was great success due to frequent updates of information with the maximam transparency. Good access to video clips, and images contributed to increase the number of news articles and the visibility in media. Direct communication by using social media added a human dimension to the mission. Telling the risks openly helped the public to understand the challenge and dificulties of the space mission.

In this talk, we will describe our overall strategy and its implementation for the outreach activities of the phase of near asteroid operation of Hayabusa2. Analysing news articles and social media activities, we will share results, and lessons learned to utilize our experience for future missions.

Keywords: Hayabusa2, Outreach strategy, Science communication

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How to activate discussion on on-line science cafe: Case study of "Science Agora 2020"

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3], Junya Terazono[4]

1. Kyoto City University of Arts, 2. Kyoto University, 3. University of Tokyo, 4. National Institute of Information and Communications Technology

It has been a long time since the "science café" has been held in Japan to provide the general public with an opportunity to casually participate in and discuss science. However, despite their purpose and advantages, they often take the form of a lecture by the speaker and a question-and-answer session by the participants, and it is necessary to devise a way to facilitate discussion by both the speaker and the general participants. In recent years, various scientific events have shifted to online format, and the Science Café needs to be constructed in such a way that discussions can be held online. As for science cafés, the author and his colleagues have developed a "discussion-type science café" that aims to make discussion easier by clearly indicating the axes of discussion and having multiple topic providers (Tamazawa and Kazai 2020 jjsc accepted). We are also working on the online version. In the case of a format that does not involve an actual venue, it will be necessary to devise publicity strategies and facilitators that are unique to the online format. As an example, I will report on a science café on space development held as a part of Science Agora in November 2020.

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A practical report of virtual field activities with high-resolution panorama (GigaPans) at multiple scales and live broadcasting

*Norihito Kawamura[1], Takashi Sawaguchi[2], Jiro Komori[3]

1. School of Regional Resource Management, Graduate School, University of Hyogo, 2. Toyo Univ., 3. Teikyo Heisei Univ.

We condcted a veirtual geotours using a GigaPan image and live broadcasting. The students could make observations through the web site. Outreach activities for students utilizing the high-resolution images and live broadcasting will be enable to teach studenst in distance areas geological field work skills .

Keywords: GigaPan, geology, Anden geosite, Ikuta Ryokuchi Park, lower secondary school student, upper secondary school students

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Verification of demands for a location-based geological site interpretation service

*Keisuke Ito[1]

1. Geokatsu Inc.

Outreach in academia is very important for understanding the activities of academia in society. Earth and planetary science, in particular, is a field of research familiar to mankind, and can be a compass to show the state of mankind and what paths , beyond the framework of science, it should take in the future. The mission of Geokatsu Inc. is to create businesses that contribute to the solution of global issues by finding interfaces between the field of earth and planetary science, and society. G-Tour is designed for mobile devices. Users receive a push notification when they enter within a few meters of a geological site, and can read a description of the site by tapping on the push notification. Expected users are mountain climbers and campers. We are currently conducting a needs assessment in low mountains areas of the Kanto area, and will share the results of this needs assessment and knowledge gained at the conference.

Keywords: geological site, outreach, location information

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[J] Oral | G (General)：General

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.03 Zoom Room 03

[G-02] Outreach and geoscience education

convener:Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Jiro Komori(Teikyo Heisei University), Satoko Oki(Faculty of Environment and information Studies)

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

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

[G02-05] History of public understanding of global warming -When were we able to recognize it?-

★Invited Papers

*Jiro Komori[1] (1.Teikyo Heisei University)

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

[G02-06] Visual demonstration of greenhouse gas using 15μm absorption band of carbon dioxide.

*Akira Yamamoto

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

[G02-07] Class proposals and practices for remote learning of chemistry experiments for earth science students.

*Mana Yasui[1], Taisei Fujimura[2], Chiharu Tano[3], Fumitaka Kondo[3], Kenji Yonemochi[3] (1.Waseda research institute for science and engineering, 2.The department of resources and environmental engineering, Waseda University, 3.Faculty of Education and Integrated Arts and Sciences, Waseda University)

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

[G02-08] Trial of composing a melody using ground motion records of the 2013 earthquake near Awaji Island

*Nobuyuki Yamada[1], Shiina Yamamoto[1] (1.Kochi University)

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

[G02-09] Education for awareness about sediment related disasters and trial of providing risk information at an elementary school

*Shusuke Miyata[1], Kensuke Takenouchi[2], Ryoko Shimasaki[1], Akira Kamata[2], Daizo Tsutsumi[3], Kotaro Ichida[1], Masaharu Fujita[1] (1.Kyoto University, 2.Kagawa University, 3.Mie University)

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

[G02-10] Discussion

History of public understanding of global warming -When were we able to recognize it?-

*Jiro Komori[1]

1. Teikyo Heisei University

In order for us to take action to limit global warming, it is important to understand "when the problem first became apparent" and "when we first learned about it". In this presentation, I will discuss the history of understanding by researchers, government agencies, mass media, and the general public, as revealed in compilations of literature (e.g., Weart (2019) The Discovery of Global Warming https://history.aip.org/climate/index.htm) and newspaper databases.

Researchers' understanding dates back to J. Fourier's study on the greenhouse effect in the Earth's atmosphere in 1824, but the 1938 report by G.S. Callender appears to be the first to present and predict specific warming data (Hawkins and Jones, 2013. RMetS, 139, 1961- 1963). In Japan, Yamamoto (1957, Meteorological Research Notes, 55, 113-117.) is considered to be an early report (Tomari, 2018. JpGU prep. MZZ40-02).
As a governmental organization, the Japan Meteorological Agency revised its long-term forecast from "colding" to "warming" in the late 1970s and early 1980s.
In terms of books for the general public, a boundary may be drawn between the sales of 80,000 copies of "The Ice Age is Coming" in 1976 and the publication of translated books on global warming in Japan in 1983 and 1984.
As for the mass media, the term "global warming" has been used in foreign newspapers since the 1960s, but it did not really increase until 1988, the year the IPCC was established. The term "global warming" has had several peaks since then, but the 1997 and 2007 peaks can be attributed to the Kyoto Protocol and A. Gore's "An Inconvenient Truth" respectively. In Japanese newspapers, the use of the term "global warming" increased slightly around 1975, and then increased rapidly from 1988, as in the case of foreign newspapers. On the other hand, the term "global cooling" was used from the 1960s to 1983.

Keywords: climate change, public understanding, awareness history, global warming skepticism, newspaper database, negative legacy

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Visual demonstration of greenhouse gas using 15 μm absorption band of carbon dioxide.

*Akira Yamamoto

An uncooled infrared camera was made that visualizes the infrared radiation emitted by carbon dioxide, which is an important greenhouse gas. It has become possible to perform a demonstration with a consistent and clear physical meaning of global warming for the first time, that is: the generation of carbon dioxide by burning fossil fuels, the greenhouse effect that the infrared radiation emitted by carbon dioxide in the atmosphere warm the earth's surface, and the mechanism of global warming that the concentration in the atmosphere increases as infrared radiation that warm the earth surface temperature increases.

Figure

A gas included in a polyethylene bag was photographed by the infrared camera (a). The whiter the color, the stronger the infrared emission. Infrared emission by carbon dioxide (c) is much stronger than emission from a polyethylene bag only((b), the air included). The room temperature is around 25 degrees C, and the background is about 5 degrees C lower than the room temperature using wet Kent paper.

Keywords: Visual demonstration of greenhouse gas, infrared camera, thermography, infrared emission, carbon dioxcide



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Class proposals and practices for remote learning of chemistry experiments for earth science students.

*Mana Yasui[1], Taisei Fujimura[2], Chiharu Tano[3], Fumitaka Kondo[3], Kenji Yonemochi[3]

1. Waseda research institute for science and engineering, 2. The department of resources and environmental engineering, Waseda University, 3. Faculty of Education and Integrated Arts and Sciences, Waseda University

The new coronavirus infection forced many universities to change all classes remotely during the spring 2020 semester. In the chemistry experiment course for students studying earth science, we tried a new proposal when remotening the experiment class. We will also report the results from the feedback from students.

The biggest concern in the remote learning of experiments is that the technique of experimental operation cannot be inherited.Regarding the remoteization of experimental subjects, we expected face-to-face lessons in the fall semester. For this reason, we have reorganized the annual experimental items as planned to be conducted after the fall semester, especially for those that require learning of experimental operations.For this reason, analytical experiments were actively placed in the spring semester. The aim is to cultivate the basic data handling and concepts required for analysis when using analytical instruments such as the calibration curve and least squares method. The lesson was organized by creating a video that handles analytical equipment, giving students dummy data, deriving analytical values from the data, and encouraging consideration. However, I thought that it would be very disadvantageous for students studying earth science to not be able to realize the connection between the actual substance and what they are analyzing, considering the future specialized education in earth science.Therefore, in the "water hardness analysis using chelatometric titration", the water used for the analysis was collected at actual sites such as rivers and springs. Then, the video of the water collection was prepared as a teaching material after adding explanations such as the hinterland and the origin of the spring water. Here, it was recognized that the feeling of imagining the relationship between actual substances and analysis results varies considerably from person to person.
In the fall semester, face-to-face communication was realized and wet phylogenetic analysis operations became possible, but due to the influence of the third wave of new coronavirus infection, we applied distance learning again.We tried to propose a lesson in which students infer and think by themselves from the numerical values read using difficult instrumental analysis.Regarding this, we will consult with TA (Master's Course Student of Earth Science) who is a member of this presentation, and ask junior students to actually think about the content (meteorite analysis) that is close to the theme of his master's thesis. Coincidentally, the sample of "Hayabusa2" had just arrived in Japan, so We think it was a good time to arouse interest. We also report the interesting characteristics of the submitted report.

Keywords: earth science students, chemistry experiments, remote learning

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Trial of composing a melody using ground motion records of the 2013 earthquake near Awaji Island

*Nobuyuki Yamada[1], Shiina Yamamoto[1]

1. Kochi University

It is important to understand about the strong ground motion in order to protect ourselves from them. In this report, we attempted to express the ground motion records in a way other than the time history waveforms for the outreach of earthquake education and disaster prevention. In particular, we sought a method to convert the seismic motion records into a melody that enables us to "feel" the nature of seismic motion by listening to the melody. In this study, we modified the method of Yamada and Okubo (2012) for the 2013 earthquake near Awaji Island, and sought to express sensory to the differences of seismic wave propagation and seismic motion at each location.

In this paper, we show the spatial characteristics of the ground motion from the K-NET records of the 2013 Awaji Island earthquake (277 points), and introduce an attempt to create a melody using these data. For data processing, the Fourier spectrum of the velocity record for 20.48 s after the S-wave arrival time of the UD component was calculated, and the peak value and dominant frequency of the spectrum were extracted. From the results, we can see the trend of ground motion such as longer period in the sedimentary basins. In addition, we used them to create a musical score, using the strength, height, and placement of notes. To determine the pitch of a note, the relationship between the key number and the frequency of the note was retained and applied to the frequency characteristics of seismic motion. The maximum spectral amplitude was used for the intensity of the sound, and the maximum spectral amplitude was correlated with the reference value of the intensity symbol to create a musical score. In order to arrange the determined notes on the score, the temporal characteristics were retained and the order of S-wave arrival was set, with a time frame of 1 second and 0.01 second per note. In the 1 s case, there are points at which the S-wave arrives at almost the same time, resulting in a large number of overlapping scales in a single note, and in the 0.01 s case, there are many blank time slots, each of which creates its own problems, and there is room for ingenuity in the way the notes are arranged. The speed of the song and the type of sound are also issues that need to be addressed in the future. On the other hand, we have attempted to create a version of this report that is limited to the Shikoku region, where the number of observation records has been reduced. In the future, we believe that the combination of the melody we created and the visual representation method, as well as the process of creating the melody itself, will help us understand seismic motion in a fun way. Although it is impossible to judge the impressions and quality of the results because they are subjective, we would like to make further efforts based on the problems we encountered.

The contents of this report are based on the graduation research of the co-author, Ms. Shiina Yamamoto in 2020. And we used K-NET data provided by National Research Institute for Earth Science and Disaster Resilience. This research was supported in part by Grant-in-Aid for Scientific Research (C) (19K02615). I would like to express my gratitude to all of them.

Keywords: ground motion record, composing a melody, education for disaster mitigation

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Education for awareness about sediment related disasters and trial of providing risk information at an elementary school

*Shusuke Miyata[1], Kensuke Takenouchi[2], Ryoko Shimasaki[1], Akira Kamata[2], Daizo Tsutsumi[3], Kotaro Ichida[1], Masaharu Fujita[1]

1. Kyoto University, 2. Kagawa University, 3. Mie University

Sediment related disasters such as landslide and debris flow occur locally and unexpectedly. More than 80 % of human damages and losses due to sediment related disasters took place in buildings, implying late evacuation actions during heavy storms. Therefore, it is essential to understand the disaster risks at one’s own place for early evacuation actions. Education of disaster mitigation can contribute to understanding the disasters and their risks, which has been referred in guidelines of disaster mitigations at schools. As available land is generally limited in mountainous areas, public facilities such as schools must be located at areas with danger of sediment related disasters. According to the guidelines above, schools are requested to establish disaster mitigations individually. Real-time risk information of sediment related disasters is useful for schools in mountainous areas. We will present an education program on precipitation and sediment related disasters and real-time risk information based on observation and a simple model at Tochio elementary school, Takayama city, Gifu prefecture.

Because Tochio elementary school is situated adjacent to steep slopes, the site of the school is specified as the high- and very high-risk areas of landslide and/or debris flows (as called as ‘yellow zone’ and ‘red zone’, respectively). A huge debris flow at a torrent close to the school caused casualties and damages in 1979. The adjacent steep slopes and the previous debris flow disaster indicate the risk of the school. Tochio elementary school has been tackled education on mitigation of sediment related disasters in which our lectures, 4 classes per year, have been included. Our education program consists of classes on 1) what are sediment related disasters, 2) precipitation and evacuation actions, 3) ‘Cross-road game’ drill, and 4) what are disasters in winter. To realize amount of precipitation, the relationship between precipitation observed at the school and students’ feeling of precipitation was recorded. The recorded results showed large variations of sensitivity on precipitation among the students, suggesting that the difference between criterions of precipitation for disaster alert and residents’ feeling of precipitation should be recognized and is critical for effective risk information.

To provide real-time risk information for the school, we try to establish a method for evaluating the risk of the adjacent steep slope in real time. Discharge of a spring in the adjacent slope is observed and simulated by a simple function model. The spring discharge is assumed to be correlated to the groundwater level in the slope. Thus, the greater spring discharge can be assumed as the higher risk level of the slope. The input data for the model is only observed precipitation at the school, so that the risk information can be estimated in real time at the school. This information can contribute avoiding human damages at the school.

Keywords: Landslide, Precipitation, Evacuation

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[J] Oral | G (General) | General

[G-02] Outreach and geoscience education

convener:Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA(Ochanomizu University), Ken Tsukada(Hiratsuka City Museum), Jiro Komori(Teikyo Heisei University), Satoko Oki(Faculty of Environment and information Studies)
Sun. Jun 6, 2021 10:45 AM - 12:15 PM Ch.03 (Zoom Room 03)
The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

12:00 PM - 12:15 PM

[G02-10]Discussion

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[J] Oral | G (General)：General

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.03 Zoom Room 03

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo), Chairperson:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo)

We will provide and discuss various educational practices (teachings and procedures)
for elementary, junior high school, high school, and university students. We also welcome ONLINE education, fieldwork reports, and outreach reports for all grades.
Besides, especially for liberal arts level geoscience education of undergraduate,
we will consider the problems, such as online education, contents, and prospects of our current geoscience situation.
Furthermore, we will also think about fundamental teaching material development and
the sharing of teaching material data.

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

[G03-01] Authentic learning from perspective of aerospace - JAXA space education material "Earth Observation Coloring" -

*Yusuke Koga[1], Kenta Nomura[1] (1.Japan Aerospace Exploration Agency)

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

[G03-02] Home Science of Astronomy and Earth Science for Childcare Educators and Elementary School Teachers

*Akihiko Tomita[1] (1.Wakayama University)

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

[G03-03] Promotion of STEAM education (focus on space) with public-private partnership using an online tool.

*Norika Numa[1,3], Yoshiki Teramoto[2], Kaori Shoda[2], Asuki Yokoyama[3] (1.School of science, The University of Tokyo, 2.NPO Ikeda eco staff, 3.math channel Co., Ltd)

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

[G03-04] Visualization of crustal deformations in Japan -10 years before and after the 2011 Tohoku Earthquake viewed with GNSS dates.-

*Tadayoshi Kato[1] (1.Moegino Junior High School)

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

[G03-05] A case study of bringing online field tip closer to reality
- how to deliver the online excursion with on-site live broadcasting-

*Jiro Komori[1], Norihito Kawamura[2], SAWAGUCHI TAKASHI[3] (1.Teikyo Heisei University, 2.University of Hyogo, 3.Toyo University)

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

[G03-06] Geoscience・Geography education experiences at seven Japanese universities during the COVID-19 pandemic.

*Wonsuh SONG[1] (1.Waseda University)

Authentic learning from perspective of aerospace - JAXA space education material "Earth Observation Coloring" -

*Yusuke Koga[1], Kenta Nomura[1]

1. Japan Aerospace Exploration Agency

JAXA Space Education Center support to take aerospace into education. As the philosophy of Education Center, the main goal is not learning about space, but learning with space. And it is most important to use the material of space to ignite the three hearts of “curiosity”, “adventure” and “craftmanship”.

Education Center widely covers various fields such as formal education, informal education and experience-based learning opportunities. In addition to that, Education Center develop and release space education materials which is over 300 currently. In this presentation, we introduce space education material named “Earth Observation Coloring” developed and released in 2020. We mention not only how to use, but also educational effect we expect. Finally we indicate issue and vision about this space education material from report a teacher who actually use this material wrote.

Keywords: JAXA, space education, earth obeservation

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Home Science of Astronomy and Earth Science for Childcare Educators and Elementary School Teachers

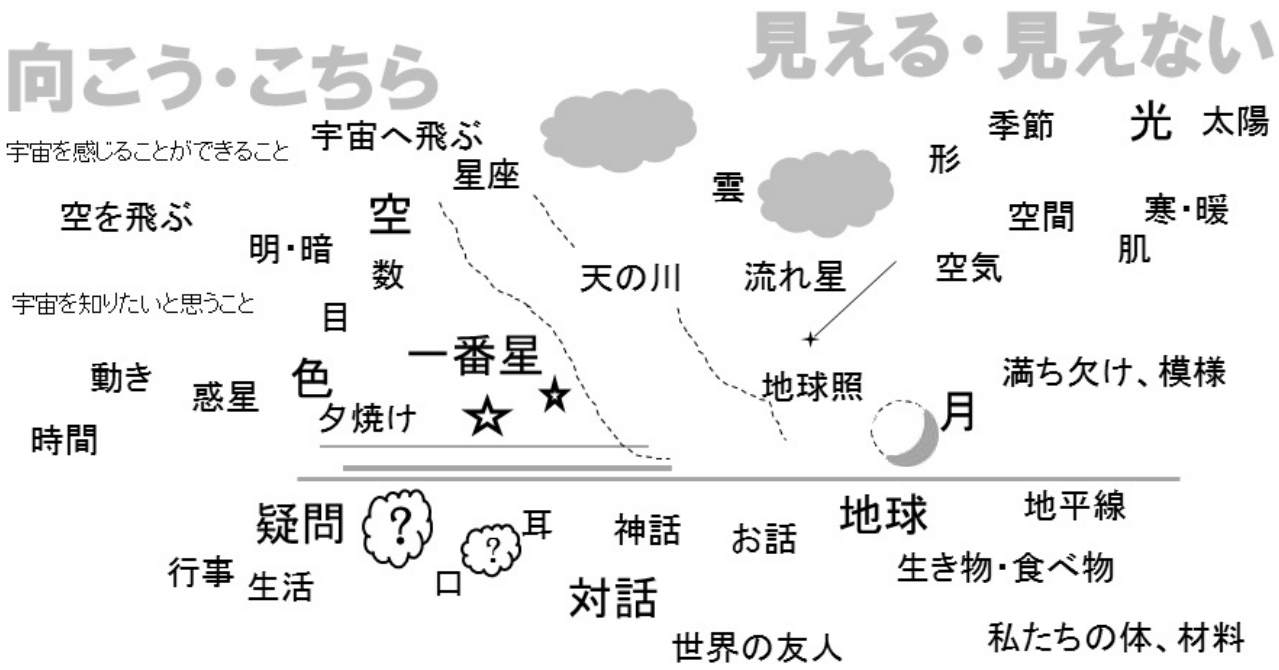
*Akihiko Tomita[1]

1. Wakayama University

The significance and importance of introducing children to the world around them, and the vast world of science, including astronomy and earth science, at all times, from infancy through elementary, middle, and high school, has been pointed out not only by researchers in science education but also by researchers in early childhood education. Various surveys have shown that many adults, even those who do not work in science, are interested in scientific topics, and would like to talk about science if given the chance. School teachers in elementary, middle, and high schools can have opportunities to train themselves in astronomy and earth science, although the problem of inadequate environment still needs to be tackled with. However, early childcare and after-school care educators have little time to do so due to not just the busy schedule of childcare, but the lack of understanding and environment for science education inside and outside the childcare actual site.
For this reason, the author has been working with researchers and practitioners of science education in childcare settings to implement activities that incorporate scientific play about the universe and the earth in everyday life (for convenience, I will call this "home science" in this presentation; e.g., the 73rd Annual Meeting of the Japan Society of Research on Early Childhood Care and Education, Symposium J-C-10 "Home Science, Home Math: What you need to encounter is always in the scenery, and you are the one who intervenes in the encounter!”).
In this presentation, I will introduce some examples of the practices and evaluation methods. Please refer to the following figure for the subject to be covered. The target age range is from 3 to 15 years old, from early childhood to school age. The practices include observation of the sky during the day, evening, and night, both outdoors and in the room; scientific play with light and color in the room; stories and awareness activities to notice the heavens throughout the year, especially the motion of the sun, and the accompanying changes of weather and living things throughout the year; and the yearly cycle of our lives.
The practices presented in this presentation are intended to be used by childcare educators (nurseries, kindergartens, preschools, and after-school care) and elementary school teachers. Although this practice is not an activity of formal education in a school classroom according to the official curriculum, it can serve as a foundation for increasing children's and students' interest in the astronomy and earth science, and for better connecting the formal educational content with life and society. There are many elementary school teachers who are interested in the field of astronomy and earth science but are not good at teaching in this field. Not only childcare educators but also such elementary school teachers will benefit from this study. In addition, it can provide good contents on astronomy and earth science, which are rarely covered in life classes for lower grades of elementary school. In response to the spread of infectious diseases, we are now in a social situation where we have no choice but to keep a physical distance from each other, and this is expected to continue for some time to come. Activities that do not require special equipment and can be done outdoors and in a relaxed indoor environment have the potential to be used in schools under these circumstances, as well as for independent learning by children and students. As an evaluation method, I will introduce the method of recording episodes in childcare settings. Although this is different from the official evaluation method used in formal school education, it is in the same direction in that it looks at thinking, expression, and proactive attitude, and expects the acquisition of knowledge and skills based on these. In addition, I will show how this activity has helped improve the confidence of teacher-training students who are not good at science teaching.

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Keywords: Astronomy education, Early childhood education, Primary education



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Promotion of STEAM education (focus on space) with public-private partnership using an online tool.

*Norika Numa[1,3], Yoshiki Teramoto[2], Kaori Shoda[2], Asuki Yokoyama[3]

1. School of science, The University of Tokyo, 2. NPO Ikeda eco staff, 3. math channel Co., Ltd

STEAM education is an education policy that includes the areas of science, technology, engineer, art (liberal arts) and mathematics as a form of creative education. Interdisciplinary learning is needed for critical-thinking and creating things. For example, we can see the importance of this policy playing part in our developing society. Society is changing rapidly due to technological advances, so the qualities and skills required for human resources in today’s society is changing. To adapt the changing society, creating new things as well as integrating skills and concepts from various disciplines are important.
One real-life example of STEAM education in action is at Shibaura Institute of Technology Junior High School. Second graders were tasked to create beetle-type robots in a day. This approach brings a sense of accomplishment and self-esteem to the students, as well as, improving their problem-solving abilities. However, human resources, time and platforms are still insufficient to carry out STEAM education, hence more time is still needed to promote STEAM education. In addition, education at schools abruptly came to a halt due to the outbreak of COVID-19. Thus, we believe STEAM education could be promoted as a means of being an online education tool to improve learning.
Last year, we promoted STEAM education as an environmental business promotion project at Ikeda City, Osaka Prefecture. This project was sponsored by Ikeda City, with the cooperation of the board of education of Ikeda City, and planned and operated by NPO Ikeda eco staff). STEAM education was promoted through environmental learning. Familiar things around us are “environment” and the “purpose of environmental learning” is to be aware of the relationships between oneself and familiar events. From here, thinking how actions and decisions can affect an outcome is important. In particular, Ikeda eco staff were interested in STEAM education focusing on space based on the findings of The Greenhouse Gases Observing Satellite “IBUKI”. On the other hand, I worked on STEAM education to promote about space and mathematics. I also conducted lectures on math channel Co., Ltd. This way, STEAM education focusing on space was implemented through the cooperation of the three parties.
The project was named “Have fun with Mathematics and Space at home”. There were around 52 participants. The participants participated from their homes, and each participant was connected with the online tool, Zoom. The contents of the project are as follow. First, the participants compared the size of different planets using things at home. Since the size of planets cannot measure directly, it is difficult to imagine their size by only using figures. Thus, by replacing the size of planets with things at home, the participants were able to feel the universe closer. After that, I introduced my recent study on meteorites, and I brought out interest in space by interacting with the participants through their questions. Through these exchanges, it made me ask questions about the universe, and think about the issues I could tackle in my research. Finally, small groups were formed (4-5 participants per groups) using the function of breakout room in Zoom for more interaction time between the participants.
By comparing the size of planets with familiar objects at home, participants could understand more on the universe qualitatively and quantitatively. Moreover, for the ‘Questions and Answers’ section, I received many good questions. As for the questionnaires, many participants answered the event was fun. There was also feedback such as future approaches. Based on the above results, STEAM education could be promoted with public-private partnership other than at school. In this presentation, the approach of STEAM education and how to promote STEAM education with public-private partnership will be introduced.

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Keywords: STEAM education, public-private partnership, primary education, online

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Visualization of crustal deformations in Japan -10 years before and after the 2011 Tohoku Earthquake viewed with GNSS dates.-

*Tadayoshi Kato[1]

1. Moegino Junior High School

March 11, 2021 marks the 10th anniversary of the 2011 Tohoku Earthquake. The earthquake, which observed the largest magnitude in Japan's observation history, was recorded by various observation networks and recording media, and was also captured by the “GNSS Earth Observation Network System” (GEONET). GEONET has accumulated coordinate value data from 1996 to the present, and has continued to observe daily crustal deformations associated with this earthquake with an observation network of about 1,400 points. This observational data is open to the public on the Geospatial Information Authority of Japan website and can be accessed by anyone. However, since it is difficult to process a huge amount of data and visualize the observation results, it is difficult for students to grasp the appearance of Japan. On the other hand, applications and tools that can display the earth and planets in 2D or 3D, such as “Dagke Earth” (http://earth.dagik.org), are appearing as digital teaching materials and have been emphasized in recent years. These can be used for active learning, which "not only gives students knowledge and information, but also allows students to observe problems and draw conclusions." The introduction of these kinds of ICT in schools and educational institutions has begun to gradually progress, and it is expected that the number of places where these teaching materials can be used will increase in the future.

Daily observation data is stored as GEONET data from 1996 to the present, and crustal deformations during any period can be displayed as vector diagrams or baseline length graphs. In addition, the analysis coordinate values (F3 solution and F4 solution) analyzed by the Geospatial Information Authority of Japan for general use are also open to the public. However, it is difficult to intuitively grasp how Japan is fluctuating by utilizing these databases and expressing baseline length graphs and maps, and there are aspects that can only be understood by people with some specialized knowledge. In this study, we created a map that can capture the temporal fluctuations of Japan by calculating the displacement amount of each electronic reference point using the F3 solution and exaggerating the crustal deformations.

The map created by exaggerating the amount of displacement (variable topographic map) changes the shape of Japan after that depending on the reference year. In particular, the change is remarkable when the base year is before and after a relatively large earthquake. In this study, we set three periods: 1996 to 2020, when GEONET began observing Japan, 1996 to 2010, and 2011 to 2020, with the 2011 Tohoku Earthquake as the boundary. By comparing the monthly crustal deformation maps of each month, we attempted to visualize the steady movements of Japan and the aftereffect movements that are prominent after a large earthquake.

In order to capture crustal deformations, there are many aspects that must be captured by continuous observation in units of several years to several decades, so in elementary and junior high school education, it is difficult to observe during class hours, as a huge amount of data is handled. However, effectively studying the use observations that GEONET has accumulated using the new method should help us to think about the appearance of the country in which we live. In addition, if students can freely change the analysis period and exaggeration ratio of the crustal deformation map created, it will be a tool

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to help students learn independently.

Keywords: crustal deformation, Japan, Digital teaching material

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A case study of bringing online field tip closer to reality - how to deliver the online excursion with on-site live broadcasting-

*Jiro Komori[1], Norihito Kawamura[2], SAWAGUCHI TAKASHI[3]

1. Teikyo Heisei University, 2. University of Hyogo, 3. Toyo University

1. Introduction
Due to the COVID-19 infection control measures, opportunities for "a real" field training and trips are decreasing. On the other hand, there are more chances to conduct online tours. Originally, classroom-to-classroom teleclasses and exchange classes using videoconferencing systems were conducted in the late 1980s (e.g., Shimizu, 1986; Kawamura, 1993). In the 2000s, the use of high-speed Internet connections led to an increase in the introduction of remote classes, and there have been cases of classroom-to-field connections (e.g., Soma et al., 2000; Kawamura et al., 2011).

Since 2010, the use of smartphones and satellite phones has contributed to the diversity of connectivity. However, these are online applications as part of a class, and there are probably no examples of "field trip" around research and learning targets. Hayakawa et al. (2015 JpGU abstract) are exploring the construction of online pilgrimage contents based on actual pilgrimages and maps on the Internet. However, since users use these contents on demand (at different times) after they are made public, there is no direct interaction between guides and participants.

After 2020, there are several projects called online field trip, such as a connecting with several museums ("Gakujyutu Yaei 2020". https://amane-project.jp/post-1111/). Among them, the group "Geography Plaza for Everyone! (https://geo-plaza.hatenablog.com/) is organizing an online tour of the city center based on Google Street View as a tour in the field of geography. This tour using Zoom is close to the original tour where the guide and participants communicate with each other.

In addition, the Izu Peninsula Geopark is providing a real-time tour guide via Zoom from before the outcrop as part of the "2nd Earth Science Week Japan in Shizuoka" (https://www.earthsciweekjp.org/).

The author conducted an online tour connecting participants with outdoor landforms and outcrops as part of a project sponsored by a high school geology club and the Japanese Geology Olympiad. The preparation for this project was done by a trials and errors, without knowing the precedents mentioned above. However, it was easy to implement with only one or a few people on the instructor side, and we obtained some knowledge that will be useful in the future for online field trips and field observation for school education and lifelong education.

2. Findings
The following points were clarified by the online excursion with on-site live broadcasting.

The number of people on the sending side: It was possible for one person to guide the participants from the field. However, it is very important to have a facilitator who can act as an intermediary between the participants in case of communication breakdowns and to encourage questions from the participants.

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Whiteboards: In a normal tour, whiteboards are often used to explain terms and present overviews as a supplement to the handouts. On the other hand, in the online tour, it was possible to replace the whiteboard by writing on the tablet screen using a stylus pen. In particular, when explaining outcrop sketches, it was possible to overlay lines and text on the outcrop photos, and then erase only the photos. This is an innovation that could not be done with a whiteboard.

Fixing a smartphone on a camera stabilizer (gimbal): Fixing a smartphone on a gimbal absorbs large vibrations and prevents rapid rotation (panning) of the camera. This is useful when giving explanations while walking. It was very effective when moving by bicycle. However, when transmitting from in front of an outcrop, I often shoot with a smartphone or tablet in hand, and heavy gimbal makes my hands tired.

Microphone: Since we were participating in Zoom in the open air, the use of a microphone and earphones was essential to prevent noise. In order to avoid connection problems, we used wired microphones and earphones fixed to our heads. In addition, we used a microphone sponge as a windbreak.

Cell phone lines: Mobile phone lines were good at all sites during this "online excursion with on-site live broadcasting ". However, this is not always the case at outcrops and field trips around the country. It is necessary to confirm this in the preliminary inspection before implementation.

Keywords: remote lecture, field trip, tips introduction, outcrop definition, online meeting system, camera Stabilizer

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Geoscience・Geography education experiences at seven Japanese universities during the COVID-19 pandemic.

*Wonsuh SONG[1]

1. Waseda University

Online lectures offer many benefits. However, it was a huge test for the freshmen who had never spent their time in college and started living alone without any acquaintance or friend as Japanese universities started in April. Such suffers apply not only to students, but also to lecturers who must bring all their lectures into online. Part-time lecturers had a hard time finding a place to shoot the lectures and had no financial support to get the equipment needed to shoot, which was a burden to the household. Here I would like to share my experience of giving online lectures at several universities and what I have learned from them.

First, adding virtual field trip in on-demand class is very effective. Japanese undergraduate students are gradually becoming accustomed to online lectures and prefer on-demand lectures. Students take on-demand lessons at double speed and rewind what they didn't understand. They can take the class from the beginning even if they are late or absent. Nocturnal students can also take 9 am classes at 9 pm. In addition to the on-demand class, I held an online meeting for a physical geography class which has a lot of freshmen. I set out a task for them to find interesting terrain on the Google Maps and to investigate its land formation process with a small group. Students felt satisfied a lot to find interesting place and communicate with their classmates. I convinced that a virtual field trip will be a very important and indispensable tool for future geoscience and geography education.

Second, active learning in university classes is becoming more and more important. It is also important to attract students' interest and broaden their horizons. People can search freely and get a lot of information easily. However, students who have just entered university do not know what to look for and how to search it. It is necessary to know the background of the knowledge that has been earned by simple memorization. Students should know where and how to get reliable information and how to apply it to their present and future life. The lecturer should give important keywords regarding to the content. The students should practice more to do active learning. The existence of lecturers who can move students and broaden their horizons will become more important.

Third, it is also important to make students aware of the current situation and raise their motivation. I explained the value of the class on the first day for every lecture. The cost can be calculated simply by using total cost paid by the student for 4 years, excluding the opportunity cost, and the number of credits required for graduation. Students pay for one class (fifteen classes in a semester) about $ 56 in private universities, and the half in national universities. All the students were very surprised at this number. Students felt that they had to be more concentrated on their study. I sometimes hear that universities may disappear in the future, but as long as the educational background is the simplest and fair standard to prove young student's value, no matter how the times change in the future, good universities will not disappear. Universities are valuable because they provide the place and time that students can learn thinking, problem-solving, and creativity rather than the knowledge. Students should learn and think a lot during their lifetime. This keeps students growing. Lecturers have to tell this fact to the students.

Today's students are getting smarter. Their learning speed is very fast. If the students are not interested in

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the subject or the lecturer anymore, “natural selection” will be occurred in academic ecosystem. Universities are no longer a heaven. It's time for university executives, staff, faculty, and students to review and renew everything to be survived. Pandemics give us the opportunity to evolve. I hope everyone to do their best to change this crisis into an opportunity.

Keywords: Geoscience education, Geography education, Online education, University, Covid-19

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[J] Oral | G (General)：General

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.03 Zoom Room 03

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo), Chairperson:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo)

We will provide and discuss various educational practices (teachings and procedures)
for elementary, junior high school, high school, and university students. We also welcome ONLINE education, fieldwork reports, and outreach reports for all grades.
Besides, especially for liberal arts level geoscience education of undergraduate,
we will consider the problems, such as online education, contents, and prospects of our current geoscience situation.
Furthermore, we will also think about fundamental teaching material development and
the sharing of teaching material data.

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

[G03-07] **A study of the cognition regarding natural disasters of junior high school students in Kobe City, Japan.**

*Toshio Arimichi[1,2], Norihito Kawamura[2] (1.Kobe Municipal Ibukidai Junior High School, 2.Graduate School of Regional Resource Management, University of Hyogo)

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

[G03-09] Thin-Section Making Recipe in a classroom Ver3.0 -using 3D printer-

*Yoshio Okamoto[1] (1.Osaka-Kyoiku University (temporary lecturer))

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

[G03-10] Development to teaching materials related to GIGA school

*Iida Kazuya[1] (1.Komaba-Toho Junior and Senior High School)

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

[G03-11] The report of the International Earth Science Olympiad (IESO) ,2021

*Norihito Kawamura[1], Yutaka Takigami[2] (1.School of Regional Resource Management, University of Hyogo, 2.JESOC)

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

[G03-12] Discussion

A study of the cognition regarding natural disasters of junior high school students in Kobe City, Japan.

*Toshio Arimichi[1,2], Norihito Kawamura[2]

1. Kobe Municipal Ibukidai Junior High School, 2. Graduate School of Regional Resource Management, University of Hyogo

In recent years, the number of natural disasters that cause many victims has increased. A natural disaster is a phenomenon in which a critical natural hazard causes loss of human life and damage to social infrastructure. To minimize the damage caused by natural disasters, it is important to understand both their causes and potential effects. In addition, it is necessary to treat natural disasters as teaching materials, so that the experience gained can be used to help prevent damage in the future. By studying examples of natural disasters, students are made to think about the relationship between human society and the environment, and what can be done to prevent or mitigate damage from natural disasters. Opportunities to deal with natural disasters can occur within science, social studies, health and physical education, technology and home economics, and integrated study lessons, however the most suitable place to learn about the phenomena that cause natural disasters is in science classes, particularly in the study of earth science.

Since the 1995 Southern Hyogo Prefecture Earthquake, disaster education for evacuation preparedness in the event of a disaster, and for minimizing damage in the event of a disaster has progressed considerably. However, education about earth science, particularly in relation to the causes and occurrence of natural disasters has not progressed. Few papers are published, and the cognition of the general public concerning natural hazards remains low. Many core principles such as the difference between typhoon and tropical cyclone, seismic intensity and earthquake magnitude, trench type earthquake and intraplate earthquake, how to interpret the probability of precipitation, and the existence of hazard maps are important topics that the general public has little recognition of. We think that it is the responsibility of science and earth science education to provide the general public with the basic knowledge needed to fully understand the principles and the importance of natural science and natural hazard awareness.

In the *Course of Study (Science) for Junior High School* (Ministry of Education, Culture, Sports, Science, and Technology, 2018), students are to learn that volcanic disasters, earthquake disasters and benefits from nature by learning “the formation and change of the earth”, meteorological disasters and benefits from nature by learning “weather and its changes”, and the local natural disasters by learning “nature and humans”.

In addition to the Southern Hyogo Prefecture Earthquake, Kobe City also frequently suffers damage from strong winds, or flooding caused by heavy rain (including debris flows, landslides, and floods). This is due to the tilted block of Mt. Rokko. The Mt. Rokko range is a massif located on the north side of the city of

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Kobe. The rivers that flow from Mt. Rokko have a very short distance to the sea, so they are rapids with high flow rates. Moreover, since Mt. Rokko is made of weathered granite, it is easy for landslips and earthfalls to occur, often leading to debris flows. At the foot of Mt. Rokko, sand and stones carried by rivers from Mt. Rokko over the years have formed an alluvial fan on which the urban area of Kobe and its 2 million inhabitants are located, making it a heavily urbanized area with a high risk of sediment related disasters. However, in science classes at junior high school there are few opportunities to learn more about natural disasters that occur in the region. Therefore, we conducted a survey of junior high students in Kobe city concerning natural disaster cognition.

Survey Method

In November 2020, we conducted a questionnaire survey on disaster cognition for seventh grade students (987 students) and eighth grade students (1009 students) of junior high schools (13 schools) in Kobe City.

The survey consisted of eight questions:

Question 1 asked students to specify their opinion of the most frightening natural disaster.

Questions 2-4 asked students about their sources of information relating to natural disasters.

Questions 5-6 asked students to answer questions relating to the cause of earthquakes, and the ground shaking.

Questions 7-8 asked students about the causes of floods, and the places where floods can occur.

In this presentation, we will present the results of an analysis of the junior high school students' cognition of natural disasters and their learning experiences relating to them.

Keywords: questionnaire survey, junior high school students, natural disasters, earth science education, Mt.Rokko, Kobe City

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Thin-Section Making Recipe in a classroom Ver3.0 -using 3D printer-

*Yoshio Okamoto[1]

1. Osaka-Kyoiku University (temporary lecturer)

We have been developing the method to make and observe rock thin-sections easily at a secondary school classroom. Our previous method is necessary to make some parts using a lathe-machine and employ metal processing skills. This process is quite challenging to realize in a standard school. Therefore, at this conference, we will present a new approach to promote the above purpose using plastic parts made by employing a 3D-printer as alternatives to metal parts, which is very popular in science rooms at secondary schools.

The base tools are not changed 1) Homemade rock saw employing a bench-grinder, 2) Homemade rock grinder based on a kitchen knife sharpener. 3) A standard binocular microscope + a homemade polarized unit

My updated methods are as follows; The plastic arbors as alternatives to metal arbors, which fix a diamond blade or a diamond plate on the motor rods, are made by a cheap 3D printer, Cleality Ender 3 Pro (250USD). Homemade polarized unit bodies (previously made of acrylic plates) for a standard microscope to use as a polarized microscope are similar. The bottom LED system for the USB microscope was also improved. The merit of such improvement using a 3D printer is that the 3D CAD data (.stl files) are freely distributable from our website. So, no other technical skills such as metalwork, which relies on special training and high-expensive tool, are needed, although some easy additional work is still necessary. For plastic printing, it is recommended to use filament like nylon or PET because they are strong under intense stress and/or water filling condition. However, we now use standard PLA filaments, cheap and widely used. There is no inconvenience on this use by this time.

One further trial is to use a kitchen knife sharpener as a rock-saw. We made a new arbor to hold a thin diamond blade on the knife sharpener's wet stone and try to use it as rock cutting instead of the bench-grinder-based tool. Because our previous developed rock-saw based on a bench-grinder has a fatal drawback of their structure; the water from the water tank is invaded to the inside through the motor rod and rusted the bearing; finally, the motor does not work. Our 3D printer also made this arbor used on the knife sharpener. Although the 3D CAD software (Autodesk Fusion 360) has the function of creating a screw trench coupled with the motor rod, the screw trench sometimes would not go well due to the thermal expansion. So, we need only some additional smooth tapping on this screw hole before use. In this new tool, the saw's clearance is not so broad, and the main motor of the knife sharpener has less torque and speed than a bench-grinder, so we can only cut a small tip by this saw. However, it is enough to make a small number of thin-sections, and this is suitable for geoscience club students to use in a classroom safely. The water-proof system works quite well. We can purchase the diamond blade (150mm diameter, 0.5mm thickness) from a Chinese net shop at around 4 USD, including the shipping cost!

Our making and observing methods are improving now based on our trial experience for a couple of years. The basic concept is to make it easier, use only cheap mass production tools, and avoid special skills and high-expensive tools. So the details of our plans are now available and updated on our website (http://www.yossi-okamoto.net/). The contents are written both in Japanese and English for school use in foreign countries. Our method was presented in the teacher share online meeting at KVIS-SIF2021

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(Thailand), one of the best Thai science highschools I already taught as a visiting teacher.

Keywords: thin-section, rock-saw, rock-grinder, polarized unit, geoscience education

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Development to teaching materials related to GIGA school

*Iida Kazuya[1]

1. Komaba-Toho Junior and Senior High School

According to the GIGA school plan, the infrastructure of each person's terminal and communication environment is about to be developed in the classroom. Since large-scale time and space scales are handled in the earth science fields of elementary, junior high and high schools, it is estimated from the results of the national academic ability survey that there is difficulty in learning due to the concept of space. In addition, many geological events have vast time and space scales, and unlike physics, chemistry, and biology, it is often difficult to conduct experiments in the classroom.
There are many apps on PCs and tablets that are excellent at grasping large-scale time and space scales (Google Map, Geographical Survey Map, etc.), and are compatible with earth science education. In addition, by using AR teaching materials, it is possible to capture the geological events in the field in a pseudo manner. In this presentation, we plan to report on the development of teaching materials and lesson practice using PCs and tablets for students.

Keywords: GIGA school plan, AR, development teaching material, GSI Maps, 3D printer

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The report of the International Earth Science Olympiad (IESO) ,2021

*Norihito Kawamura[1], Yutaka Takigami[2]

1. School of Regional Resource Management, University of Hyogo, 2. JESOC

We report outline and history of Earth Science Olympiad.

Keywords: IESO, high school student

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[J] Oral | G (General) | General

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo), Chairperson:Masatsune Hatakeyama(Seiko Gakuin High School), Yoshihiro Niwa(Center for Ocean Literacy and Education, Graduate School of Education, The University of Tokyo)

Sun. Jun 6, 2021 3:30 PM - 5:00 PM Ch.03 (Zoom Room 03)

We will provide and discuss various educational practices (teachings and procedures)
for elementary, junior high school, high school, and university students. We also welcome ONLINE education, fieldwork reports, and outreach reports for all grades.
Besides, especially for liberal arts level geoscience education of undergraduate,
we will consider the problems, such as online education, contents, and prospects of our current geoscience situation.
Furthermore, we will also think about fundamental teaching material development and
the sharing of teaching material data.

4:45 PM - 5:00 PM

[G03-12]Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.25 Zoom Room 25

[M-IS13] Dynamics of eruption cloud and cumulonimbus; modelling and observation

convener:Eiichi Sato(Meteorological Research Institute), Fukashi Maeno(Earthquake Research Institute, University of Tokyo), Takeshi Maesaka(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Eiichi Sato(Meteorological Research Institute)

Volcanic eruption clouds (eruption column, pyroclastic flow, and umbrella cloud) and cumulonimbus are similar phenomena in the atmosphere. Models that can precisely reproduce the physical processes in such phenomena, and accurate observations have been required. Recently, the development of remote sensing techniques such as weather radar and weather satellite are remarkable, and they are being adopted for volcanic eruption monitoring. However, it is indispensable to verify the results of modeling and remote sensing using in-situ observations. In this session, we will discuss the modelling and the observations of eruption clouds and cumulonimbus from the viewpoint of meteorology, volcanology, geology, and other related fields. The related phenomena such as ashfall, rainfall, snowfall, hail and volcanic block will also be discussed.

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

[MIS13-01] Radar Meteorological Study on Falling Volcaic Ash Particles

★Invited Papers

*Masayuki Maki[1] (1.Research and Education Center for Natural Hazards, Kagoshima University)

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

[MIS13-02] PUFF Model Prediction of Volcanic Ash Plume Dispersal for Sakurajima Using MP Radar Observation

*Hiroshi Tanaka[1], Haruhisa Nakamichi[2], Masato Iguchi[2] (1.Center for Computational Sciences, University of Tsukuba, 2.Sakurajima Volcano Research Center, DPRC, Kyoto University, Kagoshima)

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

[MIS13-03] Numerical simulation of wind flow around Sakurajima with eruption

*Takashi Maruyama[1], Masato Iguchi[1] (1.Disaster Prevention Research Institute, Kyoto University)

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

[MIS13-04] Highspeed image observation of ballistic projectiles at Sakurajima volcano and a numerical model of ballistics

*Kae Tsunematsu[1], Saruta Shusaku[1], Taishi Yamada[2], Masato Iguchi[2] (1.Yamagata University, 2.Kyoto University)

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

[MIS13-05] Pattern classification of parent clouds of tornadoes in Tosa Bay

*Koji Sassa[1], Kotarou Fujii[2] (1.Natural Science Cluster, Kochi University, 2.Graduate School of Integrated Arts and Sciences, Kochi University)

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

[MIS13-06] Cloud-Scientific Study of Volcano Eruption -perspective-

★Invited Papers

*Yasushi Fujiyoshi[1] (1.Emeritus Prof. of Hokkaido University)

Radar Meteorological Study on Falling Volcaic Ash Particles

*Masayuki Maki[1]

1. Research and Education Center for Natural Hazards, Kagoshima University

In the present study, we describe fundamental characteristics of falling volcanic ash particles such as the particle size distribution, fall velocity, shape, et al. from the radar meteorological view point. Because it is beneficial for the weather radar monitoring of ash fall to identify similarities and differences between rain drops and ash particles, we present the results of analyses of the rain drop data collected by two-dimensional video disdrometers, As for the volcanic ash particles, we presented the results of Maki et al. (2021) who analyzed the particle size distribution (PSD) of falling volcanic ash particles measured using optical disdrometers during six explosive eruptions of the Sakurajima volcano in Kagoshima Prefecture, Japan. We found that PSD for both rain drops and ash particles could be expressed by the gamma distribution, $N(D) = N_0 D^{\mu} \exp(-\Lambda D)$, where $N(D)$ is the particle size distribution, D is the particle diameter, N_0 is the intercept parameter, Λ is the slope parameter, and μ is the shape parameter. The relationships between each of the gamma PSD parameters were shown to be a characteristic of falling volcanic ash particles. The strong correlation between R_A/N_w and D_m suggests that the normalized intercept parameter N_w and mass-weighted mean diameter D_m are suitable for estimating the ash fall rate R_A. We also derived empirical power law relationships between pairs of integrated PSD parameters: R_A, the volcanic ash mass concentration C_A, the reflectivity factor Z, and the total number of the ash particles per unit volume N_T. The results of the present study provide essential information for studying microphysical processes in volcanic ash clouds, for developing a method for quantitative ash fall estimation using weather radar, and for improving ash transport and sedimentation models.

Keywords: particle size distribution, disdrometer, polarimetric radar parameters

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PUFF Model Prediction of Volcanic Ash Plume Dispersal for Sakurajima Using MP Radar Observation

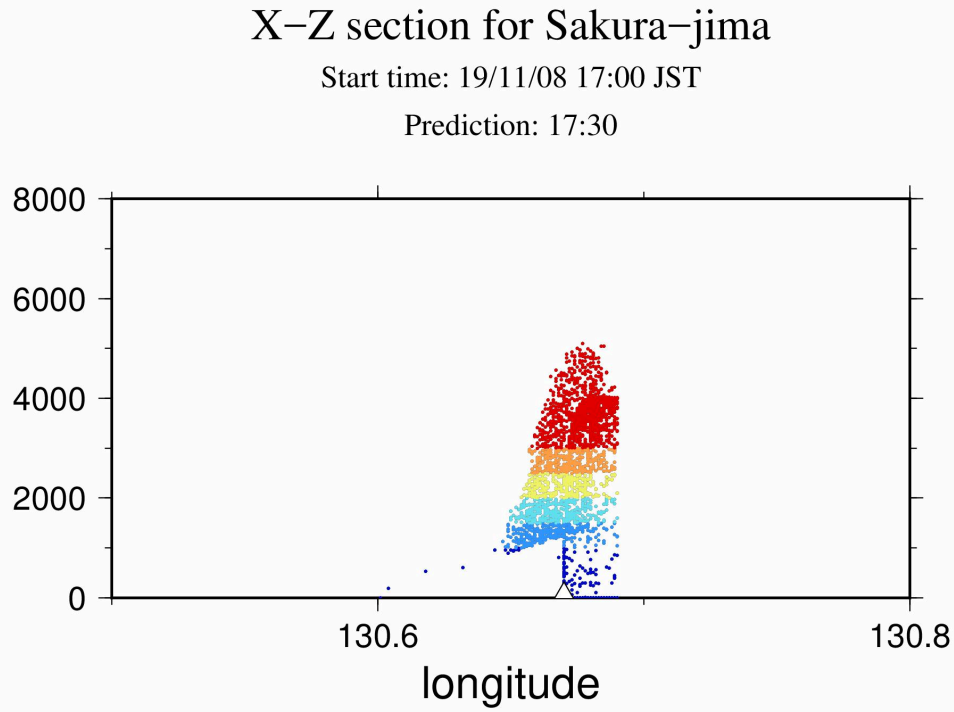
*Hiroshi Tanaka[1], Haruhisa Nakamichi[2], Masato Iguchi[2]

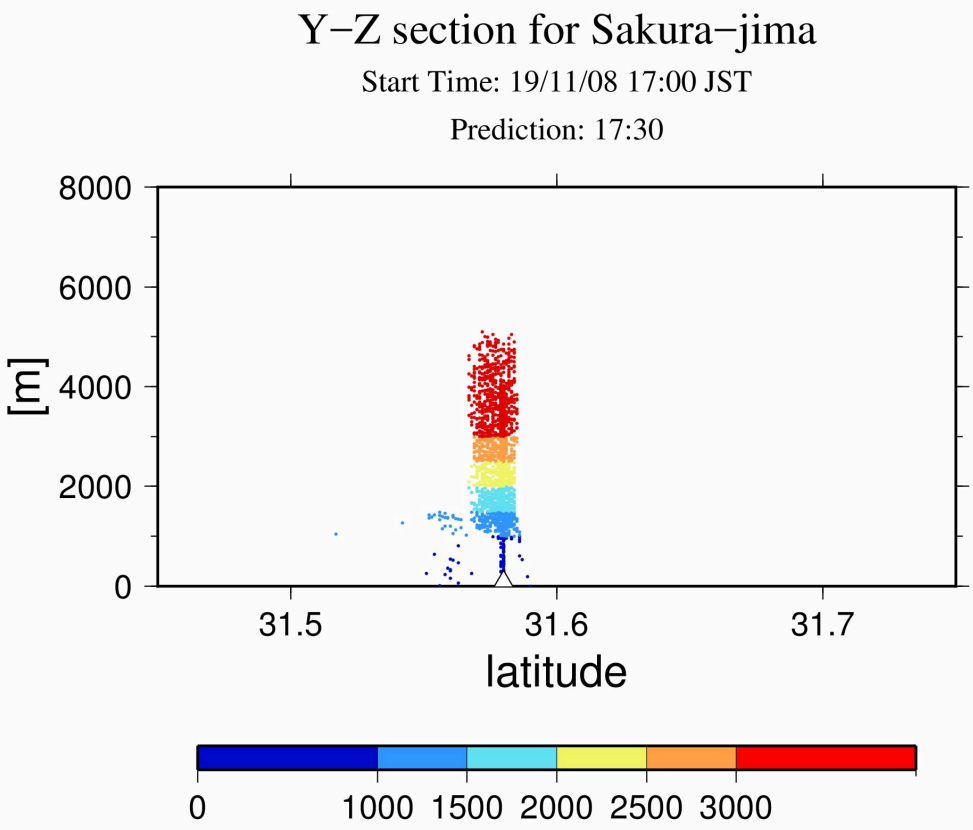
1. Center for Computational Sciences, University of Tsukuba, 2. Sakurajima Volcano Research Center, DPRC, Kyoto University, Kagoshima

In this study, a real-time volcanic ash plume prediction by the PUFF system was applied to the Sakurajima volcano (which erupted at 17:24 Japan Standard Time (JST) on 8 November, 2019), using the direct observation of the multi-parameter (MP) radar data installed at the Sakurajima Volcano Research Center. The MP radar showed a plume height of 5500 m a.s.l. around the volcano. The height was higher than the 4000 m by the PUFF system, but was lower than the observational report of 6500 m by the Japan Meteorological Agency in Kagoshima. In this study, ash particles by the MP radar observation were assimilated to the running PUFF system operated by the real-time emission rate and plume height, since the radar provides accurate plume height. According to the simulation results, the model prediction has been improved in the shape of the ash cloud with accurate plume top by the new MP radar observation. The plume top is corrected from 4000 m to 5500 m a.s.l., and the three-dimensional (3D) ash dispersal agrees with the observation. It was demonstrated by this study that the direct observation of MP radar obviously improved the model prediction, and enhanced the reliability of the prediction model.

Keywords: ash dispersion, Sakurajima volcano, data assimilation

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Numerical simulation of wind flow around Sakurajima with eruption

*Takashi Maruyama[1], Masato Iguchi[1]

1. Disaster Prevention Research Institute, Kyoto University

1. Introduction
Volcanic eruption products such as ash, ciders, hazardous gas and so on sometimes cause disasters. Volcanic ash harms crops, traffics, transportations, human health and so on. Flying ciders, lapilli and volcanic blocks often cause loss of lives and structures so as the eruption of Mt. Ontake in September 2014 causing 63 deaths and missing persons [1]. Accurate prediction of the product’ s distribution is necessary for prevention and mitigation of the disaster. The distribution of flying products is affected by the air flow around the volcano, therefore the prediction of the flow field is essential for the prevention and mitigation of the volcanic disasters.
The trajectory of the volcanic smoke, ash and the flying product is directly affected by the wind flow, resulting in a distribution of the density of eruption products. The flow field around the volcano varies with the meteorological condition, the topography and the surface roughness. And fluctuation of the flow affects the distribution of the density.
2. Outline of Calculation
We designed a numerical simulation of wind flow around Sakurajima Volcano. The large eddy simulation using the Smagorinsky model was used for calculating the turbulent flow fields. The spatial averaging was conducted to the governing equation of the fluid and the effect of drag caused by the surface roughness such as plants and the buildings are added to the governing equations as a canopy model [2]. The curvilinear coordinate system was used for generating the topography. The meteorological condition was introduced as an inflow condition with wind velocity and temperature field obtained from the mesoscale numerical weather prediction model WRF. The eruption was expressed as a blowout of hot air and the effect of buoyancy was introduced by Boussinesq approximation. The volcanic ash was calculated as a diffusion of scalar density.
3. Calculated Results
Turbulent wind flow around Sakurajima volcano with eruption was simulated. The distribution of plants and buildings on the ground surface was obtained from the GIS data base and field survey. Space-time variation of wind velocity, temperature and ash density was obtained as shown in Figure 1.
4. Conclusions
Numerical method of turbulent flow field around a volcano with eruption was presented. The effect of surface roughness, topography, meteorological condition and eruption was reflected to the simulated turbulent wind fields.
Reference
1. Oikawa, T.; Yamaoka, K.; Yoshimoto, M.; Nakada, S.; Takeshita, Y.; Maeno, F.; Ishizuka, Y.; Komori, J.; Shimano, T.; Nakano, S. The 2014 Eruption of Ontake Volcano, Central Japan. Volcanol. Soc. Japan 2015, 60, 411–415.
2. Maruyama, T. (2008). Large eddy simulation of turbulent flow around a windbreak. Journal of Wind Engineering and Industrial Aerodynamics 96, 1998–2006.
Acknowledgments: This research was funded by Integrated Program for Next Generation Volcano Research and Human Resource Development・Issue D: Development of volcanic disaster countermeasure technology・Sub-theme 2: “Development of real-time volcanic ash hazard evaluation method”.

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Keywords: numerical simulation, wind flow, eruption, Sakurajima

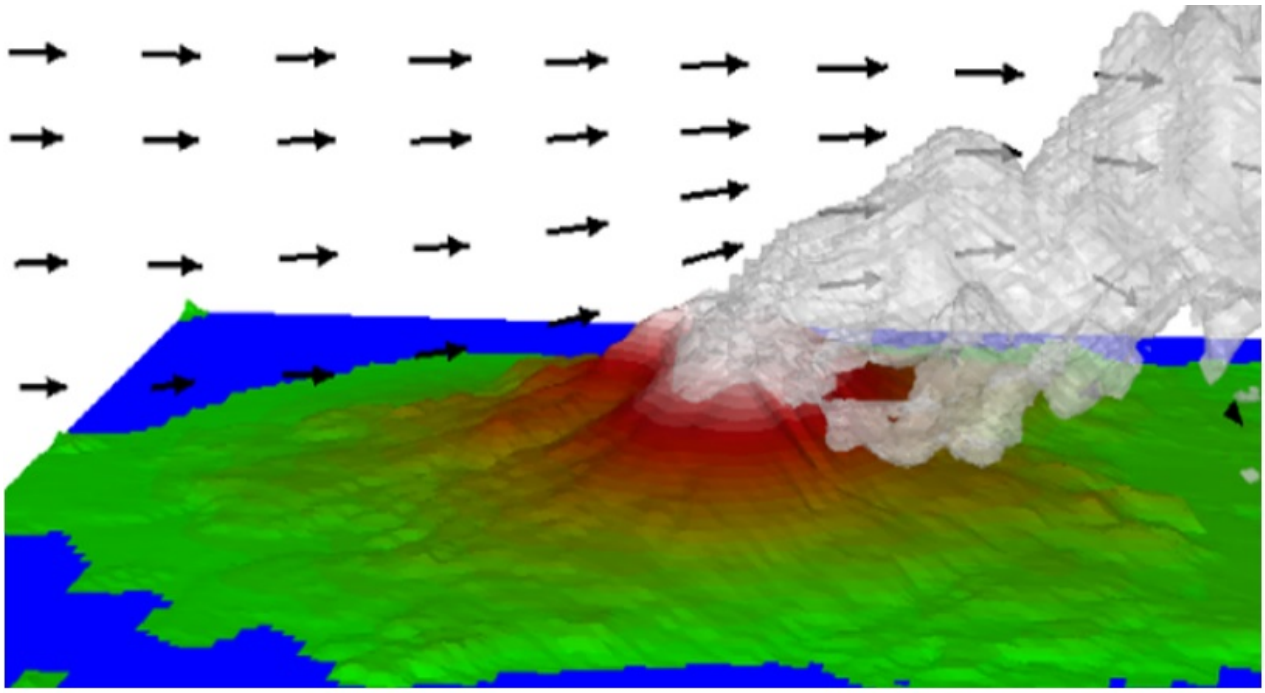


Fig. 1 Simulated diffusion of volcanic ash in the neutral wind condition

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Highspeed image observation of ballistic projectiles at Sakurajima volcano and a numerical model of ballistics

*Kae Tsunematsu[1], Saruta Shusaku[1], Taishi Yamada[2], Masato Iguchi[2]

1. Yamagata University, 2. Kyoto University

Sakurajima is one of the most active volcanoes in Japan and in the world, erupting explosively. Vulcanian eruptions are the most frequent eruption type in Sakurajima, and ballistic blocks are often ejected during vulcanian eruptions. In Sakurajima, a ballistic block ejected during the eruption on June 4, 2020 and it landed in the resident area called “Yuno”, 3.4 km from the vent. This was an exceptional event that a block traveled so long distance (longer than 2.5 km) after the block landed also in the Yuno area in 1987. The impact crater due to the ballistic block was six meters in diameter. Moreover, near the block landing location, another block penetrated the roof of the hut. Thus, people living near the volcano have risks being hit by blocks, and it is important for assessing ballistic hazards using numerical models.

Recently, numerical models of ballistics were suggested by Tsunematsu et al. (2016), Biass et al. (2016) and Bertin (2017), while the models cannot express some characteristics of ballistic transport. Especially, the model consists mainly of gravity and air drag terms, but some phenomena, such as that larger particles travel shorter distance than smaller particles, are not reproduced by these models. It is necessary to elucidate another force by observations of experiments or real eruptions. In fact, based on the hypothesis that the ejection of ballistic projectiles is affected by the gas flow near the vent, we carried out experiments. However, we could not verify our hypothesis. Therefore, we have observed the vulcanian eruption in Sakurajima volcano and a numerical simulation result using a model Ballista (Tsunematsu et al., 2016) is compared with the block trajectories.

Campaign observation was carried out on Mt. Harutayama in Sakurajima from January 25 to January 29, 2021 using two highspeed cameras installed on a roof terrace of the Harutayama branch of Sakurajima Volcano Research Center. Mt. Harutayama is located approximately 2.7 km from the Sakurajima active vent “A” and “B”. One highspeed camera is for a monochrome shooting with an 800 mm zoom lens and another is for a color shooting with a 135 mm zoom lens.

During the campaign observation, the weather was sometimes unstable and sometimes the Harutayama region was covered by the ash clouds due to the Sakurajima continuous ash ejection. We successfully shoot an explosion at 16:48 (JST) on January 28. A seismic monitor showed the explosion waves, and the switch was turned on at the same time as the sound of the explosion. Although the color highspeed camera did not record any block as the magnification of this camera was not enough, the monochrome camera recorded seven blocks traveling in the air.
The vertical speed of these blocks was ~10 to 50 m/s, which was much smaller than the ejection speed recorded during the Strombolian eruptions (Taddeucci et al., 2017). As the crater wall around the vent A and B was ~400 m higher than the bottom of the craters, the blocks travelled this vertical interval. The smaller velocity was probably due to the velocity decay during the travel of this height difference. In our presentation, we would like to present the result of the image analysis of the explosion and discuss the ballistic transport mechanism based on the comparison of these result with simulated trajectories.

Keywords: Ballistic projectiles, Explosive eruptions, Sakurajima volcano, Numerical models

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Pattern classification of parent clouds of tornadoes in Tosa Bay

*Koji Sassa[1], Kotarou Fujii[2]

1. Natural Science Cluster, Kochi University, 2. Graduate School of Integrated Arts and Sciences, Kochi University

The coast line of Tosa Bay in Kochi Prefecture is one of the area where tornadoes frequently occur. We have continuously made the radar observation with the radar network composed of six compact polarimetric radars of Kochi University. Most of parent clouds of tornadoes reported by JMA Kochi observatory were captured by our radars from 2014 to 2020. The present study aims to classify the parent clouds of tornadoes and to clarify their characteristics. Our final goal is the establishment of warning system automatically detecting the parent clouds with machine learning.
From the results of analysis, we found that the parent clouds could be classified to following 5 patterns; supercell, wavy cloud, cloud cluster, squall line and isolated cell. Fig.1 shows the example of supercell. The mesocyclone is shown in the southwest end of the high intensity echo region. Fig. 2 shows the example of wavy clouds appeared far away from the typhoon. The vortex is shown in the southwest end of the southern system. The example of cloud cluster composed of small cumulonimbi is shown in Fig.3 The moving velocity of the system was quite slow. Fig.4 shows the example of squall line. The moving direction was east and it has large angle with respect to the direction of the system. The example the one of the isolated cells passing through the radar was the parent cloud of a tornado is shown in Fig.5. The hook echo which shows the existence of a tornado vortex is clearly observed in the east end of the isolated cell, though its horizontal scale is small about 10 km in length.
The majority was the isolated cell. 11 cases were found to be it. The length of the isolated cells was less than 10 km in most cases. The length of the other systems exceeded 20km, but the width of wavy cloud and squall line was about 5km. The moving velocity of the supercell, wavy cloud and squall line was larger than the other systems. And we also found that the vortex located in the rear side of most of the parent clouds.
In the present study, we will discuss about the temporal change of the parent clouds.

Keywords: Radar observation, Tornado, Parent cloud

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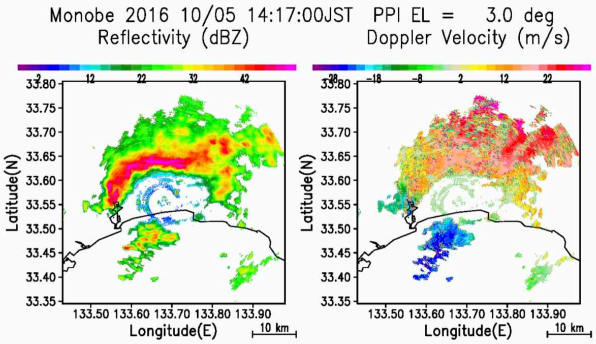


Fig.1 Example of supercell

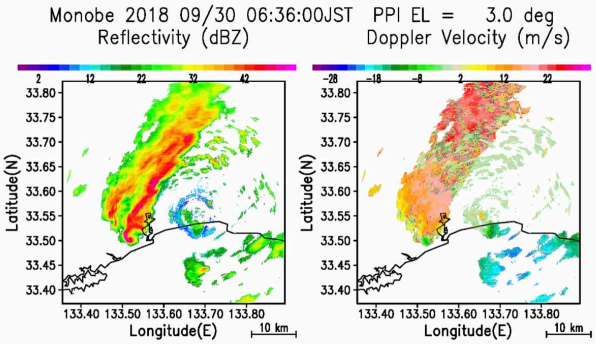


Fig.2 Example of wavy cloud

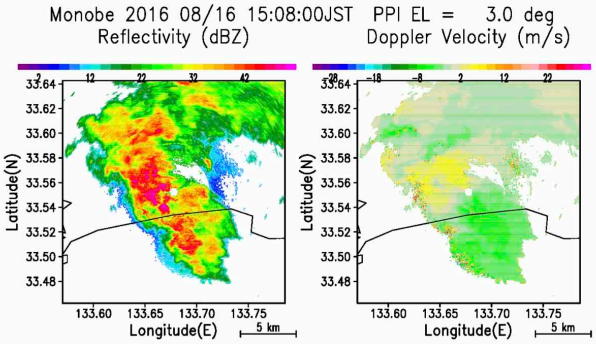


Fig.3 Example of cloud cluster

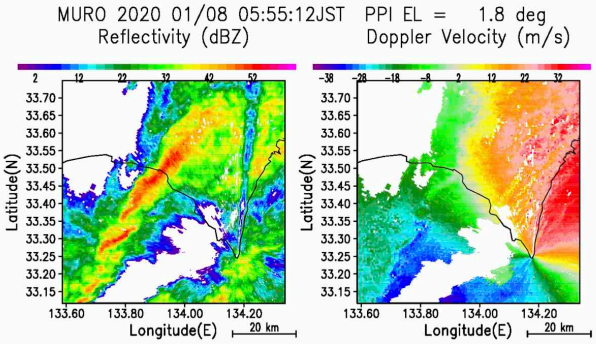


Fig.4 Example of squall line

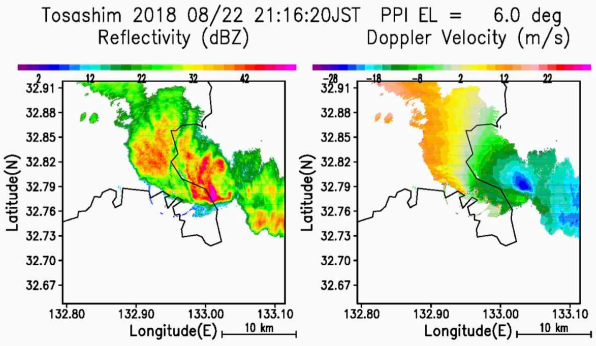


Fig.5 Example of isolated cell

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Cloud-Scientific Study of Volcano Eruption -perspective-

*Yasushi Fujiyoshi[1]

1. Emeritus Prof. of Hokkaido University

This presentation aims to emphasize how cooperative observation and modeling of volcanic eruption clouds will result in mutual benefit.

Many numerical models can simulate atmospheric convective clouds if initial and environmental conditions (CCN, IN, vertical profiles of temperature, humidity, and winds, etc.) are given. However, it is almost impossible to observe these conditions, because natural clouds develop sporadically, move fast, and change rapidly. Indeed, strictly speaking, there are no numerical models verified by field observations. If we know where a cloud develops, we will be able to verify and improve the formula and parameters assumed in these cloud models.

Volcanic eruption clouds, on the other hand, develop at the same place. Therefore, observation of volcanic eruption clouds has the potential to validate numerical models. For example, using marine radars, we succeeded in estimating the high-temporal (2 sec.) and spatial (5 m) change of height, volume, and ascending speed of Sakurajima volcanic clouds (Maki et al., 2020). These data will be useful to study the dynamics of convection in the air. We also observed a small rain cloud originated from the volcanic eruption (Fig. 1). A small eruption occurred at 09:46 JST on 18 Sep. 2019, and the ash cloud reached 1800 m a.s.l.. A small cloud (condensation) began to develop at 9:50 JST, precipitation occurred at 09:51 JST, and raindrops reached the ground surface at 09:55 JST. These high-temporal and spatial data are also useful to validate microphysical processes used in cloud models.

On 5 Nov. 2019, rising volcanic ash began to fall rapidly (Fig. 2). A small eruption occurred at 12:41 JST, and the ash cloud reached 1900 m a.s.l.. The radar echo indicates that the ash cloud began to dissipate in its middle part at 12:45 JST. The lower part of the ash cloud went down to the ground very fast like a downburst. The upper air sounding data suggests that this downburst-like phenomenon was caused by dry air intrusion at the middle part level. This case clearly shows that vertical atmospheric stratification strongly affects volcanic ash transport and dispersion. We also compared electric potential gradient changes with the temporal change of radar echoes of eruption clouds. These surface and in-situ data will be useful to study the charging, charge separation, and lightning mechanisms of volcanic clouds as well as the electrification of natural clouds.

Modeling eruption clouds is challenging for meteorological researchers, although almost the same physical processes are involved both in eruption clouds and atmospheric clouds. For example, turbulence and updraft within eruption clouds are much stronger than those in atmospheric clouds. Components within eruption clouds are more complicated than those in atmospheric clouds. A larger size range of particles is included in eruption clouds than those in atmospheric clouds. Vertical profiles of temperature and updraft within eruption clouds are opposite to those within atmospheric clouds. Some volcanic ejecta is formed by fragmentation and solidification of liquid state lava. On the other hand, raindrops (liquid) are formed by melting and fragmenting snow particles (solid-state). Figure 3 shows 2DVD (2-Dimensional Video Distrometer) images of melting snow particles. It is quite interesting that these melting particles have almost the same shape as those of volcanic bombs (aggregates, spindle-shaped, ribbon-shaped, Peles’ s tear, etc.).

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Reference
Maki, M., et al., 2020: Monitoring of Sakurajima Volcanic Eruption Columns with Marine Radar - Results of Observations in 2018 -, *Disaster Prevention Research Institute Annuals. B*, 2020, 63.B: 136-148.

Keywords: cloud science, volcanic eruption

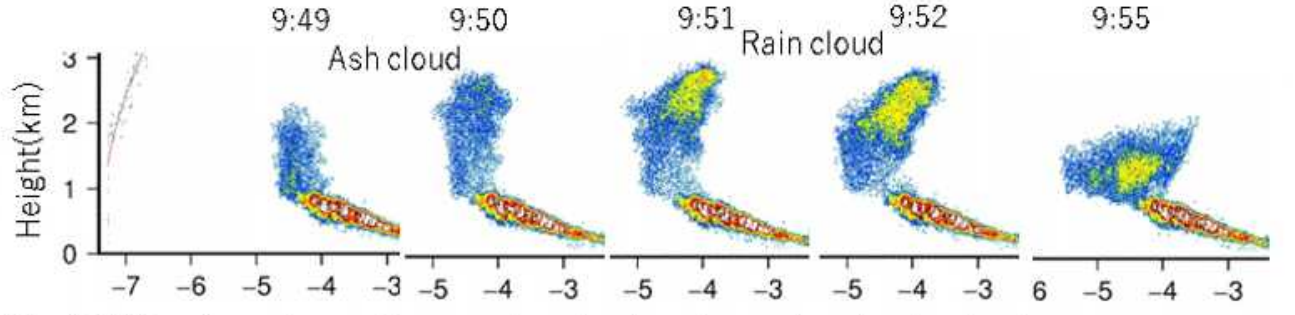


Fig.1 RHI radar echoes of an erupion cloud and associated rain cloud.

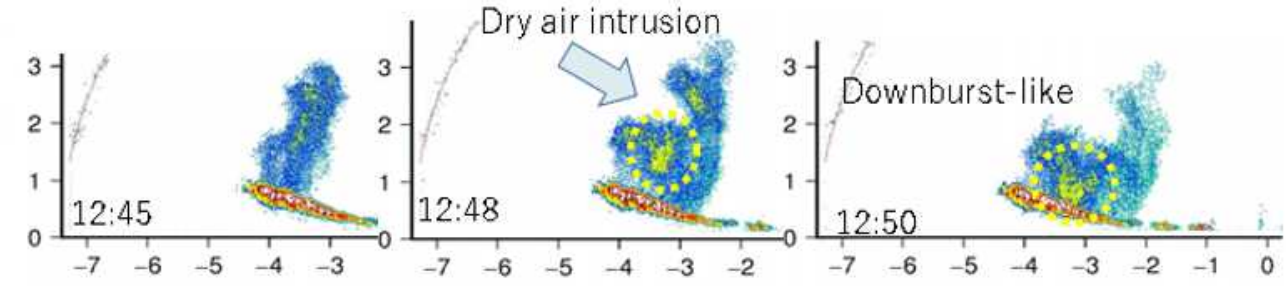


Fig. 2 RHI radar echoes of an ash cloud and associated downburst-like phenomenon.

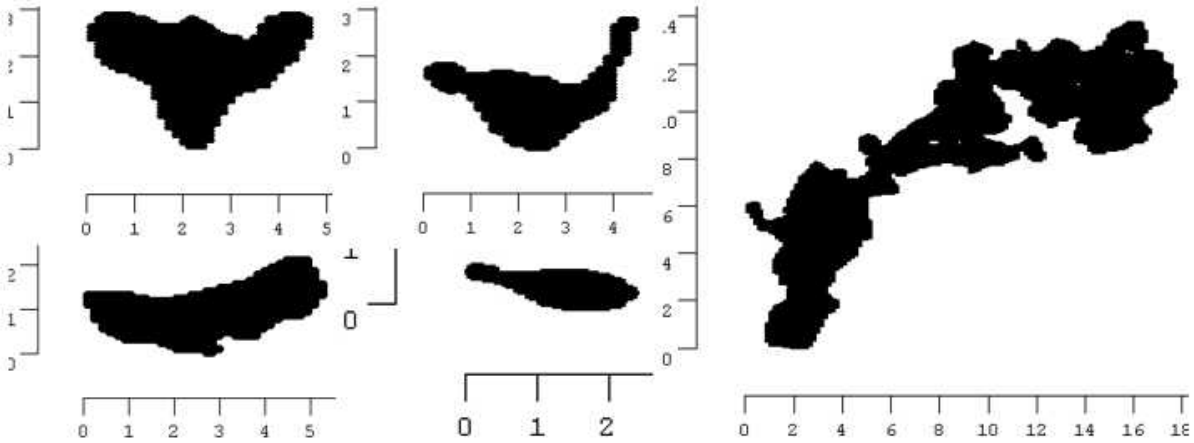


Fig. 3 2DVD-images of melting snow particles observed at Sapporo, Japan.

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.17 Zoom Room 17

[M-IS15] Tsunami deposit: research progress after the 2011 Tohoku-oki earthquake and prospects

convener:Masaki Yamada(Department of Geology, Faculty of Science, Shinshu University), Takashi Ishizawa(International Research Institute of Disaster Science, Tohoku University), Masashi Watanabe(Chuo University), Koichiro Tanigawa(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Masaki Yamada(Department of Geology, Faculty of Science, Shinshu University), Takashi Ishizawa(International Research Institute of Disaster Science, Tohoku University)

The 2011 off the Pacific coast of Tohoku Earthquake and associated tsunami have an influence on the development of tsunami deposit research. After the tsunami, a lot of findings have been reported in various research fields. However, it has been still uncertain how to use the tsunami deposit to estimate its size and source and the risk assessment. As it commemorates the 10th anniversary of the 2011 off the Pacific coast of Tohoku Earthquake, we would like to review research progress over the past decade and share in the vision of future researches. In this session, we welcome research from all aspects of sedimentary records of modern and paleo tsunamis and numerical and experimental modeling studies for risk assessment. We also include research on other event deposits, such as river floodings and storm surges, that they are considered important for identification of tsunami deposits in geological strata.

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

[MIS15-01] Sedimentation and erosion by the 2011 Tohoku-oki tsunami

★Invited Papers

*Kazuhisa Goto[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

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

[MIS15-02] How much we had understood a history of giant earthquakes along the Japan trench -progress and remaining problems-

★Invited Papers

*Yuki Sawai[1] (1.Geological Survey of Japan, AIST)

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

[MIS15-03] Advances in tsunami numerical modeling after the 2011 Tohoku earthquake and future challenges related to tsunami deposit research

★Invited Papers

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

Sedimentation and erosion by the 2011 Tohoku-oki tsunami

*Kazuhisa Goto[1]

1. Department of Earth and Planetary Science, The University of Tokyo

Sedimentation and erosion by the 2011 Tohoku-oki tsunami were investigated from various aspects not only by sedimentological and micropaleontological ways but also by geochemical and agricultural approaches. Since the possible predecessors including the AD869 Jogan event were well studied before the event, it was also possible to test the validity of the pre-event paleotsunami researches that had been done along the Pacific coast of Tohoku. Also, numerous data about tsunami such as flow depth and inundation area obtained by the efforts of tsunami researchers provided us a rare opportunity to quantitatively compare the tsunami deposit characteristics with flow dynamics. In these points, paleotsunami research after the 2011 Tohoku-oki event has drastically been changed both in its quality and quantity. Then, what did we actually learn from the 2011 Tohoku-oki event and how such knowledge has been incorporated in the paleotsunami research?

Lessons learned from the 2011 Tohoku-oki event can be classified into expected and unexpected results. For instance, sedimentary features such as grading and lamination and distribution pattern as well as the sedimentary process were more or less reasonable based on the pre-2011 knowledge since they are similar to those of other modern tsunami deposits formed by, e.g., the 2004 Indian Ocean tsunami. Also, sedimentary characteristics of the 2011 tsunami deposits were remarkably similar to that formed by paleotsunamis in this region so that identification procedures used in the pre-2011 paleotsunami researches can be evaluated as valid. As expected, diverse size of sedimentary grains from mud to meter-long boulders were transported depending on the sediment source and size of local tsunami. Considering the fact that over thousand tons of huge blocks were transported by the 2011 tsunami, even few thousand tons of enigmatic boulders reported in the world might be explained by large, but not extremely large, tsunami similar to the 2011 one.

On the other hand, some survey results were somewhat beyond the common knowledge of paleotsunami research at that time. For example, sandy deposits were not necessarily distributed up to the maximum tsunami inundation limit so that estimation of earthquake magnitude from paleotsunami research might have been underestimated. While, muddy deposits or geochemical signature, which had been generally overlooked, were important to appropriately estimate the inundation area from the deposits. Also, tsunami deposits were not necessarily of marine source so that absence of marine microfossils does not indicate the event deposit is not formed by the tsunami. These results commonly indicate that paleotsunami research before the 2011 Tohoku-oki event had a chance of underestimation for the estimation of recurrence interval and tsunami/earthquake size.

Now, ten years since the 2011 event, identification of tsunami deposit and its usage to understand paleotsunami events have been under improvement. Paleotsunami research should expand its research field to overcome the remaining difficulties. For example, scarce of modern examples of other water-related event deposits such as flood or storm deposits prevent us to understand the identification criteria of tsunami deposits. Also, technical improvements and reconsideration of research scheme might be essential for efficient, high-accuracy, and high-resolution estimation of paleotsunami recurrence interval and size.

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How much we had understood a history of giant earthquakes along the Japan trench -progress and remaining problems-

*Yuki Sawai[1]

1. Geological Survey of Japan, AIST

The 2011 Tohoku earthquake disaster was broadcasted as “unexpected disaster” by non-geologists but also surprised them because it had been not well known that geologists had previously studied geological evidence for 869 Jogan earthquake and tsunami: a potential predecessor of the 2011 event.

The Jogan tsunami deposit was first reported in Sendai by Abe et al. (1990 Zishin) and Minoura and Nakaya (1991 J. Geol.). Sugawara et al. (2001 Research Report of Tsunami Engineering) later found a similar sand deposit in Soma, Fukushima prefecture. Building on their research, research groups of Geological Survey of Japan, AIST traced the Jogan sandy deposits using several hundred cores along leveled transects in Sendai, Ishinomaki, and Minami-Soma regions. On the basis of such geological records, the source of the Jogan tsunami was examined by comparison between simulated inundation areas and the observed extent of Jogan tsunami deposits (Namegaya et al., 2010 AFRC reports; Satake et al., 2008b AFRC reports). These results had been submitted to the Japanese government, but they were not employed by governmental assessments of subduction zone earthquakes until the 2011 Tohoku earthquake.

After the 2011 disaster, many researchers began to study tsunami geology along the Tohoku coast to extend tsunami history in millennium time scale. In Iwate and Aomori prefectures, they identified Jogan tsunami deposits as well as historical (Goto et al. 2015 Mar. Geol.) and prehistoric (Tanigawa et al. 2014 JQS) tsunami deposits. Also, a tsunami of 1454 in the Sendai plain was reexamined on the basis of historical documents (Namegaya and Yata, 2014 Zishin) and stratigraphic and geomorphological evidence (Sawai et al., 2015 GRL).

In the last two decades, tsunami geology has developed along the Pacific coast of Tohoku region, but there still remain issues that should be tackled. For example, the moment magnitude of the Jogan earthquake may have been greater than the present model proposed by Namegaya and Satake (2014 GRL). They constrained their fault parameters using distributions of tsunami deposits at multiple sites along the trench, but the modeled fault may be extended farther north or south if the recent geological data were involved. Also, a parent earthquake is still unknown for a tsunami deposit in 17th-century along the Pacific coast of Aomori prefecture (Tanigawa et al. 2014 JQS). These problems may be solved by future comprehensive research.
This presentation is based on description in Sawai (2020 ESR).

Keywords: subduction zone great earthquakes, tsunami deposit, Japan trench

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Advances in tsunami numerical modeling after the 2011 Tohoku earthquake and future challenges related to tsunami deposit research

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1. International Research Institute of Disaster Science, Tohoku University

Tsunami numerical modeling, such as source modeling and hazard assessment, has been playing a crucial role in policy making and consensus building for disaster mitigation actions. While the 2011 Tohoku-oki earthquake tsunami brought unexpected disasters, it also left valuable lessons for improving tsunami numerical modeling. Since tsunamis cause not only surges and inundations of the seawater, but also induced phenomena such as sediment erosion and deposition, debris drift and structural damage, development of multi-physics model is a key challenge, in terms of improved hazard assessment. Verification and validation of such multi-physics models have been promoted with aids from the groundbreaking data of the Tohoku-oki earthquake and tsunami.

Tsunami numerical modeling has been used to estimate the source of past disastrous tsunamis by bridging the findings from different disciplines, such as seismology, geodesy, geology, geomorphology, ecology, coastal engineering, archaeology and history. An established approach is comparison of the spatial distribution of tsunami deposits, such as sand layers and boulders, and simulated tsunami inundation area. Although gaps between sediment distribution and inundation limit are a well-known concern, source models of paleotsunami events, such as the 869 Jogan earthquake tsunami in the Tohoku region, have been deduced based on such comparisons. Upgrading the ability of the source modeling is expected with aids from the sediment transport simulations. Numerical modeling of tsunami-induced sediment transport and morphological change due to the Tohoku-oki tsunami have been providing physical explanations for geological and geomorphological features of sandy tsunami deposits in Sendai Bay and Sanriku Coast. It encourages application of the tsunami sediment transport modeling to paleotsunami researches. A recent case study of the 1867 Keelung tsunami in the northern Taiwan demonstrated that the tsunami sediment transport modeling benefit interpreting sparse historical and geological records of the tsunami and estimating the mechanism and size of the tsunamigenic earthquake.

A key challenge of tsunami numerical modeling is quantification and reduction of uncertainty. Various factors are involving in the uncertainty in tsunami numerical modeling, such as inputs, formulations and model parameters. With regard to the modeling of paleotsunami deposits, the uncertainty due to inputs include the vegetation, sediment source and grain-size composition and sea level, in addition to the bathymetry and topography at that time. A numerical experiment showed that simulated thickness and inland extent of onshore sandy tsunami deposits may be several times larger or smaller, depending on the assumptions of the height of coastal sand dunes. A systematic framework to quantify the uncertainty is needed for further utilization of tsunami numerical modeling. The quantification of uncertainty provides the range of variability of the outputs, which is beneficial when comparing the simulations with sedimentary data. Efforts to collect contextual data, such as long-term change in coastal environment, annual and seasonal variation of beach topography and anthropogenic land modification, in addition to

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reconstructed paleo-topographic and bathymetric data, will be needed to reduce the uncertainty in numerical modeling of paleotsunamis.

Keywords: source modeling, sediment transport modeling, uncertainty

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.17 Zoom Room 17

[M-IS15] Tsunami deposit: research progress after the 2011 Tohoku-oki earthquake and prospects

convener:Masaki Yamada(Department of Geology, Faculty of Science, Shinshu University), Takashi Ishizawa(International Research Institute of Disaster Science, Tohoku University), Masashi Watanabe(Chuo University), Koichiro Tanigawa(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Masashi Watanabe(Chuo University), Koichiro Tanigawa(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

The 2011 off the Pacific coast of Tohoku Earthquake and associated tsunami have an influence on the development of tsunami deposit research. After the tsunami, a lot of findings have been reported in various research fields. However, it has been still uncertain how to use the tsunami deposit to estimate its size and source and the risk assessment. As it commemorates the 10th anniversary of the 2011 off the Pacific coast of Tohoku Earthquake, we would like to review research progress over the past decade and share in the vision of future researches. In this session, we welcome research from all aspects of sedimentary records of modern and paleo tsunamis and numerical and experimental modeling studies for risk assessment. We also include research on other event deposits, such as river floodings and storm surges, that they are considered important for identification of tsunami deposits in geological strata.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MIS15-04] **Application of DNN inverse model to large scale tsunamis to reconstruct the flow conditions of modern and ancient tsunamis**

★Invited Papers

*Rimali Mitra[1], Hajime Naruse[1], Tomoya Abe[2], Shigehiro Fujino[3], Daisuke Sugawara[4] (1.Kyoto University, Graduate School of Science, 2.Research Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 3.University of Tsukuba, 4.Tohoku University, IRIDeS)

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

[MIS15-05] Analysis of the Response of Tsunami Sediment Transport Numerical Simulation to Parameter Uncertainty

*Hidetoshi Masuda[1], Daisuke Sugawara[2], Shuro Yoshikawa[3], Hideyuki Sakurai[3], Fumihiko Imamura[2] (1.Division of Geoenviromental Science, Faculty of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Institute of Technology, Shimizu Corporation)

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

[MIS15-06] Event deposits in Lake Jusan, western part of Aomori Prefecture, NE Japan

*Fumika Hirano[1], Atsushi Urabe[2] (1.Faculty of Science, Niigata University, 2.Research Institute for Natural Hazards and Disaster Recovery, Niigata University)

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

[MIS15-07] Features of 17th-century tsunami deposits formed by tsunami crossing river channel and detection using X-ray computed tomography

*Kohei Iwaki[1], Yasuhiro Takashimizu[2], Yuichi Nishimura[3], Takashi Chiba[4] (1.Graduate School of Science and Technology, Niigata University, 2.Mathematical and Natural Sciences, Institute of Humanities, Social Sciences and Education, Niigata University, 3.Graduate School of Science, Hokkaido University, 4.Faculty of Bioresource Sciences, Akita Prefectural University)

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

[MIS15-08] Identification of invisible tsunami deposits formed by the 2011 Tohoku-oki tsunami

*Tetsuya Shinozaki[1], Yuki Sawai[1], Dan Matsumoto[1], Koichiro Tanigawa[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

Application of DNN inverse model to large scale tsunamis to reconstruct the flow conditions of modern and ancient tsunamis

*Rimali Mitra[1], Hajime Naruse[1], Tomoya Abe[2], Shigehiro Fujino[3], Daisuke Sugawara[4]

1. Kyoto University, Graduate School of Science, 2. Research Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 3. University of Tsukuba, 4. Tohoku University, IRIDeS

The 2011 Tohoku-oki tsunami and 2004 Indian Ocean tsunami caused significant economic losses and fatalities in the coastal areas. These modern tsunamis could be traced back and linked to the ancient tsunamis such as 869 Jogan tsunami as a precursor for 2011 Tohoku-oki tsunami. The Deep Neural network (DNN) 1D inverse model has the potential to predict the values of hydraulic conditions such as maximum inundation distance, flow velocity and maximum flow depth, sediment concentration of different grain-size classes using the thickness and grain-size distribution of the tsunami deposit from the post-tsunami survey around Sendai plain and other locations. The DNN model incorporates the forward model, which was based on non-uniform, unsteady transport of suspended sediments during turbulent mixing. The forward model employs iterative random flow conditions as boundary conditions to produce artificial training data sets which represent depositional characteristics, such as, thickness and grain-size distribution. Then the DNN was trained to find relationships between simulation results and initial conditions using the artificial output datasets of forward model. Finally, the DNN model was applied to natural field data sets from different locations. The quantification of uncertainty of the model predicted results was also reported using the jackknife method. The model successfully reconstructed the flow conditions of 2011 Tohoku-oki tsunami from Sendai plain and Joban coast, 2004 Indian Ocean tsunami from Phra Thong island, Thailand and 869 Jogan tsunami from Sendai plain. The estimated of values maximum inundation distance flow velocity, maximum flow depth were reasonable and close to the measured or reported values from the study area. Despite having topographical complicacy and lesser sampling locations for ancient deposits, the DNN model have the potential to predict the flow characteristics from the deposits satisfactorily. These qualitative and quantitative estimations demonstrated that the DNN inverse model is a potential tool for evaluating tsunami hazard and mitigation strategies.

Keywords: Tsunami Deposit, DNN inverse model, Machine learning

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Analysis of the Response of Tsunami Sediment Transport Numerical Simulation to Parameter Uncertainty

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1. Division of Geoenviromental Science, Faculty of Science, Tohoku University, 2. International Research Institute of Disaster Science, Tohoku University, 3. Institute of Technology, Shimizu Corporation

Numerical simulation of tsunami-induced sediment transport is a powerful technique for improving our understanding of sedimentological characteristics of tsunami. Recently, validation of the simulation has been conducted using the vast amount of data obtained from the 2011 Tohoku-oki Tsunami (TOT) as a benchmark (Sugawara et al., 2014). Numerical simulations are generally affected by uncertainty related to input parameters for the model, however, few studies investigated the uncertainty systematically and comprehensively. In this study, sensitivity analyses using the TUNAMI-STM numerical model are conducted on the southern part of Sendai Bay, Miyagi Prefecture, where large-scale geomorphological changes due to the 2011 TOT were observed (Udo et al., 2013), in order to establish a systematic framework for evaluating the uncertainty in the simulation.

Sensitivity analysis was performed with ten parameters in total, such as grain size and settling velocity. A combination between grain size and other parameters, such as critical friction velocity and coefficient of transport formula, was taken into account in several cases. The area of comparison was divided into six segments, in which volumes of the tsunami-induced erosion and deposition varied significantly (Udo et al., 2013). The sensitivity was examined using simulated volumes of erosion and deposition for each case normalized by the outputs of a reference case.

The sensitivity was high in grain size and Manning’ s roughness coefficient, which exhibited larger change rates of the erosion and deposition volume to change rates of the parameter. Besides, change rates of the erosion and deposition volumes by single simulation showed variabilities among the segments. As a result of detailed analysis focusing on sensitivity to the grain size, significant correlations were identified among the changes of the volume of onshore deposition, offshore erosion, the survival rate of the coastal dike (i.e. the ratio of fixed bed and a total length of dike) and height of the dike. In addition, changes in the sensitivity corresponding to the dimension of the segments were analyzed using narrower segments. These results suggest that the magnitude of the effect of parameter uncertainty depends on the distribution of coastal dike and spatial scale of comparison between simulation and observation.

Keywords: Tohoku-oki tsunami, Sendai Bay, sediment transport , numerical modeling

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Event deposits in Lake Jusan, western part of Aomori Prefecture, NE Japan

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1. Faculty of Science, Niigata University, 2. Research Institute for Natural Hazards and Disaster Recovery, Niigata University

In this study, the first boring survey was conducted in the central part of the Lake Jusan, a lagoon along the coast of the Japan Sea to analyze tsunami records on the coast of the Japan Sea in NE Japan. As a result of this survey, nine layers of tsunami deposits caused by the offshore tsunami were identified, and their ages were estimated.
The transport process was restored for tsunami deposits formed by tsunamis that entered the coastal lacustrine that are different from tsunami deposits that run up to land. Additionally, the formative process of the tsunami deposits in lacustrine was clarified by observing composition of particles and their roundness. The characteristics of the constituent particle indicated that tsunami deposits of the JSK-1 core were transported by backwash in a lacustrine environment. The results of this research contribute to the elucidation of tsunami records in the Japan Sea region and the analysis of the source faults distributed offshore of NE Japan.

Keywords: Japan Sea, tsunami deposit, Lake Jusan

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Features of 17th-century tsunami deposits formed by tsunami crossing river channel and detection using X-ray computed tomography

*Kohei Iwaki[1], Yasuhiro Takashimizu[2], Yuichi Nishimura[3], Takashi Chiba[4]

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Tsunami deposits distributed during run-up show inland fining and thinning trends. However, the effect of abandoned river channels within the run-up area on deposit features is unknown and was investigated in this study. Tsunami deposits are an effective index by which to estimate the inundation area of historical and paleo tsunamis. However, the actual inundation area and distribution limit of tsunami deposits are distinct; the former is generally wider than the latter. Therefore, this study also verified the effectiveness of X-ray computed tomography (CT) analysis for reconstructing the actual distribution of the deposits. The study was conducted in a coastal lowland of the Yufutsu Plain in Hokkaido, Japan, interspersed with back marshes, ponds, and depressions (interpreted as traces of abandoned river channels) behind coastal sand dunes. Samples extracted using a geoslicer and peat sampler were used for core, X-ray CT, and grain size analyses, and the weight of clastic grain contents was measured using organic matter treatments. The lithofacies of the tsunami deposits changed from sand to sandy peat with gradually decreasing sand content. However, X-ray CT analyses identified the presence of clastic materials beyond the area in which sand was visually identifiable, and a positive correlation existed between the mean CT value and the clastic material content of the tsunami deposits, suggesting that the mean CT value could be used as a proxy for the tsunami deposit distribution. The thickness of the tsunami deposits along shore-normal transects generally presented inland thinning part with local coarsening trends in abandoned channels (topographical depressions), which was indicative of the sudden deposition of transported grains under tsunami deceleration during run-up into these channels. The mode grain size and mud content of the tsunami deposits along the shore-normal transect generally indicated inland fining and increasing trends, respectively, which also suggested deceleration of the tsunami run-up flow. However, the mode grain size became coarser after the tsunami flowed across abandoned channels. Thus, these coarse materials may have originated from the channel deposits, a possibility which should be explored in further research.

Keywords: Tsunami deposit, X-ray CT, Grain size distribution

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Identification of invisible tsunami deposits formed by the 2011 Tohoku-oki tsunami

*Tetsuya Shinozaki[1], Yuki Sawai[1], Dan Matsumoto[1], Koichiro Tanigawa[1]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

We conducted a field survey at Oirase town, Aomori Prefecture, to examine the identification of invisible tsunami deposit. Evidence of paleo-tsunamis is not always preserved as a visible deposit. Near the inundation limit, tsunami deposits tend to be thin and fine-grained because the weakened tsunami flow cannot transport coarser particles and large amounts of sand; thus, tsunami deposits can be difficult to identify from underlying and overlying sediment by eye observation. Identification of invisible tsunami evidence as well as visible tsunami deposits is necessary for more accurate estimation of tsunami recurrence and its magnitude.

To examine the identification of invisible tsunami deposits, we focused on the 2011 Tohoku-oki tsunami because we have information on inundation area and sediment distribution. In October 2020, we set two transects that were nearly perpendicular to the shoreline. About 20 cm deep sediment samples were directly collected from walls of excavated pits at 12 locations. Based on the eye observation, sediments consist of an upper soil layer and a lower thick fine to medium sand layer. At the relatively seaward locations, 1.5 to 4 cm-thick fine to medium sand layer, which is considered as the 2011 tsunami deposit, was intercalated within the soil layer. On the other hand, no sand layer within the soil was found by eye observation at the relatively landward locations. As well as the eye observation, we could not identify event deposits by CT images and the depth profile of sand contents. In the study sites, wind may constantly transport sand particles from the beach to the landward sampling locations around the inundation limit (about 300 m from the shoreline and about 150 m from the beach). This setting made it difficult to identify evidence of tsunami inundation based on CT images and sand contents. In the presentation, we discuss about invisible tsunami deposits based on the data of CT, sand contents, and depth profile of grain size distribution and organic geochemistry.

Keywords: Invisible tsunami deposits, 2011 Tohoku-oki tsunami, Aomori, Grain-size distribution, Organic geochemistry

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.16 Zoom Room 16

[M-IS22] Geopark

convener:Takayuki Arima(Yokohama City University), Keiichi Tadokoro(Research Center for Seismology, Volcanology and Earthquake and Volcano Research Center, Nagoya University), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Takayuki Ogata(Graduate School of Engineering and Science, University of the Ryukyus), Chairperson:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Takayuki Arima(Yokohama City University)

This session targets interdisciplinary and multidisciplinary discussion on geopark, involving geoheritage, geodiversity, geoconservation, geotourism, sustainable development, governance, risk management, science communication and geoscientific education. These topics contribute to scientific and attractive activities in geoparks.

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

[MIS22-01] Academic Support for Geoparks: Efforts of the Geopark Assistance Committee, the Seismological Society of Japan

★Invited Papers

*Yoshihiro Hiramatsu[1] (1.School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University)

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

[MIS22-02] Preservation and utilization of earth heritage in Japan's natural monument system

★Invited Papers

*Tadahiro Shibata[1] (1.The Unit of Natural Monuments, Monuments and Sites Division, Cultural Properties Department, Agency for Cultural Affaire)

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

[MIS22-03] Developing virtual field experience with high-resolution panorama (GigaPans) at multiple scales: Constructing a core technology for online geotours

*Norihito Kawamura[1], Takashi Sawaguchi[2] (1.School of Regional Resource Management, Graduate School, University of Hyogo, 2.Toyo University)

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

[MIS22-04] Subaqueous volcanic rocks as the object for the geo tourism-related to NHK Buratamori and geoparks

*Hiromitsu Yamagishi[1], Yoshiaki Matsuda[1], Kazuo Shimura[2] (1.NPO Hokkaido Research Center of Geology(HRCG), 2.Shin Engineering Consultant)

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

[MIS22-05] Disaster risk reduction in Geopark from social geographical approach : focusing on social capital for community resilience

*Akifumi Nakamura[1] (1.Muroto Geopark Promotion Committee)

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

[MIS22-06] The Land Use Change and Socio-economic Impact of Baiyankeng Geo-cultural Village, China

*Wenqi ZHAO[1] (1.University of Tsukuba)

Academic Support for Geoparks: Efforts of the Geopark Assistance Committee, the Seismological Society of Japan

*Yoshihiro Hiramatsu[1]

1. School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University

For the development and enhancement of geopark activities, organic cooperation between Geoparks in various regions and academic societies with academic expertise is indispensable. The Seismological Society of Japan established the Geopark Assistance Committee in 2017 to support geopark activities in Japan, to disseminate and raise awareness of seismological knowledge, and to promote seismological research.

The Seismological Society of Japan has been recommending members to the Japan Geopark Committee since the beginning of geopark activities in Japan. As a project of the Social Activity Fund, the Seismological Society of Japan has held seminars for residents in Sanriku (2011 off the Pacific coast of Tohoku Earthquake), Kurikoma (2008 Iwate-Miyagi Nairiku Earthquake), and Aso (2016 Kumamoto Earthquake) Geoparks. Children's Summer School on Earthquake and Volcanoes and Teacher's License Renewal Course have been held with the support of the geoparks in the areas.

Efforts to establish a committee to support geopark activities began in 2014 with the establishment of the Geopark Working Group. In addition, a series of articles on Japanese Geoparks began in "Nai Furu". In 2016, the Preparatory Working Group for the Geopark Assistance Committee was set up to study the support activities of the Seismological Society of Japan and the need for support. In 2017, The Geopark Support Committee was established.

The main activities of the Geopark Assistance Committee are earthquake seminar for geopark staffs and geopark tours for members of the Seismological Society of Japan. In 2017-2019, the earthquake seminar held in Makuhari during JpGU: in 2017, how to obtain and use seismic data obtained from Hi-net, K-NET, and KiK-net in real-time, and how to use seabed topographic map data, in 2018, the introduction of past damaging earthquakes (historical earthquakes) around Japanese Geoparks, and in 2019, demonstration of various functions and usage of GSI maps.

Geopark tours are conducted with the cooperation of geoparks after the Fall Meeting of Seismological Society of Japan: Aso Geopark and Mashiki Town in 2017, Bandaisan Geopark and Aizuwakamatsu City in 2018, and a tour of Abuyama Observatory, Kyoto University, and the Hanaore Fault withOike Guide, although those are not a geopark, in 2019.

The Geopark Assistance Committee discussed how to realize seismic activity at a geosite, and the NIED implemented the "NIED Quake map!". Itoigawa UNESCO Global Geopark introduced it with the reopening of Fossa Magna Park in July 2018, and as of February 2021, it has also been introduced in Hakusan Tedorigawa Geopark, Shikoku Seiyo Geopark, Happo-Shirakami Geopark, and Sanriku Geopark.

In 2020, the JpGU was postponed and held remotely, so that we held an online earthquake seminar in October. The main theme of the workshop was how to communicate seismic activity. There were presentations as follows: how to find out about historical earthquakes and disasters, how the Hot Spring Research Institute, Kanagawa Prefecture, as a home doctor, and the Hakone Geomuseum disseminates

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information about the activities of the Hakone Volcano in 2015 to a local society, and examples of the use of the "NIED Quake map!" from five geoparks. The number of participants was 62, the largest number in the past. The results of the post-event questionnaire showed the usefulness of the online seminar.

We would like to improve the scientific value of Geopark activities and communicate with the local community through Geoparks, together with those in Geoparks, by continuing to support Geopark activities.

Acknowledgments: We are grateful to the Japanese Geoparks Network and those in the Geoparks for their cooperation to the activities of the Geopark Assistance Committee, the Seismological Society of Japan.

Keywords: earthquake, earthquake seminar, geopark tour, seismicity, visualization

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Preservation and utilization of earth heritage in Japan's natural monument system

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1. The Unit of Natural Monuments, Monuments and Sites Division, Cultural Properties Department, Agency for Cultural Affaire

Geoparks evaluate and organize the legal protection of geoscientific heritage sites such as geosites. According to the "Guidelines for the Conservation of Natural Resources of the Japanese Geopark Network" (2018) formulated by the Japan Geopark Network Conservation Working Group, research and data collection on geosites to evaluate their scientific value and conservation plans It is stated that important geosites that have been formulated will be legally protected. The Natural Parks Act, the Law for the Protection of Cultural Properties, and the Law for the Protection of Cultural Properties of prefectures and municipalities are applied as general legal protection and security measures in Japan. Recently, the outcrops of the Itoigawa-Shizuoka Tectonic Line, which is the most important geosite of the Itoigawa UNESCO Global Geopark, and the Mizonokuchi Cave of the Kirishima Geopark are in early 2021. It is expected to be designated as a natural monument. In addition, in recent years, it has been designated as a natural monument in domestic geoparks such as Byobugaura in Choshi Geopark, Sedimentary layers and the marine mammal fossils in Paleo-Chichibu-Bay in Chichibu Geopark. On the other hand, there is an opinion that it is necessary to clarify the procedure by regulation accompanying the designation of natural monuments, and to support private organizations and local governments that promote the utilization of academic research, education, tourism use, etc. Therefore, this time, based on this situation in Japan, we will explain the natural monument system, and the status of support for natural monument designation standards and flows, laws and regulations, preservation and utilization plan formulation, surveys and maintenance before and after designation. Introducing.

Keywords: Natural monument, Geopark

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Developing virtual field experience with high-resolution panorama (GigaPans) at multiple scales: Constructing a core technology for online geotours

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GigaPan images are very useful for virtual geotour!

Keywords: GigaPan, mosaic composite image, virtual tour, Anden geosite, Oga Peninsula-Ogata Geopark

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Subaqueous volcanic rocks as the object for the geo tourism-related to NHK Buratamori and geoparks

*Hiromitsu Yamagishi[1], Yoshiaki Matsuda[1], Kazuo Shimura[2]

1. NPO Hokkaido Research Center of Geology(HRCG), 2. Shin Engineering Consultant

Recently, Japanese geologic term "Suirei-hasaigan"(hyaloclastite) or "Suirei-hasaiyougan" as a composition of subaqueous volcanoes has been known to be public by NHK TV Program such as “NHK Buratamori Atami, Shiretoko and Muroran” and the other programs. Such subaqueous volcanic rocks have been shown in many geoparks (Fig.1) in Japan: particularly, pillow lavas are exhibited in geoparks of Shimokita, Oga, Sanriku, Sado, Itoigawa, Shimonita, Simane Peninsula, Seiyo, Muroto etc., but hyaloclastites ("Suirei-hasaigan" or "Suirei-hasaiyougan") are displayed only in Izu Peninsula, San-in and Shimane Hanto Shinjiko geopark.
During 1970 to 1980’s the discussions and studies on the genesis of “Kuroko” (Sulphide Ore Deposits) had been popular in Japan, but later almost of the metal mines have been abolishid and then the researching and studies have been declined.
On the otherhand, in engineering geological fields, such as highway and tunnel construction, investigation on the subaqueous volcanic rocks has been attention, for instance, rock classification is usually done by mechanical classification, however, the subaqueous volcanic rocks display variable and heterogeneous facies differently from the other rocks, namely the classification needs knowledges of the occurrence of the rocks. Namey, such subaqueous volcanic rocks show different physical properties such as porosity, alteration and weathering processes, from subaerial ones and others. In terms of disaster problem, these subaqueous volcanic rocks have been attention also. For examples, 1971 Shizuoka Ohkuzure Rock Falls and 1996 Hokkaido Shakotan Toyohama Rock falls generated from the subaqueous volcanic rocks.
In terms of basic geology, Dr Kazuo Amano, proposed “Green Tuff Renaissance” meaning re-evaluation of the Neogene tectonics studies which have been studied much in the 1970’s in Japan. While, in the field of current oceanography, the sea bottom black smoke related to marine resources, has necessity of knowledge of Black Ore Deposits (KurokoVMS) during 1970-1980’s. While, the new technology such as drone (UAV) mapping of seashore bench, and digital exploring of the current ocean volcanology needs much knowledge of ancient subaqueous volcanic rocks.
Backbones of the Japanese islands were formed by subaqueous volcanism since the 10M, therefore one to thirds of the Japanese islands have been developed on the basement of the subaqueous volcanic rocks.
In this presentation, We review the terminology of the subaqueous volcanic rocks such as hyaloclastite, and report aerial and cruising geo-tour for Muroran Etomo Peninsula (Fig.1) composed of variable shapes of felsic subaqueous volcanic rocks.

Keywords: Subaqueous volcanic rocks, Pillow lava, Hyaloclastite, Geopark, NHK Buratamori, Muroran Etomo Peninsula

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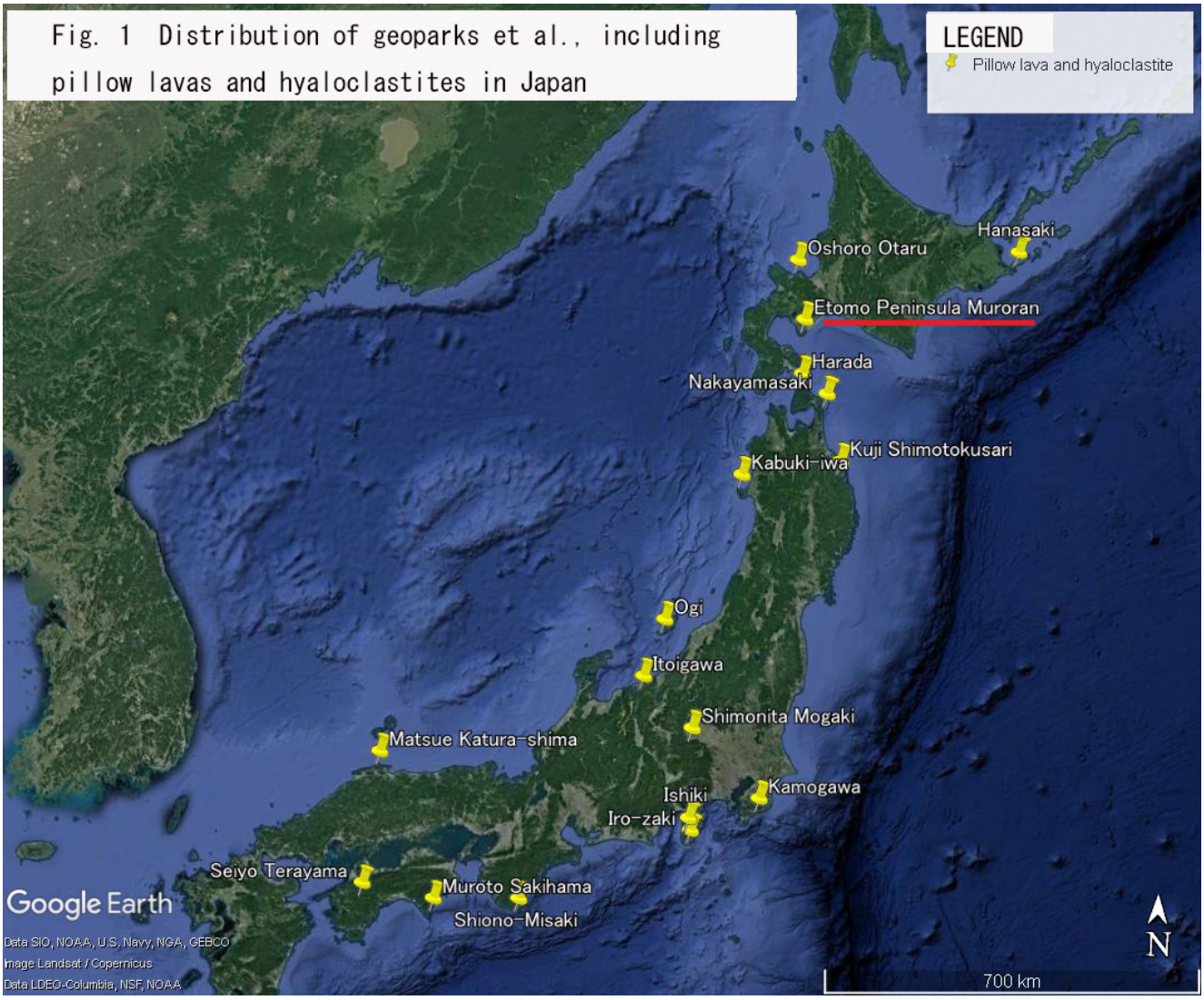


Fig. 1 Distribution of geoparks et al., including pillow lavas and hyaloclastites in Japan

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Disaster risk reduction in Geopark from social geographical approach : focusing on social capital for community resilience

*Akifumi Nakamura[1]

1. Muroto Geopark Promotion Committee

In recent years, mesurements of disaster risk reduction is active in various Geoparks. In Muroto Geopark, structural measures such as ocean wave barriers, tsunami evacuation towers, tsunami shelters, and evacuation routes have been constructed for coming Nankai Trough earthquake. On the other hand, if we consider disaster risk reduction and mitigation as well as recovery and reconstruction after disaster, it is necessary to improve community resilience in total. This presentation considers disaster risk reduction in Geoparks based on social geographical approach. Shaw and Sharma (2011) classified risks into two categories : Shocks and Stresses. Shock is a threat to the region, referring to "low probability but rapid onset and high impact events that cause immediate and visible damage," such as natural hazards, epidemics, conflicts, and terror. Stresses refer to "slow onset and low impact processes that are of high probability in the context of a day-to-day continuum of hardships," such as poverty, public health, and sea level rise. In Muroto, there is high level interest on shocks caused by natural hazards such as earthquakes, tsunamis, and typhoons, but there seems to be little interest in chronic stresses such as population and birthrate decline, aging population, economic inequality, and infrastructure deterioration. Otherwise, even though locals recognize those are problems in itself, they do not notice that community resilience is weakend by such stresses. In social science research dealing with community resilience, the concept of social capital gives us clues to consider. Researches on the heat wave of Chicago, Hurricane Katrina, and the Great East Japan Earthquake showed that social capital as a resource to reduce damage during disaster and to enhance recovery after shocks. In addition, social capital is social networks, reciprocity, and trust that are built in daily life, and is expected to relieve daily and chronic stresses. This presentation discusses a case of Tanegashima, engaged in regional activities to maintain and enhance social capital. It also considers several characteristics of social capital in the island found on a questionnaire survey. As Geoparks, it is important to present comprehensive approach for disaster risk reduction including both social scientific and natural scientific perspectives.

Keywords: Disaster risk reduction, Resilience, Social capital, Island

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The Land Use Change and Socio-economic Impact of Baiyankeng Geo-cultural Village, China

*Wenqi ZHAO[1]

1. University of Tsukuba

1. Introduction

Over the years, the three-dimensional rural issues concerning agriculture, countryside and farmers are long-standing problems in Chinese society. The government of China released a package of policies charting the roadmap for rural vitalization. Among the policies, the government of Zhejiang Province proposed a strategy of *Geo-cultural village* in 2013, on account of a lack of cultivated land for the large population in Zhejiang. The policy of Geo-cultural village is considered to be a model of endogenous development. Although most of the Geoparks in China are operated by the government, the policy of Geo-cultural village gives a top priority to self-governance by the villagers. This research aims to illustrate the land use change, industrial transformation and the impact on rural society and economy after Baiyankeng village has been registered as the first Geo-cultural village in China. The data of this research are collected from the interviews of the village committee, reports and statistical yearbooks of the local government.

2. Research Area

Baiyankeng village is one of the traditional villages in Kuaijishan mountains of middle Zhejiang, where Chinese Torreya trees have been cultivated through long periods of ancient grafting and artificial selection techniques from the weathering of Cretaceous volcanic rock strata. The project of Geo-cultural village has started here since Kuaijishan Ancient Chinese Torreya Community was registered as a *Globally Important Agricultural Heritage System* in 2013. By 2019, there are 251 families living here with a registered population of 760. The total area of the village is 6.03 square kilometers, 23.2% and 26.3% of which are respectively covered by Torreya forests and tea plantations. Other forests occupy 31.55% and only 4.5% is cultivated land. The villagers are mainly growing Chinese Torreya and Chinese tea for a living.

3. The Change of Land Use and Socio-economic Situation of Baiyankeng Village

The policy of Geo-cultural village caused many changes in the village from 2013 to 2019. The development of geo-tourism, homestay business, and Torreya production distinctly raised the income and increased the economic condition of the village. Although people are still going out of the village for part-time jobs, some people returned to the village to grow Chinese Torreya or to do some service jobs for geo-tourism. The land of planted Torreya trees is increasing, while the land of tea plantations is decreasing. In the meantime, however, some wild forests have been destroyed by cultivation of fields for Torreya. In addition, the fundamental facilities are constructed such as road and parking lot.

4. The Driving Forces behind the Change in Land Use and Socio-economic Situation

Initially the soil in the village is suitable to cultivate Torreya trees. Since Chinese tea is common around China but Chinese Torreya is distinctive, growing Torreya is easier to receive benefits than growing tea. The visitors would like to buy Torreya nuts rather than buying tea. Also, more labors are demanded and more chances for working in the village are provided due to the development of geo-tourism. After the improvement of the infrastructure, the living condition has become better. More and more previous villagers who took part-time jobs in the city would like to return to the village to work. Furthermore, the support of the local government and the enthusiastic members of the village committee give a big push to

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this rural vitalization project.

5. Summary

Geo-cultural village aims to make use of the geological resources, inherit traditional ideas and rebuild cultures. It can be considered as a new model of endogenous development. The policy causes a positive impact on land use suitability, solving the three-dimensional rural issues and promoting social and economic development. Meanwhile, there are problems with self-governance, the prevention of over-development that should be considered for future research.

Keywords: Geo-cultural Village, Endogenous Development, Chinese Torreya, Land Use, Rural Vitalization, Baiyankeng Village

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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.10 Zoom Room 10

[M-IS24] Geophysical fluid dynamics-Transfield approach to geoscience

convener:Keita Iga(Atmosphere and Ocean Research Institute, The University of Tokyo), Shigeo Yoshida(Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University), Takatoshi Yanagisawa(Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Hidenori AIKI(Nagoya University), Chairperson:Kensuke Nakajima(Department of Earth and Planetary Sciences,Flculty of Sciences,Kyushu University)

This session on geophysical fluid dynamics is open to discussions and researches on fluid phenomena in whatever fields of earth and planetary sciences, e.g., motions in the earth and planetary interior, oceans, atmospheres, volcanoes, and the ionosphere, conducted with whatever methods. Talks intending to stimulate exchange of ideas among multiple fields of researches or those identifying concepts that are commonly applicable to wide range of geophysical fluids are especially welcome.

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

[MIS24-01] Balance of baroclinicity and restoring force due to stable temperature stratification in developing horizontal convection in a finite fluid layer

*Tomomi Terada[1], Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3,2], Takehiro Miyagoshi[3], Yuichi Murai[2] (1.Graduate School of Engineering, Hokkaido University , 2.Faculty of Engineering, Hokkaido University, 3.Japan Agency for Marine-Earth Science and Technology)

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

[MIS24-02] Quasi-periodic oscillations of convection patterns and heat transport in horizontally finite geometries

*Takatoshi Yanagisawa[1], Megumi Akashi[2], Yuji Tasaka[3], Ataru Sakuraba[4] (1.Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology, 2.Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf, 3.Faculty of Engineering, Hokkaido University, 4.Department of Earth and Planetary Science, University of Tokyo)

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

[MIS24-03] Cyclonic-anticyclonic asymmetry on maintained vortices near the westerlies focused on external vortices

*Koryu Yamamoto[1], Keita Iga[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[MIS24-04] High-frequency measurement of a double helical vortex with a sonic anemometer thermometer for laboratory use

*Toshihisa Itano[1] (1.National Defense Academy)

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

[MIS24-05] Numerical experiments of surface flows on giant planets produced by forcings representing thunderstorms

Ryoma Suzuki[2], *Youhei SASAKI[1], Masaki Ishiwatari[3] (1.Institute of Fundamental Sciences, Faculity of Science and Engineering, Setsunan University, 2.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

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

[MIS24-06] Discussion

Balance of baroclinicity and restoring force due to stable temperature stratification in developing horizontal convection in a finite fluid layer

*Tomomi Terada[1], Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3,2], Takehiro Miyagoshi[3], Yuichi Murai[2]

1. Graduate School of Engineering, Hokkaido University , 2. Faculty of Engineering, Hokkaido University, 3. Japan Agency for Marine-Earth Science and Technology

Convection driven by a temperature gradient along a horizontal surface at the same level is termed horizontal convection and plays important roles in various fluid motions on the Earth, e.g. oceanic flows, atmospheric flows, liquid metal flows inside the outer core. Conventionally, horizontal convection has been studied on its equilibrium state, i.e. a flow state after a sufficiently long time for thermal diffusion. Both buoyancy and baroclinicity dominate the equilibrium horizontal convection. By contrast, during a temporal evolution from a certain initial state toward an equilibrium state, effect of restoring force becomes prominent instead of that of the buoyancy. The developing horizontal convection has been scarcely discussed, and it is worth investigating.

In this study, we aim to identify the contribution of stable temperature stratification on flow characteristics of developing horizontal convection, where the stratification relaxes with time. Visualization experiments were performed adopting a rectangular vessel where differential heating is imposed at the top and other boundaries are thermally insulated. We could observe formation of circulating flows owing to the baroclinicity of the horizontal temperature gradient. Using particle tracking velocimetry, various flow characteristics, e.g. stream functions, thickness of circulating flows, total kinetic energy, were quantified. It was found that the degree of stratification becomes a primary parameter determining the flow features of developing horizontal convection. This finding extends the conventional scalings of Rayleigh number applicable in the equilibrium state by adding the stratification parameter even in the developing state.

Keywords: Horizontal convection, Temporal evolution, Stable temperature stratification

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Quasi-periodic oscillations of convection patterns and heat transport in horizontally finite geometries

*Takatoshi Yanagisawa[1], Megumi Akashi[2], Yuji Tasaka[3], Ataru Sakuraba[4]

1. Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology, 2. Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf, 3. Faculty of Engineering, Hokkaido University, 4. Department of Earth and Planetary Science, University of Tokyo

Pattern of Rayleigh-Bernad convection at low Prandtl numbers has been a hot topic in recent years. In laboratory experiments, patterns existing in turbulent convection of liquid metals are observed and quantified by ultrasonic velocity measurements. In numerical simulations, calculations of convection in horizontally wide geometries are realized and so-called superstructures are identified in turbulence. We reported transitions from roll-like to cell-like structure in turbulent convection of a liquid metal experiment with the increase of the Rayleigh number (Ra) for a vessel having aspect ratio five (Akashi et al., 2019, Phys. Rev. Fluids). Both roll- and cell-like structures were marked by quasi-periodic oscillations whose periods are comparable to the turn-over time of the flow.
Here we studied the dependency of the features on aspect ratios of the square geometry confined by no-slip side walls by numerical simulations. The aspect ratio of the geometry (=A) is defined by the horizontal length of square vessel to its layer thickness, and we examined A from 0.5 to 20. The value of Prandtl number was fixed at 0.025 and Ra numbers were set around 10^5, where features of turbulence are clearly recognized. There exist organized flow structures in turbulence. When A < 4, the patterns are roll-like showing strong directionality. When 4 < A < 6, the patterns are cell-like with similar flow velocities for two horizontal directions. In both cases the patters are consist of a single or a pair of circulation and show quasi-periodic oscillations. For geometries with larger A, the patterns are composed of multiple cells and rolls; quasi-periodic oscillations are not observed any more. The degree of heat transport and its fluctuation in time are closely related to the convection pattern. We quantified them by using time averaged value of the Nusselt numbers (Nu) and their standard deviations. The dependence of Nu on A is not monotonic but complicated reflecting the transition of patterns. We found that Nu shows maximum where pattern changes from roll to cell, and that the fluctuation of Nu is very small at that point.

Keywords: convection pattern, quasi-periodic oscillation, heat transport

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Cyclonic-anticyclonic asymmetry on maintained vortices near the westerlies focused on external vortices

*Koryu Yamamoto[1], Keita Iga[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

The weather in mid- and high-latitude area including Japan is affected by the meandering westerlies. They occasionally result in vortices such as blocking anticyclones and cut-off cyclones. It is suggested by several previous studies that the way how anticyclones and cyclones sustain themselves for some days and maintain their position can be different between polarity. Few studies, however, have clarified the cyclonic-anticyclonic asymmetry by comparing them comprehensively. In the present study, we focus on maintained vortices near the westerlies, and we also analyzed their migration and how the potential vorticity flowed into them which can be one of the reasons of the migration. First, maintained anticyclonic and cyclonic non-dipole vortices are extracted from a global reanalysis as we symmetrically applied the previous and objective method to extract blocking anticyclones to cyclones. The analysis period is for 61 years, from March 1958 to February 2019. Geopotential height on 500hPa surface is used to extract them. A comparison of the anticyclones and cyclones extracted shows that several characteristics such as migration length of their center are suggested to be different with statistical significance. Furthermore, detailed examination of their migration during particular periods confirms that the cyclones exhibit larger movement in the east-west direction but smaller in the north-south direction than the anticyclones do. Next, composited maps which show how the potential vorticity into the vortices are made and analyzed in order to discover the differences in the migration. The results show that the maps are consistent with the migration. It is confirmed that air with high potential vorticity flows into the cyclones mainly from the west, whereas air with low potential vorticity doesn't show such a tendency for the anticyclones. Finally, in order to confirm the inflow and investigate the origins of the air into the vortices, we conducted a backward trajectory analysis. The result shows that the origins are migrating disturbances in the westerlies and vortices which existed in the previous time. Diabatic effects also contribute to the anomalous potential vorticity around the center of the vortices. It is confirmed that almost all the cyclones are accompanied with an area where the potential vorticity decreases due to strong convection to their south side, whereas the anticyclones are not. The present study has confirmed that anticyclones and cyclones can have different mechanisms for maintenance near the westerlies.

Keywords: cyclonic-anticyclonic asymmetry, potential vorticity, trajectory analysis

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High-frequency measurement of a double helical vortex with a sonic anemometer thermometer for laboratory use

*Toshihisa Itano[1]

1. National Defense Academy

The multiple-vortex phenomenon, in which the core of a vortex is destabilized to split into a pairs of secondary vortices intertwined with each other and revolving around the radius of the maximum wind of the parent vortex, was discovered in the middle 1960’s and reproduced in a laboratory experiment in early 1970’s. Afterwards, in 1980’s, a similar kind of tornado simulators, which could reproduce the multiple-vortex phenomenon, were designed in several universities and the wind and pressure distributions, etc. were examined in addition to the condition for the formation. However, due to the restrictions on the instruments available at that time, direct measurement by one- or two-dimensional hot-wire anemometer and/or photometric analysis of stroboscopic photography visualized by smoke wire were simply carried out in most of the case. It should be noted that we can’t obtain the turbulent momentum transport and its cospectra by one- dimensional probe of the hot-wire anemometer. Also, even with the two- dimensional probe, two components of the wind velocity are not obtained necessarily: the measuring surface of the probe has to be turned parallel to the wind direction, and the fluctuations of the wind direction must be restricted within 90 degree. In this respect, to measure the multiple vortex phenomenon, where secondary vortices are embedded within the primary vortex, is quite difficult because the wind direction tends to be reversed frequently (Indeed, Monji (1985) gave up tp measure the core part of the multiple-vortex phenomenon.). Laser Doppler velocimeter (LDV) and Cobra probe, a kind of Pitot tube, were introduced for the measurement of laboratory tornadoes in 1990’s and after 2000, respectively. Especially, the latter is an attractive instrument, which can measure not only three components of wind velocity but also the pressure in the same time. Nevertheless, it could not be used for the multiple-vortex phenomenon since it can’t measure the flow from behind. By considering the above situations, we would like to introduce our attempt to measure the multiple-vortex phenomenon with a sonic anemometer thermometer (SAT) for laboratory use.

We focused on a “double helical vortex” which appears in our tornado simulator at National Defense Academy (1.9m<diameter>×0.95m<height>, aspect ratio a=0.857(=0.3m/0.35m)) when the inflow angle is θ=45 degree (i.e. the swirl ratio a (=tanθ/(2a)=0.58)) and the frequency of the fan is 10Hz (i.e. Reynolds number Re=16,800). We set 72 observation points, every 3cm and 5cm in the radial and vertical directions, respectively, within a vertical cross section of the simulator. The WA-790 <Sonic>, the probe of which has the base line of 3cm between a pair of its transducers, is adopted and high frequency observation is carried out for 10 minutes with 10Hz at each point. Results indicate that in most of the region, the basic swirling flow deviates inward (less than 10 degrees) from the tangential direction and the elevation angle increases with height. Meanwhile, the downward flow exists in the core part, where net wind speed is weak, forming an “eye”. Standard deviation of the wind speed is large at the shear region surrounding the “eye”, which indicates the existence of the secondary vortices. Covariance of the wind fluctuations implies the momentum of the basic swirling flow is transported both upward and outward in most of the region, but inward transported is detected around the radius of the maximum wind of the basic swirling flow.

Keywords: multiple-vortex, sonic anemometer thermometer, momentum transport

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Numerical experiments of surface flows on giant planets produced by forcings representing thunderstorms

Ryoma Suzuki[2], *Youhei SASAKI[1], Masaki Ishiwatari[3]

1. Institute of Fundamental Sciences, Faculity of Science and Engineering, Setsunan University, 2. Department of Cosmosciences, Graduate School of Science, Hokkaido University, 3. Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

It is known that the surfaces of giant planets have the banded structures consisting of equatorial jets with wide latitudinal widths and mid-latitudinal jets with narrow latitudinal widths, and the vortex structures in the polar regions.Large-scale structures such as banded structures and polar vortices can be formed from small-scale turbulence due to the inverse cascade effect (e.g. Showman et al., 2009). Thunderstorms are considered to be a candidate for causing such small-scale turbulence (e.g. Ingersoll et al., 2000). Showman (2007) and Brueshaber et al. (2019) performed calculations in the framework of the shallow water system with the mass forcing representing thunderstorms. Showman (2007) showed the formation of the banded structures with restricting the computational domain to the latitude range 0-70 degrees and the longitude range of 0-120 degrees. Brueshaber et al. (2019) found the polar vortex structures were formed in the computational domain from latitude 60 degrees to high latitude. In addition, their results showed that the number and size of polar vortices, and the sign of vorticity significantly depend on the value of Burger number (Bu=$(L_d/a)^2$, L_d: deformation radius, a: planetary radius). However, computational domains used by previous studies are restricted to a part of the sphere. In cases of calculation by regional model, the structure of jets and vortices may change due to momentum transport from regions outside the restricted computational domain.
The purpose of this study is to perform global calculations and to investigate whether the jet and polar vortex structures can be formed by the mass forcing representing thunderstorms. These structures are compared with the results obtained in previous studies to validate the domain calculations. The model used in this study is the Hierarchical Spectral Models for GFD (SPMODEL; Takehiro et al. 2006, Takehiro et al. 2013). The used equations are 1.5-layer shallow water equations with the mass forcing representing thunderstorms. The experiments are performed with changing values of the Burger number. In this presentation, the results of numerical experiments and the consistency with previous studies will be reported.

Keywords: Jovian planets, Banded structure, Polar vortex, Shallow water model

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[J] Oral | M (Multidisciplinary and Interdisciplinary) | M-IS Intersection

[M-IS24] Geophysical fluid dynamics-Transfield approach to geoscience

convener:Keita Iga(Atmosphere and Ocean Research Institute, The University of Tokyo), Shigeo Yoshida(Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University), Takatoshi Yanagisawa(Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology), Hidenori AIKI(Nagoya University), Chairperson:Kensuke Nakajima(Department of Earth and Planetary Sciences,FIculty of Sciences,Kyushu University)
Sun. Jun 6, 2021 9:00 AM - 10:30 AM Ch.10 (Zoom Room 10)
This session on geophysical fluid dynamics is open to discussions and researches on fluid phenomena in whatever fields of earth and planetary sciences, e.g., motions in the earth and planetary interior, oceans, atmospheres, volcanoes, and the ionosphere, conducted with whatever methods. Talks intending to stimulate exchange of ideas among multiple fields of researches or those identifying concepts that are commonly applicable to wide range of geophysical fluids are especially welcome.

10:15 AM - 10:30 AM

[MIS24-06]Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 9:00 AM - 10:30 AM JST | Sun. Jun 6, 2021 12:00 AM - 1:30 AM UTC | Ch.11 Zoom Room 11

[M-IS25] Atmospheric electricity: Electrical phenomena associated with extreme weather

convener:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Daohong Wang(Gifu University), Chairperson:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Daohong Wang(Gifu University)

In recent years, extreme weather events have occurred frequently not only in Japan but also in other countries around the world. In particular, last year's typhoons 15 and 19 caused tremendous damage in Japan. This year's Atmospheric Electricity session will focus on observational and theoretical studies of atmospheric electrical phenomena associated with extreme weather.
This session will consist of invited presentations introducing above-mentioned fields by leading experts, and contributed presentations on the latest observational and theoretical research results in these fields. For example, we welcome lightning activity associated with many of extreme weather events such as typhoons, heavy rains, wind gusts, and their effects on the upper atmosphere/ionosphere. Besides, we certainly welcome papers regarding all topics on atmospheric electricity including lightning physics, lightning observation technology, electrical effects of thunderstorms, mesospheric transient luminous events (TLEs), lightning-related high-energy phenomena, global electric circuit, atmospheric ion, aerosol, fair-weather electricity, lightning protection, terrestrial electromagnetic noise environment (e.g. wave propagation in the magnetosphere and ionosphere).

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

[MIS25-01] Understanding of fine structure of cumulonimbus using new observational method

★Invited Papers

*Fumiaki Kobayashi[1] (1.National Defense Academy)

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

[MIS25-02] Various common meteorological characteristics obtained by multiple observation results of downburst

*Hisato Iwashita[1], Fumiaki Kobayashi[2] (1.Meisei Electric Co.,Ltd, 2.National Defense Academy)

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

[MIS25-03] Observations of summer thunderstorms using dual polarized phased array weather radar and three-dimensional lightning location system using LF band in Kanto area

*Hiroshi Kikuchi[1], Yuhei Kamei[1], Yoshitaka Nakamura[3], Eiichi Yoshikawa[5], Takeshi Morimoto[4], Tomoo Ushio[2], Yasuhide Hobara[1] (1.The University of Electro Communications, 2.Osaka University, 3.Kobe City College of Technology, 4.Kinki University, 5.Japan Aerospace Exploration Agency)

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

[MIS25-04] 3D characteristics of lightning activity in Typhoon Faxai (2019)

*Namiko Sakurai[1], Hironori Fudeyasu[2], Paul R. Krehbiel[3], Ronald J. Thomas[3], William Rison[4], Daniel Rodeheffer[4] (1.National Research Institute For Earth Science and Disaster Prevention, 2.Yokohama National University, 3.New Mexico Tech, 4.LMA technologies)

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

[MIS25-05] Citizen science "Thundercloud project" for mapping observations of gamma rays from thunderstorms

*Teruaki Enoto[1], Yuko Ikkatai[2], Yuuki Wada[1], Gabriel Diniz[1], Masaki Numazawa[1], Yo Kato[1], Shoko Miyake[3], Kazuhiro Nakazawa[4], Shohei Hisadomi[4], Yuna Tsuji[4], Takayuki Yuasa, Harufumi Tsuchiya[5], Takeshi

Morimoto[6], Yoshitaka Nakamura[7], Masashi Kamogawa[8] (1.RIKEN, 2.The University of Tokyo, 3.National Institute of Technology, Ibaraki College, 4.Nagoya University, 5.JAEA, 6.Kinki University, 7.Kobe City College of Technology, 8.Global Center for Asian and Regional Research, University of Shizuoka)

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

[MIS25-06] Radioluminescence appeared above the epicenter immediately before and after the 1995 Kobe earthquake

*Yuji Enomoto[1], Tsuneaki Yamabe[1], Shigeki Sugiura[2], Hitoshi Kondo[2] (1.Shinshu Univeristy, Ueda Campus Fii, 2.Genesis Research Institute Inc.)

Understanding of fine structure of cumulonimbus using new observational method

*Fumiaki Kobayashi[1]

1. National Defense Academy

Extreme weather, such as local heavy rain, tornado and downburst, and supertyhoon, is caused by developing cumulonimbus (e.g., supercell). Understanding of fine structure of cumulonimbus is important at the points of weather forecasting and disaster mitigation. In this lecture, the front of cumulonimbus observation using new observational method would be introduced.

Keywords: extreme weather, tornado, cumulonimbus, weather radar

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Various common meteorological characteristics obtained by multiple observation results of downburst

*Hisato Iwashita[1], Fumiaki Kobayashi[2]

1. Meisei Electric Co.,Ltd, 2. National Defense Academy

In recent years, it is eminent that the very severe damage caused by not only a synoptic atmospheric phenomenon such as typhoon or linear precipitation zone but also a localized extreme weather such as downburst or tornado. The observation technology of ground surface radar and satellite radar had developed remarkably. The radar which can observe the spatial and temporal structure of a localized extreme weather has appeared. But, the ground surface meteorological observation network which can sufficiently validate the observation result of meteorological radar has not easily appeared.

The high density ground surface meteorological observation network (POTEKA) of the North Kanto plain area observed multiple gust events which included the 3 eminent downbursts of F1 category (Fujita scale) / JEF1 category (Japan enhanced Fujita scale). These observation results revealed the various meteorological characteristics, for example, the ground surface meteorological change characteristic just under a downburst, the cumulonimbus advancing characteristic which caused a downburst, the existence of the divergent wind by a downburst and the horizontal scale of a downburst.

Keywords: downburst, tornado, localized, extreme weather, high density, ground surface observation

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Observations of summer thunderstorms using dual polarized phased array weather radar and three-dimensional lightning location system using LF band in Kanto area

*Hiroshi Kikuchi[1], Yuhei Kamei[1], Yoshitaka Nakamura[3], Eiichi Yoshikawa[5], Takeshi Morimoto[4], Tomoo Ushio[2], Yasuhide Hobara[1]

1. The University of Electro Communications, 2. Osaka University, 3. Kobe City College of Technology, 4. Kinki University, 5. Japan Aerospace Exploration Agency

In Japan, a X-band dual polarized phased array weather radar (DP-PAWR), which simultaneously transmits pulses of horizontal and vertical polarized radiation, was developed and installed in December 2017 at Saitama University. The DP-PAWR has a scanning scheme similar to the PAWR, which also performs mechanical and electronic scanning at azimuth and elevation angles, respectively. The DP-PAWR yields polarimetric precipitation measurements via three-dimensional volume scanning in less than 1 min, 10 sec at the shortest, in a range of up to 80 km. The DP-PAWR is also able to provide coverage of urban areas in Tokyo.
In 2020, our research group (Japan Aerospace Exploration Agency, Kobe City College of Technology, Osaka University, Kinki University, and UEC are included) has installed 13 LF sensor network to obtain the 3D location of lightning discharges in the Kanto area in Japan. The system provides the 3D location of lightning discharges using the time-of-arrival location technique. The mean distance between stations is approximately 20-30 km. The electric field antenna bandwidth is broad from 51 Hz to 550 kHz. Its signal is sampled at 5 MHz. The recorded waveforms allow detailed analysis of lightning discharge processes.
In this presentation, we will show the case study of simultaneous lightning and precipitation observations with the DP-PAWR and 3D Lightning location system. The relationship between the initiation of lightning discharges and hydrometer types in the thunderstorm is also discussed.

Keywords: Phased array weather radar , Lightning discharges

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3D characteristics of lightning activity in Typhoon Faxai (2019)

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1. National Research Institute For Earth Science and Disaster Prevention, 2. Yokohama National University, 3. New Mexico Tech, 4. LMA technologies

This study examined 3D characteristics of lightning activity associated with Typhoon Faxai (T1915) using Tokyo Lightning Mapping Array (Tokyo LMA) and JMA C-band Doppler radar. Lightning flashes were observed in the eyewall and outer-rainband in the typhoon. In the observation area of Tokyo LMA, the number of lightning in the eyewall were more observed than that in the outer-rainband. Most of lightning in the eyewall were observed when the typhoon center was located over the sea. On the other hand, lightning in the outer-rainband were observed when the typhoon center was approaching to Kanto region and passing over Tokyo bay or Kanto region. There were developed convective cells in the eyewall which had 10 km echo top height and lightning location sources were observed in the upper layer of the developed convective cells and surrounding upper stratiform region. Flash size in the eyewall was about 21 km in average off the coast of Ibaraki Prefecture.

Keywords: lightning, Typhoon, LMA

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Citizen science "Thundercloud project" for mapping observations of gamma rays from thunderstorms

*Teruaki Enoto[1], Yuko Ikkatai[2], Yuuki Wada[1], Gabriel Diniz[1], Masaki Numazawa[1], Yo Kato[1], Shoko Miyake[3], Kazuhiro Nakazawa[4], Shohei Hisadomi[4], Yuna Tsuji[4], Takayuki Yuasa, Harufumi Tsuchiya[5], Takeshi Morimoto[6], Yoshitaka Nakamura[7], Masashi Kamogawa[8]

1. RIKEN, 2. The University of Tokyo, 3. National Institute of Technology, Ibaraki College, 4. Nagoya University, 5. JAEA, 6. Kinki University, 7. Kobe City College of Technology, 8. Global Center for Asian and Regional Research, University of Shizuoka

The Gamma-ray Observation of Winter Thunderclouds (GROWTH) collaboration has measured high-energy atmospheric phenomena along the Sea of Japan since 2006. This campaign observed prolonged bremsstrahlung radiations from relativistic electrons accelerated by thunderclouds' electric field and short bursts from photonuclear reactions induced by terrestrial gamma-ray flashes (TGFs). Since the gamma rays can fly only a few hundred meters in the atmosphere, mapping observations is essential to compare high-energy events with meteorological observations. We are now distributing portable radiation detectors to citizen supporters and establish a new extended mapping observation network at Kanazawa that incorporates the Citizen Science method. The device is named Cogamo (Compact Gamma-ray Monitor), which operates with a single button and automatically sends data over the network. We aim to have citizen supporters take pictures of gamma-ray emitting clouds and study whether relativistic electron flow in thunderclouds is involved in the initiation of lightning discharges.

Keywords: high-energy atmospheric physics, gamma rays from thunderstorms, citizen science

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Radioluminescence appeared above the epicenter immediately before and after the 1995 Kobe earthquake

*Yuji Enomoto[1], Tsuneaki Yamabe[1], Shigeki Sugiura[2], Hitoshi Kondo[2]

1. Shinshu Univeristy, Ueda Campus Fii, 2. Genesis Research Institute Inc.

Immediately before and after the Kobe earthquake that occurred at 05:46 (LT) on January 17, 1995, the night sky, which should have been dark, became as bright as the daytime. While there were many eyewitness testimonies, photographs demonstrating this phenomena was taken by N. Yokota, who lives in Izumi-Ohtsu, Osaka. A total of 5 photographs were taken, and from these photographs, fairly bright illuminants can be seen in two places above near the epicenter. This illuminant stays at an altitude of about 0.7km-2.5km, and linear mottled clouds are emitted from the illuminants. This luminescence / streak cloud has almost no change during the shooting time of several minutes and thus has a long life. By referring to other electromagnetic and radon observation data, it was concluded that this illuminants should be attributed to radioluminescence (α-ray, γ-ray) due to the decay of radon emanated from the fault.

Keywords: 1995Kobe earthquake, Radioluminescence, Earthquake lights



図.1 地震直後の震源方向の光る夜空の写真5枚（泉大津市在住：横田安子氏提供）
Fig.1 Five photos of the glowing night sky in the direction of the epicenter immediately after the Kobe earthquake(provided by Yasuko Yokota,Izumi-Ohtsu city)

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.12 Zoom Room 12

[M-IS26] Gas hydrates in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology)

An increasing number of researches focusing on natural gas hydrates has recently been conducted from the environmental, material, and resource scientific viewpoints. This session aims to share and discuss the latest research results associated with natural/experimental gas hydrates to understand and examine the nature and potential of gas hydrates in the past-present-future of the Earth and the development/application for our life. Because the researches on gas hydrates are interdisciplinary, broad topics from field and experimental researches, modeling, etc. will be presented in this session.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[MIS26-01] Massive seafloor methane release near the edge of the gas hydrate stability zone in southern Brazil

★Invited Papers

*Marcelo Ketzer[1], Daniel Praeg[2], Luiz F. Rodrigues[3], Adolpho Augustin[3], Maria A. G. Pivel[4], Mahboubeh Rahmati-Abkenar[1], Dennis J. Miller[5], Adriano R. Viana[5], José A. Cupertino[3] (1.Department of Biology and Environmental Science, Faculty of Health and Life Sciences, Linnaeus University, 2.Géoazur, 3.Petroleum and Natural Resources Institute, Pontificia Universidade Catolica do Rio Grande do Sul, 4.Instituto de Geociências, Universidade Federal do Rio Grande do Sul, 5.Petrobras)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[MIS26-02] **Experimental Verification of CH_4-CO_2 Replacement Occurring in Natural Gas Hydrates for Energy Recovery and CO_2 Sequestration**

★Invited Papers

*Yongwon Seo[1] (1.Ulsan National Institute of Science and Technology, Republic of Korea)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[MIS26-03] **Gashydrate accumulations in the Asian Seas and perspective on comparable research in the Indo-Pacific Region**

★Invited Papers

*Renat B. Shakirov[1], Hitoshi Tomaru[2], Pawan Dewangan[3], Prakash Kumar[4], Anatoly Obzhirov[1], Ryo Matsumoto[5] (1.POI FEB RAS, 2.Chiba University, 3.CSIR-NIO, 4.CSIR-NGRI, 5.Meiji University)

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

[MIS26-04] High-resolution seafloor observation of a shallow methane hydrate area off Sakata, eastern margin of the Sea of Japan, using a three-dimensional pictorial mapping system

*Miho Asada[1], Mikio Satoh[1], Manabu Tanahashi[1], Toshiyuki Yokota[1], Shusaku Goto[1] (1.NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST))

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

[MIS26-05] Survey of methane hydrate off Tokachi, Pacific Ocean

*Satoshi Yamashita[1], Akihiro Hachikubo[1], Hirotoshi Sakagami[1], Masaaki Konishi[1], Kzutaka Tateyama[1], Hirotsugu Minami[1] (1.Kitami Institute of Technology)

Massive seafloor methane release near the edge of the gas hydrate stability zone in southern Brazil

*Marcelo Ketzer[1], Daniel Praeg[2], Luiz F. Rodrigues[3], Adolpho Augustin[3], Maria A. G. Pivel[4], Mahboubeh Rahmati-Abkenar[1], Dennis J. Miller[5], Adriano R. Viana[5], José A. Cupertino[3]

1. Department of Biology and Environmental Science, Faculty of Health and Life Sciences, Linnaeus University, 2. Géoazur, 3. Petroleum and Natural Resources Institute, Pontificia Universidade Catolica do Rio Grande do Sul, 4. Instituto de Geociências, Universidade Federal do Rio Grande do Sul, 5. Petrobras

Ocean warming is causing gas hydrate dissociation and massive seafloor methane release in several places around the world. Our multidisciplinary and multi-scale data set demonstrated this phenomenon for the first time in the southern hemisphere, in the Rio Grande Cone, southern Brazil. Acoustic imaging of the water column shows the existence of hundreds of gas flares near the edge of the calculate methane hydrate stability zone and the outcrop of the bottom simulating reflection. Stable and radiogenic carbon isotope data of methane in gas hydrates, pores, and gas bubbles venting from the seafloor, suggest that gas hydrate dissociation is the main source of gas for the flares. Our data further indicates that gas hydrate dissociation is linked to contemporary ocean warming, and that anaerobic oxidation of methane cannot consume the massive amounts of gas released from hydrate dissociation, resulting in widespread seafloor methane emissions.

Keywords: gas hydrate, climate change, gas flares, sulphate reduction

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Experimental Verification of CH_4-CO_2 Replacement Occurring in Natural Gas Hydrates for Energy Recovery and CO_2 Sequestration

*Yongwon Seo[1]

1. Ulsan National Institute of Science and Technology, Republic of Korea

CH_4 recovery using CO_2 injection into natural gas hydrates is very attractive because it can perform dual functions of energy production and CO_2 sequestration. In this study, the CH_4-CO_2 replacement that occurs in various gas hydrate structures (sI, sII, and sH) was investigated with a primary focus on phase behaviors and structural transformation. To verify the influence of CO_2 injection on the thermodynamic stability of gas hydrates, phase equilibria of the initial CH_4 hydrate (sI), CH_4 + C_3H_8 hydrate (sII), and CH_4 + 2,2-dimethylbutane (neohexane, NH) hydrate (sH) were compared with those of the corresponding gas hydrates replaced with CO_2. After the replacement reaction was completed, significant shifts in the hydrate equilibrium curves of each system were observed, which indicates that the substantial extent of the replacement was achievable through CO_2 injection. The initial and replaced hydrates were analyzed via ^{13}C NMR spectroscopy and powder X-ray diffraction (PXRD) to examine cage-dependent guest distributions and possible structural transition. To identify heat generation or absorption during the replacement process and to elucidate its influence on the thermal properties of the replaced hydrates, the changes in heat flow and dissociation enthalpies (ΔH_d) were measured using a high-pressure micro-differential scanning calorimeter (HP μ-DSC). The replacement behaviors were strongly dependent on the structure of initial gas hydrates. The overall experimental results provide further insights into the cage-specific occupation of external gas molecules and thermodynamic stability for the real replacement occurring in natural gas hydrate reservoirs for CH_4 recovery and CO_2 sequestration.

Keywords: natural gas hydrates, replacement, CO2 sequestration, phase behavior, structural transformation

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Gashydrate accumulations in the Asian Seas and perspective on comparable research in the Indo-Pacific Region

*Renat B. Shakirov[1], Hitoshi Tomaru[2], Pawan Dewangan[3], Prakash Kumar[4], Anatoly Obzhirov[1], Ryo Matsumoto[5]

1. POI FEB RAS, 2. Chiba University, 3. CSIR-NIO, 4. CSIR-NGRI, 5. Meiji University

Gas hydrates - green energy resource of the future and modern marine phenomena, which significance growing up from year to year but still studied poorly in marine expeditions due to the lack of international cooperative study. Gas hydrates were found in many areas of the marginal Asian seas and evidently closely interrelated to the gas geochemistry, geology, geophysics, paleo- and oceanography, micro- and macrobiology, various environment aspects of the Asian Seas (AS) both seafloor and water column. Social effect of gashydrates research field is growing nowadays. Marginal seas of the Eastern Asia is a specific region manifested by insufficient studied gas hydrates (mainly, methane hydrates of different structures, but also carbon dioxide hydrates) phenomena as a resource, climate link and geochemical drive force, methane and accompanying gases fluxes in the "seafloor-water column-atmosphere" system. Numerous unique gas hydrate accumulations nowadays are object of few focused projects studies in Bering Sea, Japan Sea, Sea of Okhotsk, East-China Sea, South-China Sea and Philippine Sea separately by the Asian countries. There for, nature and evolution of the gas hydrate system in the lithosphere and hydrosphere of the AS, which in respect to energy resources and environmental agent is one of the most uncertain and debatable problem of World Ocean. We are also represents latest results of the bilateral Russia-Japan cooperation on gashydrates study in the Japan Sea.

Authors propose to conduct gashydrate comparable research in the promising basins of Indian Ocean and Western Pacific.

The key notice of our proposing joint research is based on the next key aspects.
Exploration of gas hydrates . Ground-truthing of gas hydrate deposits. Exploitation of gas hydrate deposits . Understanding the gas hydrate system in the active and passive continental margins; Migration of methane gas; Morphology of gas hydrates. Geo-hazards associated with gas hydrates. Cold seep and climate change.
The following scientific problems we are selected based on intense discussion:
Tectonics processes governing spatial distribution of gas hydrates: The scientists agree that most of the methane hydrate form due to gas migration from deep-seated gas reservoirs through active fault/fracture system. Several examples of methane migration through active faults are reported from both active continental margin (the Pacific Gas hydrate Rim) as well as from passive continental margin (Krishna-Godavari basin). Mapping areas of neo-tectonism based on seismological/GPS study can help in locating gas hydrate deposits. ***Role of Geo-fluids in hydrate formations*****:** It is agreed that deep-seated fluids play a major role in the formation of shallow gas hydrate deposits. ***New techniques for mapping of gas hydrate deposits:*** The conventional seismic used in gas hydrate exploration is not effective and the study of BSR may not be sufficient for mapping hydrate deposits. Most The geophysical technique should be followed by drilling/coring to validate the findings. In shallow waters, vibro-coring and drilling-rig provide long cores (up to 60 m) for validation. ***Exploitation of gas hydrate deposits:*** Indian scientists showed a keen interest in exploitation of gas hydrate deposits and highlighted some of the problems they anticipate like Sand ingress in borehole, low Gas-to-Water ratio, huge water production due to shallow acquifers, seafloor subsidence and stability and Geo-hazards triggered due to uncontrolled gas migration.

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There are several locations in the Arctic Seas, Sea of Okhotsk (more than 1000 methane flares offshore Sakhalin Island or single gas flares up to 2200 m height in Kurile Basin), and Japan Sea (Tatar strait) where significant methane flux is observed. The methane fluxes from the seep sites in Indian margin are not known and hydro-acoustic techniques can be developed for estimating methane fluxes. ***Cold seep and climate change***: It is important to understand how methane migrates upon dissociation and what the sinks of methane in seawater are. The understanding of processes will help in better designing the production technology for exploitation of gas hydrate deposits in Indian margin.
Taking into account the Second International Indian Ocean Expedition (IIOE-2) and United Nations Decade of Ocean Science for Sustainable development (2021-2030) we are discussing the opportunity Joint long term cooperation on gas hydrates.

Keywords: gashydrates, Western Pacific, Indian Ocean, marginal seas

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High-resolution seafloor observation of a shallow methane hydrate area off Sakata, eastern margin of the Sea of Japan, using a three-dimensional pictorial mapping system

*Miho Asada[1], Mikio Satoh[1], Manabu Tanahashi[1], Toshiyuki Yokota[1], Shusaku Goto[1]

1. NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Shallow methane hydrate (MH) has been reported from the top of the Sakata knoll (tentative name) along a reverse fault at the foot of the southwest side of the knoll off Sakata, along the eastern margin of the Sea of Japan (Temma and Goto, 2018). Previous observation cruises conducted in this area acquired results from acoustic mapping using research vessels and autonomous underwater vehicles, optical observations using remotely operated vehicles (ROVs), logging-while-drilling measurements, and sediment sampling (Morita, 2015; Temma and Goto, 2018; Yokota, 2020). These results reveal a depression bordered by steep slopes at the top of 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 around the depression at the top of the knoll (~15 km×~5–10 km in diameter, ~120-m relative height from the southwestern foot of the knoll). The distribution of backscatter strength is largest on the steep slopes and relatively large on the terraces within the depression and the surrounding swells continuing southwestward along the knoll.

To examine the possibility of production and to assess the environmental impact, cruise 1K20 used Kaiyomaru no.1 (Kaiyo Engineering Co., Ltd.) and the ROV-*Kaiyo3000* equipped with the *SeaXerocks 1* mapping system (Kaiyo Engineering Co., Ltd.) to acquire high-resolution 3D images on the Sakata knoll. *SeaXerocks 1* was maintained at an altitude of ~4 m above the seafloor and at a speed of ~1.5 knots. Still images and topographical data by laser scanning were acquired. The resolution of the resulting 3D images was 2 mm (in the direction orthogonal to the track) ×several centimeters (along the track), which provides a detailed distribution of the chemosynthetic animals and rocks on the seafloor. *SeaXerocks 1* does not have a function that merges overlapped images on different tracks and, thus, only displays independent images along the tracks. *SeaXerocks 1* observations were conducted in and around the depression. We observed no MH on the seafloor. Seawater tends to be turbid, and relatively large animals (e.g., of squid and starfish) are abundant in the depression. A portion of the steep slope and the hill in the center of the depression has relatively rich biological heat and rock. Sediments are present at the base of depression. The two terraces on the northern and southern sides of the depression and the swells are extensively covered with sediments; however, rock outcrops and small biological mats are rarely observed. These observations suggest that fluid seepage is limited to the steep slope around the depression and a few parts of the swells and is less active in the present stage.

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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Morita (2015) FY2014 AUV survey in shallow methane hydrate fields in Japan Sea, Japan Geoscience Union meeting 2015, MIS24-02, abstract (May 27, Chiba)
Yokota (2020) Results of high-resolution 3D seismic reflection survey, Research and development of

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shallow methane hydrate, FY2020 Achievements Report Meeting, Research and development project for shallow methane hydrate, AIST (in Japanese)

Keywords: shallow methane hydrate, acoustic mapping, 3D pictorial mapping system

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Survey of methane hydrate off Tokachi, Pacific Ocean

*Satoshi Yamashita[1], Akihiro Hachikubo[1], Hirotoshi Sakagami[1], Masaaki Konishi[1], Kzutaka Tateyama[1], Hirotsugu Minami[1]

1. Kitami Institute of Technology

In the sea area around Hokkaido, the existence of bottom simulating reflectors (BSR) has been confirmed off Abashiri, Okushiri Island, Hidaka, and Tokachi. In the Pacific Ocean off Tokachi, the National Institute of Advanced Industrial Science and Technology conducted a seismic survey (GH02) in 2002. When the sound wave cross section obtained by GH02 was examined, gas chimneys and mound topography were confirmed at about 30 points on the survey line. Therefore, we are conducting the seafloor topography and methane plume observation by the multi-beam echosounder and quantitative echo sounder, and the sampling of seafloor sediments in the Pacific Ocean off Tokachi after 2014, using the research training ship "Oshoromaru" owned by the Faculty of Fisheries, Hokkaido University. As a result, methane plumes were confirmed at more than 30 locations with characteristic seafloor topography such as faults. In the 2020 survey, methane hydrate was successfully collected at that one site. We report the relationship between the soil properties of seafloor sediments and the seafloor topography, and the methane plume and the seafloor topography, based on previous surveys off Tokachi.

Keywords: methane hydrate, Submarine topography, marine sediment

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.12 Zoom Room 12

[M-IS26] Gas hydrates in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University)

An increasing number of researches focusing on natural gas hydrates has recently been conducted from the environmental, material, and resource scientific viewpoints. This session aims to share and discuss the latest research results associated with natural/experimental gas hydrates to understand and examine the nature and potential of gas hydrates in the past-present-future of the Earth and the development/application for our life. Because the researches on gas hydrates are interdisciplinary, broad topics from field and experimental researches, modeling, etc. will be presented in this session.

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

[MIS26-06] Geochemical processes in surface sediments in a shallow gas hydrate reserve area off Sakata, eastern margin of the Japan Sea

*Yuki Ota[1], Masahiro Suzumura[1], Ayumi Tsukasaki[1], Atsushi Suzuki[1] (1.National Institute of Advanced Industrial Science and Technology)

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

[MIS26-07] Vp anomalies of gas hydrate-bearing sediments inferred from BSR and BGHS

*Ryo Matsumoto[1], Shiro Ohkawa[1] (1.Meiji University)

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

[MIS26-08] Purity and specific surface area of methane hydrate synthesized from fine ice powder and gas

*Daisuke Yahagi[1], Akihiro Hachikubo[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[MIS26-09] Three-dimensional nondestructive observation of natural methane hydrate

*Satoshi Takeya[1], Akihiro Hachikubo[2], Satoshi Yamashita[2], Hirotsugu Minami[2], Hirotoshi Sakagami[2], Kazuyuki Hyodo[3], Akio Yoneyama[4] (1.National Institute of Advanced Industrial Science and Technology, 2.Kitami Institute of Technology, 3.High Energy Accelerator Research Organization, 4.SAGA Light Source)

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

[MIS26-10] Concentration of helium at the formation of methane and helium mixed-gas hydrate

*Yuki Moriya[1], Hiromi Kimura[1], Akihiro Hachikubo[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology)

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

[MIS26-11] **Simulation of methane hydrate formation in coarse-/fine-grained sediments in the Nankai Trough, Japan**

*CHAO XU[1] (1.Chiba University)

Geochemical processes in surface sediments in a shallow gas hydrate reserve area off Sakata, eastern margin of the Japan Sea

*Yuki Ota[1], Masahiro Suzumura[1], Ayumi Tsukasaki[1], Atsushi Suzuki[1]

1. National Institute of Advanced Industrial Science and Technology

Seepage of subsurface methane into shallow sediments and water column has a substantial impact on geochemical and biogeochemical processes via various aerobic and anaerobic reactions. In a knoll in a shallow gas hydrate reserve area off Sakata, eastern margin of the Japan Sea, the potential areas bearing massive shallow methane hydrates have been identified by seismic exploration. During the survey cruise SS20-1 in July 2020, the ROV observation found patchy distribution of strongly anoxic areas covered with bacterial mats-like structures in the knoll caldera. Approximately 30-cm-long push core samples were collected within the anoxic area as well as just outside the area (a few meters away), which was covered with apparently oxic sediments. As a reference, a push core sample was collected outside the gas hydrate-bearing areas. The core samples from the anoxic site consisted of dark blackish sediments in the top 6 cm with strong hydrogen sulfide odor and below the depth sediments was consisted of dark gray silt. Top 10 cm sediments of the apparently oxic site had a grey color and below the depth sediments was dark in color likely under anoxic condition. The reference sample exhibited a gray color throughout the collected depth. The core samples were sliced into sections and subjected to various analyses of interstitial water sulfate, sedimentary total organic carbon, total sulfur (TS), trace elements and $\delta^{13}C$ of total inorganic carbon.

In sediments under anoxic condition including the entire core samples at the anoxic site and the sediments below 10 cm depth at the oxic site, TS contents were substantially high compared with those at the reference site, and the values of $\delta^{13}C$ of total inorganic carbon showed strongly negative values between −20‰ and −40‰ equivalent to those of subsurface methane. These results infer that via microbial anaerobic oxidation of methane (AOM) formation of sulfide minerals and authigenic carbonates occurs in the anoxic sediments. This is supported by the results of pore water sulfate distribution. While pore water sulfate concentrations were stable from the top to the bottom of the core sample collected from the reference site, a rapid and linear decrease was observed from the value equivalent to the seawater concentration to zero within the top 10 cm at the anoxic site. It is most likely that active AOM rapidly utilizes sulfate supplied from the overlying seawater through diffusion.

From the results of some geochemical analyses, the active AOM and sulfide mineral formation seems to have a considerable impact on the behaviors of some trace elements in the gas hydrate-bearing area. For example, strong enrichment of Mo and As was found in the anoxic sediments. Positive correlations of Mo and As contents with TS contents suggest that the AOM-derived sulfide favored the capture of Mo and As into sulfide minerals such as pyrite.
This study was conducted as a part of the methane hydrate research project funded by METI (the Ministry of Economy, Trade and Industry, Japan).

Keywords: Methane, Japan Sea, Anaerobic oxidation of methane, trace elements

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Vp anomalies of gas hydrate-bearing sediments inferred from BSR and BGHS

*Ryo Matsumoto[1], Shiro Ohkawa[1]

1. Meiji University

High amplitude, bottom simulating reflectors with reversed polarity (BSR) have been attributed to the base of gas hydrate stability (BGHS). TWT of the BSR of hydrate bearing sediments in Nankai trough were observed to be about 0.32 sec. below seafloor at about 945m of water depth (Tesuji et al., 2004), whereas they were 0.18 to 0.20 sec. at 895m to 1000m along the eastern margin of the Sea of Japan. Assuming that the average Vp of shallow subsurface marine sediments of 1.50km/sec, the actual depth of BSRs are estimated to be 240mbsf and 135 to 150mbsf respectively, which are assumed to be the depth of BGHS, an important factor of hydrate exploration. On the other hand, the depth of BGHS is identified by coring and logging penetrating through BSR profiles. In Nankai trough, Main Hole and Post Survey Wells have clearly recognized the BGHS at 263mbsf (Tsuji et al, 2004; Matsumoto et al., 2004), implying that the Vp of hydrate-bearing sediments of Nankai trough is not 1.50km/sec but 1.64m/sec for the interval between the sea-floor to the BGHS due to high Vp (~3.8km/sec) hydrates.

In the Sea of Japan, methane hydrates occur as massive and disseminated aggregates in gas chimney structure (Matsumoto et al., 2017). The stability of methane hydrate in seawater is determined by the pressure and temperature, and the depth of BGHS is uniquely determined by the temperature of bottom water, thermal gradient, and water depth. Thermal gradients on the Umitaka Spur at about 900m (W.D.) off Joetsu are approximately 10.0 +/- 1.0 degreeC, and the temperature of bottom water of 0.20 degreeC (Tomaru et al., 2019; Matsumoto et al., 2017). Therefore, the equilibrium depth of the BGHS is calculated to be 100 +/- 10 mbsf. On the other hand, a number of coring and logging holes on the Umitaka Spur identified the BGHS at the depth of 100 to 120mbsf, which are consistent with the equilibrium depth of BGHS.

BSR on the Umitaka Spur and Joetsu Knoll off Joetsu area appears at around 0.20sec TWT, whereas it occurs at 0.12sec to 0.14secTWT within hydrate-concentrated gas chimney structures. Vp of the host sediments off gas chimneys is calculated to be 1.0km/sec while it is 1.40 to 1.70km/sec for hydrate-bearing sediments in gas chimneys (Ohkawa et al., 2017). Vp off gas chimney is much lower than the velocity of water, anomalously low for marine sediments. This anomaly strongly suggest that free gas (methane) bubbles developed over the hydrate-bearing Spur and Knoll sediments. Vp of the gas chimney sediments (1.40 to 1.70km/sec) looks similar or a bit higher than “normal” marine sediments, however, the Vp is also unexpectedly low, considering that massive gas hydrates accumulates in gas chimneys by 25 to 80% by volume (Matsumoto et al., 2017). Based on the field observation, exploration and theoretical consideration of the occurrence of BSR and BGHS, we came to the hypothesis that development of free gases in shallow subsurface marine sediments is a critical factor to accumulate massive gas hydrates within gas chimneys, and the existence of free gas is to be identified by anomalously low Vp inferred from BSR and BGHS.

Keywords: gas hydrates, BSR, velocity anomaly, free gas

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Purity and specific surface area of methane hydrate synthesized from fine ice powder and gas

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1. Kitami Institute of Technology, 2. National Institute of Advanced Industrial Science and Technology

Since gas hydrates are considered for applications such as gas storage and transportation media, an efficient method of their formation has been investigated. There are two methods for generating gas hydrate: (1) agitating water and gas and (2) contacting ice and gas. In this study, we focused on the latter method, which does not require an agitation system and can be combined with storage system. The purity of gas hydrate is controlled by some factors, such as the contact area between the ice and gas, temperature, pressure, and reaction time. The effect of temperature on the purity of gas hydrate has not been investigated in detail below the ice point. We formed samples of methane hydrate by contacting fine ice powder and guest gas, and measured their specific surface area by a gas adsorption method.
Finely powdered ice was scraped with a microtome and put into a pressure cell at 253 K, and measured their specific surface area. The pressure cell was then evacuated at the temperature of liquid nitrogen and research grade methane was introduced. Temperature of the pressure cell was controlled from 225 K to 268 K in a cold room or thermostatic bath for a week. After that, the pressure cell was immersed in liquid nitrogen and the liquefied excess methane was evacuated to leave only methane hydrate and unreacted ice in the cell. The cell was weighed on an electronic balance to calculate the purity of methane hydrate. The hydration number of methane hydrate was supposed to be 6, because the effect of temperature and pressure on hydration number of methane hydrate is relatively small.
Original specific surface area of fine ice powder was around 254 [m^2 kg^{-1}], and it was almost uniform in the range of ±2%. The purity of methane hydrate formed at 225 K was low (about 70%), and showed a peak maximum (more than 95%) at around 245-255 K. At higher temperatures (higher than 255 K), the purity decreased. In the temperature range of 245-255 K, the purity was higher in the sample produced in the cold room than in the sample produced in the thermostatic bath. These differences might be due to the fluctuation of ambient temperature in the cold rooms compared to the liquid bath.

Keywords: gas hydrate, hydration number, methane, specific surface area

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Three-dimensional nondestructive observation of natural methane hydrate

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1. National Institute of Advanced Industrial Science and Technology, 2. Kitami Institute of Technology, 3. High Energy Accelerator Research Organization, 4. SAGA Light Source

The density of gas hydrates varies depending on the type of guest spices encapsulated in the hydrate crystal, but is generally about the same as ice or water (0.9~1.1 g/cm^3). A material with such a relatively small density has a small absorption rate of X-rays. For this reason, it is difficult to visualize the internal structure using the X-ray absorption contrast caused by the slight difference in density within the material, which is the visualization principle of medical and industrial X-ray computed tomography (CT) systems. On the other hand, the phase of X-rays shifts significantly even in materials with small density. Therefore, if we can detect the phase shift of X-rays in a material, it is possible to observe the small density difference in the material with high sensitivity 1).

In this study, we used diffraction contrast (DEI) method2) as a method to detect the phase shift; the DEI method can detect density differences of about 0.01 g/cm^3. The DEI method can detect a density difference of about 0.01 g/cm^3 and has a relatively wide dynamic range of density (density difference: ~1 g/cm^3).3) It is also effective for high-sensitivity measurement of samples with coexisting gas (voids) in addition to gas hydrate and ice (water).3) We also performed absorption-contrast X-ray CT measurements on a sample of natural sediment. The results will be reported.

Keywords: clathrate hydrate, natural gas hydarte, Hydrate sediment, X-ray CT

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Concentration of helium at the formation of methane and helium mixed-gas hydrate

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1. Kitami Institute of Technology, 2. National Institute of Advanced Industrial Science and Technology

It is reported that helium can be enclathrated in cages composed of water molecules, i.e. gas hydrates (Londono *et al.*, 1992; Maekawa, 2003). For example, Maekawa (2003) reported that equilibrium pressure of methane and helium mixed-gas hydrate increased with composition of helium. Because helium is one of the components of natural gas, it is possible that small amount of helium molecules are enclathrated in natural gas hydrates. In the last JpGU-AGU Joint Meeting, We reported preliminary results of synthetic methane and helium mixed-gas hydrate (Kimura *et al.*, 2020). Although the composition of helium in the hydrate-bound gas was up to 6% in the last report, it must be much lower composition in natural condition. In this report, we formed methane and helium mixed-gas hydrate in the condition of lower helium concentration, and measured composition of helium in hydrate-bound and residual gases.
Experimental method is almost the same as the last report (Kimura *et al.*, 2020). Samples of mixed-gas hydrate composed of methane and helium were synthesized in a pressure cell. Gas hydrate formed at around 273 K, and residual gas in the cell was sampled and the rest of residual gas was evacuated at the temperature of liquid nitrogen. After completion of evacuation, hydrate remained in the pressure cell was dissociated at a room temperature. Samples of hydrate-bound and residual gases were stored in vials (volume: 100 mL) and their molecular composition were measured using a portable gas chromatograph (CP-4900, Varian) in the same day.
The concentration of helium in hydrate-bound gas ranged from 0.001% to 0.1%, corresponded to those in residual gas ranged from 0.1% to 10%. Therefore, concentration of helium in the hydrate-bound gas was about two orders smaller than that of residual gas, suggesting that methane preferred to be encaged in hydrate phase rather than helium. Concentration of helium in hydrate increased with the partial pressure of helium in the initial gas. We also checked a possibility that helium escaped from the hydrate phase at the vacuum process, however, concentration of helium did not change under various vacuum time.

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Keywords: gas hydrate, helium, source gas

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Simulation of methane hydrate formation in coarse-/fine-grained sediments in the Nankai Trough, Japan

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1. Chiba University

Abstract

The morphology and formation process of methane hydrate are affected significantly by the characteristics of sediments. In coarse-grained sediments, methane hydrate is formed by pore filling, while in fine-grained sediments, methane hydrate usually forms segregated lenses, veins, and nodules by replacing rock particles. At IODP Site C0002, Kumano forearc base, in the Nankai Trough, a gas bearing reservoir about 100 meters below the hydrate stability zone is discovered by logging analysis, which is used as methane source responsible for the hydrate accumulation in the numerical model. The formation of methane hydrate in coarse-grained sediments is constrained by the salt concentration in pore water, so the distribution of methane hydrate saturation is related to the distribution of salts in aqueous phase under phase equilibrium state, and the simulation results of methane hydrate distribution are consistent with the results of logging curve analysis. On the other hand, the formation mode of methane hydrate in fine-grained sediments can be determined by calculating the relative magnitude of effective stress and capillary pressure. The short-range migration theory model and patchy hydrate saturation (whereby zones with 100% pore-space hydrate saturation are embedded in hydrate-free sediments) are used to explain the profile of saturation of methane hydrate in fine-grained sediments.

Keywords: Simulation, Methane hydrate, Nankai Trough

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.16 Zoom Room 16

[M-IS27] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature)

The history of modern observation in earth and planetary sciences is often far shorter compared with the timescales of their interests. Investigation of the long-term variations and occurrences of extremely rare events requires effective use of information derived from historical documents observed and recorded by pre-modern people. Thus, historical documents have been referred in various fields of earth and planetary sciences such as seismology, climatology, meteorology and astronomy. Sharing their records, methods and experiences will be beneficial for each field and bring new insights. It is also essential to involve experienced historians because one needs to carefully investigate the reliability and the context of each document in order to use it as scientific data. On the other hand, analyzing the record in the historical documents with the eyes of modern science may also bring new insights to the historians. Cooperative work between historians and earth scientists will provide better knowledge on disaster mitigation, and science, technology and society through understanding of human reaction to historical disasters.

In this session we overview the studies using the historical documents in various fields of the earth and planetary sciences as well as the recent advances in related topics such as historical-data assimilation and digital humanities, such as AI character recognition. The aim is to promote the communication and dialogues among the researchers in various background, and thus foster the new ideas and collaborations in the study of "History X EPS."

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

[MIS27-01] Sharing historical materials: An example of multi-disciplinal examination of historical materials in Edo period

★Invited Papers

*Hirotaka Terashima[1] (1.National Archives of JAPAN)

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

[MIS27-02] Improvement of climate reconstruction by focusing on the degree of detailed description of historical daily weather record

*Kenjiro Sho[1], Yoshimi Ikeda[2], Mika Ichino[3], Junpei Hirano[4], Kooiti Masuda[5], Asanobu Kitamoto[3,6] (1.Nagoya Institute of Technology, 2.Ikeda Gakuen Ikeda Senior High School, 3.Center for Open Data in the Humanities, 4.Teikyo University, 5.Tokyo Metropolitan University, 6.National Institute of Informatic)

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

[MIS27-03] Historical atmospheric analyses by weather information assimilation using Gaussian transformation

★Invited Papers

*Xiaoxing Wang[1], Kei Yoshimura[2], Kinya Toride[2] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Institute of Industrial Science, The University of Tokyo)

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

[MIS27-04] Descriptions of natural phenomena in textbooks and people's perceptions

*Harufumi Tamazawa[1,2] (1.Kyoto City University of Arts, 2.Kyoto University)

Sharing historical materials: An example of multi-disciplinal examination of historical materials in Edo period

*Hirotaka Terashima[1]

1. National Archives of JAPAN

We have made a joint research on environmental history based on collaboration with history, biology, and forest ecology regarding historical materials of disease and insect damage that occurred in the late Edo period. Records of beech fusarium oxysporum caused by Kashinonagakikuimushi, Kashinaga or Platypus quercivorus, have not been confirmed before 1934 yet, but there is a possibility of oak damage by Kashinaga from ancient documents (Shimada Hiroshi Family, 1030, April 1863) left in Sakae Village, Nagano Prefecture. The original documents were first transcribed and interpreted based on historical methods. (1) Outbreaks of moths larvae called Kususan occured in Ohayashi or public forest between 1830 and 1843 (Tenpo year) and killed chestnuts, (2) then trees felled down with snow, (3) the reduced trees were filled up by beech. From a biology perspective, however, Kususan does not kill the trees themselves even if Kususan eats up the leaves of beech trees and konara oak. For this reason, if we think of death of trees as damage by Kashinaga, we can explain the description in the historical materials. Furthermore, it was appropriate to describe that the beech was used to resist snow from the field survey conducted by forest ecologist. In this way, knowledge of biological and forest ecology was added to historical interpretation, suggesting occurrence of damage by Kashinaga in the late Edo period. Around the same time as this study, a diary was discovered in a shrine in Iiyama City, which is a neighborhood of Sakae Village, directly describing the damage caused by Kashinaga in the 1750s. It has been pointed out that this historical document showed that damages by Kashinaga repeatedly occurred in a location with many large-diameter trees such as a shrine forest from the viewpoint of forest ecology. The introduction of unexpected perspective from natural science shows the limitations of interpretation only from historical perspective. In addition, historical examination of the historical background is also essential, for example, as there is a possibility that the document was falsely written because the residents cut trees unofficially in the forest.

Keywords: Environmental history, Ecology, Fusarium oxysporum

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Improvement of climate reconstruction by focusing on the degree of detailed description of historical daily weather record

*Kenjiro Sho[1], Yoshimi Ikeda[2], Mika Ichino[3], Junpei Hirano[4], Kooiti Masuda[5], Asanobu Kitamoto[3,6]

1. Nagoya Institute of Technology, 2. Ikeda Gakuen Ikeda Senior High School, 3. Center for Open Data in the Humanities, 4. Teikyo University, 5. Tokyo Metropolitan University, 6. National Institute of Informatic

Daily weather record of old diaries is very useful for climate reconstruction in historical times because of its exceptionally high temporal resolution as paleoclimatic proxy data. However, there is difficulty in estimating quantitative meteorological variables such as precipitation from their qualitative and subjective weather description. In this study, we attempt to develop a method to quantify weather record of diaries by focusing on the degree of detailed description of weather record.

Here we define "detailed description rate" as the proportion of the number of days with detailed weather description (more detailed than simple description in one word such as “fine” or “rain”) to the number of days with any weather description. It has high negative correlation with the threshold of recording precipitation phenomenon in diary (Sho *et al.*, 2017). Based on this relationship, we used the seasonal detailed description rate to correct the seasonal number of precipitation days for weather record of diaries written in the Edo era in Kagoshima and Kyoto, Japan. As a result, unrealistic secular trend seen in the time series of the seasonal number of precipitation days before correction was cancelled and the agreement with climatic reconstructions from other proxy data was improved for the corrected time series. This infers the possibility that the difference in weather classification criterion among writers of diary can be adjusted and long time series of a meteorological variable such as precipitation can be composed from weather record of diaries by different writers by using the detailed description rate. Moreover, we are comparing weather record of various diaries written in the Meiji and Taisho periods (late 19th to early 20th centuries) with four-hourly precipitation data at the neighboring meteorological station to understand the detailed relationships between weather recorded in diaries and actual meteorological phenomena at that time.

Keywords: historical daily weather record, detailed description rate, quantification

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Historical atmospheric analyses by weather information assimilation using Gaussian transformation

*Xiaoxing Wang[1], Kei Yoshimura[2], Kinya Toride[2]

1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Institute of Industrial Science, The University of Tokyo

Historical climate provides a reference for predicting future climate change by analyzing the past climate variability. Before the modern instrumental weather record, old descriptive sources (i.e., diaries) are important in reconstructing daily weather conditions. Data assimilation is recently widely used in climate reconstruction because it optimally combines meteorological information with a climate model. In Japan, there is a Historical Weather Database (HWDB) derived from diaries, recording daily weather information at more than 18 observation sites during the 1750s to 1870s. Cloud cover can be converted from the descriptive weather records but is difficult to assimilate because of its non-Gaussian characteristic. The objective is to reconstruct historical weather with a 6-hour temporal resolution by cloud cover data assimilation using a Gaussian transformation method. This study conducts a practical experiment in 1995 with the Global Spectral Model (GSM) and a local ensemble transform Kalman filter (LETKF) and validates the reconstruction results by reanalysis data. The observation information used in data assimilation is cloud cover categories converted from the JMA description data, keeping the consistency with the diary weather information. A control experiment without any observation assimilated (NoDA) and two experimental runs with cloud cover assimilated (NoGT and GT) are performed over Japan. Assimilation results indicate the small fluctuation amplitude in NoDA and NoGT, but GT impacts are evident in cloud cover estimation. 2-month average RMSE over the 17 observation grids are improved by 9.9% by GT, compared to NoGT. GT also contributes to RMSE reductions in three-dimensional atmospheric variables, especially in the higher troposphere. Gaussian transformation shows the great potential to improve cloud cover assimilation in actual reconstructions. This study provides a reasonable possibility to accurately reconstruct weather (for example, in the 1820s) with a higher temporal resolution.

Keywords: historical weather reconstruction, data assimilation, Gaussian transformation

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Descriptions of natural phenomena in textbooks and people's perceptions

*Harufumi Tamazawa[1,2]

1. Kyoto City University of Arts, 2. Kyoto University

By unraveling the records of the past, we can learn how people perceived natural phenomena, but there may be a gap in time between the state-of-the-art knowledge gained through specialized research in the natural sciences and the perception of the general public. However, there may be a gap between the state-of-the-art knowledge gained through specialized research in the natural sciences and the general public's perceptions over time. In the modern and post-modern periods, we can learn more about the perceptions of the time by studying the descriptions in textbooks and the extent of their dissemination. Particularly for phenomena that are unfamiliar to some people in some places, the latest knowledge is brought in from the outside, which changes how we are connected to the traditional perceptions. Although auroras are rarely seen in Japan, when they are observed on a large scale, various records may be available. On the other hand, the interpretation of these records varies from one recorder to another. In the Meiji era (1868-1912), descriptions of low-latitude auroras appeared in geography and geology textbooks, while in some books from the late Edo period (1603-1868) they were translated from European technical books. The Chinese word "red chi" was changed to "polar light" in the Meiji period (1868-1912) and written in katakana as "aurora," but the literal translation "northern light" was used in some books. In this paper, we will discuss the relationship between the phenomenon and the scientific understanding of the observed low-latitude aurora.

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.16 Zoom Room 16

[M-IS27] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Harufumi Tamazawa(Kyoto City University of Arts)

The history of modern observation in earth and planetary sciences is often far shorter compared with the timescales of their interests. Investigation of the long-term variations and occurrences of extremely rare events requires effective use of information derived from historical documents observed and recorded by pre-modern people. Thus, historical documents have been referred in various fields of earth and planetary sciences such as seismology, climatology, meteorology and astronomy. Sharing their records, methods and experiences will be beneficial for each field and bring new insights. It is also essential to involve experienced historians because one needs to carefully investigate the reliability and the context of each document in order to use it as scientific data. On the other hand, analyzing the record in the historical documents with the eyes of modern science may also bring new insights to the historians. Cooperative work between historians and earth scientists will provide better knowledge on disaster mitigation, and science, technology and society through understanding of human reaction to historical disasters.

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3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MIS27-05] Accomplishments and Potential Applications of Historical GIS: Researching Old Maps and Contributing Locally

★Invited Papers

*Akihiro Tsukamoto[1] (1.Tokushima Univ.)

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

[MIS27-06] Analysis of aftershocks of the 1855 Ansei Edo Earthquake using old documents discovered around Kanto Ko-Shinetsusing old documents discovered around Kanto Ko-Shinetsu

*Baba Michito[1], Yasuyuki Kano[1] (1.Earthquake Research Institute,University of Tokyo)

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

[MIS27-07] A historical record of frequent felt earthquakes on 1870 May and the destructive earthquake on 1870 May 13 felt in Yokohama

*Kentaro Hattori[1], Junzo Ohmura[2] (1.Kyoto Univ., 2.Tokyo Univ.)

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

[MIS27-08] Integrated IDP catalog considering the continuity of historical and modern earthquake catalog

*Yasuyuki Kano[1,2], Junzo Ohmura[1,2] (1.Earthquake Research Institute, The University of Tokyo, 2.Collaborative Research Organization for Historical Materials on Earthquakes and Volcanoes, UTokyo)

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

[MIS27-09] Discussion

Accomplishments and Potential Applications of Historical GIS: Researching Old Maps and Contributing Locally

*Akihiro Tsukamoto[1]

1. Tokushima Univ.

1. Introduction

Research that applies the vaunted functionalities of Geographic Information Systems (GIS) in data management and spatial analysis for analyzing past spaces and historical materials is gaining traction globally as a brand-new field called "Historical GIS." This paper will provide an overview of the past accomplishments of Historical GIS that have accompanied the spread of digital archiving and GIS technology, thereby further exploring their potential applications. Specifically, it will discuss the results of GIS research involving old maps and introduce cases where such results have been utilized for studying local regions.

2. Accomplishments of Historical GIS

First, the accomplishments of Historical GIS research are cited to include the construction of platforms used for developing old maps and other digitized historical records available to the public. For example, "A Vision of Britain Through Time," which is a project combining past maps with statistical data spearheaded by England's University of Portsmouth; and Old Maps Online, an online portal for old maps built using open-source resources. These projects use online maps to overlay past statistical information with old maps, allowing users to search location names, old maps, and more. In the early 2000s, online platforms were used in this manner to link old maps with historical geographic information and pursue historical GIS projects aimed at aggregating massive amounts of documents, materials, and data.
Using the knowledge accumulated thus far, GIS is now being utilized in the scientific research on spatial information associated with the geographic distribution of all past phenomena, while comprehensively considering traditional research on map history and historical geography that takes into account historic backgrounds. As a result, we have seen an increase in the sophistication of Historical GIS research (Hirai et al., 2014).

3. Approach to local learning through Historical GIS

The old maps made available to the public by Historical GIS projects have also contributed to initiatives aimed at local learning. For example, the online map system of the Tokushima Castle Museum, "A Historical Stroll Through Castle Town Tokushima," makes it possible to switch between the old map and the current map; this system was publicly released to impart local learning.
Old maps include a wealth of historical records, particularly spatial information, and it is relatively easy to integrate this information into online maps. Therefore, they are used as tools to gain an understanding of local regions based on comparisons between the present and the past data.

4. Conclusion

This report provided an overview of the trends observed in Historical GIS research and established that the discipline has developed to the point where its results are now being applied to studies based on local communities. Although Historical GIS research is one of the many fields that uses historical datasets, the use of GIS as a primary research tool renders it a rare field that is capable of constantly updating itself with the latest science and technology. This characteristic implies that GIS can not only provide academic contributions to adjacent disciplines, but also be utilized in a wide variety of applications that facilitate

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community research.

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Keywords: Historical GIS, Old Maps, Potential Applications, Local Learning

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Analysis of aftershocks of the 1855 Ansei Edo Earthquake using old documents discovered around Kanto Ko-Shinetsu sing old documents discovered around Kanto Ko-Shinetsu

*Baba Michito[1], Yasuyuki Kano[1]

1. Earthquake Research Institute,University of Tokyo

The 1855 Ansei Edo earthquake occurred around pm 9 of November 11 1855 and caused damage in Edo and around Kanto area by strong shaking. Usami (2001) estimated the epicenter of the mainshock in Northern part of Tokyo bay. For this earthquake, there are many historical documents which show the details of the aftershock activity as well as the main shock. We analyzed the aftershock activity of Ansei Edo earthquake by using “Ebihara-ke Document” discovered in the beginning of 2000 and “Ohya-ke Daily” introduced in Tsuji (2003) in addition to published historical collection of earthquakes.

We focused on temporal changes of aftershock activity of Ansei Edo earthquake. We compared the records of earthquake written in “Ansei Jishin Kakitome no Koto” in “Ebihara-ke Document” with those in the old document that has detailed record of aftershock activity in Edo, for example, “Yaburemado no Ki.” We also examined difference between the number of records in daytime and night. There are various possible reasons for the difference in the number of aftershocks recorded in each document, such as the differences in the temporal resolution of earthquakes in each archive or the differences in the seismic intensity due to differences in the epicenter and magnitude of each aftershock. In this study, we applied the Omori-Utsu formula to the aftershock records in "Ansei Jishin Kakitome no Koto", and found a good agreement between the curve of the Omori-Utsu formula applied to " Ansei Jishin Kakitome no Koto " and the number of aftershocks recorded by historical documents in Edo after the third day of the main earthquake.This suggests that the "Ansei Jishin Kakitome no Koto" may have recorded aftershocks that were overlooked by some historical documents in Edo such as the “Yaburemado no Ki”.

Next, we focused on the spatial distribution of aftershock activity of the Ansei Edo earthquake. We categorized the discription on the day when aftershock occurred into four categories: "no articles", "articles without earthquake records," "articles with earthquake records," and "articles with large earthquake records," and plotted them on a map to see the distribution of felt records for each aftershock. Then, using this map, we estimated the felt area of four aftershocks, including the earthquake of November 17 1855, which is considered to be the largest aftershock of the Ansei Edo Earthquake. We compared the time of occurrence and shaking characteristics of the earthquake on November 17 1855, which is regarded as the largest aftershock by Nakamura and Matsu'ura (2011). It was found two earthquakes occured, one at dusk and the other at night, and that the sensitivities may have differed. We also compared the distribution of seismic intensity between aftershocks and main shock.

There are various possibilities for the difference of felt distribution between the aftershock and the mainshock obtained in this study, such as the difference in the location and magnitude of the epicenters of the mainshock and aftershocks, the difference in the accuracy of time of the respective records, and the inclusion of earthquakes not included in the aftershock sequences of the Ansei-Edo Earthquake or earthquakes that occurred in the other region.

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A historical record of frequent felt earthquakes on 1870 May and the destructive earthquake on 1870 May 13 felt in Yokohama

*Kentaro Hattori[1], Junzo Ohmura[2]

1. Kyoto Univ., 2. Tokyo Univ.

On 1870 May 13, at about 2 AM, a destructive earthquake (M 6 ~ 6.5) occurred in the western part of Kanagawa Prefecture, causing damage to the Odawara area [Usami et al. (2013)]. Matsuura et al. (2006, 2020) defined the epicenter as the eastern part of Yamanashi Prefecture and concluded that the earthquake occurred at the seismically active area at the depth of 20 -30 km. Since early May, about 2 weeks before the earthquake, felt earthquakes had frequently occurred in the surrounding areas such as Shizuoka Prefecture [Ishibashi (1993)]. They have been interpreted as the foreshocks [Usami (2020)].

In order to investigate the frequently felt earthquakes this study examines the felt earthquake record written by a foreigner (James Gordon Kidd) who lived in Yokohama in the same period and compares it with other contemporary Japanese records. Kidd recorded the date of 131 earthquakes felt in Yokohama from 1870 May 1 to 26 including the size and duration of 9 large earthquakes. Based on this record, the diurnal variation of the number of felt earthquakes in Yokohama is shown in Fig. 1. The number of felt earthquakes per day was the largest on 1870 May 13, when the destructive earthquake of Odawara occurred. In addition, a peak of the number of felt earthquakes per day was observed on May 9.

We also examine the possibility that the frequently felt earthquake described by Mr. Kidd occurred off the east coast of Izu Peninsula. Since 1978, earthquake swarms off the east coast of Izu peninsula, caused by magma intrusions, have occurred repeatedly along and off the coast of Ito City, Shizuoka Prefecture [Earthquake Research Committee, Headquarters for Earthquake Research Promotion (2010)]. The Ito earthquake swarm, which occurred in the offshore area of Ito City in 1930, is also considered to have originated from magma intrusions [Center for Earthquake Prediction and Eruption Prediction, School of Science, Tohoku University (1990)]. Koyama (1993 , 1999), who examined earthquake swarms off the east coast of Izu peninsula before 1930, estimated that the swarm earthquake occurred either in 1868 May to July or in 1870 May to June. Our study raises the possibility that this earthquake swarm occurred not in 1868 (the former) but 1870 (the latter).

Keywords: historical earthquake, the 1870 Odawara earthquake, earthquake swarms off the east coast of Izu peninsula

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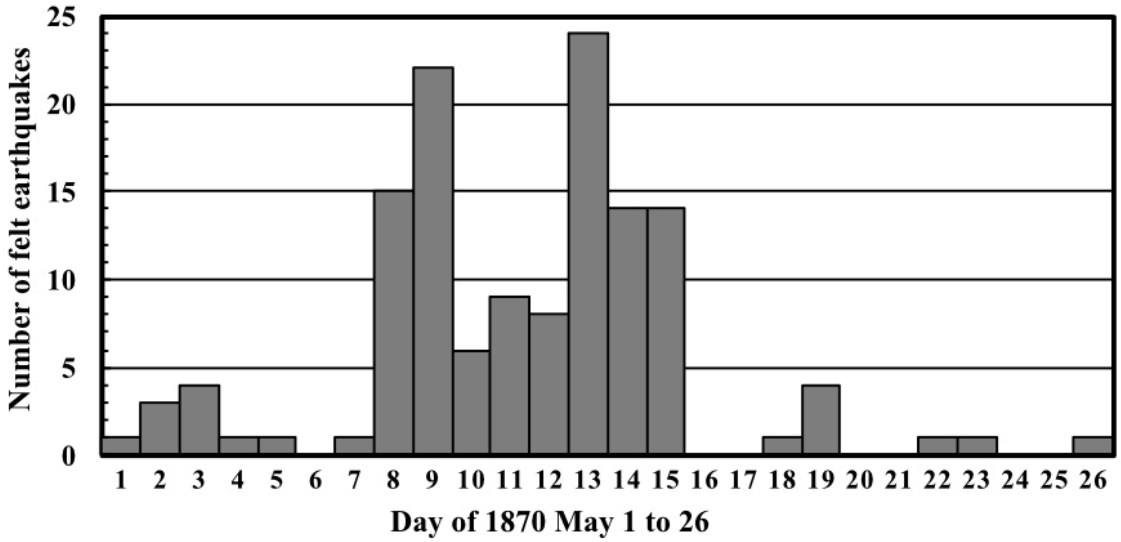


Fig. 1. Diurnal variation of the number of earthquakes felt at Yokohama from 1870 May 1 to 26.

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Integrated IDP catalog considering the continuity of historical and modern earthquake catalog

*Yasuyuki Kano[1,2], Junzo Ohmura[1,2]

1. Earthquake Research Institute, The University of Tokyo, 2. Collaborative Research Organization for Historical Materials on Earthquakes and Volcanoes, UTokyo

For historical earthquakes, seismic intensities at each point is estimated based on the description of collected historical materials, and the epicenter, hypocenter, and magnitude of the earthquake are estimated. Several catalogues of the results have been published. Regarding the seismic intensity data points (IDPs), "[Intensity distribution and iso-seismal maps for historical earthquakes in Japan]" and "[comprehensive table of Japanese historical earthquake]" are compiled. For current earthquakes, Japan Meteorological Agency has been publishing JMA seismic intensity data as part of the Seismological Bulletin of Japan. It has been maintained back to 1919 and is available online.

If the IDPs can be searched and displayed through both catalogs of historical and current earthquakes, it will be useful for estimating the epicenter of the historical earthquake and for examining the validity of seismic intensity estimation. However, the differences between the two catalogues should be carefully handled for integration. The current catalog includes JMA intensity and instrumental intensity are given. For historical earthquakes, there are cases where an estimated JMA seismic intensity is given, and expressions based on historical materials such as "earthquake" and "strong earthquake" are given. Regarding the location of the observation points, the current catalog provides the location (geographic coordinates) of the observation stations. For historical earthquakes, the observation points are determined based on descriptions of historical materials, but their accuracy varies. They can be identified at the building, and in some cases only in villages, counties, or countries. In "[Intensity distribution and iso-seismal maps for historical earthquakes in Japan]" mentioned above, the observation points are provided as current municipal level. It is necessary to identify and register observation points for historical earthquakes. Also, when integrating the catalog, it is necessary to provide information on the accuracy of the seismic intensity and location of observation points, especially in the catalog of historical earthquakes.

Even if the seismic IDPs of historical and current earthquakes are integrated, the distribution of observation points is different. When comparing seismic intensity distributions of historical and current earthquakes, it is effective to create a virtual IDPs and estimate the seismic intensity of them using the attenuation relation of seismic intensity or interpolation of the seismic intensity based on site amplification zoning. We propose a system to display the integrated catalog of observed and virtual IDPs.

Keywords: Historical earthquakes, IDP, Seismic catalog

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[J] Oral | M (Multidisciplinary and Interdisciplinary) | M-IS Intersection

[M-IS27] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Harufumi Tamazawa(Kyoto City University of Arts)

Sun. Jun 6, 2021 3:30 PM - 5:00 PM Ch.16 (Zoom Room 16)

The history of modern observation in earth and planetary sciences is often far shorter compared with the timescales of their interests. Investigation of the long-term variations and occurrences of extremely rare events requires effective use of information derived from historical documents observed and recorded by pre-modern people. Thus, historical documents have been referred in various fields of earth and planetary sciences such as seismology, climatology, meteorology and astronomy. Sharing their records, methods and experiences will be beneficial for each field and bring new insights. It is also essential to involve experienced historians because one needs to carefully investigate the reliability and the context of each document in order to use it as scientific data. On the other hand, analyzing the record in the historical documents with the eyes of modern science may also bring new insights to the historians. Cooperative work between historians and earth scientists will provide better knowledge on disaster mitigation, and science, technology and society through understanding of human reaction to historical disasters.

In this session we overview the studies using the historical documents in various fields of the earth and planetary sciences as well as the recent advances in related topics such as historical-data assimilation and digital humanities, such as AI character recognition. The aim is to promote the communication and dialogues among the researchers in various background, and thus foster the new ideas and collaborations in the study of "History X EPS."

4:45 PM - 5:00 PM

[MIS27-09]Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.09 Zoom Room 09

[M-AG38] Ten years after the Fukushima Dai-ichi NPP Accident : Dynamics of radionuclides in the environment

convener:Daisuke Tsumune(Central Research Institute of Electric Power Industry), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

Ten years have passed since the accident at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi Nuclear Power Station (NPP), which was triggered by the Great East Japan Earthquake and tsunami. Huge amount of radionuclides were emitted to the environment by the accident. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. This session focus on various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment, furthermore, to develop as global migration studies by generalization. It is expected that this session will offer a good opportunity to summarize the research activities of the past ten years and deepen the discussion on cross-disciplinary research issues for the next ten years.

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

[MAG38-01] New X-ray spectroscopic methods for the speciation of cesium in environment

★Invited Papers

*Yoshio Takahashi[1], Hikaru Miura[3], Daisuke Tsumune[3], Yuichi Kurihara[2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.JAEA, 3.CRIEPI)

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

[MAG38-02] 10-year variation of atmospheric Cs radioactivity concentration observed at highly polluted area in Fukushima

*Kazuyuki Kita[1], Naho Hayashi[1], Peng Tang[1], Kotaro Hatanaka[1], Takeshi Kinase[2], Kouji Adachi[2], Yuji Zaizen[2], Ishizuka Masahide[5], Jun Furukawa[3], Yuko Hatano[3], Keisuke Sueki[3], Yuichi Onda[3], Kazuhiko Ninomiya[4], SHINOHARA ATSUSHI[4], Sakae Toyoda[6], Keita Yamada[6], Naohiro Yoshida[6], Yukihiko Satou[7], Yasuhito Igarashi[8] (1.Faculty of Science, Ibaraki University, 2.Meteorological Research Instutite, 3.Tsukuba University, 4.Osaka University, 5.Kagawa University, 6.Tokyo Institute of Technology, 7.JAEA, 8.University of Kyoto)

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

[MAG38-03] Temporal variations and future estimations of ^{90}Sr and ^{137}Cs in atmospheric depositions after the Fukushima Daiichi Nuclear Power Plant accident with long-term observations

★Invited Papers

*Takeshi Kinase[1,2], Kouji Adachi[2], Thomas Sekiyama[2], Mizuo Kajino[2], Yuji Zaizen[2], Yasuhito Igarashi[3,4] (1.Japan Agency for Marine-earth Science and Technology, 2.Meteorological Research Institute, 3.Institute for Integrated Radiation and Nuclear Science, Kyoto University, 4.Ibaraki University)

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

[MAG38-04] Comprehensive evaluation on wet scavenging schemes for ^{137}Cs transport modeling following the Fukushima Daiichi accident

*Shuhan Zhuang[1], sheng fang[1] (1.Tsinghua University)

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

[MAG38-05] Migration and distribution of radiocesium in forest 10 years after the Fukushima nuclear accident

*Hiroaki Kato[1], Yuichi Onda[1], Zul Hilmi Saidin[1], Hikaru Iida[1], Satoru Akaiwa[1], Tomoki Shinozuka[1]
(1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

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

[MAG38-06] Discussion

New X-ray spectroscopic methods for the speciation of cesium in environment

*Yoshio Takahashi[1], Hikaru Miura[3], Daisuke Tsumune[3], Yuichi Kurihara[2]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. JAEA, 3. CRIEPI

Speciation of cesium, or radiocesium, in environment is essential for the better understanding of its behavior in environment. For this purpose, X-ray absorption fine structure spectroscopy (XAFS) in fluorescence mode is one of most effective methods, but interference of Cs signal by signals from background elements (ca. calcium (Ca) and titanium (Ti)) is a severe problem to selectively obtain the signal from Cs. 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, the two methods were applied to chemical state of radiocesium (RCs) using X-ray absorption near-edge structure (XANES) analysis in fluorescence mode for the RCs incorporated into cesium-bearing silica microparticles (CsMP) categorized as B-type (non-spherical, with diameter about 500 μm; RCs concentration lower than 50 μg/g) emitted by Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in 2011. It was difficult to observe X-ray fluorescence of Cs Lα emission in this CsMP using a silicon drift detector because the Cs concentration in the particle was three orders of magnitude smaller than the concentrations of calcium and titanium, which caused severe deterioration of the signal-to-background ratio of the Cs Lα emission line. In this study, a high energy resolution (ca. 5 eV FWHM) energy-dispersive transition edge sensor (TES) spectrometer was applied to XANES spectroscopy of trace elements in environmental materials for the first time, which enabled us to measure Cs LIII-edge XANES for RCs in CsMP. It was demonstrated that TES can be a powerful tool for the speciation of trace elements in environmental samples by fluorescence XANES considering its high energy resolution coupled with wide application range and simplicity of operation as energy-dispersive type detector. The results in this study revealed that RCs was dissolved into the silicate matrix. This information is consistent with the emission process that the type-B CsMP was formed by the cooling of melted materials during the FDNPP accident suggested in previous studies. We also employed another method using crystal analyzer coupled with Pilatus detector, instead of using TES. The energy resolution is even better than TES, which finally enables us to measure high energy resolution fluorescence detection (HERFD) XANES spectroscopy, which can give more information on the chemical state of Cs. The application of HERFD-XANES will be also given in this presentation.

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10-year variation of atmospheric Cs radioactivity concentration observed at highly polluted area in Fukushima

*Kazuyuki Kita[1], Naho Hayashi[1], Peng Tang[1], Kotaro Hatanaka[1], Takeshi Kinase[2], Kouji Adachi[2], Yuji Zaizen[2], Ishizuka Masahide[5], Jun Furukawa[3], Yuko Hatano[3], Keisuke Sueki[3], Yuichi Onda[3], Kazuhiko Ninomiya[4], SHINOHARA ATSUSHI[4], Sakae Toyoda[6], Keita Yamada[6], Naohiro Yoshida[6], Yukihiko Satou[7], Yasuhito Igarashi[8]

1. Faculty of Science, Ibaraki University, 2. Meteorological Research Instutite, 3. Tsukuba University, 4. Osaka University, 5. Kagawa University, 6. Tokyo Institute of Technology, 7. JAEA, 8. University of Kyoto

Contineous obeservation of atmospheric activity concentration of radiocesium has been carried out at sites in highly polluted area in Fukushima for about 10 years from 2011. Reviews on trend and sesonal variation of atmospheric activity concentration and their causes, as well as atmospheric resuspension of insoluble Cs particles (CsMP) will be presented.

Keywords: radiocesium, atmospheric radioacitity

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Temporal variations and future estimations of ^{90}Sr and ^{137}Cs in atmospheric depositions after the Fukushima Daiichi Nuclear Power Plant accident with long-term observations

*Takeshi Kinase[1,2], Kouji Adachi[2], Thomas Sekiyama[2], Mizuo Kajino[2], Yuji Zaizen[2], Yasuhito Igarashi[3,4]

1. Japan Agency for Marine-earth Science and Technology, 2. Meteorological Research Institute, 3. Institute for Integrated Radiation and Nuclear Science, Kyoto University, 4. Ibaraki University

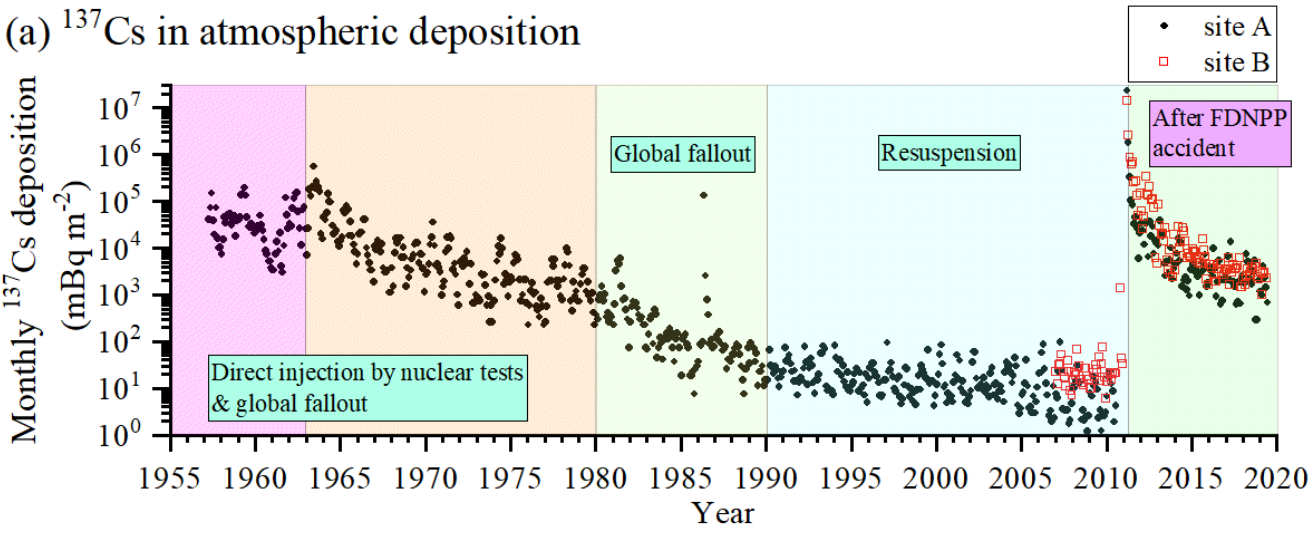
Atmospheric nuclear tests and nuclear power plant accidents have released artificial radionuclides into the atmosphere, land surface, and ocean. We have measured the artificial radionuclides, especially ^{90}Sr and ^{137}Cs, in atmospheric depositions since 1957 in the Kanto areas around Tokyo, Japan. As a result, we clarified the variations in ^{90}Sr and ^{137}Cs, which were emitted from atmospheric nuclear tests and nuclear power plant accidents, and their environmental processes due to their diffusion, deposition, and resuspension (figure). In March 2011, the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident occurred in Japan, and significant increases in ^{90}Sr and ^{137}Cs were detected at our observation sites: a suburban site in the Kanto Plain (site A) and a top of the mountain in the northwestern corner of the Kanto Plain (site B), respectively. In this study, we show our long-term observation results of ^{90}Sr and ^{137}Cs in monthly atmospheric deposition samples collected at sites A and B and estimate the current environmental processes and decay periods of ^{90}Sr and ^{137}Cs with measurements of ^{134}Cs and stable elements and isotopes (Na, Mg, Al, K, Ca, Ti, Mn, Fe, Ni, Cu, Zn, Sr, Ba, ^{9}Be, ^{133}Cs, ^{232}Th, and ^{238}U).

During the period of plume arriving at site A from the FDNPP, ^{90}Sr and ^{137}Cs in monthly deposition samples increased to 2.7×10^{3} and 3.2×10^{6} times, respectively, higher than those before the accident. Our continual observations revealed that the peak of ^{137}Cs due to the FDNPP accident was much higher than those from the nuclear weapon tests and the Chernobyl accident. On the other hand, the peak of ^{90}Sr due to the FDNPP accident was lower than that from the nuclear weapon tests in the 1960s. The monthly deposition rate of ^{137}Cs in 2018 declined to ~1/8100 and ~1/4500 of the peak levels at sites A and B, respectively, but it remained more than ~400 and ~130 times higher than those before the accident. Cesium-134 was also measured at both sites until recent observations, implying that most of the radioactive Cs were originated from the FDNPP. The current ^{90}Sr deposition, on the other hand, has returned to the same radioactive level as that before the accident at both sites. The chemical analysis suggested that dust particles were the major carriers of ^{90}Sr and ^{137}Cs during the resuspension period at site A. On the other hand, at site B, ^{90}Sr was reserved and recycled in the forest, but the source of ^{137}Cs could not be identified. Presently, the effective half-lives for ^{137}Cs deposition at sites A and B due to radioactive decay and other environmental factors are estimated as 4.7 and 5.9 years, respectively. These estimations suggest that approximately 42 and 48 years from 2011 are required to reduce the atmospheric ^{137}Cs deposition to a state similar to that before the accident at sites A and B.

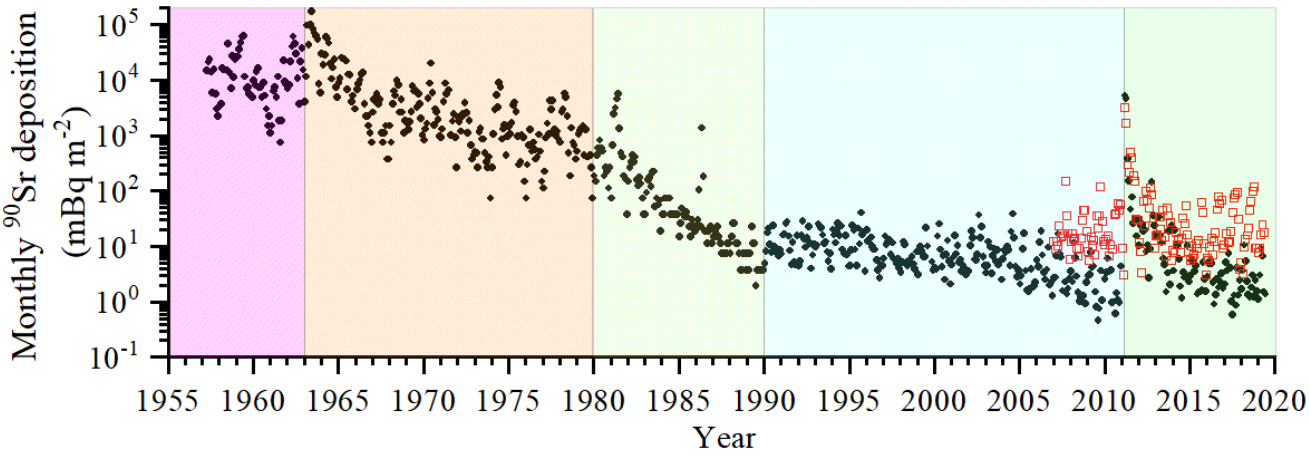
Keywords: Environmental radionuclide, Fukushima, Atmosphere, Resuspension, Deposition, Fallout

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(a) ^{137}Cs in atmospheric deposition



(b) ^{90}Sr in atmospheric deposition



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Comprehensive evaluation on wet scavenging schemes for ^{137}Cs transport modeling following the Fukushima Daiichi accident

*Shuhan Zhuang[1], sheng fang[1]

1. Tsinghua University

Wet deposition, including both the in-cloud and below-cloud scavenging, is critical for the atmospheric transport modeling of ^{137}Cs in the Fukushima Daiichi Nuclear power plant accident. Although intensively investigated, wet deposition simulation is still subject to uncertainties of meteorological input and wet scavenging modeling, leading to biased ^{137}Cs transmission prediction. To solve the problems, 25 different combinations of both the in- and below-cloud scavenging schemes were integrated into the Weather Research and Forecasting-Chemistry, realizing online coupled modeling of the wet scavenging processes and meteorology. With the same emission, meteorological input and WRF settings, these 25 models and their ensemble mean were systematically compared with a previous WRF-Chem model with a single below-cloud scheme on the same platform, based on both the cumulative deposition and ambient concentration of ^{137}Cs following the FDNPP accident. As far as we know, this is the first evaluation of both in- and below-cloud wet scavenging schemes based on the same online-coupled model, which may provide a clearer picture of the variation range among these schemes and the capability of WRF-Chem for ^{137}Cs transport modeling. The results demonstrate that the integration of the in-cloud scavenging scheme substantially improves the cumulative deposition simulation in light rain dominated area like Nakadori and around FDNPP, and the in-cloud schemes contribute predominately to the detailed deposition patterns, such as those in Nakadori area, which were missing in the previous below-cloud-only WRF-Chem. However, the 25 models show diverse behaviors in the presence of different meteorology for atmospheric concentration, though the ensemble mean achieves fair and stable performance for deposition and concentration under different plume events. Specifically, only the models considering cloud parameters show potential in optimizing the overall simulation, such as the Roselle-Bakla, Hertel-Bakla and Roselle-Apsimon. In comparison, the wet deposition models dependent only on the rain intensity are very sensitive to the meteorology. So, a combination of the in-cloud scheme with cloud parameters and a below-cloud scheme using a refined power function may be promising in improving the simulation of ^{137}Cs.

Keywords: wet deposition, in-cloud scavenging, below-cloud scavenging, WRF-Chem, Fukushima Daiichi Nuclear Power Plant accident

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Migration and distribution of radiocesium in forest 10 years after the Fukushima nuclear accident

*Hiroaki Kato[1], Yuichi Onda[1], Zul Hilmi Saidin[1], Hikaru Iida[1], Satoru Akaiwa[1], Tomoki Shinozuka[1]

1. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba

In Japan's forests, field data on the distribution and migration of radiocesium deposited by the Fukushima Daiichi Nuclear Power Plant accident, from the initial dynamics to the distribution in the forest over ten years, have been vigorously collected. The results have been published in an IAEA technical report (IAEA-TECDOC-1927, 2020) as a database of migration parameters to be compiled by an international project (MODARIA II: Modelling and Data for Radiological Impact Assessments) promoted by the International Atomic Energy Agency (IAEA). Radiocesium's transfer mechanisms in the forest by hydrological processes and the runoff through the water system were summarized based on investigations in experimental forests and watersheds in Fukushima Prefecture. Besides, we outlined the missing links that need to be clarified by re-analysis of existing data and additional experiments based on previous studies on Fukushima and Chernobyl. Finally, we discussed the direction of future monitoring surveys.

Keywords: Fukushima nuclear accident, Forest, Radiocesium

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[J] Oral | M (Multidisciplinary and Interdisciplinary) | M-AG Applied Geosciences

[M-AG38] Ten years after the Fukushima Dai-ichi NPP Accident : Dynamics of radionuclides in the environment

convener:Daisuke Tsumune(Central Research Institute of Electric Power Industry), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

Sun. Jun 6, 2021 1:45 PM - 3:15 PM Ch.09 (Zoom Room 09)

Ten years have passed since the accident at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi Nuclear Power Station (NPP), which was triggered by the Great East Japan Earthquake and tsunami. Huge amount of radionuclides were emitted to the environment by the accident. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. This session focus on various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment, furthermore, to develop as global migration studies by generalization. It is expected that this session will offer a good opportunity to summarize the research activities of the past ten years and deepen the discussion on cross-disciplinary research issues for the next ten years.

3:00 PM - 3:15 PM

[MAG38-06]Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. Jun 6, 2021 3:30 PM - 5:00 PM JST | Sun. Jun 6, 2021 6:30 AM - 8:00 AM UTC | Ch.09 Zoom Room 09

[M-AG38] Ten years after the Fukushima Dai-ichi NPP Accident : Dynamics of radionuclides in the environment

convener:Daisuke Tsumune(Central Research Institute of Electric Power Industry), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University)

Ten years have passed since the accident at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi Nuclear Power Station (NPP), which was triggered by the Great East Japan Earthquake and tsunami. Huge amount of radionuclides were emitted to the environment by the accident. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. This session focus on various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment, furthermore, to develop as global migration studies by generalization. It is expected that this session will offer a good opportunity to summarize the research activities of the past ten years and deepen the discussion on cross-disciplinary research issues for the next ten years.

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

[MAG38-07] 10-year monitoring of ^{137}Cs transport in 30 river monitoring sites in 80km from the Fukushima Daiichi nuclear power plant

★Invited Papers

*Keisuke Taniguchi[1], Yuichi Onda[1], Kazuki Fujita[2], Yukio Takeuchi[2], Kazumi Katsuno[2], Hirotsugu Arai[2], Kouki Nasu[2] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 2.Fukushima Prefectural Centre for Environmental Creation)

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

[MAG38-08] Impact of different land use along the Kasumigaura lake on suspended sediment delivery and particulate ^{137}Cs discharge

*Bin FENG[1], Yuichi Onda[1], Manabu Motohashi[1], Keisuke Taniguchi[1] (1.Center for research in isotopes and environmental dynamics, University of Tsukuba)

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

[MAG38-09] Ten years behavior of radiocaesium derived from TEPCO Fukushima Dai-ichi Nuclear Power Plant accident in surface water in the adjacent seas of the North Pacific Ocean

*Michio Aoyama[1,2], Yasunori Hamajima[3], Yayoi Inomata[3], Yuichiro Kumamoto[4], Hyoe Takata[2] (1.Center for Research in Isotopes and Environmental Dynamic, Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Institute of Environmental Radioactivity, Fukushima University, 3.The Institute of Nature and Environmental Technolog, Kanazawa University, 4.Research Institute of Global Change, The Japan Agency for Marine-Earth Science and Technology)

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

[MAG38-10] On large-scale transport of suspended particulate matter on the continental shelf break off Fukushima, Japan.

*Kohei Kawano[1], Yusuke Uchiyama[1], Yuki - Kamidaira[2] (1.Graduate school of Engineering Faculty of Engineering, Kobe University, 2.Japan Atomic Energy Agency)

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

[MAG38-11] **Long-term simulation of oceanic ^{137}Cs with direct release and river discharge after the Fukushima Dai-ichi Nuclear Power Plant accident**

*Daisuke Tsumune[1], Tsubono Takaki[1], Kazuhiro Misumi[1], Hikaru Miura[1], Yutaka Tateda[1], Michio Aoyama[2]
(1.Central Research Institute of Electric Power Industry, 2.University of Tsukuba)

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

[MAG38-12] Discussion

10-year monitoring of ^{137}Cs transport in 30 river monitoring sites in 80km from the Fukushima Daiichi nuclear power plant

*Keisuke Taniguchi[1], Yuichi Onda[1], Kazuki Fujita[2], Yukio Takeuchi[2], Kazumi Katsuno[2], Hirotsugu Arai[2], Kouki Nasu[2]

1. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 2. Fukushima Prefectural Centre for Environmental Creation

Ten years have passed since the accident at TEPCO's Fukushima Daiichi Nuclear Power Plant (FDNPP). As a result of this accident, about 2.7 PBq of ^{137}Cs was deposited on the terrestrial area in eastern Japan. It is essential to clarify the transport of ^{137}Cs through rivers to ensure residents' safety living in the basin and understand the supply of ^{137}Cs to the ocean. Therefore, 30 river monitoring stations were set up in nine river basins located within 80 km of the FDNPP. We measured the radiocesium concentrations in suspended and dissolved forms and conducted a continuous observation of water level and turbidity at those stations. Monitoring began in 2011 at six stations located on the Abukuma River and its tributary. At the other 24 stations, monitoring began in 2012. Suspended sediment (SS) samplers were set up at each station to measure the suspended ^{137}Cs concentrations. SS samples were collected from the sampler every few weeks to months, dried, and the radioactivity concentration was measured with a germanium semiconductor detector. 60-100 L of river water was collected every few months to half a year. The river water was filtered through a membrane filter with a pore size of 0.45 μm, and the radiocesium dissolved in the filtrate was collected by the AMP coprecipitation method or the cation exchange resin method. Then, the radioactivity concentration was measured by a germanium semiconductor detector. The solid-liquid distribution coefficient (Kd) of ^{137}Cs was calculated by dividing the suspended ^{137}Cs concentration by the dissolved ^{137}Cs concentration. Water discharge (Q) and SS concentration (SSC) were calculated from water level and turbidity data. The SS flux (Qss) was calculated by multiplying Q by SSC, and the ^{137}Cs flux (L) was calculated by multiplying Qss by the ^{137}Cs concentration in the relevant period. During the ten years after the FDNPP accident, the concentration of ^{137}Cs in both dissolved and suspended forms decreased significantly. After a sharp decrease in concentration during the first year after the accident, a slightly slower declining trend was observed after the second year. The effective environmental half-lives (T_{eff}) of ^{137}Cs concentrations were about 0.11(4 sites) and 0.57 years (6sites) in the dissolved and suspended forms in the first year after the FDNPP accident. After the second year, the T_{eff}s were about 2.4 years in the dissolved form (29 sites) and about 3.0 years in the suspended form (29 sites). The Kd did not show any temporal change, and its geometric mean value was 2.9×10^5 L/kg (30 sites). The ^{137}Cs flux from the Abukuma River to the Pacific Ocean from August 2011 to December 2019 was about 49 TBq, which is 2.4% of the initial deposition. The ^{137} Cs discharged from August 2011 to March 2012 is 0.9%, while the flux transported in 2019 has decreased to about 0.19%. About 80 % of the 2019 flux was released in October when the heavy rains by Typhoon Hagibis occurred. After the Chernobyl nuclear power plant accident in European rivers, the decline in the ^{137}Cs concentration became more gradual around the seventh year. Similar trends may be observed in Fukushima's rivers. Also, there are still concerns that ^{137}Cs may be supplied to downstream areas via rivers from the forests located upstream. Therefore, it is necessary to continue to accumulated data and monitor the trends.

Keywords: Cesium-137, River, Fukushima Daiichi nuclear power plant accident

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Impact of different land use along the Kasumigaura lake on suspended sediment delivery and particulate ^{137}Cs discharge

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Large quantities of ^{137}Cs released from the Fukushima Daiichi nuclear power plant are being continuously transported from surrounding rivers into Kasumigaura lake (Ibaraki prefecture), which may pose a potential radiation threat to millions of residents' health and the local industrial development. Given over 95% of ^{137}Cs in the river tightly combined with suspended sediment (SS), learning the dynamic variation in particulate 137Cs input/discharge and the behind mechanisms controlling their migration is essential for this region. Land use is usually viewed as a critical factor affecting sediment yield and ^{137}Cs inventory. Particularly in rain season, its difference in soil erodibility would be significantly amplified, altering fluvial sediment supply and particulate ^{137}Cs discharge. However, due to the lack of long-term river monitoring in Kasumigaura lake region, the dynamic variation in fluvial SS and particulate ^{137}Cs are still unknown, which also hamper our ability to learn the impact of land use differences on the ^{137}Cs dynamic transport.

To fill this knowledge gap, we conducted a six-year monitoring campaign in two sub-catchments (i.e., Koise river basin and Sakura river basin) where the former has a higher forest proportion, and the latter one has a higher agricultural land proportion. The river monitoring dataset shows the turbidity is significantly correlated with water discharge in Koise, whereas this relationship is not evident in Sakura. Through the hysteresis analysis, we discover that hysteresis type 3 appeared more frequently in Koise, suggesting the existence of delayed SS supply. The ^{137}Cs monitoring dataset demonstrates both sites present a significant exponential decrease trend in particulate ^{137}Cs concentration, but the activities in Koise are slightly higher. Furthermore, the estimated ^{137}Cs fluxes were also found higher in Koise. Considering the forest is usually farther from rivers and has a higher ^{137}Cs entrainment coefficient, these scenarios are thought as the result of the difference in sediment supply due to their different land use composing proportions. Additionally, combining synchronous rainfall records, we find both water discharge and sediment load in two catchments responded extremely well to rainfall, confirming the significant role of precipitation in fluvial sediment supply. Furthermore, we also utilize meteorological radar data, quantified land use, and ^{137}Cs inventory to reconstrue the spatial distribution of ^{137}Cs loss, which provides a potential tool to predict the ^{137}Cs loss with watershed characteristics.

Keywords: land use, suspended sediment dynamic, particulate 137Cs discharge, Fukushima nuclear accident

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Ten years behavior of radiocaesium derived from TEPCO Fukushima Dai-ichi Nuclear Power Plant accident in surface water in the adjacent seas of the North Pacific Ocean

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After the accident at TEPCO Fukushima Dai-ichi Nuclear Power Plant, hereafter FNPP1, the caesium-137 radioactivity concentration of caesium-137 in surface water increased sharply in a wide area in the western North Pacific Ocean, and then dropped sharply or gradually decreased according to the distance from the FNPP1. In the marginal seas of the North Pacific Ocean (Sea of Japan and East China Sea), a delay was observed in the increase in the concentration of caesium-137 radioactivity concentration, and the characteristics of time change were different from those in the North Pacific Ocean. An apparent characteristic of caesium-137 radioactivity concentration was a gradual decrease from 2012 in the Ogasawara region which locates in the subtropical gyre, and recently it is about the same as or lower than caesium-137 activity concentration in surface water in the Sea of Japan. However, in the southern part of the Sea of Japan, caesium-137 activity concentration reached its maximum in 2016 and then gradually decreased until 2020. The other situation was observed eg. the activity concentration of caesium-137 remained almost unchanged from 2017 to 2020 at around the Yonaguni Island, which is the entrance to the East China Sea from the North Pacific. The apparent half-life due to advection-diffusion after radioactive decay correction was 18.9 years for the Ogasawara region for the period 2012-2020 and 12.3 years for 2016-2020, while it is slightly longer at 22.4 years for 2016-2020 in the southern part of the Sea of Japan. On the other hand, in the vicinity of Yonaguni Island, there is no change or a slight increase in 2017-2020. Also, the 134Cs / 137Cs ratio increased in the vicinity of Yonaguni Island, reaching ca. 0.5 in 2020, which is about the same as those observed at Ogasawara and the Sea of Japan. These transports mainly follow the subtropical gyre. Regarding the transport of radioactive caesium to the northern part of the East China Sea and the Sea of Japan, a part of the radioactive cesium derived from FNPP1 in the subtropical mode water moved to the west, reached the bottom of the East China Sea, and then abducted to the surface layer and transported to the Sea of Japan. The transportation process by the main route of the subtropical gyre is considered to have taken longer than the shortcut to the Sea of Japan via the ocean interior of the North Pacific as mentioned above.

Keywords: TEPCO Fukushima Dai-ichi Nuclear Power Plant accident, radiocaesium, subtropical gyre, transport, half life

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On large-scale transport of suspended particulate matter on the continental shelf break off Fukushima, Japan.

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The Fukushima Dai-ichi Nuclear Power Plant (FNPP1) was damaged by the catastrophic tsunamis as the aftermath of the 2011 off the Pacific coast of Tohoku Earthquake occurred on March 11, 2011, leading to accidental leakages of radionuclide to the environment. Previous studies have investigated the released radionuclides to the ocean through the direct discharge at FNPP1 and the initial atmospheric deposition to monitor and quantify the amount of radioactivity in seawater, marine sediments, and marine organisms. Among others, the sediment trap data at two offshore stations, one at ~100 km east of FNPP1 (Otosaka et al., 2014) and the other at ~100 km southeast of the FNPP1 (Buesseler et al., 2015), have detected a substantial amount of suspended radiocesium absorbed into marine particles such as sediments originated from the FNPP1 accident, even in the deep ocean at depths of 500-1000 m. These results suggest that large-scale transport and dispersal of suspended radionuclides at O (100 km) could have occurred in the offshore direction to reach the continental shelf breaks. A high-resolution numerical ocean modeling study by Yamanishi et al. (2016) also reported that there might be sediment transport over the shelf break off FNPP1.

This study aims to demonstrate occurrences of such sediment transport to the deep ocean, and to identify possible mechanisms responsible for large-scale processes. To this end, a STEAMER-ROMS ocean circulation model in a double nested configuration forced by the MOVE-WNP oceanic reanalysis was developed, coupled with the multi-class sediment transport model along with a two-layer stratigraphy model of the marine bed and the SWAN spectral wave model. The inner-most ROMS-L2 model, which encompasses the coastal ocean from Ibaraki up until Iwate and stretches eastward beyond the Japan Trench, was exploited to conduct a reanalysis of 3-D oceanic sediment transport for 14 months after the FNPP1 accident at a horizontal grid resolution of 600 m. The ROMS-L2 model clarifies that large-scale sediment transport has occurred extensively. In particular, clay-class sediments have frequently extended to the offshore sediment trap sites, due primarily to eddy-induced transport. Four typical sediment transport pathways are identified: 1) entrainment in offshore migrating topographically-generated mesoscale eddies enhanced by the southward coastal currents, 2) entrainment in mesoscale pinch-off eddies detached from or on the Kuroshio and its extension jet, 3) intermittent onshore transport of deep-ocean sediments resuspended over deep seamount topography on the Japan Trench, and 4) local resuspension on the continental shelf slope under influences of internal tides.

Keywords: suspended particulate, large-scale transport

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Long-term simulation of oceanic ^{137}Cs with direct release and river discharge after the Fukushima Dai-ichi Nuclear Power Plant accident

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A series of accidents at the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) following the Great East Japan Earthquake and tsunami of 11 March 2011 resulted in the release of radioactive materials to the ocean. We used the Regional Ocean Model System (ROMS) to simulate the ^{137}Cs activity in the oceanic area off Fukushima, with the sources of radioactivity being direct release, atmospheric deposition, river discharge, and inflow across the domain boundary. Note that atmospheric fallout was only considered for the first month after the accident.

Measured137 Cs activity adjacent to the 1F NPP decreased exponentially with a variation of about one order of magnitude by July 2016 and has not decreased since then. The measured ^{137}Cs activity was higher than the one before the 1F NPP accident, therefore direct release from the 1F NPP site have continued to present. One possible reason for the no decrease in measured ^{137}Cs activity since July 2016 is the impact of river discharge. In this study, measured ^{137}Cs activity adjacent to the 1F NPP was assumed to be due to direct release from the 1F NPP site, and the direct release rate was estimated by the comparison between measured data adjacent to the 1F NPP and model simulation with unit release rate.

The longer-term simulation was carried out by the estimated direct release rate until September 2020. Because the spatiotemporal variability of ^{137}Cs activity was large, the simulated results were compared with the annual averaged observed ^{137}Cs activity distribution. Simulated ^{137}Cs activity was in good agreement with measurement data in 2013. The simulated ^{137}Cs activity become smaller than the observed ones in the coastal area away from the 1F NPP site after 2014. This suggests that the impact of river discharge has become relatively larger with the decrease of direct release. Normalized annual averaged ^{137}Cs activity distributions in the regional ocean were similar for each year from 2013 to 2016. This result suggests that the annual averaged distribution is predictable. The heavy rainfall caused by the typhoon in October 2019 increased the measured ^{137}Cs activity adjacent to the 1F NPP, 2F NPP and Iwasawa coast, and the increase continued for 6 months. The simulated ^{137}Cs activity with direct release were about 7 times smaller than the measured one for 6 months after heavy rain. The increase in river flow rate due to heavy rainfall was on a scale of a few days or less, and the discharge of dissolved forms is considered to be on a much shorter time scale than six months. Since the dissolved ^{137}Cs flux from rivers was small and the impact was expected to be short-lived, it is suggested that the impact may be due to re-leaching from particle ^{137}Cs deposited in estuaries.

Keywords: Fukushima Daiichi Nuclear Power Plant accident, Radioactive cesium, Regional ocean model, Direct release, River discharge

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[J] Oral | M (Multidisciplinary and Interdisciplinary) | M-AG Applied Geosciences

[M-AG38] Ten years after the Fukushima Dai-ichi NPP Accident : Dynamics of radionuclides in the environment

convener:Daisuke Tsumune(Central Research Institute of Electric Power Industry), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University)

Sun. Jun 6, 2021 3:30 PM - 5:00 PM Ch.09 (Zoom Room 09)

Ten years have passed since the accident at the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi Nuclear Power Station (NPP), which was triggered by the Great East Japan Earthquake and tsunami. Huge amount of radionuclides were emitted to the environment by the accident. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. This session focus on various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment, furthermore, to develop as global migration studies by generalization. It is expected that this session will offer a good opportunity to summarize the research activities of the past ten years and deepen the discussion on cross-disciplinary research issues for the next ten years.

4:45 PM - 5:00 PM

[MAG38-12]Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Sun. Jun 6, 2021 1:45 PM - 3:15 PM JST | Sun. Jun 6, 2021 4:45 AM - 6:15 AM UTC | Ch.13 Zoom Room 13

[M-TT43] Brand-new scope of coupling geophysics being established by infrasound and associated waves

convener:Masa-yuki Yamamoto(Department of systems engineering, Kochi University of Technology), Takayuki Otsu(Japan Weather Association), Mie Ichihara(Earthquake Research Institute, University of Tokyo), Nobuo Arai(Disaster Mitigation Research Center, Nagoya University), Chairperson:Yoshihiro Kakinami(Hokkaido Information University), Masa-yuki Yamamoto(Department of systems engineering, Kochi University of Technology)

Infrasound and associated wave studies are recently focused on coupling waves with long-distant and vertical propagation characteristics. Such kinds of waves, having with coupling process between the atmosphere and the surface of ground and ocean, are linked with elastic waves in lithosphere and oceanic sphere, as well as to atmospheric regions up to the upper atmosphere, playing a role of generating many kinds of wavelike turbulence in thermosphere. Moreover, whole on the globe, these waves excited depending on the latitude regions, as well as on the environmental regions, such as snow ice, desert, rainforest, mountain, ocean, etc., have their own characteristics. These waves can be excited by large-scale geophysical events like volcanic eruptions, tsunami, thunderstorms, etc. as well as artificial explosions, propagating with long distance. In this session, we would like to discuss such "coupling geophysics" by using many new or well-known investigated data and simulations of infrasound and associated low frequency waves. It can combine multiple spheres in geophysics and bring a brand-new scope of geophysics. Your contributions from many regions are welcome!

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

[MTT43-01] HTV Infrasound Phase Identification in Near and Far Field Records

*I. H. HAMAMA[1,2], Masa-yuki Yamamoto[1] (1.School of Systems Engineering, Kochi University of, Japan, 2.National Research Institute of Astronomy and Geophysics, NRIAG, Egypt)

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

[MTT43-02] An estimation of acoustic velocity in lower thermosphere using GNSS TEC after the foreshock of the 2011 Tohoku Earthquake

*Yoshihiro Kakinami[1], Hiroaki Saito[2], Tetsuo Yamamoto[2], Chia-Hung Chen[3], Masa-yuki Yamamoto[4], Kensuke Nakajima[5], Jann-Yenq LIU[6], Shigeto Watanabe[1] (1.Hokkaido Information University, 2.Hokkaido University, 3.National Cheng Kung University, 4.Kochi University of Technology, 5.Kyushu University, 6.National Central University)

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

[MTT43-03] Evaluation of prototype miniature microphones for observing infrasound

*Ryouichi Nishimura[1], Taira Itoh[2], Dai Adachi[2], Yasutaka Nakajima[2], Kenichi Kidokoro[2], Toshiyuki Hasumi[2], Yôiti Suzuki[1] (1.National Institute of Information and Communications Technology, 2.RION Co., Ltd.)

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

[MTT43-04] A prompt report of multiple-site infrasound observation by the nation-wide infrasound observation consortium for M 7.3 Fukushima offshore earthquake on Feb. 13, 2021

*Masa-yuki Yamamoto[1], Nobuo Arai[2], Takayuki Otsu[3], Ryouichi Nishimura[4], Takuma Oi[5], Kensuke Nakajima[6], Hideki Ueda[7], Makiko Iwakuni[3], Yoshihiro Kakinami[8], Kosuke Heki[9], Islam H. HAMAMA[1] (1.Kochi University of Technology, 2.Nagoya University, 3.JWA, 4.NICT, 5.Toho Merchantile, 6.Kyushu University, 7.NIED, 8.Hokkaido Information University, 9.Hokkaido University)

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

[MTT43-05] Three-dimensional large-scale numerical simulation of infrasound associated with tsunami generation considering wave source and atmospheric models

*Yoshiki Saito[1], Kan Okubo[1], Kentaro Uehara[2], Hidee Tatehata[2], Hiromu Yokosu[3] (1.Tokyo Metropolitan University, 2.Japan Weather Association, 3.Chubu Electric Power Company)

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

[MTT43-06] Continuous excitation of atmospheric free oscillation by cumulus heating

★Invited Papers

*Kensuke Nakajima[1] (1.Department of Earth and Planetary Sciences,Flculty of Sciences,Kyushu University)

HTV Infrasound Phase Identification in Near and Far Field Records

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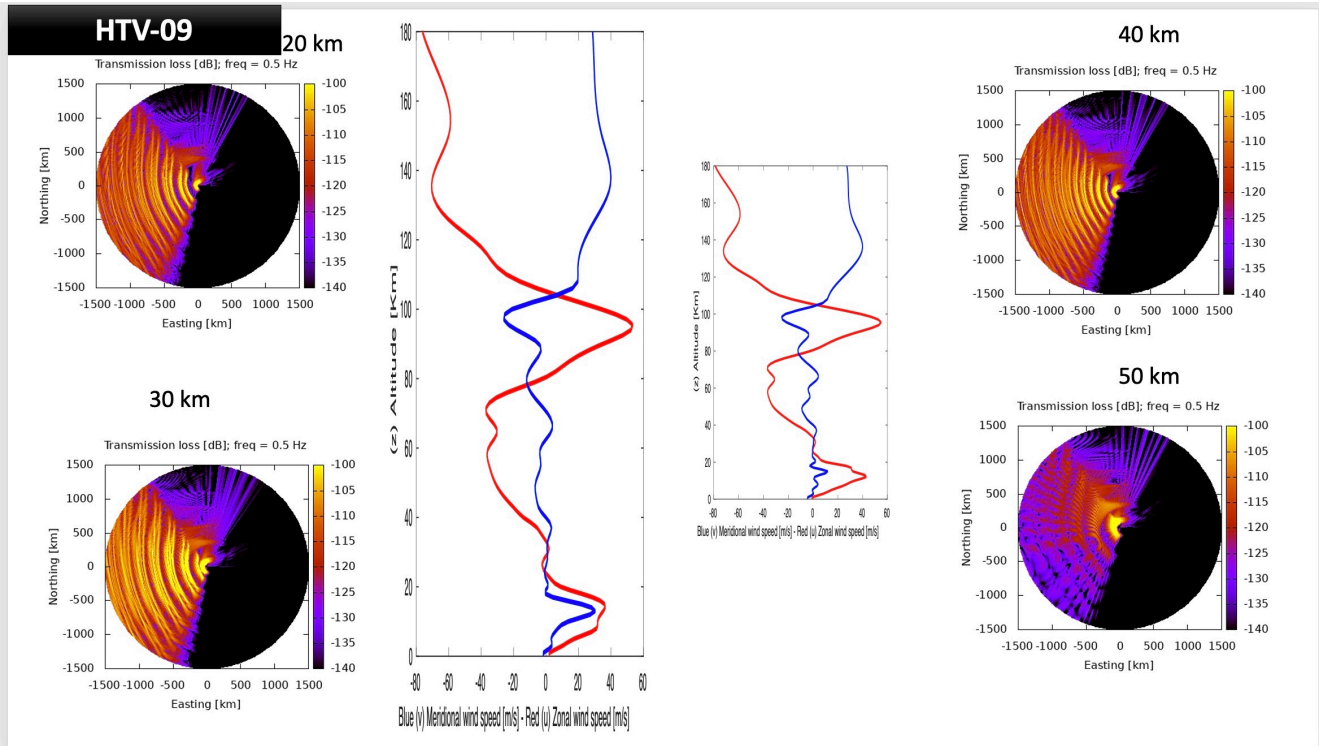
Nowadays, infrasound technology is to be involved in many applications. As the generation of shockwave in different layers in the atmosphere is a key to detect and track movable objects. Rockets can be considered one of important infrasound sources which emit acoustic signals during the launch process and the re-entry in atmosphere.

H-II Transfer Vehicle KOUNOTORI (HTV) which delivers the supplying to International Space Station (ISS) started the first mission since 2009 and operated annually until 2020, Different infrasound phases were detected at Kochi University of Technology (KUT) Infrasound Sensor Network (KUT) from HTV-06 to HTV-09. At, I30-JP infrasound observatory of the international monitoring system (IMS) recorded some phases as well. Because of the complexity of the rocket source, the assumption of point source was carried out in this study to identify the approximate height of the source in different stages which are generated infrasonic waves. Infrasound propagation modeling was applied to identify the predicted infrasound phases which could reach to the stations. Ray tracing and normal mode numerical methods were also carried out to estimate the expected celerities and the transmission loss from the source to stations from different altitudes.

In conclusion, the near and far field recordings are important in rocket induced infrasound detection to identify the different infrasound phases. In addition, the propagation modeling is a key to understand the arrivals in the stations. However, as the rocket is non-point source, additional study is still indeed to enhance the results.

Keywords: HTV, Infrasound Propagation, Ray Tracing, KUT, Rocket Launch

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An estimation of acoustic velocity in lower thermosphere using GNSS TEC after the foreshock of the 2011 Tohoku Earthquake

*Yoshihiro Kakinami[1], Hiroaki Saito[2], Tetsuo Yamamoto[2], Chia-Hung Chen[3], Masa-yuki Yamamoto[4], Kensuke Nakajima[5], Jann-Yenq LIU[6], Shigeto Watanabe[1]

1. Hokkaido Information University, 2. Hokkaido University, 3. National Cheng Kung University, 4. Kochi University of Technology, 5. Kyushu University, 6. National Central University

An acoustic wave emitted by earthquake reaches thermosphere and disturb ionospheric plasma through the collision. These disturbances are often observed in GNSS total electron content (TEC) observations. However, since TEC is the integrated plasma density, it is hard to investigate the propagation of acoustic in principle when we use a single satellite data. We found that concentrically propagating disturbance retrieved by three satellites after the foreshock of the 2011 Tohoku Earthquake on 9 March 2011. When the observed altitude is fixed an altitude, the onset points did not coincide. When we relaxed the assumption of the fix altitude, we found that the onset points coincide and altitude and geographic coordinates of the onset points are determined simultaneously. The altitudes are found to be 107.8, 131.8 and 133.3 km, and the onset time at these altitudes. As a result, the vertical velocity of acoustic wave is estimated to be 448 m/s from the travel time between the altitudes of 107.8 and 131.8 km and 370 m/s between the altitude of 107.8 and 133.3 km. These velocities are comparable to those estimated from the neutral temperature given by the empirical model NRLMSISE-00. The proposed method can determine the location of ionospheric disturbance detected in TEC independently of the seismic data and gives the information of propagation of acoustic wave in the thermosphere.

Keywords: the foreshock of the 2011 Tohoku Earthquake, velocity of acoustic wave in the thermosphere, GNSS Total electron content, an estimation of altitude of total electron content

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Evaluation of prototype miniature microphones for observing infrasound

*Ryouichi Nishimura[1], Taira Itoh[2], Dai Adachi[2], Yasutaka Nakajima[2], Kenichi Kidokoro[2], Toshiyuki Hasumi[2], Yôiti Suzuki[1]

1. National Institute of Information and Communications Technology, 2. RION Co., Ltd.

Experimental comparison was carried out among MEMS pressure sensors: DPS310, MBL1000-8, and prototype miniature microphones from the viewpoint of performance in observing relatively high frequency infrasound such as generated at volcanic eruptions. These sensors were put in a box set up in the Kagoshima University Research Forests, which is located approximately 12 km southeast from the Minamidake summit crater. MBL1000-8 is an infrasound measurement device on which eight BOSCH BME280 modules are mounted. It records the mean value of the eight sensor outputs, thereby suppressing internal noise signals relatively large at a high frequency region. On the other hand, DPS310 is a brand new MEMS pressure sensor. Many vendors supply modules to access it through a serial bus using I2C or SPI. We employed a module supplied by Seeed Studio Co. Ltd. in the experiment. According to the data sheets, relative accuracy is ±12 Pa for BME280 and ±6 Pa for DPS310. Other features are almost the same between the both. The miniature microphones were experimentally made by RION Co. Ltd., based on MEMS microphones initially designed for hearing aids and modified so as to measure infrasound. They can capture the sound up to 1 kHz so that outputs were preliminarily processed by an RC low-pass filter with the cut-off frequency of 15.9 Hz and then sampled at the sampling rate of 32 Hz with adafruit ADS1116 to acquire the data. In case of large level input, two microphones of different sensitivities were employed; one was −39.3 dBV/Pa and the other −67.1 dBV/Pa. Because of the different DC biases, outputs of these microphones were sampled with different input ranges. As a result, the minimum quantization resolution for the low sensitivity microphone was four times coarser than that of the high sensitivity. We compared the power spectrum density of the data obtained during the night because less influence of human activity was expected. The data length was six hours from the midnight. To determine the day with the least wind influence, we compared standard deviation of the data obtained everyday since the beginning of the experiment, January 19, 2021. Although the least variance was observed on 28 January, the data on 31 January was chosen for the analysis because it showed the second least variance and odd signals with an amplitude of 5 Pa often occurred on 28 January. The data was segmented into frames of 20 minutes with 50% overlap, and the mean power spectrum density was calculated. The results were approximately −12 [dB re 1 μPa^2/Hz] for the high sensitivity microphone and 24 [dB re 1 μPa^2/Hz] for the low sensitivity microphone at 10 Hz. According to literature, the electronic noise level of DASE MB2000, which is used IS of CTBTO, is approximately −8 [dB re 1 μPa^2/Hz]. Therefore, it suggests that one of the tested miniature microphones could capture infrasound with as the same noise level as MB2000. Besides, the results of MEMS pressure sensors were approximately 70 [dB re 1 μPa^2/Hz] for DPS310 and 81 [dB re 1 μPa^2/Hz] for MBL1000-8. The MEMS pressure sensors showed relatively large noise level at this frequency, but they are considered effective in measuring very low frequency infrasound, for example, a duration of over two minutes, such as observed when a tsunami happens, because its frequency is too low for microphones to capture. As described before, signals of approximately 5 Pa in amplitude were sometimes observed in the experiment. These signals were come not from the electronic circuit but from the air because all the tested sensors captured them. However, such signals were not observed in the data captured by other sensors located in different directions around Sakurajima. Therefore, the origin of these signals has not been determined yet. Possible reasons are an artificial noise made in a nearby factory or a wind generated by a truck passing by. This work was

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partly supported by JSPS KAKENHI Grant Number 17K01351 and 19H02396.

Keywords: Infrasound, Miniature microphone, MEMS, Parallel observation

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A prompt report of multiple-site infrasound observation by the nation-wide infrasound observation consortium for M 7.3 Fukushima offshore earthquake on Feb. 13, 2021

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1. Kochi University of Technology, 2. Nagoya University, 3. JWA, 4. NICT, 5. Toho Merchantile, 6. Kyushu University, 7. NIED, 8. Hokkaido Information University, 9. Hokkaido University

Nation-wide infrasound observation consortium was established in 2019 mainly for obtaining dense collaboration when any events are rarely or occasionally happened, and rapid understanding is required. Nowadays, we have almost 100 infrasound monitoring sites in Japan to detect natural geophysical events that would make disaster level affection into the human society or as a reference sensor for another type of sensing. Members of the consortium can provide some datasets on request, but there are many types of infrasound sensors whose detectable frequency range and sensitivity is different from each other.
At 23:07 JST on Feb. 13, 2021, Fukushima Offshore M 7.3 earthquake occurred, and severe vibration made more than 100 persons injured and destructed some traffic facility, buildings, etc. in and around Fukushima pref., however no apparent tsunami was observed afterward. At Ishinomaki port, slight sea level change of 20 cm was reported. There seems to be severe vibration without tsunami was because of 60 km depth of the earthquake epicenter. For this case, there is weak affection on the bottom of the ocean thus it does not make large amplitude vertical ground motion on the ocean bottom.
On the other hand, Tohoku Offshore M 9.0 earthquake occurred on Mar. 11, 2021 brought out severe tsunami disaster. At that time, an infrasound sensor located at Mizuzawa, Oshu-city, Iwate pref. recorded huge amplitude vibration signal due to severe vertical ground motion, but followed by large scale overpressure signal of 20 Pa amplitude with a period of 24 minutes. This long period signal is considered as the Lamb waves coming from the ocean surface change above the epicenter (Arai et al., 2011).
This time, the huge amplitude vibration signals due to severe vertical ground motion were also observed by multiple infrasound sensors, simultaneously, but there is no followed signal of long-period large-scale overpressure waves. We tried to estimate the infrasound tsunami magnitude for those cases and will discuss the recorded signals in comparison with the other cases as well as possibilities of dense infrasound observation for disaster mitigation.

Keywords: Infrasound, Earthquake, Lamb waves, Consortium, Multiple-site observation, Tsunami Magnitude

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Three-dimensional large-scale numerical simulation of infrasound associated with tsunami generation considering wave source and atmospheric models

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For several decades, pressure changes associated with tsunami generation have been observed in the case of large earthquakes, and the research on this phenomenon has been conducted. Past studies have reported that this change in atmospheric pressure (infrasound) is induced by the generation of a tsunami. Since infrasound propagates at a speed faster than that of a tsunami, it is expected to be applied to early detection of tsunamis. In other words, using infrasound as one of the observation targets for tsunami detection makes it possible to further improve the robustness and stability of tsunami detection. However, for this phenomenon, detailed numerical analysis considering the effects of wave sources and atmospheric environment based on actual physical phenomena has not been sufficiently studied. According to the frequency of tsunami occurrence, it is important to establish a highly reproducible numerical analysis method. Therefore, in this study, we implemented a three-dimensional large-scale propagation numerical analysis considering the wave source and atmospheric model, and numerically examined the infrasound induced by the tsunami. In this numerical experiment, tsunami-induced infrasound was compared and evaluated by removing the background atmospheric pressure trend from the observation results of the 2011 off the Pacific coast of Tohoku Earthquake. Through this research, it was clarified that a waveform close to the infrasound obtained in the field observation can be reproduced by numerical analysis employing the wave source and atmospheric environment models.

Keywords: infrasound, atmospheric pressure wave, large earthquake, tsunami, numerical simulation, disaster detection

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Continuous excitation of atmospheric free oscillation by cumulus heating

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Existence of Broadband Continuous Excitation of the Earth's Atmospheric Free Oscillation

A framework that linearizes the governing equations of the Earth's atmospheric motion, assumes periodicity in the direction of time and longitude, and separates variables in the vertical and latitudinal directions has been used as a framework for the consideration of atmospheric tides and other atmospheric waves (e.g., Chapman and Lindzen 1970). The eigenvalue (equivalent depth) of the vertical structure equation is about 10 km, and the horizontal velocity of the corresponding wave is the speed of sound (about 330 m/s). The horizontal structure equation is known as the Laplace Tidal Equation (LTE), and its modal solutions have been investigated in detail by Longuet-Higgins (1968), and they can be roughly classified into the slow westward propagating "Rossby mode" and the "gravity wave mode" with a large phase velocity. Corresponding to these modes, it has been known that there exist eastward propagating waves called "4-day waves" (zonal wavenumber 2), "5-day waves" and "10-day waves" (zonal wavenumber 1), which are associated with the Rossby mode, and "33-hour waves", which are associated with the global gravity wave mode (Kelvin mode with zonal wavenumber 1). Sakazaki and Hamilton (2020, J.Atmos.Sci), using global atmospheric reanalysis data, further showed that gravity wave modes with wavenumbers up to 10 or more are excited. On the other hand, Nishida et al (2014, Geophys.J.International) analyzed dense barometer data deployed in the eastern United States and found that Lamb waves are constantly excited from wavenumber 20 to about 1200. Lamb waves, which are trapped in the lower atmosphere and propagate horizontally at the speed of sound, correspond to gravity waves when considered globally with LTE, and their vertical structure is exactly the same as the eigenfunctions of the "vertical structure equation" mentioned earlier. Taken together, these results suggest that modes with an equivalent depth of 10 km are constantly excited in the Earth's atmosphere, almost continuously, from global modes with wavenumber of 1 to high wavenumber modes with wavenumber of 1000 or more.

Possibility of excitation by cumulus clouds

In this paper, we assume that cumulus convection is a possible source of excitation of the broadband atmospheric free oscillations described above. The first reason is that cumulus convection is an isolated disturbance with a spatial scale of about 1 km, so it can be a broadband wave source with a spatial range of wavenumber from 0 to 10,000. Second, since cumulus clouds have a lifetime of about one hour and there are large fluctuations in the heating structure even during their life cycle, they can be a broadband wave source with a frequency ranging from zero to several mHz in time.

Excitation of Lamb wave vertical modes by cumulus heating

When the atmosphere is heated, the direct response is the generation of sound waves, and the response after this propagates vertically contributes to the excitation of Lamb waves and the subsequent internal gravity waves Bannon (1995) showed that no surface pressure remains after the hydrostatic adjustment following heating. However, since the atmosphere above the heat source is displaced upward, positive heating results in a positive pressure anomaly as a contribution to the Lamb wave vertical mode. It can be seen that the amplitude can generally be estimated by the pressure response of the atmosphere confined to a vertical region of about scale height.

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Estimation of Amplitude

Based on the above discussion, we estimated the heating response of the atmosphere in the vertical layer by referring to the current Earth observation facts about the number and lifetime of cumulus clouds. The results depend on the estimate of the Q-value of the atmospheric free oscillation, but the amplitude of the Lamb wave of Nishida et al (2013) and the global mode of Sakazaki and Hamilton (2020) can be generally explained. The details will be discussed in the day.

Keywords: atmospheric free oscillation, cumulus convection, Lamb waves, infrasound

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-ZZ Others

Sun. Jun 6, 2021 10:45 AM - 12:15 PM JST | Sun. Jun 6, 2021 1:45 AM - 3:15 AM UTC | Ch.16 Zoom Room 16

[M-ZZ48] Geology and culture

convener:Hisashi Suzuki(Otani University), Tohru Sakiyama(Institute of Geo History, Japan Geochronology Network), Naoki Takahashi(Natural History Museum and Institute, Chiba), Chairperson:Tohru Sakiyama(Institute of Geo History, Japan Geochronology Network), Naoki Takahashi(Natural History Museum and Institute, Chiba)

The session "geology and culture" deals with an interdisciplinary field that discusses the relationship between human and geology. We invite following research themes on the session. (1) geology as a raw material, (2) geochemical analyses of archaeological remains, (3) relationship between geology and regional cultures, (4) geoeducation with museum and geopark, (5) letters and music with geology, and (6) geology and religion. We invite presentations of research results on all geological themes concerning human being.

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

[MZZ48-01] A use of tuff beds in strata for natural resources at the Boso Peninsula – ‘Bosyu white clay’ or ‘Bosyu sand’

*Naoki Takahashi[1], Junichi Ohki[1] (1.Natural History Museum and Institute, Chiba)

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

[MZZ48-02] Change of usage patterns of Innai Tuff Member from Yuzawa City, Akita prefecture, northeast Japan: From ‘rolling stones‘ in early modern to ‘Innai Ishi’ in modern

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

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

[MZZ48-03] Japanese marbles used in some historic western style houses in Tokyo

*Mutsuko Inui[1], Shoji Nishimoto[2] (1.School of Science and Engineering, Kokushikan University, 2.Nagoya City Science Museum)

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

[MZZ48-04] Brewing culture and geology in Japan: examples of Satsuma shochu spirits and Koshu wine

*Hisashi Suzuki[1] (1.Otani University)

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

[MZZ48-05] The investigation of the relationship between the artificial terrain change of medieval mountain castles and the landslides in 2018

*Masami Inomata[1] (1.National University Corporation Hiroshima University)

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

[MZZ48-06] **Historical distribution of granitic stone materials from Setouchi area in the San-in and Hokuriku regions, Southwest Japan**

*Tohru Sakiyama[1] (1.Institute of Geo History, Japan Geochronology Network)

A use of tuff beds in strata for natural resources at the Boso Peninsula – ‘Bosyu white clay’ or ‘Bosyu sand’

*Naoki Takahashi[1], Junichi Ohki[1]

1. Natural History Museum and Institute, Chiba

From Neogene to Quaternary marine strata construct the Boso Peninsula. Their strata deposited on deep sea and rapidly uplifted, so their strata have enough degree of consolidation and are easy to dig. So, from ancient times, digging of the strata have done for various purpose on human life in the Boso Peninsula. They are majorly divided two formation. One is use of relief feature, and the other is use of components of the strata as natural resources. This time, an example of the latter case is introduced.

The strata are mainly constructed by hemi-pelagic mudstone and turbidite sandstone, and they include numerous tephra beds. Their tephra have wide variety, but especially fine glassy tephra are used as dental powder, rice polishing powder, material of roof tile and ceramics, admixture of cement from the latter part of the Edo Period, and then used on a small scale as polishing powder of glass, mold releasing agent even today (Oya, 1990; Saito, 1998). They are dug along mining gallery focus on the several 10cm to 2m thick single tuff bed, so the gallery tilt according to dip of strata, and suddenly change their height by fault. They are dug at several points and different horizons in the Boso Peninsula, so the characteristic of the strata is common in the Boso Peninsula, and show the geological history of the Peninsula. Their tuff beds are used and named as key beds for contrast of strata which distribute distant areas. For example, ‘Kd8’ tephra in the Kiwada Formation, Kazusa Grop, at Isumi City, and ‘TK-5’ and ‘Hn-8’ tephra in Higashinagata Formation, Chikura Group, at Tateyama City (Kawakami & Shishikura, 2006). These are all Pleistocene marine strata. Their origins are not specified, but ‘Kd8’ tephra is correlated to ‘Omig’ tephra in the Uonuma Group at the Niigata area (Kurokawa et al., 2002), so they are possibly from far away area. These tephra have both geological importance and usefulness as natural resources.

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Keywords: Boso Peninsula, tuff, natural resources

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Change of usage patterns of Innai Tuff Member from Yuzawa City, Akita prefecture, northeast Japan: From ‘rolling stones‘ in early modern to ‘Innai Ishi’ in modern

*Norihito Kawamura[1]

1. School of Regional Resource Management, Graduate School, University of Hyogo

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Keywords: tuff breccia, Onnagawa Formation, magnetic susceptibility, shrine, stone work

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Japanese marbles used in some historic western style houses in Tokyo

*Mutsuko Inui[1], Shoji Nishimoto[2]

1. School of Science and Engineering, Kokushikan University, 2. Nagoya City Science Museum

Various kinds of marble had been quarried in Japan as building stone until about the end of 1960's. Marble quarries were active in Japan from the end of the 19th century, though it is not well known nowadays. Those marbles have been used for the interior finishing of many historic buildings in Tokyo. Here we report on the domestic building stones used for the interiors (mantlepieces) in some of the historic western style houses in Tokyo, designed by Josiah Conder. The houses are: the Former Iwasaki Residence, the Former Shimazu Residence, and the Former Furukawa Residence. The construction of the houses was completed between 1896 to 1917. Provenance of the marble of the mantlepieces was identified non-destructively. Marbles from Ibaraki Prefecture, Gifu Prefecture, Iwate Prefecture, Yamaguchi Prefecture, and Tokyo Metropolis were identified. The mantlepieces are the testimonial for the fact that quarrying of those marbles was active during those years. The investigation is significant for understanding the history of the use of building stones in Japan. The hisotric aspect of the marbles is an important part of the assessment of the cultural heritage.

Keywords: building stone, marble, historic building

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Brewing culture and geology in Japan: examples of Satsuma shochu spirits and Koshu wine

*Hisashi Suzuki[1]

1. Otani University

Two examples of Japanese brewing culture, Satsuma-shochu spirits in Kagoshima prefecture and Koshu wine in Yamanashi prefecture, are demonstrated in concerning with their areal geology.

Satsuma region (Kagosima prefecture): The Shirasu plateau that is composed of upper Pleistocene pyroclastic sediments is widely distributed in the Satsuma region. The plateau has water permeability due to its porous nature. This feature results in the cultivation of sweet potato on the Shirasu plateau. Soft groundwater wells out from rims of the plateau. Sweet potato and groundwater are used for brewing shochu spirits.

Katsunuma area (Koshu city, Yamanashi prefecture): Katsunuma area is a part of the Kofu basin and alluvial fans are well developed. Water permeable nature of alluvial fan is suitable for cultivation of grapevine. Although the wine brewing is not traditional in Japan, two brewers of the Katsunuma area travelled to France to learn the wine brewing in the years 1877-1879.
Both Satsuma region and Katsunuma area are characterised by the water permeability of farmlands, which are closely related with each areal geology. Whereas water is needed for brewing shochu spirits, no water is necessary to make wine. Areal geology is one of the fundamental factors to make brewing cultures in these regions.

Keywords: Shirasu plateau, alluvial fan, sweet potato, grapevine

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The investigation of the relationship between the artificial terrain change of medieval mountain castles and the landslides in 2018

*Masami Inomata[1]

1. National University Corporation Hiroshima University

The purpose of this study was to investigate the relationship between the artificial terrain change of medieval mountain castles and the landslides in Higashihiroshima City 2018.

There has been few reported on the relationship between medieval castles and the landslides.Because medieval castle ruins were not damaged.

The heavy rainfall in July 2018 caused many landslides in Higashihiroshima City. There are 165 ruins of medieval castle in this city and some of them were up stream of debris flows. The number of residence of this city is increasing continuously at the foot of mountain.
Therefore, it is necessary to clarify the risks of artificial terrain change of medieval mountain castles.

This study was performed with GIS (Geo Information System) and field study. In this research, totally 124 medieval castles were studied (Fig.1).
The analysis of GIS revealed that 59 of these medieval castles were associated with landslides.

Most of medieval castles were the fortress style, and built to mountainous terrain with construction work for defense. Those medieval mountain castles had a characteristic construction.
Typically, top of the mountain and mountainside used to be artificially modified to build medieval mountain castles. Workers created a flat area known as a *Kuruwa*, cut away at the ridge to form dry moats (*Horikiri*), and used the surplus soil accumulated during these tasks to build *Dorui*. Another structural feature was the *Kirigishi*, slopes around the *Kuruwa* that were made intentionally steeper. In addition, *Unejo-tatebori*, parallel trenches dug vertically into the *Kirigishi* slopes, was developed to prevent enemies coming up the slopes diagonally (Fig.2).

In the field survey, it was confirmed that some debris flows were generated from the lower part of *Horikiri* slope. It is highly suspected that defensive features of medieval mountain castles could have affected the flow of rainwater.

Furthermore, this city is mainly composed of the Hiroshima granite, which is relatively vulnerable to the terrain modification. The analysis by GIS revealed that 85% of medieval mountain castles that were associated with landslides, were located in The Hiroshima granite.

The analysis by GIS (Geo Information System) and field study suggest that *Horikiri*, the construction of a medieval mountain castle, is one of the causal factors with landslide.
Therefore, identifying the areas of those artificial terrain change could be effective to foresee future potential of debris flow path when landslide took place in the future.

Keywords: Construction of a medieval Mountain castle, GIS, The Hiroshima Granite

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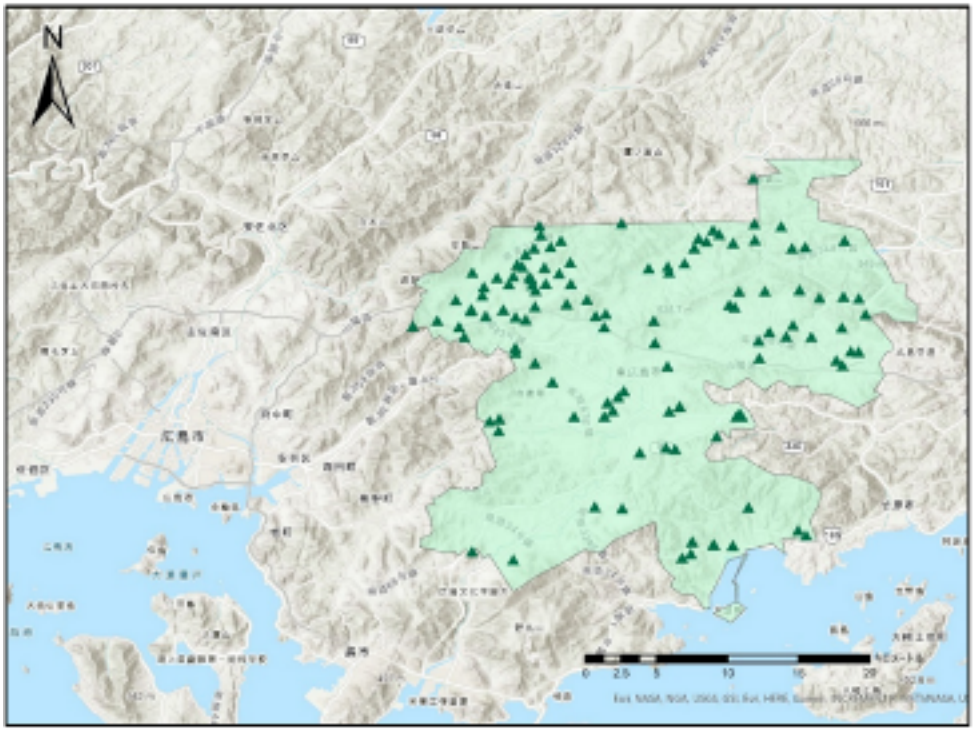


Fig1.The study area in Higashihiroshima City □ and medieval castles ▲

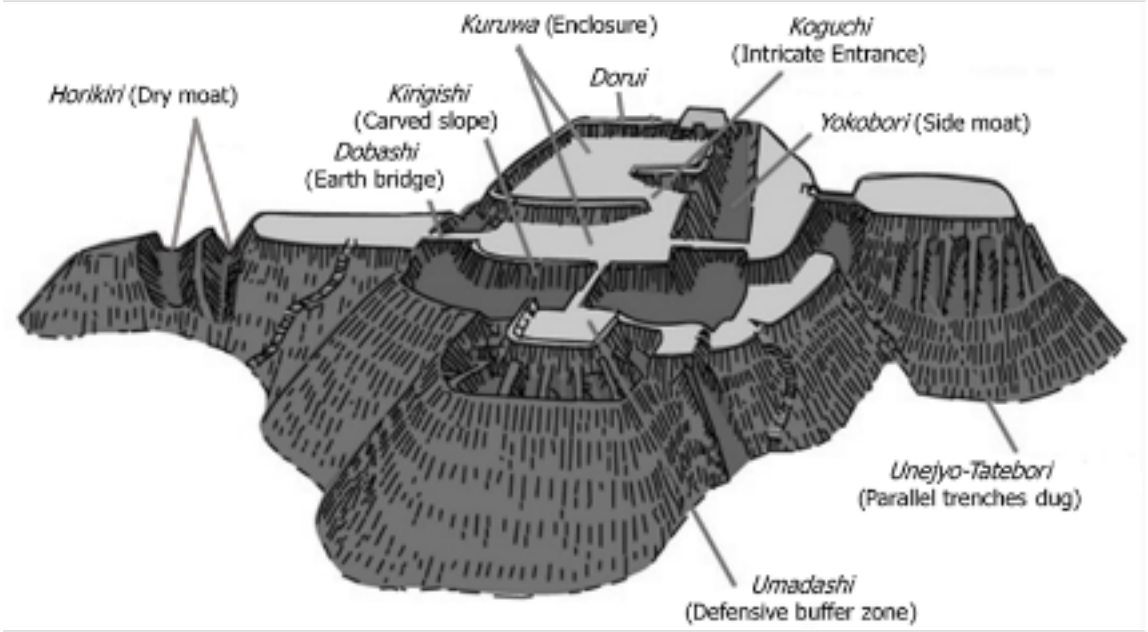


Fig2.A typical medieval mountain castle
(Created based on excavation guide: Various types of ruins[5])

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Historical distribution of granitic stone materials from Setouchi area in the San-in and Hokuriku regions, Southwest Japan

*Tohru Sakiyama[1]

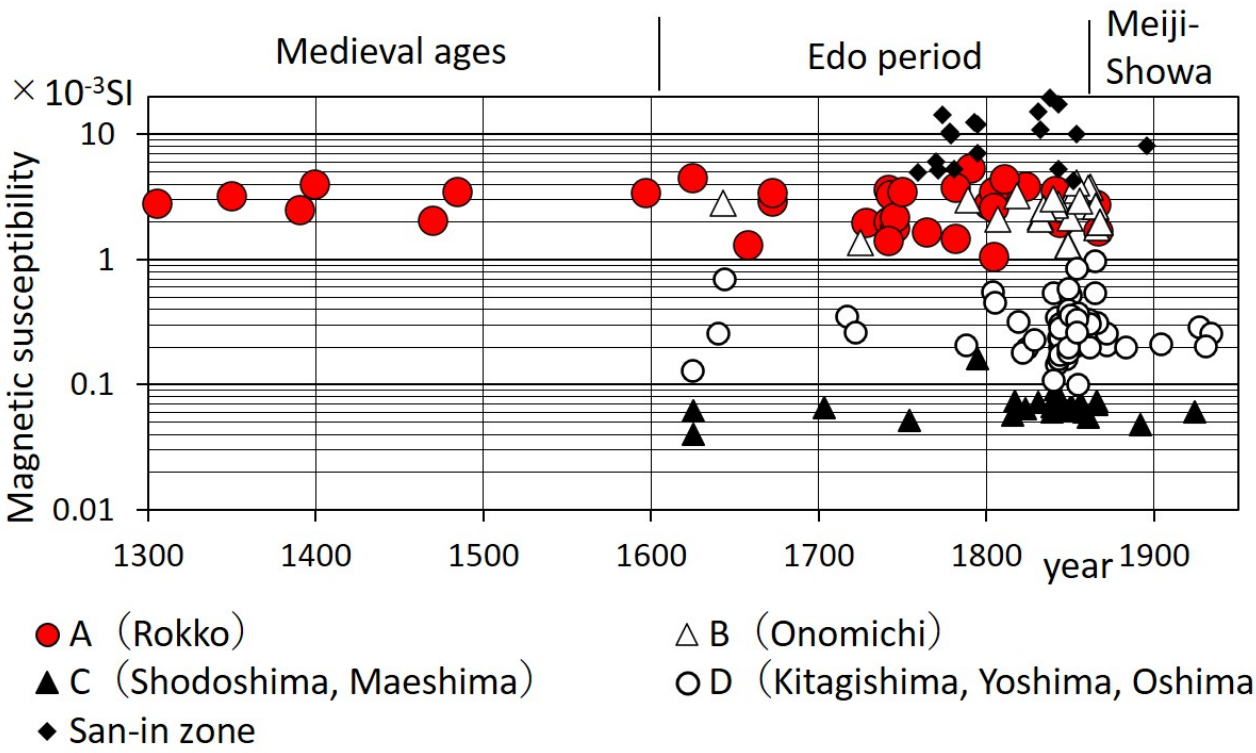
1. Institute of Geo History, Japan Geochronology Network

Many ancient quarries for granites are remained in islands and coastal area of the Seto Inland Sea. 14th to 19th century stone materials of the granites from these quarries are widely distributed in coastal area of the Sea of Japan. Identification of quarry area of the granites is one of the important issues in Japanese historical study. I reveal distribution of such granitic stone materials in San-in and Hokuriku region and discuss transition of quarried areas.

Granitic rocks of the stone materials are divided following five types resulted by magnetic susceptibility and description.
Type A (Rokko Mountains): Medium-grained biotite granite with pinkish K-feldspar interstitially, with or without hornblende. Magnetic susceptibility ranges from 1X10^{-3} to 3X10^{-3} SI.
Type B (Onomichi): Medium-grained hornblende biotite granite with white colored porphyritic K-feldspar. Magnetic susceptibility ranges from 1X10^{-3} to 3X10^{-3} SI.
Type C (Kitagishima, Yoshima or Oshima): Medium-grained biotite granite to hornblende biotite granite. Magnetic susceptibility ranges from 0.1X10^{-3} to 1X10^{-3} SI.
Type D (Shodoshima or Naoshima): Coarse-grained biotite granite. Magnetic susceptibility ranges from 0.04X10^{-3} to 0.07X10^{-3} SI.
Type E (San-in or Hokuriku area): Various granitic rocks occurred in local area. Most of them have very high magnetic susceptibility (from 5X10^{-3} to 11X10^{-3} SI), except low magnetic granites from Mihama area (from 0.03X10^{-3} to 0.05X10^{-3} SI).
Relation between age and rocks forming stone materials in San-in to Hokuriku region indicate following history. In medieval time (14th to 16th century), type A granites which have been occurred in Rokko mountains area mainly distributed to San-in area. Circulation of other granites from Setouchi area began in early 17th century and become maximum in 19th century. On the other hand, proportion of type A granites decreased from 17th to 19th century.

Keywords: granite, stone material, history, magnetic susceptibility

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Types of granitic rocks forming stone materials and their magnetic susceptibility in medieval to modern ages

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[J] Oral | EVENT：EVENT

Sun. Jun 6, 2021 12:20 PM - 1:00 PM JST | Sun. Jun 6, 2021 3:20 AM - 4:00 AM UTC | Ch.01 Zoom Room 01

[EV-25] 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-11-26] Chemical constraints on the origin and early evolution of the Solar System

[J] Oral | EVENT | EVENT

[EV-25] Lunchtime Special Lecture

Sun. Jun 6, 2021 12:20 PM - 1:00 PM Ch.01 (Zoom Room 01)

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

[E-11-26]Chemical constraints on the origin and early evolution of the Solar System

This lecture will explore present and future challenges of constraining the origin and early evolution of the Solar System from the materials science point of view. Keywords: cosmochemistry, extraterrestrial materials, star and planet formation, sample return, Solar System exploration, laboratory experiments, astronomical observation.

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[J] Oral | EVENT：EVENT

Sun. Jun 6, 2021 3:30 PM - 4:15 PM JST | Sun. Jun 6, 2021 6:30 AM - 7:15 AM UTC | Ch.13 Zoom Room 13

[EV-26] 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。
地球惑星科学関連の、有用な情報を発信してくださいますので是非ご参加ください。

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

[E-11-27] GRC virtual lab tour & the making of a diamond powder with Hime-diamond mortar

[J] Oral | EVENT | EVENT

[EV-26] Exhibitors' Seminar

Sun. Jun 6, 2021 3:30 PM - 4:15 PM Ch.13 (Zoom Room 13)

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GRC virtual lab tour &the making of a diamond powder with
Hime-diamond mortar

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