Sun. May 26, 2019

[E] Oral | U (Union)：Union

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

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

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

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

[U01-01] Panel discussion about research assessment

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

[E] Oral | U (Union)：Union

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

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

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

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

[U02-01] Managing Diversity and Inclusiveness

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

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

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

★Invited Papers

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

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

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

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

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

[U02-04] Problem in paternity leave

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

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

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

★Invited Papers

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

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

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

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

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

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

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

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

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

[PPS04-01] Recent results from the MAVEN mission

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

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

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

★Invited Papers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

★Invited Papers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

★Invited Papers

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

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

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

★Invited Papers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

★Invited Papers

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

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

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

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

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

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

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

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

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

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

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

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

★Invited Papers

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

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

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

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

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Kazuo Yoshioka(The University of Tokyo), Mitsunori Ozaki(Kanazawa University)

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

[PCG21-01] Current status and instrument development plan for future lunar exploration missions

★Invited Papers

*Makiko Ohtake[1] (1.Japan Aerospace Exploration Agency)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[PCG21-02] Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3] (1.The university of Tokyo, 2.ISAS/JAXA, 3.Osaka University)

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

[PCG21-03] Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1] (1.The university of tokyo, 2.Osaka University, 3.Nagoya University, 4.ISAS / JAXA)

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

[PCG21-04] A high-voltage pulsed power supply for on-site mass spectrometry in future solar system explorations

*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2] (1.Graduate School of Science, Osaka University, 2.ISAS/JAXA)

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

[PCG21-05] Development of DESTINY$^+$ Dust Analyzer and its expected science return

*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3] (1.Chiba Institute of Technology, Planetary Exploration Research Center, 2.University of Stuttgart, 3.Max Planck Institute for Solar System Research)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Satoshi Kasahara , Mitsunori Ozaki(Kanazawa University)

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

[PCG21-06] Satellite mission: PhoENiX (Physics of Energetic and Non-thermal plasmas in the X (= magnetic reconnection) region)

★Invited Papers

*Noriyuki Narukage[1], Mitsuo Oka[2], Yasushi Fukazawa[3], Keiichi Matsuzaki[4], Shin Watanabe[4], Taro Sakao[4], Sin-nosuke Ishikawa[5], Kouichi Hagino[6], Ikuyuki Mitsuishi[5], Tsunefumi Mizuno[3], Iku Shinohara[4], Masumi Shimojo[1], Shinsuke Takasao[5], Hiroshi Tanabe[7], Munetaka UENO[8], Tadayuki Takahashi[9], Takeshi Takashima[4], Masayuki Ohta[4] (1.National Astronomical Observatory of Japan, 2.Space Sciences Laboratory, The University of California, Berkeley, 3.Hiroshima University, 4.Japan Aerospace Exploration Agency, 5.Nagoya University, 6.Tokyo University of Science, 7.The University of Tokyo, 8.Kobe University, 9.Kavli Institute for the Physics and Mathematics of the Universe)

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

[PCG21-07] Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3] (1.Department of Solar System Sciences, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Hokkaido Information University, 3.Graduate School of Science, Kyoto University)

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

[PCG21-08] **SS-520-3 Sounding Rocket Experiment Targeting the Ion Outflow in the Polar Cusp / Aurora**

*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3] (1.Department of Solar System Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Institute of Polar Research, 3.Research Institute for Sustainable Humanosphere, Kyoto University)

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

[PCG21-09] **Development of the chip implemented as high-speed current detection circuits for particle sensors**

*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1] (1.JAXA, 2.Kyoto University)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[PCG21-10] GEO-X (GEOspace X-ray imager) : Imaging the dayside solar wind-terrestrial magnetosphere interaction

★Invited Papers

*Yuichiro Ezoe[1], Yoshizumi Miyoshi[2], Satoshi Kasahara[3], Ryu Funase[3], Harunori Nagata[4], Hiroshi Nakajima[5], Kumi Ishikawa[6], Atsushi Yamazaki[6], Hiroshi Hasegawa[6], Junko Hiraga[7], Masaki Fujimoto[6], Kazuhisa Mitsuda[6], Munetaka Ueno[8], Hiroyuki Koizumi[3], Yasuhiro Kawakatsu[6], Takahiro Iwata[6], Hironori Sahara[1] (1.Tokyo Metropolitan University, 2.Nagoya University, 3.University of Tokyo, 4.Hokkaido University, 5.Kanto Gakuin University, 6.ISAS/JAXA, 7.Kansei Gakuin University, 8.Kobe University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Shingo Kameda, Mitsunori Ozaki(Kanazawa University)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PCG21-11] **Debye: a multi-spacecraft mission to solve the electron energization problem in the solar wind**

★Invited Papers

*Fouad Sahraoui[2], Robert T Wicks[1], Daniel Verscharen[1], The Debye The Debye Team (1.Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, UK, 2.LPP CNRS Ecole Polytechnique)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PCG21-12] Comet Interceptor mission to a dynamically new comet

★Invited Papers

*Shinnaka Yoshiharu[1], Shingo Kameda[2], Satoshi Kasahara[3], Hideyo Kawakita[1], Masanori Kobayashi[4], Ryu Funase[3], Ichiro Yoshikawa[3], Jones H Geraint[5], Colin Snodgrass[6] (1.Kyoto Sangyo University, 2.Rikkyo University, 3.The University of Tokyo, 4.Chiba Institute of Technology, 5.UCL, 6.The Open University)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[PCG21-13] The concept of AI3 and impactors

★Invited Papers

*Koji Wada[1], Jakob Deller[2], Jessica Agarwal[2], Hans Martin Braun[3], Kieran Carroll[4], Hannah Goldberg[5], Martin Jutzi[6], Özgür Karatekin[7], Tomáš Kohout[8], Sampsa Pursiainen[9], Birgit Ritter[7], Olaf Roders[2], Francisco da Silva Pais Cabral[10], Fredrik Sjoberg[11], Mika Takala[9], Esa Vilenius[2], Patrick Bambach[2], Ryo Ishimaru[1], Yutaka WADA[1], Masahiko Arakawa[12], Takanao Saiki[13] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Max Planck Institute, Göttingen, 3.RST Radar System Technik, 4.Gedex Systems Inc, 5.GOMSpace, 6.University of Bern, 7.Royal Observatory of Belgium, 8.University of Helsinki, 9.Tampere University of Technology, 10.GMV, 11.OHB, 12.Kobe University, 13.JAXA)

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

[PCG21-14] Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

*Masafumi Hirahara[1], Hirotsugu Kojima[2], Naritoshi Kitamura[3], Kazushi Asamura[4], Yoshifumi Saito[4] (1.Institute of Space-Earth Environmental Research, Nagoya University, 2.Research Institute of Sustainable Humanosphere, Kyoto University, 3.Graduate School of Science, The University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PCG21-15] Current status of Life Detection Microscope (LDM) for Mars surface exploration

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

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AOS09-01] **Model Spectra for Turbulence Below and Above the Ozmidov Wavenumber**

★Invited Papers

*Eric L Kunze[1] (1.NorthWest Research Associates Redmond)

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

[AOS09-02] **A new parameterization of turbulent mixing caused by tidal flow over abyssal rough bathymetry**

*Toshiyuki Hibiya[1] (1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

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

[AOS09-03] Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Meterolorogical Agency, 3.Japan Agency of Marine-Earth Science and Technology)

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

[AOS09-04] The deep Pacific meridional overturning circulation simulated by a low-resolution ocean model

★Invited Papers

*Takao Kawasaki[1], Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Insitutute, the University of Tokyo)

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

[AOS09-05] The Role of Mixing and Geothermal Heating in Altering AABW and NADW Pathways

★Invited Papers

*Qianjiang Xing[1], Stephanie Downes[1], Kate Snow[2] (1.IMAS, Univ of Tasmania, AU, 2.School of GeoSciences, Univ of Edinburgh, UK)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Jun Nishioka(Institute of low temperature science, Hokkaido University)

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

[AOS09-06] **Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves**

★Invited Papers

*Seth L Danielson[1] (1.University of Alaska Fairbanks)

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

[AOS09-07] **Important roles of marginal seas and intermediate water for micro- and macro-nutrients circulation in the North Pacific**

*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2] (1.Hokkaido University, Institute of low temperature sciences, 2.The University of Tokyo, Atmosphere and Ocean research institute)

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

[AOS09-08] An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AOS09-09] Change in lower trophic level ecosystem and its complex mechanism in the North Pacific

★Invited Papers

Naomi Harada[1], Fujiki Tetsuichi[1], *Maki Noguchi Aita[1], Makio Honda[1], Minoru Kitamura[1], Takuhei Shiozaki[1], Yoshihisa Mino[3], Akira Kuwata[2], Kazuaki Tadokoro[2], Osamu Seki[4], Megumi Chikamoto[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Institute of Low Temperature Science, Hokkaido University, 5.International Pacific Research Center, University of Hawaii at Manoa)

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

[AOS09-10] Numerical simulation of iron cycle in the North Pacific

*Kazuhiro Misumi[1], Jun Nishioka[2], Hajime Obata[3], Daisuke Tsumune[1], Tsubono Takaki[1], Matthew C Long[4], Keith Lindsay[4], J. Keith Moore[5] (1.Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, 5.Department of Earth System Science, University of California at Irvine)

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

[AOS09-11] Influence of tide on the growth and migration of walleye pollock (*Gadus chalcogrammus*) in the Oyashio region

*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Fisheries Research and Education Agency Japan, 3. Hokkaido University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Shin-Ichi Ito(The University of Tokyo)

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

[AOS09-12] What can horizontal stirring tell us about vertical mixing?

★Invited Papers

*Sylvia T Cole[1] (1.Woods Hole Oceanographic Institution)

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

[AOS09-13] Acoustic remote sensing of ocean mixing

★Invited Papers

*Tetjana Ross[1], Andone Lavery[2], Doris Leong[3], Rolf Lueck[4] (1.Institute Of Ocean Sciences, Fisheries and Oceans Canada, 2.Woods Hole Oceanographic Institution, 3.British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 4.Rockland Scientific International)

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

[AOS09-14] Assessment of the effectiveness of the global ocean state estimation using tide-induced mixing parameterizations

*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1] (1.JAMSTEC)

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

[AOS09-15] **Energetics of Eddy-Mean Flow Interactions in Western Boundary Currents: The Kuroshio and the Gulf Stream**

★Invited Papers

*Enrique N Curchitser[1], Dujuan Kang[1], Xiaomei Yan[2] (1.Rutgers University New Brunswick, 2.Institute of Oceanology, Chinese Academy of Sciences)

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

[AOS09-16] Mixing Processes in the Kuroshio region and their influence on the low-trophic ecosystem

★Invited Papers

*Xinyu Guo[1], Takeshi Matsuno[2], Tomoharu Senju [2], Kaoru Ichikawa[2], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ayako Nishina[3], Hirohiko Nakamura[3], JING ZHANG[4], Daisuke Hasegawa[5], Naoki Yoshie[1], Toru Kobari[3] (1.Center for Marine Environmental Studies, Ehime University, 2.Research Institute for Applied Mechanics, Kyushu University,, 3.Faculty of Fisheries, Kagoshima University, 4.Graduate School of Science and Engineering, University of Toyama, 5.Tohoko National Fisheries Research Institute)

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

[AOS09-17] Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*Takeyoshi Nagai[1], Silvana Duran[2], Diego Otero[2], Yasutaka Mori[1], Naoki Yoshie[3], Kazuki Ohgi[3], Daisuke Hasegawa[4], Ayako Nishina[5], Toru Kobari[5] (1.Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2.Facultad de Pesquería, Universidad Nacional Agraria La Molina, Peru, 3.Center for Marine Environmental Studies, Ehime University, 4.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5.Faculty of Fisheries Kagoshima University)

[E] Oral | H (Human Geosciences)：H-GG Geography

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 106 1F

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University), Chairperson:Yuei-An Liou(Center for Space and Remote Sensing Research (CSRSR)), Kim-Anh Nguyen(National Central University)

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

[HGG01-01] Monitoring of Subsidence Area of Jakarta City using PS-InSAR

*Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

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

[HGG01-02] **Understanding and classifying spatial patterns of global eco-environmental vulnerability**

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.National Central University, Taiwan)

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

[HGG01-03] Human-water interface in hydrological modeling: Current status and future directions

*Yoshihide Wada[1] (1.International Institute for Applied Systems Analysis)

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

[HGG01-04] **Urban greenspace spatial patterns and eco-function by using Sentinel 2 imagery**

*Yuei-An Liou[1], Kim-Anh Nguyen[1] (1.National Central University)

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

[HGG01-05] Assessing performance of L-band SAR backscatter for above ground forest biomass estimation over complex topography

*Waqar Mirza Muhammad[1], Ji Yaqi[1], Josaphat Tetuko Sri Sumantyo[1], Hasil Khan[1] (1.Chiba University)

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

[HGG01-06] **Feasibility Analysis of Engineering Monitoring Using the VLP-16 LiDAR Puck: A Case Study in Henglingshan Tunnel**

*Zhen-Yu Wu[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Ren-Jhih Yang[1] (1.National Chung Hsing University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 106 1F

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), Chairperson:Wei Yang(Chiba University)

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

[HTT20-01] Evaluation of Climate Change Impacts on Wetland Vegetation in the Dunhuang Yangguan National Nature Reserve in Northwest China Using Landsat Derived NDVI

*Feifei Pan[1] (1.University of North Texas)

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

[HTT20-02] Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*LINLIN WANG[1] (1. Institute of Atmospheric Physics, Chinese Academy of Sciences)

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

[HTT20-03] **THE STUDY OF RIVER CHANGE DETECTION INTEGRATING OBJECT-BASED CLASSIFICATION AND EDGE EXTRACTION**

*Yu-Chan Lee[1], Fang-Shii Ning[1], Hao-Che Ho[2] (1.Department of Land Economics, National Chengchi University, 2.Department of Civil Engineering, National Taiwan University)

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

[HTT20-04] **Monitoring winter wheat spring phenology in the North China Plain using MODIS**

*Xifang Wu[1], Wei Yang[2], Chunyang Wang[3], Yuki Sofue[4], Yanjun Shen[5], Akihiko Kondoh[2] (1.Graduate School of Science and Engineering , Chiba University, 2.Center for Environmental Remote Sensing, Chiba University, 3.School of Surveying and Land Information Engineering, Henan Polytechnic University, 4.Graduate School of Science, Chiba University, 5.Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences)

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

[HTT20-05] Assessment of numerous Data Assimilation Approaches in Regional Retrieval of Ground NO_2 Spatial Distribution via Remote Sensing products

*Hugo Wai Leung MAK[1,2], Jimmy Chi-Hung FUNG[1,2] (1.Department of Mathematics, Hong Kong University of Science and Technology, 2.Division of Environment and Sustainability, Hong Kong University of Science and Technology)

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

[HTT20-06] Spectro-polarimetric BRF measurement of leaves and model of individual leaf

*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2] (1.Hokkaido University, 2.Shiga University of Medical Science)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301B 3F

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris), Chairperson:Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)

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

[SSS04-01] MyShake: A global smartphone seismic network to characterize urban earthquakes

*Richard M Allen[1], Qingkai Kong[1], Sarina Patel[1], Robert Martin-Short[1] (1.University of California Berkeley)

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

[SSS04-02] Full waveform-based automatic monitoring of microseismic activity using high sampling rate records: application to Garpenberg mine (Sweden)

★Invited Papers

*Natalia Poiata[1,2], Kadek Hendrawan Palgunadi[3], Jannes Kinscher[4], Pascal Bernard[1], Francesca De Santis[4], Emmanuelle Klein[4] (1.Institut de Physique du Globe de Paris, France, 2.National Institute for Earth Physics, Romania, 3.King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, 4.Institut National de l'Environnement Industriel et des Risques Ineris, Nancy, France)

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

[SSS04-03] A deep convolutional neural network for localizing and detecting earthquake swarm activity based on full waveforms: Chances, challenges and questions

★Invited Papers

*Marius Kriegerowski[1,2], Gesa Maria Petersen[1,2], Hannes Vasyura Bathke[2], Matthias Ohrnberger[2] (1.German Research Centre for Geosciences Potsdam, Germany, 2.Inst. of Geosciences, University of Potsdam, Germany)

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

[SSS04-04] **Fast Location Parameters Determination of Seismic Events from Few Seconds of P Wave Recorded at a Single Seismological Station Using Support Vector Machine Regression**

*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1] (1.Universidad Nacional de Colombia)

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

[SSS04-05] Foreshock activity detection by a threshold-free matched-filter technique

*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2] (1.Department of Physical Science, College of Science and Engineering, Ritsumeikan University, 2.Disaster Prevention Research Institute, Kyoto University)

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

[SSS04-06] Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

*Andri Hendriyana[1,3], Takeshi Tsuji[1,2] (1.International Institute for Carbon-Neutral Energy Research, 2.Kyushu University, 3.Bandung Institute of Technology)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Chairperson:Luca Urpi(ETH-Zurich; Swiss Seismological Service), Bogdan Enescu(Graduate Schoold of Science, Kyoto University), Francesco Grigoli(ETH-Zurich; Swiss Seismological Service), Yosuke Aoki

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

[SSS05-01] **Causality between induced seismicity b-value reduction and stress state of existing fractures**

★Invited Papers

*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4] (1.Institute of Fluid Science, Tohoku University, 2.ERL, Massachusetts Institute of Technology , 3.FREA, AIST, 4.Häring GeoProject)

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

[SSS05-02] Micromechanical model connecting earthquake statistics and observed spatiotemporal changes in source parameters of fluid induced seismicity

*Daisuke Sato[1], Keisuke Yoshida[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Tohoku University)

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

[SSS05-03] Seismicity induced by Multi-cycle operation of Hutubi underground gas storage, Xinjiang, China

*Baoshan Wang[1,2], Bo Zhang[2], Zhanbo Ji[2], Jinxin Hou[2], Lu Li[2] (1.University of Science and Technology of China, 2.Institute of Geophysics, China Earthquake Administration)

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

[SSS05-04] Investigating the origin of the Mw 5.4 Pohang, Korea, earthquake of November 15, 2017: the investigations and conclusions of the Overseas Research Advisory Committee (ORAC)

*Toshihiko Shimamoto[1], William Ellsworth[2], Shermin Ge[3], Domenico Giardini[4], John Townend[5] (1. Institute of Geology, China Earthquake Administration, 2.Stanford University, 3.University of Colorado Boulder, 4.ETH, Zurich, 5.Victoria University of Wellington)

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

[SSS05-05] **Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes**

*Martha K Savage[1], Kenny Graham[1], Yosuke Aoki[2], Richard Arnold[1], Tomomi Okada[3], Yoshihisa Iio[4], Satoshi Matsumoto[5] (1.Victoria University of Wellington, 2.Earthquake Reserach Institute, University of Tokyo, 3.Tohoku University, Sendai 980-8578, Japan, 4.Kyoto University, Uji 611-0011, Japan, 5.Kyushu University, 2-5643-29 Shin'yama, Shimabara, Nagasaki, 855-0843, Japan)

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

[SSS05-06] Long-term behavior of induced seismicity in the Val d'Agri basin (Southern Apennines, Italy).

★Invited Papers

*Luisa Valoroso[1], Luigi Improta[1], Samer Bagh[1], Davide Piccinini[1], Pasquale De Gori[1] (1.Istituto Nazionale di Geofisica e Vulcanologia)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence), Chairperson:Tatsuya Sakamaki(Tohoku University), Yoichi Nakajima(Kumamoto University)

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

[SIT20-01] Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

★Invited Papers

*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2] (1.Geodynamics Research Center, Ehime University, 2.Argonne National Laboratory, 3.The University of Chicago)

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

[SIT20-02] **Scaling pseudotachylytes from the lab to the field**

*Thomas P. Ferrand[1], Alexandre Schubnel[2], Nadège Hilairet[3], Loïc Labrousse[4], Stefan Nielsen[5] (1.Earthquake Research Institute, 2.Ecole Normale Supérieure, Paris, France, 3.Unité Matériaux et Transformations, Université de Lille, France, 4.Sorbonne Université, Institut des Sciences de la Terre Paris, France, 5.Department of Earth Sciences, Durham University, United Kingdom)

11:30 AM - 12:00 PM JST | 2:30 AM - 3:00 AM UTC

[SIT20-03] *Ab initio* molecular dynamics study of atomic diffusion in covalent liquid under high pressure

★Invited Papers

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Institute of Technology, 2.Ehime University)

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

[SIT20-04] **Pressure-induced structural change in magnesium silicate melts**

*Toshiaki Iitaka[1], Nguyen Van Hong[2] (1.RIKEN, 2.Hanoi University of Science and Technology)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Takashi Yoshino(Okayama University)

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

[SIT23-01] In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

*William F McDonough[1], Bedrich Roskovec[2], Ondrej Sramek[3] (1.Tohoku University, Sendai, Japan, 2.Universidad Catolica de Chile, Santiago, Chile, 3.Charles University, Praha 8, Czech Republic)

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

[SIT23-02] Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

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

[SIT23-03] Denoising S-Net Data to Image the Japan Trench: Comparisons to Alaska and Cascadia

*Claire Diane Doody[1,2], Qingkai Kong[1,2], William Scott[3], William Bythewood Hawley[1,2], Robert Martin-Short[1,2], Richard M Allen[1,2] (1.UC Berkeley, 2.Berkeley Seismo. Lab, 3.Imperial Coll. London)

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

[SIT23-04] **Experimental confirmation of a spineloid transitional olivine polymorph using ultrafine-grained aggregates of Mg_2GeO_4**

*Thomas P. Ferrand[1], Takehiko Hiraga[1] (1.Earthquake Research Institute)

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

[SIT23-05] Effects of fine-scale laminated heterogeneity on seismic anisotropy from long-period surface waves: Evaluation with two-dimensional waveform modelling

*Xu Yunao[1], Kazunori Yoshizawa[1,2], Takashi Furumura[3] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Japan , 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Japan, 3.Earthquake Research Institute, The University of Tokyo, Japan)

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

[SIT23-06] **Redox kinetics of olivine revealed by diffusion profile of oxygen fugacity and its implication to the redox evolution of the uppermost mantle**

*Chengcheng Zhao[1], Takashi Yoshino[1] (1.Institute for Study of the Earth's Interior, Okayama University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Dapeng Zhao(Tohoku University)

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

[SIT23-07] Reactive Melt Channelization in the Earth's Mantle

*Matej Pec[1], Benjamin Holtzman[3], Mark Zimmerman[2], David Kohlstedt[2] (1.Massachusetts Institute of Technology, 2.University of Minnesota, 3.Lamont-Doherty Earth Oservatory, Columbia University)

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

[SIT23-08] Deep structure and origin of the intraplate volcanoes in Northeast Asia

*Dapeng Zhao[1] (1.Department of Geophysics, Tohoku University)

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

[SIT23-09] 3D passive-source reverse-time migration imaging of mantle discontinuities

*Yang Shen[1], Jiahang Li[1], Hitoshi Kawakatsu[2] (1.Graduate School of Oceanography, University of Rhode Island, USA, 2.Earthquake Research Institute, University of Tokyo)

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

[SIT23-10] Configuration of slab beneath Ogasawara Islands and P-wave time differences between high and low frequencies

*Keiko Kuge[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University)

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

[SIT23-11] Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2] (1.Hiroshima Univ., 2.Univ. Bayreuth)

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

[SIT23-12] Crystal chemistry and compressibility of $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ silicate perovskites at pressures up to 95 GPa.

*Iuliia Koemets[1], Zhaodong Liu[2], Egor Gennadievich Koemets[1], Catherine McCammon[1], Artem Chanychev[1], Tomoo Katsura[1], Michael Hanfland[3], Aleksandr Chumakov[3] (1.Bayerisches Geoinstitut, Universitat Bayreuth, Bayreuth, Germany, 2.Jilin University, Changchun, China , 3.European Synchrotron Radiation Facility (ESRF), Grenoble Cedex, France.)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS), Chairperson:Kensuke Konishi(Institute of Earth Sciences)

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

[SIT24-01] Anomalous Vp/Vs Ratios at Seismic Frequencies Might Evidence Highly Damaged Rocks in Subduction Zones

*Alexandre Schubnel[1], Lucas Pimienta[2], Marie Violay[2], Jérome Fortin[1], Hélène Lyon-Caean[1] (1.Laboratoire de Géologie, ENS PARIS, 2.EPFL, Switzerland)

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

[SIT24-02] Imaging crustal seismic attenuation, central Taupo Volcanic Zone, New Zealand

*Stephen C Bannister[1], Sandra Bourguignon[1], Ted Bertrand[1], Cameron Asher[1] (1.GNS Science)

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

[SIT24-03] New Constraints on Seismological Structures of the Oceanic Asthenosphere

★Invited Papers

*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1] (1.Earthquake Research Institute, University of Tokyo, 2.Kobe University, 3.JAMSTEC)

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

[SIT24-04] Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

★Invited Papers

*Jerome Fortin[1] (1.Laboratoire de Géologie, Ecole Normale Superieure - Paris)

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

[SIT24-05] Rock anelasticity due to grain boundary premelting

★Invited Papers

*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1] (1.Earthquake Research Institute, University of Tokyo)

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

[SIT24-06] Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

*Hatsuki Yamauchi[1], Yasuko Takei[1] (1.Earthquake Research Institute, The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Yusuke Watanabe(Graduate School of Engineering, Kyoto University), Junichi Takekawa(Graduate School of Engineering, Kyoto University)

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

[STT42-01] Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

*Shimin - Zhou[1], Xinding - Fang[1] (1.Southern University of Science and Technology)

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

[STT42-02] Fundamental study on hydraulic fracturing simulation with DEM under high pressure and temperature condition

*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.kyoto university)

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

[STT42-03] A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

★Invited Papers

*Junichi Takekawa[1], Hitoshi Mikada[1] (1.Graduate School of Science, Kyoto University)

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

[STT42-04] Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

*Laszlo Olah[1], Hiroyuki K. M. Tanaka[1], Gergo Hamar[2], Dezso Varga[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Wigner Research Centre for Physics of the Hungarian Academy of Sciences)

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

[STT42-05] New development and operation of the EM-ACROSS: an investigation at Mount Kusatsu-Shirane

★Invited Papers

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Takahiro Kunitomo[3], Masato Fukai[1], Hiroshi Ichihara[2] (1.Earth and Planetary science, Tokyo Institute of Technology, 2.Graduate School of Environmental Studies, Nagoya University, 3.Nagoya University)

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

[STT42-06] A feasibility study to identify supercritical geothermal reservoirs on southern Kyushu Island using DTS and DAS systems

★Invited Papers

*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3] (1.ENAA, 2.Daiwa Exploration and Consulting Co., 3.Kyoto Univ., 4.WELMA Co. Ltd., 5.Shizuoka Univ.)

[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Junichi Takekawa(Graduate School of Engineering, Kyoto University), Yusuke Watanabe(Graduate School of Engineering, Kyoto University)

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

[STT42-07] The observation of active source and ambient noise signals with telecommunication fiber-optic cable in urban area

*Baoshan Wang[1], Xiangfang Zeng[2], Xiaobin Li[3], Weiwei Xu[4], Shanhui Xu[4], Zhenghong Song[1] (1.School of Earth and Space Sciences, University of Science and Technology of China, 2.State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, 3.Earthquake Agency of Yunnan Province, 4.Institute of Geophysics, China Earthquake Administration)

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

[STT42-08] Comparison of RTM results of time-lapse imaging in foam-assisted EOR

*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

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

[STT42-09] The estimation of physical properties of buried targets using the Cole-Cole equation in fictitious wave domain method

*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

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

[STT42-10] Numerical investigation of permeability anisotropy in porous media using a particle method

*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

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

[STT42-11] **Numerical Description of Flow Channel in Pipe Conduits Considering Solid-fluid Phase Shift with Lattice Boltzmann Method**

*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

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

[STT42-12] Evaluation of anisotropic parameters using virtual cross-dipole data with full waveform approach

*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto Univesity)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Kotaro Hirose(Waseda University School of Creative Science and Engineering), Takashi Toyofuku

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

[BPT04-01] Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

★Invited Papers

*Takuma Suzuki[1], Hiroki Hayashi[1] (1.Shimane University)

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

[BPT04-02] Mathematical models for the geochemical composition of foraminiferal calcium carbonate

*Jelle Bijma[1], Dieter Wolf-Gladrow[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung)

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

[BPT04-03] Response of structurally substituted sulfur in foraminifera shells to glacial-interglacial changes: a 1.0-million-year record from the Ontong-Java Plateau

*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Synchrotron Radiation Research Institute, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Tohoku University Museum, Tohoku University)

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

[BPT04-04] Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Center for Computational Sciences, University of Tsukuba, 3.Japan Agency for Marine-Earth Science and Technology)

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

[BPT04-05] Characterization of cogwheel structures in foraminifera

★Invited Papers

*Inge van Dijk[1], Markus Raitzsch[2], Gernot Nehrke[1], Jelle Bijma[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Am Handelshafen 12, Bremerhaven 27570, Germany, 2.MARUM - Zentrum für Marine Umweltwissenschaften, Universität Bremen, Leobener Str., 28359 Bremen, Germany)

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

[BPT04-06] Benthic foraminiferal characterizations from the seascape point of view

*Hiroshi Kitazato[1] (1.Tokyo University of Marine Science and Technology (TUMSAT))

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Jelle Bijma(AWI), 北里 洋

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

[BPT04-07] Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*Satoko Motai[1], Naotaka Tomioka[1], Jun Kawano[2], Saki Harii[3], Takaya Nagai[2], Tsuyoshi Watanabe[2], Yu Kodama[4], Motoo Ito[1] (1.Japan Agency for Marine-Earth and Technology, 2.Hokkaido University, 3.University of the Ryukyus, 4.Marine Works Japan)

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

[BPT04-08] Skeletal formation of scleractinian corals in response to Mg/Ca fluctuation

*Tomihiko Higuchi[1], Ikuko Yuyama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.University of Tsukuba)

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

[BPT04-09] **Inter-specific variations in trace element concentrations of modern brachiopod shells collected from Otsuchi Bay, Japan**

*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1] (1.Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, 2.Graduate School of Engineering and Science, University of the Ryukyus, 3.Graduate School of Environmental Studies, Nagoya University)

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

[BPT04-10] Trace element concentrations of sub-tropical modern brachiopod *Basiliola lucida* collected off Okinawa-jima, Japan

*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1] (1.Tohoku University, 2.University of the Ryukyus, 3.Advanced Industrial Science and Technology (AIST))

11:45 AM - 12:05 PM JST | 2:45 AM - 3:05 AM UTC

[BPT04-11] Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

★Invited Papers

*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4] (1.National Museum of Nature and Science, 2.Ehime University, 3.Tohoku University, 4.JAMSTEC)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Shamil Maksyutov(National Institute for Environmental Studies, Japan), Pavel Groisman(NC State University, USA), Yoshihiro Iijima(Mie University, Japan)

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

[MIS01-01] **Progress and Opportunities in Measurement and Modeling of Arctic Carbon Cycling under a Changing Climate**

★Invited Papers

*Qianlai Zhuang[1], Narasinha Shurpali[2], Torsten Sachs[3] (1.Purdue University, 2.University of Eastern Finland, 3.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences)

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

[MIS01-02] Potential climate change effects on biosystems in Siberia by the 2100s predicted from CMIP5

*Nadezhda Tchebakova[1], Elena Parfenova[1], Amber J Soja[2] (1.Sukachev Institute of Forests, Federal Research Center KSC, Siberian Branch, Russian Academy of Sciences, 2.National Institute of Aerospace, NASA Langley Research Center,)

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

[MIS01-03] Climate Change and Permafrost Degradation in Northern Eurasia: Geographic Impact Assesment

*Dmitry A Streletskiy[1] (1.George Washington University)

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

[MIS01-04] **Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales**

*Alexander Olchev[1,2], Vadim Mamkin[2], Inna Rozinkina[3], Yulia Mukhartova[4], Mikhail Nikitin[3], Ekaterina Tatarinovich[3], Julia Kurbatova[2] (1.Lomonosov Moscow State University, Faculty of Geography , 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Hydrometeorological Research Center of Russian Federation, 4.Lomonosov Moscow State University, Faculty of Physics)

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

[MIS01-05] **Changes in mountain glacier systems and the distribution of main climatic parameters on the territory of Russia (XX -XXI century)**

*Tatiana Khromova[1], Gennady Nosenko[1], Valeria Popova[1], Anton Muraviev[1], Stanislav Nikitin[1] (1.Institute of Geography Russian Academy of Sciences)

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

[MIS01-06] Projection of changes in water balance components across irrigated lands of Central Asia using a high-resolution modeling system

*Anastasiia Pikaleva[1], Ekaterina Nadyozhina[1], Alexandra Sternzat[1], Boris Egorov[1], Sergey Efimov[1], Igor Shkolnik[1] (1.Voeikov Main Geophysical Observatory)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Dmitry Streletskiy(George Washington University), Pavel Groisman(NC State University, USA), Tetsuya Hiyama(Nagoya University, Japan)

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

[MIS01-07] **Rises and Falls of the Socioeconomic-Ecological Systems along the Silk Road**

★Invited Papers

*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3] (1.Center for Global Changes and Earth Observation, Department of Geography, Environment, and Spatial Sciences, Michigan State University, 2.Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 3.NC State University Research Scholar, NOAA National Centers for Environment Information)

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

[MIS01-08] **Interdisciplinary study of the mountain geosystems in the Altay-Sayan region**

*Margarita Syromyatina[1], Yurii Kurochkin[1], Mariia Andreeva[1], Kirill Chistyakov[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

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

[MIS01-09] Where in High Mountain Pastures does Snow Seasonality Link Most Closely with Subsequent Land Surface Phenology?

*Geoffrey M Henebry[1], Monika A Tomaszewska[2] (1.Michigan State University, 2.South Dakota State University)

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

[MIS01-10] Evaluation of orographic precipitation over Central Asia and its simulated change under a warming environment

*Akiyo Yatagai[1], Ayano Senda[1], Minami Masuda[1], Vinay Kumar[2] (1.Graduate School of Science and Technology/Hirosaki University, 2.Texas A&M University)

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

[MIS01-11] The impact factor of surface spectral albedo in an arid area

*Jiaxi Yang[1], Zhenchao Li[2], Xiaoqing Gao[2], Panmao Zhai[3] (1.University of Chinese Academy of Sciences, 2.Key Laboratory of Land Surface Process and Climate Change in Cold and Arid Regions, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Lanzhou, China, 3.Chinese Academy of Meteorological Sciences)

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

[MIS01-12] **Northern Eurasia Future Initiative (NEFI) Focus on Human-Associated Extreme Events**

*Pavel Groisman[1,2,3], Alexander Shiklomanov[4], Irina Yesserkepova[5], Sergey Gulev[2], Ildan Kaipov[6] (1. NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia , 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. University of New Hampshire, Durham, New Hampshire, USA , 5.Joint Stock Company "Zhasyl Damu", Almaty, Kazakhstan, 6. National Center for Space Research and Technologies, Almaty, Kazakhstan)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-GI General Geosciences, Information Geosciences & Simulations

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Yasuhiro Murayama(NICT)

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

[MGI31-01] WDS: International Coordination for Sustainable FAIR Data, for Science and Society

*Yasuhiro Murayama[1] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology)

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

[MGI31-02] Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3] (1.National Institute of Informatics, 2.ROIS-DS Center for Open Data in the Humanities, 3.EDITORIA, The University of Tokyo, 4.SOKENDAI)

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

[MGI31-03] Data Sharing and Open Science: Practice, Expectation, Transparency, and Credit

*Shelley Stall[1] (1.American Geophysical Union)

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

[MGI31-04] Ethical issues in open science

*Yasuhisa Kondo[1] (1.Research Institute for Humanity and Nature)

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

[MGI31-05] The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*Kazuhiro Hayashi[1] (1.National Institute of Science and Technology Policy)

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

[MGI31-06] Future evolution of open archives for preprints, posters, and presentations as a key component of open science in the Earth and space sciences

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

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Shelley Stall(American Geophysics Union)

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

[MGI31-07] Cloud Computing Needs for Earth Observation Data Analysis: EGI and the European Open Science Cloud

★Invited Papers

Björn Backeberg[1], Yin Chen[1], *Tiziana Ferrari[1], Pedro Gonçalves[4], Paolo Mazzetti[3], Anabela Oliveira[2], Diego Scardaci[1], Gergely Sipos[1] (1.EGI Foundation, 2.LNEC, 3.CNR, 4.Terradue)

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

[MGI31-08] Open third generation geostationary satellites accelerate environmental studies: Case studies of CEReS, Chiba University, Japan

*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1] (1.Center for Environmental Remote Sensing (CEReS), Chiba University, Japan, 2.EORC, JAXA, 3.NICT)

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

[MGI31-09] Scientific data chain for better data publication and preservation

*Takeshi Horinouchi[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

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

[MGI31-10] Current status and problems of geodetic observation data distribution

*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5] (1.Hitotsubashi University, 2.Institute of Industrial Science, the University of Tokyo, 3.Hydrographic and Oceanographic Department, Japan Coast Guard, 4.National Institute of Information and Communications Technology, 5.Geospatial Information Authority of Japan)

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

[MGI31-11] Recent activity of data publication and data citation in the international community of geomagnetism

*Masahito Nose[1], Yasuhiro Murayama[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Strategic Program Produce Office, National Institute for Information Communications Technology)

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

[MGI31-12] IGSN: International Collaboration Makes Samples and Sample Data FAIR

*Kerstin Lehnert[1], Jens Klump[2], Lesley Wyborn[3], Sarah Ramdeen[4] (1.Columbia University, 2.CSIRO Kensington, Australia, 3.Australian National University, Canberra, Australia, 4.Ronin Institute, USA)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Baptiste Cecconi(LESIA - Observatoire de Paris)

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

[MGI31-13] Adoption of IGSN in the International Ocean Discovery Program (IODP)

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

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

[MGI31-14] Oceanogrpahic Data and Information Exchange for Open Science

*Toru Suzuki[1] (1.Marine Information Research Center)

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

[MGI31-15] The International Heliophysics Data Environment Alliance (IHDEA) initiative

★Invited Papers

*Arnaud Masson[1], Aaron Roberts[2], Shing Fung[2], Bob McGuire[2], Jack Ireland[2], Jeremy Faden[12], Jim Lewis[9], Baptiste Cecconi[7], Vincent Genot[8], J.C. Malapert[4], Keiichi Matsuzaki[3], Todd King[5], Daniel Mueller[6], Jon Vandegriff[10], Miyoshi Yoshizumi[11] (1.ESAC Science Data Center, European Space Agency, Madrid, Spain, 2.NASA/GSFC, USA, 3.JAXA, ISAS, Tokyo, 4.CNES, Toulouse, 5.UCLA, USA, 6.ESTEC, European Space Agency, Noordwijk, The Netherlands, 7.LESIA, Observatoire de Paris, France, 8.IRAP, CNRS, Toulouse, 9.Berkeley University, USA, 10.John Hopkins, APL, USA, 11.ISEE, Nagoya University, Nagoya 464-8601, Japan, 12.Cottage Systems, University of Iowa, USA)

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

[MGI31-16] **VESPA: Progress on the Planetary Science Virtual Observatory**

*Stephane Erard[1] (1.Observatoire de Paris / LESIA)

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

[MGI31-17] Publishing planetary science data following FAIR principles

*pierre le sidaner[1], Baptiste Cecconi[2], Stephane Erard[2], Cyril Chauvin[1], Albert Shih[1], Stephane Aicardi[1], Philippe Hamy[1], Alan Loh[2] (1.DIO - Observatoire de Paris, Universite PSL, CNRS UMS2201, 2.LESIA, Observatoire de Paris, Universite PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cite)

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

[MGI31-18] Community-developed open tools for supporting the ESA JUICE space mission preparation

*Baptiste Cecconi[1], Alan Loh[1], Stephane Aicardi[2], Corentin Louis[3] (1.LESIA, Observatoire de Paris, CNRS, PSL Research University, Meudon, France, 2.DIO, Observatoire de Paris, CNRS, PSL Research University, Paris, France, 3.IRAP, CNRS-Université Paul Sabatier, Toulouse, France)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center), Chairperson:Junichi Kurihara(Hokkaido University), Tetsuro Ishida(Hokkaido University)

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

[MSD42-01] Present status of Asian Micro-satellite Consortium

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

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

[MSD42-02] **Updates on the Development of the Image Acquisition and Scheduler Portal for the Asian Microsatellite Consortium (AMC) from the Philippines' STAMINA4Space Program**

*Mark Edwin Tupas[1], Alvin Retamar[2], Gay Jane Perez[1], Joel Joseph Jr Marciano[2], Romer Kristi Aranas[1], Benjamin Joseph Jiao[1] (1.University of the Philippines - Diliman, 2.Department of Science and Technology - Advanced Science and Technology Institute)

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

[MSD42-03] **Overview of MicroDragon, a microsatellite for ocean color observation**

*Huy Xuan Le[1], Thao Thi Nguyen[1], Junichi Kurihara[2] (1.Vietnam National Space Center, 2.Graduate School of Science, Hokkaido University)

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

[MSD42-04] Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*Tetsuro Ishida[1], Mark Jayson Felix[2], Ellison Caparas Castro[2], Shielo Baes Namuco[2], Francisco Miguel Felicio[2], Harry Casimir Merida[2], Kaye Kristine Vergel[2], Gay Jane Perez[2], Joel Joseph Marciano[3,4], Yukihiro Takahashi[1] (1.Faculty of Science, Hokkaido University, 2.Institute of Environmental Science and Meteorology, University of the Philippines Diliman, 3.Advanced Science and Technology Institute, Department of Science and Technology, 4.Electrical and Electronics Engineering Institute, University of the Philippines Diliman)

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

[MSD42-05] MICROSATELLITE TECHNOLOGY DEVELOPMENT STATUS IN MONGOLIA BASED ON ITS NEEDS

*Erdenebaatar Dashdondog[1], Begzsuren Tumendemberel[2], Turtogtokh Tumenjargal[3], Ulam-Orgikh Duger[4] (1.Senior Lecturer of the National University of Mongolia, 2.Hokkaido University, 3.Researcher National University of Mongolia, 4.Professor National University of Mongolia)

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

[MSD42-06] Potential Agricultural Applications of Microsatellites for Malaysian Agriculture

*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2] (1.Universiti Putra Malaysia , 2.Hokkaido University)

Mon. May 27, 2019

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

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

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

convener:Jun Kimura(Osaka University), Yasumasa Kasaba(Planetary Plasma and Atmospheric Research Center, Tohoku University), Kunio M. Sayanagi(Hampton University), Chairperson:笠羽 康正, Kazuo Yoshioka(The University of Tokyo)

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

[PPS01-01] Circulation of plasma in the Jupiter's inner magnetosphere revealed from time variation in radial profile of plasma temperature and density obtained by Hisaki/EXCEED observation

*Reina Hikida[1], Kazuo Yoshioka[2], Fuminori Tsuchiya[3], Masato Kagitani[3], Go Murakami[4], Tomoki Kimura[5], Atsushi Yamazaki[4], Ichiro Yoshikawa[2] (1.Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 2.Department of Complexity Science and Engineering, Graduate School of Frontier Science, the University of Tokyo, 3.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 4.Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA) , 5.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University)

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

[PPS01-02] Volcanic change of the distribution of Io’s neutral oxygen cloud observed by Hisaki

*Ryoichi Koga[1], Fuminori Tsuchiya[1], Masato Kagitani[1], Takeshi Sakanoi[1], Tomoki Kimura[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Go Murakami[3], Atsushi Yamazaki[3], Howard Todd Smith[4], Fran Bagenal[5] (1.Tohoku University, 2.The University of Tokyo, 3.ISAS/JAXA, 4.Johns Hopkins University, 5.University of Colorado)

4:00 PM - 4:18 PM JST | 7:00 AM - 7:18 AM UTC

[PPS01-03] New pictures of Jovian magnetosphere obtained from the Hisaki satellite observation

★Invited Papers

*Fuminori Tsuchiya[1], Kazuo Yoshioka[2], Tomoki Kimura[1], Chihiro Tao[3], Ichiro Yoshikawa[2], Go Murakami[4], Hajime Kita[4], Ryoichi Koga[1], Hikida Reina[2], Fumiharu Suzuki[2], Sooman Han[2], Masato Kagitani[1], Takeshi Sakanoi[1], Hiroaki Misawa[1], Yasumasa Kasaba[1], Atsushi Yamazaki[4] (1.Tohoku University, 2.The University of Tokyo, 3.NICT, 4.ISAS/JAXA)

4:18 PM - 4:33 PM JST | 7:18 AM - 7:33 AM UTC

[PPS01-04] Axisymmetric conductivities of Jupiter's middle- and low-latitude ionosphere

*Yuki Nakamura[1], Koichiro Terada, Chihiro Tao[2], Naoki Terada[1], Yasumasa Kasaba[3], Hajime Kita[4], Aoi Nakamizo[2], Akimasa Yoshikawa[5], Shinichi Ohtani[6], Fuminori Tsuchiya[3], Masato Kagitani[3], Takeshi Sakanoi[3], Go Murakami[4], Kazuo Yoshioka[7], Tomoki Kimura[1], Atsushi Yamazaki[4], Ichiro Yoshikawa[8] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.National Institute of Information and Communications Technology, 3.Planetary Plasma and Atmospheric Research Center, Tohoku University, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 5.Department of Earth and Planetary Sciences, Kyushu University, 6.The Johns Hopkins University Applied Physics Laboratory, 7.Graduate School of frontier Science, The University of Tokyo, 8.The University of Tokyo)

4:33 PM - 4:51 PM JST | 7:33 AM - 7:51 AM UTC

[PPS01-05] The magnetospheres of Saturn and Jupiter as viewed by Cassini and Juno

★Invited Papers

*G Provan[1], Stanley W. H. Cowley[1], Emma Jane Bunce[1] (1.University of Leicester)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS05] Recent advances of Venus science

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Masaru Yamamoto(Research Institute for Applied Mechanics, Kyushu University), Kevin McGouldrick(University of Colorado Boulder), Chairperson:Takeshi Horinouchi

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

[PPS05-01] **Super-rotation of Venusian atmosphere in the equatorial region may be caused by the density driven separation**

*Adhithiyan Neduncheran[1], Ugur Guven[1,2], Ananyo Bhattacharya[3] (1.University of Petroleum and Energy Studies, India, 2.United Nations Centre for Space Science and Technology Education in Asia and the Pacific, 3.Sardar Vallabhbhai National Institute of Technology,India)

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

[PPS05-02] Comparison of horizontal distributions of temperature and UV absorbers at the Venus cloud-tops

*Shinichiro Kawase[1], Makoto Taguchi[1], Tetsuya Fukuhara[1], Yeon Joo Lee[2], Atsushi Yamazaki[3,4] (1.Rikkyo University, 2.Max Planck Institute for Solar System Research, 3.Institute of Space and Astronautical Science, 4.Japan Aerospace Exploration Agency)

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

[PPS05-03] Orographic Gravity Waves in the Venus Atmospheric

*Anna Suzuki[1], Masahiro Takagi[1], Yasumitsu Maejima[2], Hiroki Ando[1], Norihiko Sugimoto[3], Yoshihisa Matsuda[4] (1.Kyoto Sangyo University, 2.RIKEN Advanced Institute for Computational Science, 3.Keio University, 4.Tokyo Gakugei University)

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

[PPS05-04] Atmospheric structures simulated by T21 and T63 Venus GCMs with radiative transfer

*Masaru Yamamoto[1], Kohei Ikeda[2], Masaaki Takahashi[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.National Institute for Environmental Studies)

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

[PPS05-05] Thermal-tides structure at the cloud level of Venus derived from Akatsuki/LIR observations

★Invited Papers

*Toru Kouyama[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Takeshi Imamura[3], Masahiko Futaguchi[4], Takeru Yamada[2], Masahiro Akiba[2], Yeon Joo lee, Takao M. Sato[7], Shin-ya Murakami[5], George HASHIMOTO[6], Takehiko Satoh[5], Masato Nakamura[5] (1.AIST, 2.Rikkyo Univ., 3.Tokyo Univ., 4.Toho Univ., 5.JAXA, 6.Okayama Univ., 7.Hokkaido Information Univ.)

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

[PPS05-06] From Venus to Mars: viewpoint of comparative meteorology

★Invited Papers

*Takeshi Imamura[1], Kazunori Ogohara[2], Hiromu Nakagawa[3], Shohei Aoki[3] (1.The University of Tokyo, 2.University of Shiga Prefecture, 3.Tohoku University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS05] Recent advances of Venus science

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Masaru Yamamoto(Research Institute for Applied Mechanics, Kyushu University), Kevin McGouldrick(University of Colorado Boulder), Chairperson:Takehiko Satoh

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

[PPS05-07] A two-stage evolution model of Venus's mantle and its implication for the Earth

★Invited Papers

*Masaki Ogawa[1] (1.Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo)

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

[PPS05-08] Interaction between the thermosphere and the cloud-level atmosphere of Venus studied with simultaneous observations by Hisaki and Akatsuki

*Yusuke Nara[1], Takeshi Imamura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Kei Masunaga[2], Atsushi Yamazaki[3], Shigeto Watanabe[4], Manabu Yamada[5], Yeon Joo Lee[1], Naoki Terada[6], Kanako Seki[1] (1.The University of Tokyo, 2.Swedish Institute of Space Physics, 3.ISAS/JAXA, 4.Hokkaido Information University, 5.Chiba Institute of Technology, 6.Tohoku University)

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

[PPS05-09] Mesoscale Dyanmics in the Venus Atmosphere

*Kevin McGouldrick[1], Javier Peralta[2], Takehiko Satoh[2] (1.University of Colorado Boulder, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS05-10] Periodicity analysis of Venus' cloud-top temperature measured by Akatsuki LIR

Naoya Kajiwara[1], *Takeshi Imamura[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Toru Kouyama[3] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.College of Science, Rikkyo University, 3.National Institute of Advanced Industrial Science and Technology)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[PPS05-11] Modeling Venus-like Worlds Through Time: The habitable zone, and the evolution of Venus' atmosphere.

★Invited Papers

*Michael Way[1,2,3], Anthony Del Genio[1] (1.NASA Goddard Institute for Space Studies, 2.GSFC Sellers Exoplanet Environments Collaboration, 3.Department of Physics and Astronomy, Uppsala University, Sweden)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS05] Recent advances of Venus science

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Masaru Yamamoto(Research Institute for Applied Mechanics, Kyushu University), Kevin McGouldrick(University of Colorado Boulder), Chairperson:Kevin McGouldrick

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

[PPS05-12] Cloud top structure of Venus retrieved from the Akatsuki IR2 dayside observations

★Invited Papers

*Takao M. Sato[1], Takehiko Satoh[2], Hideo Sagawa[3], Naohiro Manago[2], Yeon Joo Lee, Shin-ya Murakami[2], Kazunori Ogohara[4], George HASHIMOTO[5], Yasumasa Kasaba[6], Atsushi Yamazaki[2], Manabu Yamada[7], Shigeto Watanabe[1], Takeshi Imamura[8], Masato Nakamura[2] (1.Hokkaido Information University, 2.ISAS/JAXA, 3.Kyoto Sangyo University, 4.University of Shiga Prefecture, 5.Okayama University, 6.Tohoku University, 7.Chiba Institute of Technology, 8.The University of Tokyo)

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

[PPS05-13] Formation of superrotation studied by a TEM model

*Takeshi Horinouchi[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

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

[PPS05-14] Morphological Feature Extraction from Venus' Cloud Images Using Principal Component Analysis

*Minori Narita[1], Takeshi Imamura[1], Yusuke Nara[1], Yeon Joo Lee, Shigeto Watanabe[2], Atsushi Yamazaki[3], Takehiko Satoh[3], Makoto Taguchi[4], Tetsuya Fukuhara[4], Manabu Yamada[5] (1.The University of Tokyo, 2.Hokkaido Information University, 3.ISAS/JAXA, 4.Rikkyo University, 5.PERC/Chiba Institute of Technology)

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

[PPS05-15] **Principal Components of UV Albedo Variability in Venus' Atmosphere as seen at 283 nm**

*Pushkar Kopparla[1], Yeon Joo Lee[1], Takeshi Imamura[1], Atsushi Yamazaki[2] (1.GSFS, University of Tokyo, 2.ISAS, JAXA)

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

[PPS05-16] Active and inactive behaviors of the planetary-scale waves on Venus cloud top

★Invited Papers

*Masataka Imai[1], Toru Kouyama[1], Yukihiro Takahashi[2], Takeshi Horinouchi[3], Takeshi Imamura[4], Atsushi Yamazaki[5], Shigeto Watanabe[6], Manabu Yamada[7], Masato Nakamura[5], Takehiko Satoh[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Graduate School of Frontier Sciences, University of Tokyo, 5.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 6.Space Information Center, Hokkaido Information University, 7.Planetary Exploration Research Center, Chiba Institute of Technology)

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

[PPS05-17] **Long-term behaviour of the morphology and dynamics of Venus's middle clouds with Akatsuki/IR1.**

★Invited Papers

*Javier Peralta[1], Naomoto Iwagami[2], Sánchez-Lavega Agustín[3], Yeon Joo Lee[4], Ricardo Hueso[3], Minori Narita[4], Takeshi Imamura[4], Phil Miles[5], Anthony Wesley[6], Emmanuel Kardasis[7], Seiko Takagi[8] (1.Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), Sagamihara, Japan, 2.Tokyo 156-0044, Japan, 3.Escuela de Ingeniería de Bilbao, University of the Basque Country (UPV/EHU), Bilbao, Spain, 4.Graduate School of Frontier Sciences, The University of Tokyo, Japan, 5.Rubyvale QLD, Australia, 6.Astronomical Society of Australia, Australia, 7.Hellenic Amateur Astronomy Association, Greece, 8.Research and Information Center, Tokai University, Japan)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-EM10] Multi-scale Coupling in the Magnetosphere-Ionosphere-Thermosphere System

convener:Yue Deng(University of Texas at Arlington), Toshi Nishimura(Boston University), Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Yanshi Huang(Harbin Institute of Technology, Shenzhen), Chairperson:Yue Deng(University of Texas at Arlington), Huixin Liu(Kyushu University, Japan), Yanshi Huang(Harbin Institute of Technology, Shenzhen, China), Yukitoshi Nishimura(Boston University)

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

[PEM10-01] Auroral fragmentation into patches and pressure balance condition in the source magnetosphere

★Invited Papers

*Kazuo Shiokawa[1], Katsuki Nishi[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

[PEM10-02] Formation and Evolution of Polar Cap Ionospheric Patches and Their Associated Upflows and Scintillations: A Review

★Invited Papers

*Qing-He Zhang[1], Zan-Yang Xing[1], Yong Wang[1], Yu-Zhang Ma[1] (1.Institute of Space Sciences, Shandong University, Weihai, China)

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

[PEM10-03] Global ionospheric disturbances during the 6-10 September 2017 solar storms

★Invited Papers

*Shunrong Zhang[1] (1.MIT Haystack Observatory)

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

[PEM10-04] Multiscape Coupling of Sub-auroral Polarization Streams

*Nozomu Nishitani[1], Tomoaki Hori[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

[PEM10-05] Scale sizes of mass density enhancements inferred from accelerometer measurements

*Yanshi Huang[1], Cheryl Huang[2] (1.Harbin Institute of Technology, Shenzhen, China, 2.Space Physics Directoriate, Air Force Research Laboratory, Kirtland AFB, USA)

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

[PEM10-06] **Meso-scale forcing in the upper atmosphere: sources and impacts**

*Yue Deng[1], Qingyu Zhu[1], Cissi Lin[1] (1.University of Texas at Arlington)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Antti Pulkkinen(NASA/GSFC)

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

[PEM12-01] NASA Heliophysics Division Space Weather Update

★Invited Papers

*Nicola Justine Fox[1] (1.NASA Headquarters)

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

[PEM12-02] NOAA's Current and Future Space Weather Architecture

★Invited Papers

*Elsayed R Talaat[1] (1.NOAA National Environmental Satellite, Data, and Information Service)

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

[PEM12-03] Community Coordinating Modeling Center (CCMC): A hub for collaborative assessment and improvement of space weather capabilities.

★Invited Papers

*Maria M Kuznetsova[1], M. Leila Mays[1], Edward J Semones[2], Peter J Macneice[1], Lutz Rastaetter[1], Ja Soon Shim[1], Yihua Zheng[1], Katherine Garcia-Sage[1], Joycelyn Jones[1], Yaireshka m Collado-Vega[1], Richard E Mullinix[1], Chiu Wiegand[1] (1.NASA Goddard Space Flight Center, 2.NASA Johnson Space Center)

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

[PEM12-04] Different flux evolutions of relativistic electrons of the outer belt associated with high-speed coronal hole streams; Arase and Van Allen Probes observations

*Yoshizumi Miyoshi[1], Satoshi Kurita[1], Ryuho Kataoka[2], Shinji Saito[1], Vania Jordanova[3], Iku Shinohara[4], Takefumi Mitani[4], Takeshi Takashima[4], Nana Higashio[4], Satoshi Kasahara[5], Shoichiro Yokota[6], Tomoaki Hori[1], Kunihiro Keika[5], Yoshiya Kasahara[7], Shoya Matsuda[4], Atsushi Kumamoto[8], Fuminori Tsuchiya[8], Masafumi Shoji[1], Ayako Matsuoka[1], Mariko Teramoto[1], Harlan Spence[9], Geoff Reeves[3], Daniel Baker[10] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.NIPR, 3.Los Alamos National Laboratory, 4.JAXA, 5.University of Tokyo, 6.Osaka University, 7.Kanazawa University, 8.Tohoku University, 9.University of New Hampshire, 10.University of Colorado)

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

[PEM12-05] Study on the predictability of imminent giant solar flares based on the theory of double-arc instability

*Kanya Kusano[1], Tomoya Iju[2], Yumi Bamba[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.NAOJ)

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

[PEM12-06] Update of space weather research and operation activities in NICT

*Mamoru Ishii[1] (1.National Institute of Information and Communications Technology)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Ryuho Kataoka(National Institute of Polar Research)

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

[PEM12-07] Commercial Space Weather Activities From a USA small Business Perspertive

★Invited Papers

*Chigomezyo Mudala Ngwira[1], Geoff Crowley[1], Chad Fish[1] (1.Atmospheric and Space Technology Research Associates, LLC)

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

[PEM12-08] Development of coronal mass ejection arrival time forecasting system using interplanetary scintillation observations

★Invited Papers

*Kazumasa Iwai[1], Daikou Shiota[2], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Mitsue Den[2], Yûki Kubo[2] (1.Institute for Space–Earth Environmental Research (ISEE), Nagoya University, 2.National Institute of Information and Communications)

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

[PEM12-09] Development of real-time prediction system of CME arrival and magnetic field with SUSANOO-CME MHD simulation

*Daikou Shiota[1,2], Seiji Yashiro[3], Kazumasa Iwai[2] (1.National Institute of Information and Communications Technology (NICT), 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Catholic University)

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

[PEM12-10] The Role of a Tiny Brightening in a Huge Geo-effective Solar Eruption Leading to the St Patrick's Day Storm

*Yumi Bamba[1,2], Satoshi Inoue[1], Keiji Hayashi[1,3,4] (1.Institute for Space-Earth Environmental Research/Nagoya University, 2.Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency, 3.Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, 4.State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences)

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

[PEM12-11] Critical Parameters of Photospheric Magnetic Field to Produce Eruptive Solar Flares and CMEs in Active Regions

*Pei Hsuan Lin[1], Kanya Kusano[1], Daikou Shiota[2], Satoshi Inoue[1], KD Leka[1,3], Yuta Mizuno[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Information and Communications Technology, 3.NorthWest Research Associates)

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

[PEM12-12] Simulation study on internal velocity field variation of eruptive prominence

★Invited Papers

*Takafumi Kaneko[1], Kanya Kusano[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Antti Pulkkinen(NASA/GSFC)

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

[PEM12-13] Is intensity of auroral electrojet predictable?

★Invited Papers

*Yusuke Ebihara[1], Takashi Tanaka[2], Naoki Kamiyoshikawa[3] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.Kyushu University, 3.Mitsubishi Electric Corporation)

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

[PEM12-14] Geoelectromagnetics with the Geophysical Instrument Combination of Hydro-Québec, AUTUMNX, and USArray Magnetotellurics

★Invited Papers

*Martin G Connors[1], Sébastien Guillon[2], Adam Schultz[3], Naoto Imamura[3] (1.Athabasca University, 2.Hydro-Québec TransÉnergie, 3.Oregon State University)

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

[PEM12-15] Quantifying the Latitudinal Extent of the Aurorae During Large Geomagnetic Storms

*Sean Blake[1,2], Antti Pulkkinen[1], Pete Schuck[1] (1.NASA Goddard Space Flight Center, Space Weather Laboratory, Greenbelt, Maryland, USA, 2.Catholic University of America, Department of Physics, Washington DC, USA)

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

[PEM12-16] Simulation of Geomagnetically Induced Current (GIC) Flowing in 500 kV Power Grid in Japan Including a Three-Dimensional Ground Inhomogeneity

*Satoko Nakamura[1], Yusuke Ebihara[1], Shigeru Fujita[2], Tada-nori Goto[3], Shinichi Watari[4] (1.Research Institute for Sustainable Humanosphere, Kyoto University., 2.Meteorological College, Japan Meteorological Agency, 3.Graduate School of Engineering, Kyoto University, 4.National Institute of Information and Communications Technology)

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

[PEM12-17] Reproducibility of the geomagnetically induced currents in Hokkaido with a two-layer conductivity model

*Takashi Kikuchi[1,2], Yusuke Ebihara[2], Kumiko K. Hashimoto[3], Shinichi Watari[4] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute for Sustainable Humanosphere, Kyoto University, 3.Kibi International University, 4.National Institute of Information and Communications Technology)

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

[PEM12-18] Fan-shaped aurora as seen from Japan during a great magnetic storm on 11 February 1958

*Ryuho Kataoka[1], Shiori Uchino[1], yasunori Fujiwara[1], Shigeru Fujita[1], Kazuaki Yamamoto[2] (1.National Institute of Polar Research, 2.National Institute of Japanese Literature)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Kanya Kusano(Nagoya University)

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

[PEM12-19] Application Usability Levels: Their evolution and eco-system

★Invited Papers

*Alexa Jean Halford[1], Adam Kellerman[2], Jeff Klenzing[3], Katherine Garcia-Sage[3], Brett A Carter[4], Daniel T Welling[5], Barbara Thompson[3], Antti A Pulkkinen[3] (1.The Aerospace Corporation, 2.UCLA, 3.NASA/GSFC, 4.RMIT, 5.UT Arlington)

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

[PEM12-20] The Operational Space Weather Forecast at NICT, Japan

★Invited Papers

*Kosuke Sakai[1], Kentaro Ukawa[1], Kentaro Kawahara[1], Mamoru Ishii[2], Yuki Kubo[2] (1.Systems Engineering Consultants Co., LTD., 2.National Institute of Information and Communications Technology)

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

[PEM12-21] PROGRESS: An overview of data products

*Michael A Balikhin[1], Simon N Walker[1] (1.University of Sheffield)

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

[PEM12-22] The Probability of Satellite Anomalies by a Disastrous Solar Flare

*Daikichi SEKI[1,2,3] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2.Centre for the Study of Existential Risk, University of Cambridge, 3.Astronomical Observatory, Kyoto University)

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

[PEM12-23] **Operational Forecasting of Solar Flares using Deep Neural Network**

*Naoto Nishizuka[1], Yuki Kubo[1], Komei Sugiura[1], Mitsue Den[1], Mamoru Ishii[1] (1.National Institute of Information and Communications Technology)

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

[PEM12-24] **Spring-Autumnal asymmetry in geomagnetic activity and its origin over last 140 years**

*Hao Luo[1], Xiaoming Sha[1] (1.IGGCAS)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301B 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

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

[AOS09-18] Searching 18.6 year tidal modulation impact in a global gridded ocean oxygen dataset with its improvements

*Shoshiro Minobe[1] (1.Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

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

[AOS09-19] Contribution of tidal energy dissipation to variations of transient climate response and steric sea level rise through ocean heat uptake

*Michio Watanabe[1], Hiroaki Tatebe[1], Tatsuo Suzuki[1], Kaoru Tachiiri[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[AOS09-20] A Wave Resolving Simulation for Upper Ocean Turbulence Driven by Wave-Current Interaction

*Yutaka Yoshikawa[1], Yasushi Fujiwara[1], Yoshimasa Matsumura[2] (1.Graduate School of Science, Kyoto University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AOS09-21] Revisiting the Characteristics of Mixing Efficiency in the Brazil Basin

*Takashi Ijichi[1], Louis St. Laurent[1], Kurt Polzin[1] (1.Woods Hole Oceanographic Institution)

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

[AOS09-22] Instabilities of finite-amplitude internal wave beams

*Yohei Onuki[1], Yuki Tanaka[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

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

[AOS09-23] Evaluation of nutrient flux enhanced by double diffusion in the Kuroshio using glider measurements

*Keunjong Lee[1], Ryo Yamamoto[1], Ichiro Yasuda[1], Takahiro Tanaka[2] (1.Atmosphere and Ocean Research Institute, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

convener:Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Takafumi Hirata(Faculty of Environmental Earth Science, Hokkaido University), Enrique N Curchitser(Rutgers University New Brunswick), Eileen E Hofmann(Old Dominion University), Chairperson:Shin-Ichi Ito(The University of Tokyo)

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

[AOS12-01] Projected coastal hypoxia in a coupled bio-physical model of the California Current System.

★Invited Papers

*Enrique N Curchitser[1], Raphael Dussin[1,2], Charles Stock[3], Nicoals van Oostende[4] (1.Rutgers University New Brunswick, 2.Lamont-Doherty Earth Observatory of Columbia University, 3.NOAA Geophysical Fluid Dynamics Laboratory, 4.Princeton University)

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

[AOS12-02] **Decadal salinity variation in the western North Pacific correlated with the strength of the Oyashio and the Kuroshio Extension**

*Hitoshi Kaneko[1], Takeshi Okunishi[2], Shinya Kouketsu[3], Sachihiko Itoh[1], Takashi Seto[4], Hiroshi Kuroda[5], Yugo Shimizu[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Japan Agency for Marine-Earth Science and Technology, 4.National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 5.Hokkaido National Fisheries Research Institute, Japan Fisheries Research and Education Agency)

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

[AOS12-03] **Multiscale routes to supply nutrients through the Kuroshio nutrient stream**

*Takeyoshi Nagai[1], Sophie Clayton[2], Yusuke Uchiyama[3] (1.Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2.Ocean, Earth & Atmospheric Sciences, Old Dominion University, 3.Kobe University)

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

[AOS12-04] **Seasonal variability of upper-ocean primary production around the Kuroshio analyzed using a ROMS-NPZD model**

*Xu Zhang[1], Yusuke Uchiyama[1,2], Yota Suzue[3], Hidekatsu Yamazaki[4] (1.Kobe University, 2.Port and Airport Research Institute, 3.Construction Technique Institute Engineering Co., Ltd., 4.Tokyo University of Marine Science and Technology)

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

[AOS12-05] Nutrient and light conditions at subsurface chlorophyll maximum: physical-biogeochemical observations along a mid-Pacific meridional transect

*Sachihiko Itoh[1], Hitoshi Kaneko[1], Shinya Kouketsu[2], Takeshi Okunishi[3], Hiroshi Ogawa[1], Mitsuhide Sato[4], Hiroaki Saito[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marin-Earth Science and Technology, 3.Tohoku National Fisheries Research Institute, Fisheries Research Agency, 4.The Hong Kong University of Science and Technology)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

convener:Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Takafumi Hirata(Faculty of Environmental Earth Science, Hokkaido University), Enrique N Curchitser(Rutgers University New Brunswick), Eileen E Hofmann(Old Dominion University), Chairperson:Yoshimasa Matsumura(Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AOS12-06] A Lagrangian view of spring phytoplankton blooms

★Invited Papers

*Shinichiro Kida[1], Taka Ito[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Georgia Institute of Technology)

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

[AOS12-07] Significance of acclimation process in simulating chlorophyll distribution in the Arctic Ocean

*Yoshio Masuda[1], Yasuhiro Yamanaka[1], Takafumi Hirata[1], Hideyuki Nakano[2] (1.Graduate School of Environmental Earth Science, Hokkaido University, 2.Meteorological Research Institute)

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

[AOS12-08] Responses of lower-trophic level ecosystem to nutrient variation in the central part of the Seto Inland Sea

*Naoki Yoshie[1], Hayato Mizuguchi[1], Xinyu Guo[1], Michio Yoneda[2], Katsuyuki Abo[2], Tomoaki Kono[2], Tatsunori Fujita[3] (1.Center for Marine Environmental Studies, Ehime University, 2.Japan Fisheries Research and Education Agency, 3.Kagawa Prefectural Fisheries Research Center)

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

[AOS12-09] Effects of the temperature and fish size on metabolism and swimming performance of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

*Chenying Guo[1], Shin-ichi Ito[1], Michio Yoneda[2], Hajime Kitano[2] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Fisheries Research and Education Agency Japan)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[AOS12-10] Sensitivity analyses of growth and migration of Japanese anchovy (*Engraulis japonicus*) in the East China Sea using a fish growth-migration model.

*Shin-ichi Ito[1], Takashi Setou[2], Michio Yoneda[2], Motomitsu Takahashi[2], Michiya Matsuyama[3], Chenying Guo[1], Takashi Kitagawa[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Fisheries Research and Education Agency Japan, 3.Kyushu University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

convener:Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Takafumi Hirata(Faculty of Environmental Earth Science, Hokkaido University), Enrique N Curchitser(Rutgers University New Brunswick), Eileen E Hofmann(Old Dominion University), Chairperson:Enrique Curchitser(Rutgers University)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[AOS12-11] Micro-scale patchiness enhances trophic transfer efficiency and potential plankton biodiversity

★Invited Papers

*Hidekatsu Yamazaki[1], Anupam Priyadarshi[2], Lan Smith[3], Sandip Mandal[4], Mamoru Tanaka[1] (1.Tokyo University of Marine Science and Technology, 2.Banaras Hindu University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Public Health Foundation of India)

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

[AOS12-12] Long term observations of marine snow, using cabled observatory system

*Marika Takeuchi[1,2], Mark Doubell[3], Jim Mitchell[2], Hidekatsu Yamazaki[1] (1.Tokyo University of Marine Science and Technology, 2.Flinders University, 3.South Australia Research and Development Institute)

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

[AOS12-13] An insight into the area characteristic of seasonal change in nitrogen isotope ratio based on a marine nitrogen isotope model

*Chisato Yoshikawa[1], Masahito Shigemitsu[1], Akitomo Yamamoto[1], Akira Oka[2], Naohiko Ohkouchi[1] (1.JAMSTEC, 2.AORI)

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

[AOS12-14] Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain

*S. Lan Smith[1], Yoshikazu Sasai[1], Chisato Yoshikawa[2] (1.Marine Ecosystem Dynamics Research Group, RCGC, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan, 2.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan)

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

[AOS12-15] Discussions

Shin-ichi Ito[2], *Takafumi Hirata[1] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 104 1F

[A-CG33] Extratropical oceans and atmosphere

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Yoshi N Sasaki(Hokkaido University), Hatsumi Nishikawa(Institute of Low Temperature Science, Hokkaido University), Shun Ohishi(Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Kazuaki Nishii(三重大学)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[ACG33-01] Gulf Stream and Kuroshio are synchronized

★Invited Papers

*Tsubasa Kohyama[1], Hiroaki Miura[1], Shoichiro Kido[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

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

[ACG33-02] A study on mixed layer depth variability in the Kuroshio Extension region based on a frontal Ekman model

*Tomoki Tozuka[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

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

[ACG33-03] Mechanisms of Reemergence in the North Pacific revealed by Mixed Layer Heat Budget Analysis

*Kazumichi Murata[1], Shoichiro Kido[1], Tomoki Tozuka[1] (1.Department of Earth and Planetary Science, School of Science, The University of Tokyo)

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

[ACG33-04] Formation mechanism for the North Pacific Transition domain SST and SSS fronts

*Hatsumi Nishikawa[1], Humio Mitsudera[1], Takeshi Okunishi[2], Shin-ichi Ito[3], Taku Wagawa[4], Daisuke Hasegawa[2], Toru Miyama[5], Hitoshi Kaneko[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5.Japan Agency for Marine-Earth Science and Technology)

2:50 PM - 3:10 PM JST | 5:50 AM - 6:10 AM UTC

[ACG33-05] Impact of the Kuroshio front on frontal structure of an extratropical cyclone associated with heavy precipitation

★Invited Papers

*Hidetaka Hirata[1], Ryuichi Kawamura[2], Mayumi K Yoshioka[1], Masami Nonaka[3], Kazuhisa Tsuboki[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Department of Earth and Planetary Sciences, Kyushu University, 3.Application Laboratory, Japan Agency for Marine-Earth Science and Technology)

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

[ACG33-06] Discussion on future studies on the role of midlatitude oceans

*Kazuaki Nishii[1] (1.Graduate School of Bioresources, Mie University)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 104 1F

[A-CG33] Extratropical oceans and atmosphere

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Yoshi N Sasaki(Hokkaido University), Hatsumi Nishikawa(Institute of Low Temperature Science, Hokkaido University), Shun Ohishi(Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Shun Ohishi

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

[ACG33-07] Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

★Invited Papers

*Naoya Takahashi[1], Tadahiro Hayasaka[1] (1.Center for Atmospheric and Oceanic Studies, Graduate School of Science, Tohoku University,)

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

[ACG33-08] **Sea surface temperature trend in the East China Sea during the 20th century simulated by a regional ocean model**

*Yoshi N Sasaki[1], Chisato Umeda[1] (1.Hokkaido University)

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

[ACG33-09] Kuroshio Extension and Gulf Stream's influences on the variability of near-surface baroclinicity and the associated atmospheric fields

★Invited Papers

*Bunmei Taguchi[1], Kazuaki Nishii[2], Hisashi Nakamura[1,3] (1.Research Center for Advanced Science and Technology, The University of Tokyo, 2.Graduate School of Bioresources, Mie University, 3. Application Laboratory, Japan Agency of Marine-Earth Science and Technology)

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

[ACG33-10] Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

*Morio Nakayama[1], Masatoshi Mizukoshi[1], Hisashi Nakamura[1], Yu Kosaka[1], Bunmei Taguchi[1], Masato Mori[1], Fumiaki Ogawa[2] (1.RCAST, the University of Tokyo , 2.The University of Bergen)

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

[ACG33-11] **Hydro-climatic variation in northwestern China and its multi-decadal to multi-centennial teleconnection with the Pacific Ocean**

*Harry F Lee[1] (1.The Chinese University of Hong Kong)

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

[ACG33-12] Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2] (1.Graduate School of Bioresources, Mie University, 2.Research Center for Advanced Science and Technology, The University of Tokyo)

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

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

[H-DS11] Subaqueous Landslides and Their Anthropogenic Impact for Coastal Regions

convener:Yujin Kitamura(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University), Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Chairperson:Yujin Kitamura(Kagoshima University), Masayuki Utsunomiya(Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Yasuhiro Yamada(JAMSTEC)

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

[HDS11-01] Distribution and sedimentological characteristics of the submarine landslides filling Hidaka Trough, offshore southern Hokkaido, northern Japan with special attention to the uppermost Quaternary submarine landslide bodies

*Hiroyuki Arato[1] (1.Graduate School of International Resource Sciences, Akita University)

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

[HDS11-02] Origin and distribution of mass-transport deposits in the Pleistocene forearc basin, central Japan, deduced from tephro- and biostratigraphy

*Masayuki Utsunomiya[1], Yuzuru Yamamoto[2], Kiyohide Mizuno[1] (1.Geological Survey of Japan, AIST, 2.JAMSTEC)

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

[HDS11-03] Physico-chemical properties of sediment cores from Yatsushiro Sea, western Kyushu

*Yujin Kitamura[1], Ryoya Goto[2], Koki Hori[2], Yuta Ikebata[2], Haruka Kageyama[2], Kuniyo Kawabata[1], Daiki Oyama[1], Kaede Yamasaki[2], Hakuho-maru KH-18-3 Scientists (1.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301B 3F

[H-CG26] Deltas and estuaries: multidisciplinary analyses of complex river-mouth systems

convener:Yoshiki Saito(Estuary Research Center, Shimane University), Guan-Hong Lee(Inha University), David L Dettman(University of Arizona), Kazuaki Hori(Department of Geography, Graduate School of Environmental Studies, Nagoya University), Chairperson:Yoshiki Saito(Shimane Univ/ GSJ, AIST), David Dettman(University of Arizona)

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

[HCG26-01] Recent Changes of the Asian Major Deltas

★Invited Papers

*Paul Liu[1] (1.North Carolina State University Raleigh)

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

[HCG26-02] **Matching trends in channel width, sinuosity, and depth along the fluvial to marine transition zone of tide-dominated river deltas: the need for a revision of depositional and hydraulic models**

★Invited Papers

*Marcello Gugliotta[1], Yoshiki Saito[1] (1.Shimane University)

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

[HCG26-03] **Effects of an Estuarine Dam on Sediment Flux Mechanisms in a Macrotidal Estuary**

Steven Miguel Figueroa[1], *Guan-Hong Lee[1] (1.Inha University)

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

[HCG26-04] **Late Pleistocene sedimentary evolution of the north Jiangsu coastal plain revealed by OSL dating based chronostratigraphy**

*Lei Gao[1], Hao Long[1], Ping Zhang[2], Toru Tamura[3,4], Ji Shen[1] (1.Nanjing Institute of Geography and Limnology, CAS,China, 2.Geological Survey of Jiangsu Province (GSJP), Key Lab of EFGD, Ministry of LR, China, 3.Geological Survey of Japan (GSJ), AIST, 4.Graduate School of Frontier Sciences, The University of Tokyo)

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

[HCG26-05] The sedimentary environments and provenance of the late Quaternary sediments, in South Yellow Sea shelf, eastern China

*Yong Yin[1] (1.School of Geography and Ocean Science, Nanjing University)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301B 3F

[H-CG27] Turbidity current: from triggers for the generation to the depositional and morphologic al processes

convener:Miwa Yokokawa(Osaka Institute of Technology), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Norihiro Izumi(Faculty of Engineering, Hokkaido University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Chairperson:Miwa Yokokawa(Osaka Institute of Technology), Norihiro Izumi(Hokkaido University)

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

[HCG27-01] Inverse analysis of turbidity currents using two dimensional shallow water model

*Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

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

[HCG27-02] Inverse Analysis of Experimental Scale Turbidity Currents by Deep Learning Neural Network

*Cai Zhirong[1], Hajime Naruse[1], Qifeng Yao[1] (1.Kyoto University)

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

[HCG27-03] Conditions for development of depositional submarine channels: examination by flume experiments

*Justine Poppeschi[1], Kazushi Nakata[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

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

[HCG27-04] Cyclic steps formed by long-runout turbidity currents

*Zhuyuan Wu[1], Norihiro Izumi [1] (1.Hokkaido University)

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

[HCG27-05] Is surface sediment remobilization more popular mechanism for generating earthquake-induced turbidity current? Evidence of radiocarbon dates from the westernmost Nankai and Japan Trench subduction zones

*Ken Ikehara[1], Toshiya Kanamatsu[3], Tobias Schwestermann[2], Arata Kioka[2], Michael Strasser[2] (1.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology, 2.Universität Innsbruck, 3.Japan Agency for Marine-Earth Science and Technology)

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

[HCG27-06] Shallow-subsurface event stratigraphy along the hadal trench axis of the Japan Trench

*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], M. Strasser[1,4] (1.Universität Innsbruck, Austria, 2.GSJ-AIST, Japan, 3.JAMSTEC, Japan, 4.MARUM-U. Bremen, Germany)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301B 3F

[H-CG27] Turbidity current: from triggers for the generation to the depositional and morphologic al processes

convener:Miwa Yokokawa(Osaka Institute of Technology), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Norihiro Izumi(Faculty of Engineering, Hokkaido University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Chairperson:Hajime Naruse(Kyoto University), Ken Ikehara(AIST)

10:45 AM - 11:07 AM JST | 1:45 AM - 2:07 AM UTC

[HCG27-07] Canyon changes caused by an earthquake-triggered turbidity current in the 2016 M7.8 Kaikōura Earthquake, New Zealand

★Invited Papers

*Joshu J Mountjoy[1], Jamie D Howarth[2], Alan R Orpin[1], Philip M Barnes[1], David A Bowden[1], Ashley A Rowden[1], Alexander C. G. Schimel[1], Caroline Holden[3], Huw J Horgan[2], Scott D Nodder[1], Jayson R Patton[4], Geoffroy Lamarche[1,5], Matt Gerstenberger[3], Aaron Micallef[6], Arne Pallentin[1], Tim Kane[1] (1.NIWA, Wellington. New Zealand, 2.VUW, Wellington. New Zealand, 3.GNS Science, Lower Hutt. New Zealand, 4.HSU, Arcata CA. USA, 5.UoA, Auckland. New Zealand, 6.UoM, Msida. Malta)

11:07 AM - 11:29 AM JST | 2:07 AM - 2:29 AM UTC

[HCG27-08] Far More Prolonged Deep-sea Turbidity Currents triggered by typhoon and earthquake in the Gaoping Submarine Canyon

★Invited Papers

*Yanwei Zhang[1], Zhifei Liu[1], Yulong Zhao[1], Xiaodong Zhang[1] (1.Tongji University)

11:29 AM - 11:51 AM JST | 2:29 AM - 2:51 AM UTC

[HCG27-09] **Filling the gap between turbidity current processes and products in British Columbia fjords**

★Invited Papers

*Sophie Hage[1,2,3] (1.School of Ocean and Earth Sciences, University of Southampton, United Kingdom, 2.National Oceanography Centre Southampton, United Kingdom, 3.Department of Geography, Durham University, United Kingdom)

11:51 AM - 12:13 PM JST | 2:51 AM - 3:13 AM UTC

[HCG27-10] **Sediment transfer from shelf to abyss through giant ganyons and valleys system in deep-sea carbonate slopes (Bahamas)**

★Invited Papers

*Thierry Mulder[1], Hervé Gillet[1], Vincent Hanquiez[1], Audrey Recouvreur[1], Kelly Fauquembergue[1], Johan Le Goff[2], John J.G. Reijmer[2], Emmanuelle Ducassou[1], Margot Joumes, Thibault Cavailhes[1], Elsa Tournadour[5], Jean Borgomano[3], Emmanuelle Poli[4] (1.University of Bordeaux, UMR CNRS 5805 EPOC, Allée Geoffroy Saint Hilaire, Pessac, France, 2.King Fahd Univ. of Petroleum. and Minerals, Dhahran, Saudi Arabia., 3.Aix Marseille University, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France., 4.Total, CSTJF, avenue Larribau, Pau, France, 5.Ifremer, Centre de Brest, Plouzané)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-SS07] Rigorous Seismicity Modelling and Hypothesis Testing

convener:Jiancang Zhuang(Institute of Statistical Mathematics), Danijel Schorlemmer(GFZ German Research Centre for Geosciences), Matt Gerstenberger(GNS Science), Hiroshi Tsuruoka(Earthquake Research Institute, Tokyo Univ.), Chairperson:Matthew Gerstenberger(GNS Science, New Zealand), Danijel Schorlemmer(GFZ-Potsdam, Germany)

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

[SSS07-01] Improving medium-term earthquake forecasts by compensating the EEPAS model for the time-lag

★Invited Papers

David Rhoades[1], Christophersen Annemarie[1], *Matt Gerstenberger[1] (1.GNS Science)

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

[SSS07-02] Earthquake probability forecast incorporating non-seismic data

*Peng Han[1], Jiancang Zhuang[2], Yosihiko Ogata[2], Katsumi Hattori[3] (1.Southern University of Science and Technology, Shenzhen, China, 2.The Institute of Statistical Mathematics, Tokyo, Japan , 3.Chiba University, Chiba, Japan)

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

[SSS07-03] **Extended versions of the space-time ETAS model and application to the 2016 Kumamoto earthquake sequence**

★Invited Papers

*YICUN GUO[1], Jiancang Zhuang[1], Yosihiko Ogata[1] (1.The Institute of Statistical Mathematics, Tokyo, Japan)

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

[SSS07-04] CSEP Japan results and future developments

*Naoshi Hirata[1], Hiroshi Tsuruoka[1], Danijel Schorlemmer[3], Jiancang Zhuang[2] (1.Earthquake Research Institute, the University of Tokyo, 2.Institute of Statistical Mathematics, 3.GFZ German Research Centre for Geosciences)

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

[SSS07-05] From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

★Invited Papers

*Kuo-Fong Ma[1,2,3], Mingshen Yen[1], Yiwun Liao[1], Henyi Su[2] (1.Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC, 2.Department of Earth Sciences, National Central University, Taiwan, ROC, 3.Institute of Earth Sciences, Academia Sinica, Taiwan, ROC)

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

[SSS07-06] **High resolution space-time models forecasting 3D seismicity beneath the Greater Tokyo Area**

★Invited Papers

*Yosihiko Ogata[1,2], Koichi Katsura, Hiroshi Tsuruoka[2], Naoshi Hirata[2] (1.Research Organization of Information and Systems, The Institute of Statistical Mathematics, 2.Earthquake Research Institute, The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Anselme Borgeaud, Taku Tsuchiya

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

[SIT21-01] The role of stishovite as a deep nitrogen carrier indicated from high-pressure and high-temperature experiments

*Ko Fukuyama[1], Hiroyuki Kagi[1], Toru Inoue[2,3], Toru Shimei[3], Sho Kakizawa[3], Shunichi Hishita[4], Yuji Sano[5], Naoto Takahata[5] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 3.Geodynamics Research Center, Ehime University, 4.National Institute for Materials Science, 5.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[SIT21-02] 3-D P- and S-velocity structure of the D″ layer beneath Central America and the Caribbean using waveform inversion

★Invited Papers

*Anselme F. E. Borgeaud[1,2], Kenji Kawai[1], Robert J. Geller[1] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Institute of Earth Sciences, Academia Sinica)

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

[SIT21-03] Uniaxial deformation experiments of bridgmanite using D-111 type high pressure apparatus

★Invited Papers

*Noriyoshi Tsujino[1], Daisuke Yamazaki[1], Yu Nishihara[2] (1.Institute for Planetary Materials, Okayama University, 2.Geodynamics Research Center, Ehime University)

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

[SIT21-04] Waveform inversion for 3D anisotropic structure in D″ beneath the Northern Pacific: Constraints on mineralogy and flow in the lowermost mantle

*Yuki Suzuki[1], Kenji Kawai[1], Robert J. Geller[1] (1.Department of Earth and Planetary Sciences, School of Science,The University of Tokyo)

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

[SIT21-05] Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

*Sho Kakizawa[1], Toru Inoue[1,2,3], Ryotaro Abe[1], Minami Kuroda[4], Naoya Sakamoto[5], Hisayoshi Yurimoto[4,5,6] (1.Geodynamics Reseach Center, Ehime University, 2.Graduate School of Science, Hiroshima University, 3.Hiroshima Institute of Plate Convergence Region Research, 4.Graduate School of Science, Hokkaido University, 5.Creative Research Institution, Hokkaido University, 6.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[SIT21-06] Origin and role of lost continents

*Shigenori Maruyama[1], Kenji Kawai[2], Steeve Gréaux[3], Taku Tsuchiya[3], Dapeng Zhao[4] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, School of Science, University of Tokyo, 3.Ehime University, 4.Department of Geophysics, Tohoku University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Kenji Ohta, Riko Iizuka

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

[SIT21-07] Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

★Invited Papers

*Zhongqing Wu[1] (1.University of Science and Technology of China)

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

[SIT21-08] Discussion

*Kenji Ohta[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

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

[SIT21-09] ***Ab initio* anharmonic lattice dynamics for Fe-bearing lower mantle minerals**

*Haruhiko Dekura[1], Taku Tsuchiya[1] (1.Geodynamics Research Center, Ehime University)

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

[SIT21-10] **Measurements of high pressure-temperature thermal conductivity of the Earth's lower mantle minerals in a laser-heated diamond anvil cell**

*Kenji Ohta[1], Akira Hasegawa[1,2], Takashi Yagi[2], Yoshiyuki Okuda[1], Koutarou Onga[1], Kei Hirose[3,4], Yasuo Ohishi[5] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, 3.Earth-Life Science Institute, Tokyo Institute of Technology, 4.Department of Earth and Planetary Science, The University of Tokyo, 5.Japan Synchrotron Radiation Research Institute)

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

[SIT21-11] Is there evidence for a paleo-LLSVP beneath Eurasia?: Implications for the origin of the Siberian Traps

*Tsubasa Ue[1], Yuki Suzuki[1], Kenji Kawai[1] (1.Department of Earth and Planetary Sciences, Graduate School of Science, The University of Tokyo)

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

[SIT21-12] Possible compositional region of Al-bearing anhydrous bridgmanite

*Toru Inoue[1,2], Masamichi Noda[2], Sho Kakizawa[2] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.Geodynamics Research Center, Ehime University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Hitoshi Gomi, Tsuyoshi Iizuka

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

[SIT21-13] Evolution of the Earth mantle and its possible interaction with core: view from olivine and its inclusions study

★Invited Papers

*Alexander V Sobolev[1], Valentina G. Batanova[2] (1.ISTerre Institute of Earth Sciences, 2.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygina str. 19, Moscow 119991, Russia.)

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

[SIT21-14] Discussion

*Tsuyoshi Iizuka[1] (1.University of Tokyo)

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

[SIT21-15] Ultralow-velocity zones possibly explained by light element-enriched iron compounds

*Liang Yuan[1], Eiji Ohtani[1], Xiang Wu[2], Shengxuan Huang[3], Daijo Ikuta[1], Tatsuya Sakamaki[1], Seiji Kamada[1], Hiroshi Fukui[4,5], Satoshi Tsutsui[6], Hiroshi Uchiyama[6], Daisuke Ishikawa[5,6], Naohisa Hirao[6], Alfred Q. R. Baron[5] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan, 2.State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China, 3.Key Laboratory of Orogenic Belts and Crustal Evolution, MOE, Peking University and School of Earth and Space Sciences, Peking University, Beijing 100871, China, 4.Center for Novel Material Science under Multi-Extreme Conditions, Graduate School of Material Science, University of Hyogo, Hyogo 678-1297, Japan, 5.Materials Dynamics Laboratory, RIKEN SPring-8 Center, Hyogo 679-5148, Japan, 6.Japan Synchrotron Radiation Research Institute (JASRI), SPring-8, Hyogo, 679-5198, Japan)

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

[SIT21-16] High-precision $^{142}W/^{144}W$ ratios of oceanic island basalts and Large Igneous Province basalts.

Asako Takamasa[1], *Katsuhiko Suzuki[1], Yusuke Fukami[2], Tsuyoshi Iizuka[3] (1.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 2.Department of Subsurface Geobiological Analysis and Research, Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Science, The University of Tokyo)

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

[SIT21-17] Some technological developments in high temperature generation using KMA and precise melting/phase relations of minerals and rocks under deep mantle conditions

*Tetsuo Irifune[1,2], Youmo Zhou[1], Takeshi Arimoto[1], Hideharu Kuwahara[1], Ryuichi Nomura[3], Masayuki Nishi[1], Momoko Yamaguchi[1], Yoshinori Tange[4], Takahiro Kuribayashi[5], Zhaodong Liu[6] (1.Geodynamics Research Center, Ehime University, 2.Eearth Life Science Institute, Tokyo Institute of Technology, 3.Hakubi Center/ Graduate School of Human and Environmental Studies, Kyoto University, 4.Research & Utilization Division, Japan Synchrotron Research Institute, 5.Graduate School of Science, Tohoku University, 6.Institute of Super Hard Materials, Jilin University)

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

[SIT21-18] Zr isotope constraints on early Earth differentiation

*Tsuyoshi Iizuka[1], Keita Itano[1], Shinji Yamamoto[2] (1.University of Tokyo, 2.Yokohama National University)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-CG49] Hard-Rock Drilling Science: From Continental to Deep Sea Drilling, and Oman Project

convener:Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Eiichi TAKAZAWA(Department of Geology, Faculty of Science, Niigata University), Norikatsu Akizawa(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Katsuyoshi Michibayashi

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

[SCG49-01] **Geochemical and Geochronological Constraints on the Origin and Emplacement of the East Taiwan Ophiolite: Implication for Subduction Initiation of the South China Sea.**

*Chiou-ting Lin[1], Ron A. Harris[2], Wei-dong Sun[1], Guo-liang Zhang[1] (1.Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, 2.Department of Geology, Brigham Young University)

3:45 PM - 4:05 PM JST | 6:45 AM - 7:05 AM UTC

[SCG49-02] Towards a complete profile of hydrothermal alteration in the lower oceanic crust and uppermost mantle; Insights from the Oman Drilling Project and ChikyuOman2017 and 2018

★Invited Papers

*Damon A H Teagle[1], Michelle Harris[2], Gretchen Früh-Green[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Oman Drilling Project Science Team[1] (1.Ocean & Earth Science, National Oceanography Centre Southampton, University of Southampton, SO14-3ZH, Southampton, UK, 2.School of Geography, Earth and Environmental Sciences, Plymouth University, UK, 3.Earth Sciences, ETH Zürich, Switzerland, 4.Geology, Niigata University, Japan, 5.Earth and Planetary Sciences, Nagoya University, Japan, 6.LDEO, Columbia University, New York, USA)

4:05 PM - 4:25 PM JST | 7:05 AM - 7:25 AM UTC

[SCG49-03] Peridotite alteration in OmanDP cores

★Invited Papers

*Peter B Kelemen[1], Juan Carlos de Obeso[1], Craig Manning[2], Marguerite Godard[3], Wolfgang Bach[4], Merry Yue Cai[1], Saebyul Choe[5], Judith Coggon[6], Eric Ellison[7], Alireza Eslami[8], Katy Evans[9], Michelle Harris[10], Wolf-Achim Kahl[4], Jürg Matter[6], Katsu Michibayashi[11], Keichi Okazaki[12], Philippe Pézard[3], Damon A.H. Teagle[6], Alexis Templeton[7], OmanDP Oman Drilling Project Science Team (1.LDEO, 2.UCLA, 3.U. Montpellier, 4.U. Bremen, 5.AMNH, 6.U. Southampton, 7.U. Colorado, 8.U. Tehran, 9.Curtin U., 10.U. Plymouth, 11.Nagoya U., 12.JAMSTEC)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[SCG49-04] Low-salinity aqueous fluid inclusions in dolomite veins of a listvenite of Oman Drilling Project Phase 1

*Tatsuhiko Kawamoto[1], Hiroki Sato[2], Toma Takahashi[3], Juan Miguel Guotana[4], Tomoaki Morishita[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 Science Party (1.Department of Geoscience, Faculty of Science, Shizuoka University, 2.Faculty of Science, Kyoto University, 3.Faculty of Geosciences and Civil Engineering, Kanazawa University, 4.Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa University, 5.Lamont-Doherty Earth Observatory, Columbia University, 6.School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, 7.School of Geography, Earth and Environmental Sciences, Plymouth University, 8.Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 9.Institute of Science and Technology, Niigata University)

4:40 PM - 5:00 PM JST | 7:40 AM - 8:00 AM UTC

[SCG49-05] Hydration and development of fracture network within oceanic lower crust: an evidence from CM1A of Oman Drilling

★Invited Papers

*Atsushi Okamoto[1], Kazuki Yosida[1], Ryosuke Oyanagi[2], Oman Drilling Project Phase 2 Science Party[3] (1.Graduate School of Environmental Studies, 2.JAMSTEC, 3.Oman Drillng Project Phase 2 Science Party)

[E] Oral | B (Biogeosciences)：B-BG Biogeosciences & Geosphere-Biosphere Interactions

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

[B-BG01] Elemental cycling in terrestrial and coastal ecosystems- Carbon and Nitrogen perspectives

convener:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata),
Chairperson:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata)

3:35 PM - 4:00 PM JST | 6:35 AM - 7:00 AM UTC

[BBG01-01] **Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem**

★Invited Papers

*Santanu Ray[1] (1.Systems ecology and ecological modelling laboratory, Dept. of Zoology, Visva-Bharati University, Santiniketan 731235, India)

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

[BBG01-02] ^{17}O-rich nitrate as a tracer for constraining nitrogen transformations in coastal sediments

*Chawalit Charoenpong[1,2], Scott D Wankel[2], Carolyn Buchwald[3,2], Wiebke Ziebis[4] (1.Chulalongkorn University, 2.Woods Hole Oceanographic Institution, 3.Dalhousie University, 4.University of Southern California)

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

[BBG01-03] **Exploring changes in bacterioplankton community structure in response to tannic acid, a major component of litterfall, in a mangrove ecosystem: a laboratory mesocosm approach**

*Anwesha Ghosh[1] (1.Integrative Tax Microb Ecol Res Group, Dept. of Biol Sci, IISERK)

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

[BBG01-04] **Diel variations of dissolved inorganic carbon in the Pearl River plume and the northern South China Sea shelf upwelling during summer**

*Wei-Jen Huang[1], Kai-Jung Kao[1], Yu-Shih Lin[1], James T. Liu[1], Chen-Tung Arthur Chen[1] (1.National Sun Yat-sen University)

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

[BBG01-05] **Spatial and vertical variations of carbon and nitrogen isotopes of larch forest and NDVI in Eastern Siberia**

*Aleksandr Nogovitcyn[1], Atsuko Sugimoto[2], Ruslan Shakhmatov[1], Tomoki Morozumi[1], Shunsuke Tei[2], Yumiko Miyamoto[2], Trofim Maximov[3,4] (1.Graduate School of Environmental Science, Hokkaido University, Sapporo, Hokkaido, Japan, 2.Arctic Research Center, Hokkaido University, Sapporo, Hokkaido, Japan, 3.Institute for Biological Problems of Cryolithozone, Siberian Blanch of Russian Academy of Sciences, Yakutsk, Yakutia, Russia, 4.International Center for Biogeoscience Educational and Scientific Trainings (BEST), North-Eastern Federal University, Yakutsk, Yakutia, Russia)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS02] Drilling Earth Science

convener:Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Azumi Kuroyanagi(Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku University), Kosei E. Yamaguchi(Toho University and NASA Astrobiology Institute), Chairperson:Azumi Kuroyanagi(Tohoku University), Kan Hsiung(JAMSTEC)

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

[MIS02-01] Planktonic foraminiferal biostratigraphy in the South China Sea IODP Exp. 367 U 1499

*Akira Furusawa[1], Hiroki Hayashi[1] (1.Interdisciplinary Graduate School of Science and Engineering, Shimane University)

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

[MIS02-02] High heat with slow cooling of rift margin in the South China Sea, IODP Exp.368

*Arito Sakaguchi[1,2], Nobuaki Osono[1], Keita Nakano[1] (1.Yamaguchi Univ., 2.JAMSTEC)

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

[MIS02-03] Abundant ferromanganese microparticles in oxic pelagic sediments (IODP Exp. 329)

*Go-Ichiro Uramoto[1,2], Yuki Morono[2], Naotaka Tomioka[2], Shigeyuki Wakaki[2], Ryoichi Nakada[2], Rota Wagai[3], Kentaro Uesugi[4], Akihisa Takeuchi[4], Masato Hoshino[4], Yoshio Suzuki[4,5], Satoshi Mitsunobu[6], Fumito Shiraishi[7], Hiroki Suga[5], Yasuo Takeichi[8], Yoshio Takahashi[5], Fumio Inagaki[2] (1.Kochi University, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Agriculture and Food Research Organization, 4.Japan Synchrotron Radiation Research Institute, 5.University of Tokyo, 6.Ehime University, 7.Hiroshima University, 8.High Energy Accelerator Research Organization)

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

[MIS02-04] **Regional stratigraphic framework, Gas Hydrate occurrence and distribution of National Gas Hydrate Program Expedition 02 (NGHP-02) Area-B, offshore eastern India**

*KanHsi Hsiung[1], Saneatsu Saito[1], Toshiya Kanamatsu[1], Yoshinori Sanada[1], Yasuhiro Yamada[1], KYAW MOE[1], Yohei Hamada[1], Yasuyuki Nakamura[1], HungYu Wu[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[MIS02-05] Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

*Akira Ijiri[1], Shigeyuki Wakaki[1], Yoshiro Nishio[2], Yohei Hamada[1], Tsuyoshi Ishikawa[1], Fumio Inagaki[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kochi University)

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

[MIS02-06] Recent progress and perspective on paleomagnetism by means of deep-sea drilling

*Toshitsugu Yamazaki[1], Yuhji Yamamoto[2], Toshiya Kanamatsu[3], Yuho Kumagai[4], Norihiro Nakamura[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Center for Advanced Marine Core Research, Kochi University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Tohoku University)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS02] Drilling Earth Science

convener:Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Azumi Kuroyanagi(Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku University), Kosei E. Yamaguchi(Toho University and NASA Astrobiology Institute), Chairperson:Kosei Yamaguchi(Toho University), Yasuhiro Yamada(JAMSTEC)

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

[MIS02-07] Patterns in natural fractures during transitions between stress regimes

*Nikita Dubinya[1] (1.The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences)

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

[MIS02-08] ICDP DSeis 1: Introduction into JpGU 2019 papers on Drilling into Seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

*Hiroshi Ogasawara[1], Bennie Liebenberg[2], Martin Ziegler[3], Yasuo Yabe[4], Ray Durrheim[5], Musa Manzi[5], Tullis C Onstott[6], Thomas Weirsberg[7] (1.Faculty of Science and Engineering, Ritsumeikan University, 2.Moab Khotsong mine, South Africa, 3.ETH, Zurich Dep. Earth Sciences, 4.Graduate School of Science, Tohoku Univ., 5.Univ. Witwatersrand, School of Geoscience, South Africa, 6.Princeton Univ., Dept. Geoscience, USA, 7.GFZ, Potzdam, Germany)

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

[MIS02-09] ICDP DSeis 2: Preliminary results of physical property measurement and XRD analysis of the M5.5 fault material recovered from DSeis Project

*Tetsuro Hirono[1], Yuki Yukoyama[1], Shunya Kaneki[2], Hiroshi Ogasawara[3], Yasuo Yabe[4], Takuya Matsuzaki[5], Yuhji Yamamoto[5], Hidekazu Tokuyama[5], Tullis C. Onstott[6], Martin Ziegler[7], Durrheim Ray[8], Esterhuizen van Heerden[9], Bennie Liebenberg[9], The ICDP DSeis team (1.Department of Earth and Space Science, Graduate School of Science, Osaka University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Ritsumeikan University, 4.Tohoku University, 5.Center for Advanced Marine Core Research, Kochi University, 6.Princeton University, 7.ETH Zurich, 8.Witwatersrand University, 9.Moab Khotsong mine)

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

[MIS02-10] ICDP DSeis 3: Spatial variation in stress state in the source region of Orkeny earthqauke (M5.5) based on analyses of the ICDP-DSeis borehole cores

*Yasuo Yabe[1], Akimasa Ishida[2], Kosuke Sugimura[2], Kanematsu Makoto[2], Mitsuya Higashi[2], Shunsuke YOSHIDA[2], Bennie Liebenberg[7], Takatoshi Ito[3], Akio Funato[5], Bryan Watson[6], Raymond Durrheim[4], Hiroshi Ogasawara[2] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.Faculty of Science and Engeneer, Ritsumeikan University, 3.Institute of Fluid Science, Tohoku University, 4.School of Geoscience, University of the Witwatersrand, 5.Fukada Geological Institute, 6.School of Mining Engeneering, University of the Witwatersrand, 7.Moab Khotsong mine)

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

[MIS02-11] Applications of DCDA method for in-situ crustal stress measurement - Rock core samples from NIED seismic observation wells -

*Kentaro Omura[1], Weiren Lin[2], Takatoshi Ito[3], Akio Funato[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Graduate School of Engineering, Kyoto University, 3.Institute of Fluid Science, Tohoku University, 4.Fukada Geological Institute)

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

[MIS02-12] Temperature depth profile in a 700 m deep vertical borehole in Aso volcanic zone

*Weiren Lin[1], Susumu Shibutani[1,2], Koichiro Sado[2], Nana Kamiya[1], Tatsuhiro Sugimoto[1], Terasu Sano[1], Kazuya Ishitsuka[1], Xiaoqiu Yang[4], Aiming Lin[3] (1.Graduate School of Engineering, Kyoto University, 2.Chi-ken Sogo Consultants Co., Ltd., 3.Graduate School of Science, Kyoto University, 4.South China Sea Institute of Oceanology, Chinese Academy of Sciences)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS02] Drilling Earth Science

convener:Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Azumi Kuroyanagi(Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku University), Kosei E. Yamaguchi(Toho University and NASA Astrobiology Institute), Chairperson:Yumiko Harigane(産総研), Natsue Abe(R&D Center for Ocean Drilling Science, JAMSTEC)

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

[MIS02-13] Estimation of Shear Stress and Lithology Prediction Using Machine Learning and Surface Drilling Data

Tomoya Inoue[1], *Ryuta Tanaka[1], Junya Ishiwata[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[MIS02-14] Overview of drilling of crust-mantle boundary of Oman ophiolite: the ICDP Oman Drilling Project

*Eiichi TAKAZAWA[1,4], Damon A H Teagle[2], Katsuyoshi Michibayashi[3], Yoshihiko Tamura[4], Jude Ann Coggon[2], Juerg Matter[2], Peter B Kelemen[5], Oman Drilling Project Phase 2 Science Party (1.Department of Geology, Faculty of Science, Niigata University, 2.University of Sauthampton, 3.Nagoya University, 4.JAMSTEC, 5.Columbia University)

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

[MIS02-15] Geophysical Logging of Crust-Mantle boundary at Oman Ophiolite

*Yasuhiro Yamada[1], Kyaw Moe[1], Philippe Pezard[2], Juerg Matter[3], OmanDP Science Party (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Géosciences Montpellier, Université de Montpellier, 3.Southampton University)

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

[MIS02-16] Overview of the physical property measurements, ChikyuOman 2017 and 2018: Crust and Mantle sections from ICDP Oman Drilling Project Phase I and II

*Natsue Abe[1], Keishi Okazaki[1,11], Ikuo Katayama[2], Kohei Hatakeyama[2], Yuya Akamatsu[2], Benoit Ildefonse[3], Ole Ivar ulven[4], Gilbert Hong[5], Wenlu Zhu[6], Benoit Cordonnier[4], Katsuyoshi Michibayashi[7], Eiichi TAKAZAWA[8], Michell Harris[12], Damon Teagle[10], Peter Kelemen[9], Marguerite Goddard[3], Jurg Matter[10], Jude Coggon[10], The Oman Drilling Project Science Party (1.Japan Agency for Marine-Earth Science and Technology, 2.Hiroshima University, 3.Universitè de Montpellier, 4.University of Oslo, 5.Seoul National University, 6.University of Maryland, 7.Nagoya University, 8.Niigata University, 9.Columbia University, 10.University of Southampton, 11.Kanazawa University, 12.Polymouth University)

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

[MIS02-17] Exploring the deep subseafloor biosphere and biogeochemical carbon cycling beneath the Arctic ocean

*Fumio Inagaki[1], Steffen Leth Jørgensen[2], Rolf Birger Pedersen[2] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Department of Earth Science, University of Bergen, Norway)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 104 1F

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Yusaku Ohta

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

[MTT46-01] The latest status of Quasi-Zenith Satellite System (QZSS) and its future expansion

★Invited Papers

*Satoshi Kogure[1] (1.QZSS Straetegy Office, National Space Policy Secretariate, Cabinet Office)

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

[MTT46-02] Application of the GNSS-A for other academic fields and fundamental marine information network

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

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

[MTT46-03] Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

*Yusuke Tanaka[1], Yusaku Ohta[1], SHINICHI MIYAZAKI[2] (1.Tohoku University, 2.Kyoto University)

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

[MTT46-04] Assimilation experiments of GNSS-derived ZTD and Sentinel-derived products into WRF to improve forecasts of severe rain events in Italy

*Eugenio Realini[1], Martina Lagasio[2], Luca Pulvirenti[2], Antonio Parodi[2], Andrea Gatti[1], Giulio Tagliaferro[1], Giovanna Venuti[3], Stefano Barindelli[3], Emanuele Passera[4], Alessio Rucci[4], Nazzareno Pierdicca[5], Bjorn Rommen[6] (1.Geomatics Research & Development srl, 2.CIMA Research Foundation, 3.Dept. of Civil and Environmental Engineering, Politecnico di Milano, 4.TRE Altamira srl, 5.Dept. of Information Engineering, Electronics and Telecommunications, Sapienza Univ. of Rome, 6.European Space Agency (ESA-ESTEC))

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

[MTT46-05] **An analysis of tropospheric delays using goGPS software on all GEONET stations during the passage of Typhoon Jebi in September 2018**

*Andrea Gatti[1], Eugenio Realini[1], Giulio Tagliaferro[1] (1.Geomatics Research & Development srl)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 104 1F

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Takuya Tsugawa

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

[MTT46-06] **A new perspective of the storm-time dynamics of the ionosphere using global GNSS-TEC observation data**

★Invited Papers

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

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

[MTT46-07] Ionospheric space weather studies for GNSS users

*Takuya Tsugawa[1], Kornyanat Hozumi[1], Punyawi Jamjareegulgarn[2], Supnithi Pornchai [2], Susumu Saito[3], Yuichi Otsuka[3,4], Shinichi Hama[1], Takahiro Naoi[1], Mamoru Ishii[1] (1.NICT, 2.KMITL, 3.ENRI, 4.Nagoya Univ.)

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

[MTT46-08] QZSS geostationary satellite for ionospheric TEC observations

*Kosuke Heki[1] (1.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

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

[MTT46-09] Precise estimation of total electron content by double-shell model using local receiver network

*Takashi Maruyama[1,2], Kornyanat Hozumi[1], Guanyi Ma[2], Qingtao Wan[2] (1.National Institute of Information and Communications Technology, 2.National Astronomical Observatories, Chinese Academy of Sciences)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[MTT46-10] Investigation of sea surface height detection by Global Navigation Satellite System Reflectometry (GNSS-R)

*Osamu Isoguchi[1], Kaoru Ichikawa[2], Yukihito Kitazawa[3] (1.RESTEC, 2.Kyushu Univ., 3.ISAS/JAXA)

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

[MTT46-11] Discussion

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

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

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Yoshinori Shoji(Meteorological Research Institute)

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

[MTT46-12] Study on tropospheric delay variations extracted from a short baseline analysis and their application to meteorological observation

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

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

[MTT46-13] Water vapor estimation using digital terrestrial broadcasting waves - Field test in Tokyo metropolitan area and trial production of small devices -

*Seiji Kawamura[1], Hiroshi HANADO[1], Hiroki Ohta[1], Yoshinobu Matsumura[2], Ryosuke Mori[2], Kazuyoshi Noda[2], Teruaki Hasegawa[2] (1.National Institute of Information and Communications Technology, 2.Socionext Inc.)

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

[MTT46-14] Water vapor estimation via propagation delay of 920MHz wireless communication signal

*Nobuyasu Shiga[1], Satoshi Yasuda[1], Seiji Kawamura[1], Hiroshi HANADO[1], Ryuichi Ichikawa[1], Hironori Iwai[1], Shinsuke Satoh[1] (1.National Institute of Information and communications technology)

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

[MTT46-15] Comparison of a water vapor observation with GPS and high sensitivity microwave radiometer, KUMODeS

*Taketo Nagasaki[1], Osamu Tajima[2], Ryuichi Ichikawa[3], Hiroshi Takiguchi[4], Kentaro Araki[5], Hiroshi Ishimoto[5] (1.High Energy Accelerator Research Organization, IPNS, 2.Kyoto University, 3.National Institute of Information and Communications Technology, 4.Japan Aerospace Exploration Agency, 5.Meteorological Research Institute)

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

[MTT46-16] Development and Observation of Water Vapor Raman Lidars for Localized Torrential Rainfall Prediction

*Tomohiro Nagai[1], Tetsu Sakai[1], Satoru Yoshida[1], Toshiharu Izumi[2], Sho Yokota[1], Hiromu Seko[1], Yoshinori Shoji[1], Koichi Shiraishi[3] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Japan Meteorological Agency, 3.Fukuoka University)

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

[MTT46-17] Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

*Yoshinori Shoji[1], Teruyuki Kato[2], Yukihiro Terada[3], Toshitaka Tsuda[4], Masanori Yabuki[4] (1.The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute, 2.Hot Springs Research Institute/Kanagawa Prefectural Government, 3.Natinal Institute of Technology, Kochi College, 4.Research Institute for Sustainable Humanosphere/Kyoto Unversity)

Tue. May 28, 2019

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

convener:Jun Kimura(Osaka University), Yasumasa Kasaba(Planetary Plasma and Atmospheric Research Center, Tohoku University), Kunio M. Sayanagi(Hampton University), Chairperson:Kunio Sayanagi(Hampton University), Takeshi Kuroda

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

[PPS01-06] Radiative transfer simulation including a non-LTE model for terahertz observations of Ganymede's atmosphere

*Takayoshi Yamada[1], Ladislav Rezac[2], Richard Larsson[2], Paul Hartogh[2], Naohiro Yoshida[3], Yasuko Kasai[1,3] (1.National Institute of Information and Communications Technology, 2.Max Planck Institute for Solar System Research, 3.Tokyo Institute of Technology)

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

[PPS01-07] Vertical Mass Flux by the 2010-2011 Great Storm of Saturn

*Kunio M. Sayanagi[1], Jacob L. Gunnarson[1], John J. Blalock[1], Richard K. Achterberg[2], F. Michael Flasar[2], Andrew P. Ingersoll.[3], Shawn P. Ewald[3], Ulyana A. Dyudina[3] (1.Hampton University, 2.NASA Goddard Space Flight Center, 3.California Institute of Technology)

9:30 AM - 9:48 AM JST | 12:30 AM - 12:48 AM UTC

[PPS01-08] Microwave observations of the giant planets - Cassini/Radar and Juno/MWR

★Invited Papers

*Cheng Li[1], Virgil Adumitroaie[2], John Arballo[2], Sushil K Atreya[3], Scott J Bolton[4], Andrew Ingersoll[1], Michael Janssen[2], Steven Levin[2], Jonathan Lunine[5], Glenn Orton[2], Paul Steffes[6], Hunter Waite[4] (1.California Institute of Technology, 2.Jet Propulsion Laboratory, 3.University of Michigan Ann Arbor, 4.Southwest Research Institute, 5.Cornell University, 6.Georgia Institute of Technology)

9:48 AM - 10:06 AM JST | 12:48 AM - 1:06 AM UTC

[PPS01-09] **Tracing Formation and Evolution of Outer Solar System Bodies through Stable Isotopes and Noble Gas Abundances**

★Invited Papers

*Kathleen Mandt[1] (1.Johns Hopkins University Applied Physics Laboratory)

10:06 AM - 10:24 AM JST | 1:06 AM - 1:24 AM UTC

[PPS01-10] Icy Giant Planet Exploration

★Invited Papers

*Sushil K Atreya[1], Mark D. Hofstadter[2], Amy Simon[3], Kim R. Reh[2], Olivier Mousis[4], Krista Soderlund[5] (1.University of Michigan Ann Arbor, 2.Jet Propulsion Laboratory, 3.Goddard Space Flight Center, 4.Laboratoire d'Astrophysique de Marseille, 5.University of Texas at Austin)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

convener:Jun Kimura(Osaka University), Yasumasa Kasaba(Planetary Plasma and Atmospheric Research Center, Tohoku University), Kunio M. Sayanagi(Hampton University), Chairperson:Jun Kimura(Osaka University), 鎌田 俊一(北海道大学創成研究機構)

10:45 AM - 11:03 AM JST | 1:45 AM - 2:03 AM UTC

[PPS01-11] Saturn's ring rain and Enceladus' subsurface ocean as seen by the Cassini Cosmic Dust Analyser

★Invited Papers

*Sean Hsu[1], Sascha Kempf[1], Mihaly Horanyi[1], Ralf Srama[2], James O'Donoghue[3] (1.LASP, University of Colorado, Boulder, CO, USA, 2.IRS, University of Stuttgart, Stuttgart, Germany, 3.NASA Goddard Space Flight Center, Greenbelt, Maryland, USA)

11:03 AM - 11:18 AM JST | 2:03 AM - 2:18 AM UTC

[PPS01-12] **Titan Trek: A New Online NASA Visualization and Analysis Portal for Saturn's Largest Moon**

*Emily Law[1], Brian Hamilton Day[2] (1.NASA Jet Propulsion Laboratory, 2.NASA Ames Research Center)

11:18 AM - 11:36 AM JST | 2:18 AM - 2:36 AM UTC

[PPS01-13] Internal structure of icy moons: ice-ocean systems as commonly seen in the outer solar system

★Invited Papers

*Hauke Hussmann[1] (1.DLR Institute of Planetary Research)

11:36 AM - 11:51 AM JST | 2:36 AM - 2:51 AM UTC

[PPS01-14] Callisto as a keystone to reproduce the formation process of the Jovian system

*Yasuhito Sekine[1], Shunichi Kamata[2], Yuhiko Aoyama[3], Masahiro Ikoma[3], Takayuki Tanigawa[4] (1.Earth-Life Science Insitute, Tokyo Institute of Technology, 2.Creative Res. Institution, Hokkaido Univerisity, 3.Dept of Earth and Planetary Sci., University of Tokyo, 4.Nat'l Inst. Tech., Ichinoseki Col.)

11:51 AM - 12:09 PM JST | 2:51 AM - 3:09 AM UTC

[PPS01-15] Origin of Jupiter Trojan asteroids: To be explored by OKEANOS

★Invited Papers

*Yoko Kebukawa[1], Tatsuaki Okada[2], Motoo Ito[3], Jun Aoki[4], Yosuke Kawai[4], Jun Matsumoto[2], Noel Grand[5], Arnaud Buch[6], Michisato Toyoda[4], Hervé Cottin[5], Hisayoshi Yurimoto[7,2], Hajime Yano[2], Takahiro Iwata[2], Osamu Mori[2] (1.Yokohama National University, 2.Japan Aerospace Exploration Agency, 3.Kochi Institute for Core Sample Research JAMSTEC, 4.Osaka University, 5.LISA, Université Paris-Est Créteil, 6.Ecole Centrale Paris, 7.Hokkaido University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Masateru Ishiguro(Seoul National University)

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

[PPS03-01] The shape and origin of the rubble-pile asteroid Ryugu

★Invited Papers

*Sei-ichiro WATANABE[1,5], Masatoshi Hirabayashi[2], Naru Hirata[3], Naoyuki Hirata[4], Rina Noguchi[5], Yuri Shimaki[5], Hitoshi Ikeda[6], Eri Tatsumi[7], Makoto Yoshikawa[5], Shota Kikuchi[5], Hikaru Yabuta[8], Tomoki Nakamura[9], Shogo Tachibana[7,5], Yoshiaki Ishihara[10], Tomokatsu Morota[1], Kohei Kitazato[3], Naoya Sakatani[5], Koji Matsumoto[11,12], Koji Wada[13], Hiroki Senshu[13], Chikatoshi Honda[3], Tatsuhiro Michikami[14], Hiroshi Takeuchi[5], Toru Kouyama[15], Rie Honda[16], Robert Gaskell[17], Eric Palmer[17], Olivier S. Barnouin[18], Patrick Michel[19], Paul Abell[20], Yukio Yamamoto[5], Satoshi Tanaka[5], Kei Shirai[5], Moe Matsuoka[5], Seiji Sugita[5,7], Tatsuaki Okada[5], Noriyuki Namiki[11], Masahiko Arakawa[4], Masateru Ishiguro[21], Kazunori Ogawa[4], Fuyuto Terui[5], Takanao Saiki[5], Satoru Nakazawa[5], Yuichi Tsuda[5], Hayabusa2 Science Team (1.Division of Earth and Planetary Sciences, Graduate School of Science, Nagoya University, 2.Auburn University, 3.University of Aizu, 4.Kobe University, 5.ISAS, JAXA, 6.Research and Development Directorate, JAXA, 7.University of Tokyo, 8.Hiroshima University, 9.Tohoku University, 10.National Institute for Environmental Studies, 11.National Astronomical Observatory of Japan, 12.SOKENDAI, 13.Chiba Institute of Technology, 14.Kindai University, 15.National Institute of Advanced Industrial Science and Technology, 16.Kochi University, 17.Planetary Science Institute, 18.John Hopkins University, 19.Universite Cote d'Azur, Observatorie de la Cote d'Azur, 20.NASA, Johnson Space Center, 21.Seoul National University)

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

[PPS03-02] Results of Hayabusa2 Near Infrared Spectroscopy at Asteroid Ryugu

*Takahiro Iwata[1], Kohei Kitazato[2], Masanao Abe[1], Makiko Ohtake[1], Yusuke Nakauchi[1], Moe Matsuoka[1], KOHJI TSUMURA[3], Shuji Matsuura[4], Lucie Riu[1], NIRS3 Team (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.The University of Aizu, 3.Tohoku University, 4.Kwansei Gakuin University)

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

[PPS03-03] Impact experiment on asteroid Ryugu by Small-Carry on impactor of Hayabusa-2 and observation of the impact ejecta by a Deployable CAMera-3

★Invited Papers

*Masahiko Arakawa[1], Takanao Saiki[2], Toshihiko Kadono[3], Yasuhiko Takagi[4], Koji Wada[5], Yu-ichi Iijima[2], Hiroshi Imamura[2], Chisato Okamoto[1], Yuri Shimaki[2], Kei Shirai[2], Satoru Nakazawa[2], Masahiko Hayakawa[2], Naru Hirata[6], Hajime Yano[2], Hirotaka Sawada[2], Kazunori Ogawa[1], Ko Ishibashi[5], Hiroshi Kimura[5], Masanori Kobayashi[5], Naoya Sakatani[2], Hajime Hayakawa[2], Rie Honda[7], Seiji Sugita[8], Tomokatsu Morota[9], Shingo Kameda[10], ERI TATSUMI[8], Chikatoshi Honda[6], yokota yasuhiro[2], Toru Kouyama[11], Manabu Yamada[5], Hidehiko Suzuki[12], Kazuo Yoshioka[13], Yuichiro Cho[8], Moe Matsuoka[2] (1.Graduate School of Science, Kobe University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.University of Occupational and Environmental Health, 4.Aichi Toho University, 5.Planetary Exploration Research Center, Chiba Institute of Technology, 6.Dep. of Computer Science and Engineering, Univ. of Aizu, 7.Department of Science and Technology, System of Natual Science, Kochi University, 8.Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo, 9.Graduate School of Environmental Studies, Nagoya University, 10.School of Science, Rikkyo University, 11.National Institute of Advanced Industrial Science and Technology, 12.Department of physics, Meiji university, 13.Graduate School of frontier Science, The University of Tokyo)

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

[PPS03-04] Impact cratering experiments on glass beads with bead size frequency distribution: Implications for cratering process on asteroid Ryugu

*Minami Yasui[1], Masahiko Arakawa[1], Sunao Hasegawa[2], Yuya Yamamoto[1], Ryo Sugimura[1] (1.Graduate School of Science, Kobe University, 2.ISAS, JAXA)

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

[PPS03-05] Enhancement of impact heating in strength-supported media

*Kosuke Kurosawa[1], Hidenori Genda[2], Shigeru Wakita[2], Thomas M Davison[3], Ryuki Hyodo[2], Tomoki Nakamura[4] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Department of Earth Science & Engineering, Imperial College London, 4.Department of Earth Science, Tohoku University)

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

[PPS03-06] Global Thermal Inertia and Surface Roughness of Asteroid 162173 Ryugu by TIR on Hayabusa2

*Yuri Shimaki[1], Hiroki Senshu[2], Naoya Sakatani[1], Tatsuaki Okada[1,3], Tetsuya Fukuhara[4], Satoshi Tanaka[1], Makoto Taguchi[4], Takehiko Arai[5], Hirohide Demura[6], Yoshiko Ogawa[6], Kentaro Suko[6], Tomohiko Sekiguchi[7], Toru Kouyama[8], Jun Takita[9], Tsuneo Matsunaga[10], Takeshi Imamura[3], Takehiko Wada[1], Sunao Hasegawa[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Chiba Institute of Technology, 3.University of Tokyo, 4.Rikkyo University, 5.Ashikaga University, 6.University of Aizu, 7.Hokkaido University of Education, 8.National Institute of Advanced Industrial Science and Technology, 9.Hokkaido Kitami Hokuto High School, 10.National Institute for Environmental Studies)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Olivier Barnouin(Johns Hopkins University Applied Physics Laboratory)

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

[PPS03-07] Asteroid Ryugu's parent body and its properties inferred from Haybusa2 multi-band imaging observations

★Invited Papers

*Seiji Sugita[1,6], Rie Honda[2], Tomokatsu Morota[3], Shingo Kameda[4], ERI TATSUMI[1], Chikatoshi Honda[7], yokota yasuhiro[2,5], Toru Kouyama[8], Naoya Sakatani[5], Manabu Yamada[6], Hidehiko Suzuki[10], Kazuo Yoshioka[1], Yuichiro Cho[1], Moe Matsuoka[5], Kazunori Ogawa[9], Deborah Domingue[11], Hideaki Miyamoto[1], Olivier Barnouin[12], Patrick Michel[13], Carolyn Ernst[12], Sei-ichiro WATANABE[3], Yuichi Tsuda[5] (1.University of Tokyo, 2.Kochi University, 3.Nagoya University, 4.Rikkyo University, 5.JAXA/ISAS, 6.Chiba Institute of Technology, PERC, 7.University of Aizu, 8.National Institute of Advanced Industrial Science and Technology, 9.Kobe University, 10.Meiji University, 11.Planetary Science Institute, 12.Johns Hopkins University/Applied Physics Laboratory, 13.Observatoire de la Coˆte d'Azur)

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

[PPS03-08] REDDENING PROCESS OF THE RYUGU SURFACE BASED ON THE CRATER SIZE-FREQUENCY DISTRIBUTION

*Tomokatsu Morota[1], Yuichiro Cho[2], Masanori Kanamaru[3], Rie Honda[4], Shingo Kameda[5], ERI TATSUMI[2], yokota yasuhiro[6], Toru Kouyama[7], Hidehiko Suzuki[8], Manabu Yamada[9], Naoya Sakatani[6], Chikatoshi Honda[10], Masahiko Hayakawa[6], Kazuo Yoshioka[2], Moe Matsuoka[6], Tatsuhiro Michikami[11], Hideaki Miyamoto[2], Hiroshi Kikuchi[2], Ryodo Hemmi[2], Masatoshi Hirabayashi[12], Naoyuki Hirata[13], Naru Hirata[10], Carolyn Ernst[14], Olivier Barnouin[14], Hirotake Sawada[6], Seiji Sugita[2] (1.Nagoya University, 2.The University of Tokyo, 3.Osaka University, 4.Kochi University, 5.Rikky University, 6.JAXA, 7.AIST, 8.Meiji University, 9.Chiba Institute of Technology, 10.The University of Aizu, 11.Kindai University, 12.Auburn University, 13.Kobe University, 14.Johns Hopkins University/Applied Physics Laboratory)

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

[PPS03-09] Preliminary report on global distribution visible spectra of asteroid Ryugu based on clustering

*Rie Honda[1], Yasuhiro Yokota[1,2], Eri Tatsumi[3], Antonella Barucci[12], Davide Perna[13], Moe Matsuoka[2], Deborah Domingue[14], Tomokatsu Morota[4], Shingo Kameda[5], Toru Kouyama[15], Hidehiko Suzuki[6], Manabu Yamada[10], Naoya Sakatani[2], Chikatoshi Honda[7], Lucille LeCorre[14], Masahiko Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Tomoki Nakamura[9], Takahiro Hiroi[11], Hirotaka Sawada[2], Yuki Fujii[1], Seiji Sugita[3], Ryo Hayashi[1] (1.Kochi University, 2.ISAS/JAXA, 3.University of Tokyo, 4.Nagoya University, 5.Rikkyo University, 6.Meiji University, 7.Aizu University, 8.Kobe University, 9.Tohoku University, 10.Chiba Institute of Technology, 11.Brown University, 12.Paris Observatory, 13.INAF, 14.Planetary Science Institute, 15.National Institute of Advanced Industrial Science and Technology)

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

[PPS03-10] Visible spectra of small bright spots on asteroid 162173 Ryugu

*Chiho Sugimoto[1], Eri Tatsumi[1], Yuichiro Cho[1], Kazuo Yoshioka[1], Hirotaka Sawada[2], Yasuhiro Yokota[2], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Tomokatsu Morota[4], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Chikatoshi Honda[9], Kazunori Ogawa[10], Deborah Domingue[11], Patrick Michel[12], Seiji Sugita[1] (1.University of Tokyo, 2.JAXA/ISAS, 3.Kochi University, 4.Nagoya University, 5.Rikkyo University, 6.Chiba Institute of Technology, 7.AIST, 8.Meiji University, 9.University of Aizu, 10.Kobe University, 11.Planetary Science Institute, 12.Nice Observatory)

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

[PPS03-11] Geomorphological characteristics of asteroid Ryugu: implications to its evolutional history

*Hideaki Miyamoto[1], Ryodo Hemmi[1], Hiroshi Kikuchi[1], Goro Komatsu[2], Chikatoshi Honda[3], Tatsuhiro Michikami[4], Tomokatsu Morota[5], Yuichiro Cho[1], Olivier S Barnouin[6], Sho Sasaki[7], Naru Hirata[3], Naoyuki Hirata[8], Rie Honda[10], Shingo Kameda[11], ERI TATSUMI[1], Yasuhiro Yokota[12], Toru Kouyama[13], Hidehiko Suzuki[14], Manabu Yamada[15], Naoya

Sakatani[12], Masahiko Hayakawa[12], Kazuo Yoshioka[1], Moe Matsuoka[12], Masatoshi Hirabayashi[9], Hirotaka Sawada[12], Seiji Sugita[1] (1.University of Tokyo, 2.D'Annunzio University, 3.Aizu University, 4.Kinki University, 5.Nagoya University, 6.Johns Hopkins University, 7.Osaka University, 8.Kobe University, 9.Auburn University, 10.Kouchi University, 11.Rikkyo University, 12.ISAS/JAXA, 13.AIST, 14.Meiji University, 15.Chiba Inst Tech)

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

[PPS03-12] Global distribution of sub-meter boulders measured with texture analysis of Ryugu images

*Naoya Tanabe[1], Yuichiro Cho[1], ERI TATSUMI[1], Tomokatsu Morota[4], Chikatoshi Honda[9], Tatsuhiro Michikami[11], Patrick Michel[12], Carolyn Ernst[13], Olivier S Barnouin[13], Kazuo Yoshioka[1], Sawada Hirotaka[2], yokota yasuhiro[2,3], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Kazunori Ogawa[10], Seiji Sugita[1] (1.University of Tokyo, 2.JAXA/ISAS, 3.Kochi University, 4.Nagoya University, 5.Rikkyo University, 6.Chiba Inst. Tech., PERC, 7.AIST, 8.Meiji University, 9.University of Aizu, 10.Kobe University, 11.Kindai University, 12.Observatoire de la Côte d'Azur, 13.Johns Hopkins University APL)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Masanao Abe(Institute of Space and Astronautical Science, JAXA)

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

[PPS03-13] Brightness and morphology variations on surface boulders of 162173 Ryugu: Space Weathering, Breccia, and Thermal Cracks

*Sho Sasaki[1], Seiji Sugita[2], Eri Tatsumi[2], Hideaki Miyamoto[3], Chikatoshi Honda[4], Tomokatsu Morota[5], Masatoshi Hirabayashi[6], Shiho Kanda[1], Naru Hirata[4], Takahiro Hiroi[7], Tomoki Nakamura[8], Takaaki Noguchi[9], Rie Honda[10], Tatsuhiro Michikami[11], Sei-ichiro Watanabe[5], Noriyuki Namiki[12], Patrick Michel[13], Shingo Kameda[14], Toru Kouyama[15], Hidehiko Suzuki[16], Manabu Yamada[17], Hiroshi Kikuchi[3], Yuichiro Cho[2], Kazuo Yoshioka[18], Masahiko Hayakawa[19], Moe Matsuoka[19], Rina Noguchi[19], Naoya Sakatani[19], Hirotaka Sawada[19], yokota yasuhiro[19,10], Makoto Yoshikawa[19] (1.Department of Earth and Space Science, School of Science, Osaka University, 2.Department of Earth and Planetary Science, School of Science, University of Tokyo, 3.Department of Systems Innovation, School of Engineering, University of Tokyo, 4.University of Aizu, 5.Graduate School of Environmental Studies, Nagoya University, 6.Auburn University, 7.Brown University, 8.Department of Earth and Planetary Materials Sciences, Faculty of Science, Tohoku University, 9.Department of Arts and Science, Kyushu University, 10.Department of Science and Technology, System of Natural Science, Kochi University, 11.Faculty of Engineering, Kinki University, 12.RISE Project, National Astronomical Observatory of Japan, 13.Observatoire de la Cote d'Azur, 14.School of Science, Rikkyo University, 15.National Institute of Advanced Industrial Science and Technology, 16.Department of physics, Meiji university, 17.Planetary Exploration Research Center, Chiba Institute of Technology, 18.School of frontier Science, University of Tokyo, 19.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS03-14] Topography of large craters and equatorial bulge of 162173 Ryugu

*Noriyuki Namiki[1,2], Takahide Mizuno[3], Hiroki Senshu[4], Hirotomo Noda[1,2], Koji Matsumoto[1,2], Naru Hirata[5], Ryuhei Yamada[5], Yoshiaki Ishihara[6], HItoshi Ikeda[3], Hiroshi Araki[1,2], Keiko Yamamoto[1,2], Shinsuke Abe[7], Fumi Yoshida[4], Arika Higuchi[1], Sho Sasaki[10], Shoko Oshigami[1], Seiitsu Tsuruta[1], Kazuyoshi Asari[1], Seiichi Tazawa[1], Makoto Shizugami[1], Hideaki Miyamoto[8], Hirohide Demura[5], Jun Kimura[10], Toshimichi Otsubo[9] (1.National Astronomical Observatory of Japan, 2.SOKENDAI (The Graduate University for Advanced Studies), 3.Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science, 4.Chiba Institute of Technology, 5.The University of Aizu, 6.National Institute of Advanced Industrial Science and Technology, 7.Nihon University,8Osaka University, 8.The University of Tokyo, 9.Hitotsubashi University, 10.Osaka University)

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

[PPS03-15] Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

*Ryuhei Yamada[1], Keiko Yamamoto[2], Hiroshi Araki[2], Hirotomo Noda[2], Hiroki Senshu[3], Noriyuki Namiki[2], Koji Matsumoto[2], Fumi Yoshida[3], Shinsuke Abe[4], Naru Hirata[1] (1.The University of Aizu, Department of Computer Science and Engineering, 2.National Astronomical Observatory of Japan, 3.Chiba Institute of Technology, 4.Nihon University)

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

[PPS03-16] Improved Trajectory of Hayabusa2 by Combining LIDAR Data and a Shape Model

*Koji Matsumoto[1], Hirotomo Noda[1], Yoshiaki Ishihara[2], Hiroki Senshu[3], Keiko Yamamoto[1], Naru Hirata[4], Naoyuki Hirata[5], Noriyuki Namiki[1], Toshimichi Otsubo[6], Sei-ichiro WATANABE[7], Takahide Mizuno[8], Yukio Yamamoto[8], Hitoshi Ikeda[8], Naoko Ogawa[8], Shota Kikuchi[8], Takanao Saiki[8], Yuichi Tsuda[8] (1.RISE Project, National Astronomical Observatory of Japan, 2.National Institute for Environmental Studie, 3.Chiba Institute of Technology, 4.The University of Aizu, 5.Kobe University, 6.Hitotsubashi University, 7.Nagoya University, 8.JAXA)

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

[PPS03-17] Present status of preparation for the Ryugu sample curation returned by the Hayabusa2

*Toru Yada[1], Masanao Abe[1], Aiko Nakato[1], Kasumi Yogata[1], Kanako Sakamoto[1], Masahiro Nishimura[1], Tatsuaki Okada[1], Yuki Nakano[2], Miwa Yoshitake[1], Kazuya Kumagai[3], Ayako Iwamae[3], Shizuho Furuya[1], Shogo Tachibana[4,1],

Hisayoshi Yurimoto[1,2] (1.Japan Aerospace Exploration Agency, 2.Hokkaido University, 3.Marine Works Japan Ltd., 4.University of Tokyo)

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

[PPS03-18] Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

*Motoo Ito[1], Naotaka Tomioka[1], Masayuki Uesugi[2], Kentaro Uesugi[2], Ohigashi Takuji[3], Akira Yamaguchi[4], Naoya Imae[4], Yuzuru Karouji[5], Naoki Shirai[6], Toru Yada[5], Masanao Abe[5] (1.Kochi Institute for Core Sample Research, JAMSTEC, 2.JASRI, 3.UVSOR Synchrotron Facility, Institute for Molecular Science, 4.National Institute Polar Research, 5.JAXA, 6.Tokyo Metropolitan University)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Ryuho Kataoka(National Institute of Polar Research)

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

[PEM12-25] Variation of carbon-14 in tree rings around the onset of the Spoerer Minimum

★Invited Papers

*Hiroko Miyahara[1], Fuyuki Tokanai[2], Toru Moriya[2], Motonari Ohyama[3], Masataka Hakozaki[4], Mirei Takeyama[2], Hirohisa Sakurai[2] (1.Musashino Art University, 2.Yamagata University, 3.Tohoku University, 4.Nagoya University)

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

[PEM12-26] Current Status of WASAVIES: Warning System for Aviation Exposure to Solar Energetic Particles

★Invited Papers

*Tatsuhiko Sato[1], Ryuho Kataoka[2,3], Daikou Shiota[4,5], Yuki Kubo[4], Mamoru Ishii[4], Hiroshi Yasuda[6], Shoko Miyake[7], InChun Park[5], Yoshizumi Miyoshi[5] (1.Japan Atomic Energy Agency, 2.National Institute of Polar Research, 3.SOKENDAI, 4.National Institute of Information and Communications Technology, 5.Nagoya University, 6.Hiroshima University, 7.National Institute of Technology, Ibaraki College)

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

[PEM12-27] Statistical analysis of solar energetic particle events

*Kosuke Kihara[1], Yuwei Huang[2], Nobuhiko Nishimura[3], Seiji Yashiro[4], Nariaki Nitta[5], Kiyoshi Ichimoto[2], Ayumi Asai[2] (1.Department of Astronomy, Kyoto University, 2.Astronomical Observatory, Kyoto University, 3.Institute for Space Earth Environmental Research, Nagoya University, 4.The Catholic University of America, 5.Lockheed Martin Advanced Technology Center)

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

[PEM12-28] Long-term variation of galactic cosmic ray intensity observed with the Nagoya multidirectional muon detector

*Kazuoki Munakata[1], Rafael Mendonca[2], Chihiro Kato[1], Munetoshi Tokumaru[3] (1.Department of Physics, Faculty of Science, Shinshu University, 2.INPE, Brazil, 3.ISEE, Nagoya University)

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

[PEM12-29] Solar modulation of galactic cosmic rays during grand minima: A hybrid simulation

*Shoko Miyake[1], Tomoaki Matsumoto[2,3], Ryuho Kataoka[4,5], Tatsuhiko Sato[6], Daikou Shiota[7], Hiroko Miyahara[8], Shinsuke Imada[9], Haruka Ueno[10] (1.NIT, Ibaraki College, 2.Hosei Univ., 3.Princeton Univ., 4.NIPR, 5.SOKENDAI, 6.JAEA, 7.NICT, 8.Musashino Art Univ., 9.Nagoya Univ., 10.JAXA)

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

[PEM12-30] Overview of radio propagation project

*Kornyanat Hozumi[1], Hiroyuki Nakata[2], Susumu Saito[3], Takumi Kondo[1], Ryo Nakao[2], Takashi Maruyama[1], Takuya Tsugawa[1], Mamoru Ishii[1] (1.National Institute of Information and Communications Technology, 2.Graduate School of Engineering, Chiba University, Chiba, Japan, 3.National Institute of Maritime, Port and Aviation Technology, Electronic Navigation Research Institute (ENRI), Tokyo, Japan)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Kaori Sakaguchi

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

[PEM12-31] Dynamic Spectral Characteristics of Equatorial Plasma Bubbles

★Invited Papers

*Tatsuhiro Yokoyama[1], Charles L Rino[2], Charles S Carrano[2] (1.Kyoto University, 2.Boston College)

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

[PEM12-32] Recent advances in space weather monitoring using the Super Dual Auroral Radar Network

★Invited Papers

*Evan G Thomas[1], Simon G Shepherd[1] (1.Dartmouth College)

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

[PEM12-33] **A Study of Solar Flare Effects on Radio Wave Propagation using SuperDARN & riometer**

*Shibaji Chakraborty[1], Joseph Baker[1], John Michael Ruohoniemi[1], Nozomu Nishitani[2] (1.Virginia Tech, 2.Institute for Space-Earth Environmental Research, Nagoya University)

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

[PEM12-34] Exploring the use of cell phone GNSS receivers for global monitoring of the ionosphere

*Dawn Kellogg Merriman[1], Omar A Nava[1], Jennifer L Meehan[2], Hsien-Liang R Tseng[1] (1.AFIT, 2.NOAA)

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

[PEM12-35] Large enhancements of global GPS total electron content during a magnetic storm on 7-8 November 2004

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

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

[PEM12-36] Large scale traveling ionospheric disturbances origin and propagation

*Iurii Cherniak[1,2], Irina Zakharenkova[2,5], Paul Prikryl[3,4], William Schreiner[1] (1.COSMIC Program Office, University Corporation for Atmospheric Research, 2.University of Warmia and Mazury in Olsztyn, 3.Physics Department, University of New Brunswick, 4.Geomagnetic Laboratory, Natural Resources Canada, 5.West Department of IZMIRAN)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Danny Summers, Yoshizumi Miyoshi(ISEE, Nagoya University)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PEM13-01] Developing an improved understanding of Earth's outer radiation belt electrons with combined observations from Van Allen Probes, MMS, and Arase

★Invited Papers

*Drew L Turner[1], Ian Cohen[2], Alexander Boyd[1,3], Joseph Fennell[1], Geoff Reeves[3], Yoshizumi Miyoshi[4] (1.Aerospace Corporation El Segundo, 2.Johns Hopkins University Applied Physics Lab, 3.Los Alamos National Laboratory, 4.Nagoya University)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PEM13-02] Recent results from Van Allen Probes and future prospects from the CeREs Cubesat

★Invited Papers

*Shrikanth G Kanekal[1], Daniel N Baker[2], Ashley Greeley[1], Lauren Blum[1], Quintin Schiller[1], David G Sibeck[1], Hong Zhao[2], Xinlin Li[2], Allison Jaynes[3] (1.NASA Goddard Space Flight Center, 2.LASP, University of Colorado, Boulder, 3.Univeristy of Iowa)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[PEM13-03] **Optimal Use of Time Lags Between MMS Spacecraft : Application to the Estimation of Wave-Vectors**

*Gerard Marcel CHANTEUR[1,2,3], Drew L. Turner, Olivier Le Contel[1,2,3], Alessandro Retino[1,2,3], Laurent Mirioni[1,2,3] (1.CNRS, 2.SORBONNE UNIVERSITE, 3.ECOLE POLYTECHNIQUE)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[PEM13-04] Conjugate observation of EMIC waves by Arase and RBSP with associated POES and AARDDVARK detected electron precipitation

*Aaron T. Hendry[1], Ondrej Santolik[1,2], Yoshizumi Miyoshi[3], Yoshiya Kasahara[4], Yasumasa Kasaba[5], Ayako Matsuoka[6], Craig J Rodger[7], Mark Clilverd[8], Masafumi Shoji[3], Shoya Matsuda[6], Craig Kletzing[9], Iku Shinohara[6] (1.Dept. of Space Physics, Inst. of Atmospheric Physics, Czech Acad. of Science, 2.Fac. of Mathematics and Physics, Charles Univ., 3.Inst. for Space Earth Environmental Research, Nagoya Univ., 4.Graduate School of Natural Science and Technology, Kanazawa Univ., 5.Planetary Plasma and Atmospheric Research Center, Tohoku Univ., 6.Inst. of Space and Astronautical Science, Japan Aerospace Exploration Agency, 7.Dept. of Physics, Univ. of Otago, 8.British Antarctic Survey (NERC), 9.Dept. of Physics and Astronomy, Univ. of Iowa)

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

[PEM13-05] Over-darkening pulsating aurora: simultaneous observations with Arase and an all-sky camera in Scandinavia

*Keisuke Hosokawa[1], Yoshizumi Miyoshi[2], Shin-ichiro Oyama[2], Yasunobu Ogawa[3], Satoshi Kurita[2], Yoshiya Kasahara[4], Mitsunori Ozaki[4], Yasumasa Kasaba[5], Satoshi Yagitani[4], Shoya Matsuda[6], Fuminori Tsuchiya[5], Atsushi Kumamoto[5], Iku Shinohara[6], Ryoichi Fujii[7] (1.Department of Communication Engineering and Informatics, University of Electro-Communications, 2.ISEE, Nagoya University, 3.National Institute of Polar Research, 4.Kanazawa University, 5.Tohoku University, 6.ISAS/JAXA, 7.Research Organization of Information and Systems)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Yoshizumi Miyoshi(ISEE, Nagoya University), Danny Summers

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[PEM13-06] Deformation of electron pitch angle distributions caused by chorus waves observed by the Arase satellite

★Invited Papers

*Satoshi Kurita[1], Yoshizumi Miyoshi[1], Satoshi Kasahara[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Iku Shinohara[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.The University of Tokyo, 3.Graduate School of Science, Osaka University, 4.Information Media Center, Kanazawa University, 5.ISAS/JAXA)

3:50 PM - 4:10 PM JST | 6:50 AM - 7:10 AM UTC

[PEM13-07] Electron scattering by isolated chorus elements observed near the magnetospheric equator

★Invited Papers

*Satoshi Kasahara[1], Yoshizumi Miyoshi[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Kunihiro Keika[1], Tomoaki Hori[2], Iku Shinohara[5] (1.The university of Tokyo, 2.Nagoya University, 3.Osaka University, 4.Kanazawa University, 5.Institute of Space and Astronautical Science)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[PEM13-08] Continuous precipitation of low-energy electrons associated with pulsating aurora obtained by the Reimei satellite

*Takeshi Sakanoi[1], Fukizawa Mizuki[1], Yoshizumi Miyoshi[2], Yusuke Ebihara[3], Kazushi Asamura[4], Masafumi Hirahara[2] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.ISEE, Nagoya University, 3.RISH, Kyoto University, 4.ISAS/JAXA)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[PEM13-09] Origin of energetic electron precipitation with fast fluctuation: Data-driven simulations using the ERG plasma wave observations

*Shinji Saito[1], Yoshizumi Miyoshi[2], Shoya Matsuda[3], Satoshi Kurita[2], Yoshiya Kasahara[4], Atsushi Kumamoto[5], Fuminori Tsuchiya[5], Ayako Matsuoka[3] (1.Graduate School of Science, Nagoya University, 2.ISEE, Nagoya University , 3.ISAS/JAXA, 4.Kanazawa University, 5.Tohoku University)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[PEM13-10] Conjugated quasi-periodic ELF/VLF emissions between the Arase satellite and both Van Allen Probes

*Claudia Martinez Calderon[1,2], Frantisek Nemec[3], Kazuo Shiokawa[2], Yuto Katoh[1], Yoshiya Kasahara[4], Shoya Matsuda[2], Fuminori Tsuchiya[1], Atsushi Kumamoto[1], Mariko Teramoto[2], Ayako Matsuoka[5], Yoshizumi Miyoshi[2], Ondrej Santolik[6,3], George Hospodarksy[7] (1.Dept. Geophys., Grad. Sch. Sci., Tohoku University, 2.Instute for Space-Earth Environmental Research, Nagoya University, 3.Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic, 4.Kanazawa University, 5.Japan Aerospace Exploration Agency, 6.Institute of Atmospheric Physics, Prague, Czech Republic, 7.Department of Physics and Astronomy, University of Iowa, USA)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

convener:Toshimori Sekine(Center for High Pressure Science and Technology Advanced Research), Takuo Okuchi(Institute for Planetary Materials, Okayama University), Chairperson:Toshimori Sekine(HPSTAR & Osaka University), Ai-Cheng Zhang(Nanjing University)

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

[PCG22-01] Shock-induced phase transformation in howardite-eucrite-diogenite meteorites

★Invited Papers

*Ai-Cheng Zhang[1,2], De-Liang Chen[1], Run-Lian Pang[1] (1.School of Earth Sciences and Engineering, Nanjing University, China, 2.CAS Center for Excellence in Comparative Planetary, China)

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

[PCG22-02] Lattice-shear-induced metastable formation of high-pressure silicates in shocked meteorites

★Invited Papers

*Naotaka Tomioka[1], Takuo Okuchi[2], Masaaki Miyahara[3] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.Institute for Planetary Materials, Okayama University, 3.Department of Earth and Planetary Systems Science, Hiroshima University)

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

[PCG22-03] Can high-pressure polymorphs clarify an ordinary chondrite parent-body breakup?

*Masaaki Miyahara[1], Akira Yamaguchi[2], Masato Saitoh[1], Kanta Fukimoto[1], Takeshi Sakai[3], Hiroaki Ohfuji[3], Naotaka Tomioka[4], Yu Kodama[5], Eiji Ohtani[6] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.National Institute of Polar Research, 3.Geodynamics Research Center, Ehime University, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 5.Marine Works Japan, 6.Department of Earth Sciences, Graduate School of Science, Tohoku University)

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

[PCG22-04] Linking occurrence and texture of dense silicate minerals in shocked meteorites with laser-shock experimental results of Mg_2SiO_4 analyzed by XFEL probe

*Takuo Okuchi[1], Narangoo Purevjav[1], Norimasa Ozaki[2], Takeshi Matsuoka[2], Yusuke Seto[3], Yoshinori Tange[4], Toshinori Yabuuchi[5], Naotaka Tomioka[6], Toshimori Sekine[7], Ryosuke Kodama[2] (1.Institute for Planetary Materials, Okayama University, 2.Graduate School of Engineering, Osaka University, 3.Graduate School of Science, Kobe University, 4.Japan Synchrotron Radiation Research Institute, 5.RIKEN Harima Branch, 6.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 7.Center for High Pressure Science and Technology Advanced Research)

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

[PCG22-05] **Laser-shock evolution of organic molecules in carbonaceous meteorite**

*Hikaru Yabuta[1], Hikaru Fujioka[2], Tatsuhiro Sakaiya[2], Tadashi Kondo[2], Sohsuke Ohno[3], Kosuke Kurosawa[3], Toshihiko Kadono[4], Keisuke Shigemori[5], Yoichiro Hironaka[5], Takamitsu Yamanaka[6] (1.Hiroshima University, Department of Earth and Planetary Systems Science, 2.Osaka University, Department of Earth and Space Science, 3.Chiba Institute of Technology, Planetary Exploration Research Center (PERC), 4.University of Occupational and Environmental Health, 5.Osaka University, Institute of Laser Engineering, 6.Center for High Pressure Science & Technology Advanced Research, Shanghai, China)

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

[PCG22-06] Shock barometer using cathodoluminescence and synchrotron angle-dispersive x-ray diffraction analyses of minerals

★Invited Papers

*Masahiro KAYAMA[1] (1.Tohoku University)

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

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

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

convener:Toshimori Sekine(Center for High Pressure Science and Technology Advanced Research), Takuo Okuchi(Institute for Planetary Materials, Okayama University), Chairperson:Takuo Okuchi(Okayama University), Yongjae Lee(Yonsei University)

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

[PCG22-07] Dynamic Compression at Pohang X-ray Free Electron Laser Facility (PAL-XFEL)

★Invited Papers

*Yongjae Lee[1] (1.Yonsei University, Seoul, Korea)

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

[PCG22-08] Exploration of extreme melt states of silicate usign high-power laser and XFEL

★Invited Papers

*Norimasa Ozaki[1] (1.Osaka University)

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

[PCG22-09] Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

*Yuhei Umeda[1], Norimasa Ozaki[1], Toshimori Sekine[2], Bruno Albertazzi[3], Alessandra Benuzzi-Mounaix[3], Riccardo Bolis[3], Marco Guaruaglini[3], Kento Katagiri[1], Kodama Ryosuke[1], Michel Koeing[3], Kohei Miyanishi[4], Shintaro Morioka[1], Toyohito Nishikawa[1], Syugo Ohi[5], Alessandra Ravasio[3], Yoichi Sakawa[4], Takayoshi Sano[4], Tomoko Sato[6] (1.Graduate School of Engineering, Osaka Univ., 2.Center for High Pressure Science & Technology Advanced Research, 3.Ecole Polytechnique, 4.Institute of Laser Engineering, Osaka University, 5.Shiga Univ., 6.Graduate School of Science, Hiroshima University)

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

[PCG22-10] **An experimental design to determine iron melting at the Earth's core conditions via in-situ X-ray diffraction technique at high power laser facility**

★Invited Papers

*Hao Liu[1] (1.Laser fusion research center)

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

[PCG22-11] **Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique**

*Kohei Miyanishi[1], Norimasa Ozaki[2], Satoshi Ohmura[3], Marion Harmand[4], Andy Krygier[5], Toyohito Nishikawa[2], Yuhei Umeda[2], Shigemori Keisuke[1], Youichi Sakawa[1], Takayoshi Sano[1], Ryosuke Kodama[1,2] (1.Institute for Laser Engineering, Osaka University, 2.Graduate school of engineering, Osaka University, 3.Faculty of Engineering, Hiroshima Institute of Technology, 4.IMPMC, Sorbonne Université, 5.LLNL)

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

[PCG22-12] **Laser shock compression in LFRC**

*Liang Sun[1] (1.Laser Fusion Research Center, CAEP)

[E] 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 | 104 1F

[A-AS03] Large-scale moisture and organized cloud systems

convener:Hiroaki Miura(The University of Tokyo), Atsushi Hamada(University of Toyama), Satoru Yokoi(Japan Agency for Marine-Earth Science and Technology), Masaki Satoh(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Hiroaki Miura

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

[AAS03-01] Boundary-Layer Control on Convective Self-Aggregation

★Invited Papers

*Da YANG[1,2] (1.University of California, Davis, 2.Lawrence Berkeley National Laboratory)

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

[AAS03-02] Statistical Properties of Cumulus Ensembles in High-Resolution Radiative-Convective Equilibrium Simulations

*Tomoro Yanase[1,2], Tetsuya Takemi[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

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

[AAS03-03] **The role of interactive SST in the cloud-resolving simulations of aggregated convection**

★Invited Papers

*Chien-Ming Wu[1], Yan-Ting Chen[1] (1.National Taiwan University)

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

[AAS03-04] **Role of coastal convection to moisture buildup during the South China Sea summer monsoon onset**

*Wei-Ting Chen[1], Wei-Ming Tsai[1,2], Chien-Ming Wu[1], Peng-Jen Chen[1] (1.National Taiwan University, 2.University of Miami)

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

[AAS03-05] Resolution dependencies of tropical convection in a global cloud/cloud-system resolving model

★Invited Papers

*Tomoki Miyakawa[1], Hiroaki Miura[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Graduate School of Science, The University of Tokyo)

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

[AAS03-06] Effects of the local convection over the western Maritime Continent on the large-scale: numerical study during the YMC Sumatra campaigns

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

[E] 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 | 104 1F

[A-AS03] Large-scale moisture and organized cloud systems

convener:Hiroaki Miura(The University of Tokyo), Atsushi Hamada(University of Toyama), Satoru Yokoi(Japan Agency for Marine-Earth Science and Technology), Masaki Satoh(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Satoru Yokoi

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

[AAS03-07] A Mechanism for the Maintenance of Sharp Tropical Margins

★Invited Papers

*Hirohiko Masunaga[1], Brian Earle Mapes[2] (1.Nagoya University, 2.University of Miami)

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

[AAS03-08] Observational Evidence of Mixed Rossby-Gravity Waves as a Driving Force for the MJO Convective Initiation and Propagation

*Daisuke Takasuka[1,2], Masaki Satoh[1], Satoru Yokoi[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

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

[AAS03-09] A characteristic of the MJO as a part of enhanced large-scale zonal circulation

*Tamaki Suematsu[1], Hiroaki Miura[2] (1.Atmosphere and Ocean Reaserch Institute, The University of Tokyo, 2.School of Science, The University of Tokyo)

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

[AAS03-10] **The role of the moisture on the occurrences and distribution of the Amazonian mesoscale convective systems**

*Amanda Rehbein[1,2], Masaki Satoh[2], Tercio Ambrizzi[1] (1.Univ. of Sao Paulo, 2.Univ. of Tokyo)

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

[AAS03-11] Interdecadal Change of the Impact of Eurasian Snow on Spring Precipitation Over Southern China

*Dingrui Cao[1] (1.Zhejiang University)

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

[AAS03-12] Atmospheric Rivers and related atmospheric circulations associated with Japanese disastrous precipitation in warm season

Naho Suetou[1], *Akiyo Yatagai[1], Yukari Takayabu[2] (1.Graduate School of Science and Technology/Hirosaki University, 2.Atmosphere and Ocean Research Institute/The University of Tokyo)

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

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

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Isao Machida(Geological Survey of Japan, AIST)

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

[AHW23-01] Method for measuring the pore air pressure in the mountainous slope for rainfall-runoff processes research

★Invited Papers

*Sho Iwagami[1], Shoji Noguchi[1], Takanori Shimizu[1], Tayoko Kubota[1], Shin'ichi Iida[1], Makoto Araki[1] (1.Forestry and Forest Products Research Institute, Forest Research and Management Organization, National Research and Development Agency)

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

[AHW23-02] **A method to quantify the influence of total water storage change on climate elasticity of streamflow**

*Yin Tang[1] (1.Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science)

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

[AHW23-03] **Trade-off analysis of discharge-desiltation-turbidity and sediment simulation of a combined reservoir–river system under multi-phase and multi-layer conjunctive releasing operation**

*Chien-Lin Huang[1], Nien-Sheng Hsu[1], Gene Jiing-Yun You[1] (1.National Taiwan University, Taiwan)

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

[AHW23-04] Gradient change of soil moisture effect on next-day precipitation identified via a Random Forest-Granger causality model

*Lu Li[1], Wei ShangGuan[1], Shu Peng Zhang[1], Jin Jing Pan[1], Nan Wei[1], Yong Jiu Dai[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University)

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

[AHW23-05] **Using data-driven methods to explore the predictability of surface soil moisture with FLUXNET site data**

*jinjing Pan[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University.)

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

[AHW23-23] Global Analyis of the Hydrological Sensitivity to Climate Variability

*Marisol Dominguez[1], Hugo Alberto Gutierrez-Jurado[1] (1.University of Texas at El Paso)

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

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

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Megumi Watanabe

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

[AHW23-06] **A review on the global soil property maps for Earth system model**

Yongjiu Dai[1], *Wei Shangguan[1], Dagang Wang[2], Nan Wei[1], Qinchuan Xin[2], Hua Yuan[1], Shupeng Zhang[1], Shaofeng Liu[1], Fapeng Yan[3], Xingji Lu[1] (1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University, 2.School of Geography and Planning, Sun Yat-sen University, 3.College of Global Change and Earth System Science, Beijing Normal University)

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

[AHW23-07] **Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model**

*Indishe Prabath Senanayake[1], In-Young Yeo[1,2], Natthachet Tangdamrongsub[3,4], Garry R Willgoose[1], Gregory R Hancock[5], Tony Wells[1], Bin Fang[6], Venkataraman Lakshmi[6], Jeffrey P Walker[7] (1.School of Engineering, Faculty of Engineering and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia., 2.Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA., 3.Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA., 4.Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA., 5.School of Environmental and Life Sciences, Faculty of Science, The University of Newcastle, Callaghan, NSW 2308, Australia., 6.School of Earth Ocean and Environment, University of South Carolina, Columbia, SC 29223, United States., 7.Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia.)

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

[AHW23-08] Representation of dams in global flood inundation simulations by coupling the global hydrological model H08 and the global hydrodynamic model CaMa-Flood

*Julien Eric Boulange[1], Naota Hanasaki[1] (1.National Institute for Environmental Studies)

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

[AHW23-09] An investigation into a potential long subglacial river beneath the Greenland ice sheet using SICOPOLIS simulations.

*Christopher Chambers[1], Ralf Greve[1], Bas Altena[2], Pierre-Marie Lefeuvre[2] (1.Hokkaido University, 2.University of Oslo)

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

[AHW23-10] **Changes in Annual Rainfall patterns in the Democratic Republic of Congo: Congo river basin**

*Chetan Sharma[1], Chandra Shekhar Prasad Ojha[1] (1.Indian Institute of Technology Roorkee)

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

[AHW23-11] Seasonality in the extreme precipitation events linked to temperature over Japan

*Sridhara Nayak[1], Tetsuya Takemi[1] (1.Disaster Prevention Research Institute, Kyoto University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

convener:Kazuhito Ichii(Chiba University), Prabir Patra(Research Institute for Global Change, JAMSTEC), Forrest M. Hoffman(Oak Ridge National Laboratory), Makoto Saito(National Institute of Environmental Studies), Chairperson:Kazuhito Ichii

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

[ACG32-01] A high-resolution fossil fuel CO2 emission gridded dataset for tracer transport simulations and flux inversions: An overview, evaluations, applications and future perspectives

★Invited Papers

*Tomohiro Oda[1,2], Shamil Maksyutov [3], Miguel O. Roman [2,4], Zhousen Wang [4], Thomas Lauvaux[6,5], Sha Feng [5], Rostyslav Bun [7,8], James Wang [2,1], Randy Kawa [1], Lesley Ott[1], Steven Pawson[1] (1.NASA Goddard Space Flight Center, Greenbelt, MD, USA , 2.Universities Space Research Association, Columbia, MD, USA , 3.Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan , 4.Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA , 5.Department of Meteorology and Atmospheric Science, Penn. State University, State College, PA, USA , 6.Laboratoire des sciences du climat et de l'environnement, Gif sur Yvette, France, 7.Lviv Polytechnic National University, Lviv, Ukraine , 8.University of Dąbrowa Górnicza, Górnicza, Poland)

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

[ACG32-02] **Towards Decreasing the Uncertainty in Global Carbon Dioxide Emission Inventory**

*Richao Cong[1], Makoto Saito[1], Ryuichi Hirata[1], Akihiko Ito[1] (1.Center for Global Environmental Research, National Institute for Environmental Studies)

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

[ACG32-03] Evaluation of MIROC4-ACTM reanalysis of GHGs concentrations using aircraft

*Jagat Bisht[1], Prabir Patra[1], Naveen Chandra[1], Sergey Gromov[2], Taku Umezawa[3], Andreas Zahn[4], cARL A. M. Brenninkmeijer[5] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan, 2.Max Planck Institute for Chemistry, Mainz, Germany, 3.National Institute for Environmental Studies, Tsukuba, Japan, 4.Karlsruhe Institute of Technology (KIT), Institute for Meteorology and Climate Research, Karlsruhe, Germany, 5.Max Planck Institute for Chemistry, Air Chemistry Division, Mainz, Germany)

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

[ACG32-04] **Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product**

*Tazu Saeki[1], Yosuke Niwa[1], Makoto Saito[1] (1.National Institute for Environmental Studies)

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

[ACG32-05] **Attribution of the ambiguity in methane's growth rate shifts during 1988-2016.**

*Naveen Chandra[1], Prabir Patra[1] (1.Japan Agency for Marine Earth Science and Technology)

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

[ACG32-06] **Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño**

*Masayuki Kondo[1], Peter Landschützer[2], Yousuke Iida[3], Richard Houghton[4], Stephen Sitch[5] (1. Center for Environmental Remote Sensing, Chiba University, 2.Max Planck Institute for Meteorology, 3.Global Environment and Marine Department, Japan Meteorological Agency, 4.Woods Hole Research Center, 5.University of Exeter)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

convener:Kazuhito Ichii(Chiba University), Prabir Patra(Research Institute for Global Change, JAMSTEC), Forrest M. Hoffman(Oak Ridge National Laboratory), Makoto Saito(National Institute of Environmental Studies), Chairperson:Prabir Patra

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

[ACG32-07] Observing vegetation seasonal dynamics in Japan with Himawari-8 hypertemporal data

*Tomoaki Miura[1,2], Shin Nagai[2], Kazuhito Ichii[3], Hiroki Yoshioka[4] (1.University of Hawaii at Manoa, 2.Japan Agency for Marine-Earth Science and Technology, 3.Center for Environmental Remote Sensing, Chiba University, 4.Aichi Prefectural University)

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

[ACG32-08] Carbon and Water Fluxes at High spatial Resolutions through Down-Scaling

*Jiquan Chen[1], Pietro Sciusco[1], Ranjeet John[1], Zutao Ouyang[1] (1.Michigan State University)

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

[ACG32-09] **Connecting Satellite Based Spectral Modelling Approach and Forest Inventory to Model Biomass and Carbon Stocks in Natural and Planted Forest over part of Semi-arid zone, India**

*SWATI UNIYAL[1], Siti Raju Rao (1.Andhra University)

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

[ACG32-10] **Allocation of forest net primary production varies by forest age and air temperature**

*Xiang Song[1], Xiaodong Zeng[1], Dongxiao Tian[2] (1.IAP, CAS, 2.Beijing Meteorological Information Center)

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

[ACG32-11] Analyzing Model Biases in Terrestrial Carbon Cycle Submodels in Earth System Models and Offline Models

*Kazuhito Ichii[1], Kazutaka Murakami[2], Hiroaki Takayama[3], Tomohiro Hajima[3], Kaoru Tachiiri[3] (1.Chiba University, 2.National Institute for Environmental Studies, 3.Japan Agency for Marine-Earth Science and Technology)

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

[ACG32-12] Assessing terrestrial biogeochemical feedbacks in a strategically geoengineered climate

*Forrest M. Hoffman[1,2], Cheng-En Yang[2,1], Joshua S. Fu[2,1], Simone Tilmes[3], Lili Xia[4], Douglas G. MacMartin[5], Jadwiga H. Richter[3], Michael Mills[3], Ben Kravitz[6] (1.Oak Ridge National Laboratory, 2.University of Tennessee, 3.National Center for Atmospheric Research, 4.Rutgers University, 5.Cornell University, 6.Pacific Northwest National Laboratory)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 304 3F

[H-DS09] Landslides and related phenomena

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Gonghui Wang(Disaster Prevention Research Institute, Kyoto University), Fumitoshi Imaizumi(Faculty of Agriculture, Shizuoka University), Chairperson:Fumitoshi Imaizumi

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

[HDS09-01] Mechanical behavior modulated by shear surface morphology of simulated shear zone

*Yao Jiang[1], Gonghui Wang[2], Toshitaka Kamai[2] (1.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 2.Research Center on Landslide, Disaster Prevention Research Institute, Kyoto University, Japan)

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

[HDS09-02] On the Pre-failure Shear Behavior of Clayey Soil

*Chengrui Chang[1], Gonghui Wang[1] (1.Disaster Prevention Research Institute, Kyoto University)

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

[HDS09-03] **GeoGuard: low-cost GNSS sensors for the continuous monitoring of landslides and structures**

*Andrea Gatti[1], Giulio Tagliaferro[1], Eugenio Realini[1], Stefano Caldera[1] (1.Geomatics Research & Development srl)

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

[HDS09-04] **Landslide Susceptibility Analysis in the Chenyulan River Watershed, Taiwan**

*Po-Tsun Yeh[1], Kuang-Tsung Chang[1] (1.National Chung Hsing University, Taiwan)

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

[HDS09-05] Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

*Jamie Rhys Evans[1], Fumitoshi Imaizumi [1] (1.Faculty of Agriculture, Shizuoka University)

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

[HDS09-06] Landslides induced by the knickpoint migration in the southern and the eastern margins of the Tibetan Plateau.

*Masahiro Chigira[1], Ching-Ying Tsou[2], Siyuan Zhao[4], Xiong Wu[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Hirosaki University, 3.Souithwest Jiaotong University, 4.Graduate School of Science, Kyoto University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 304 3F

[H-DS09] Landslides and related phenomena

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Gonghui Wang(Disaster Prevention Research Institute, Kyoto University), Fumitoshi Imaizumi(Faculty of Agriculture, Shizuoka University), Chairperson:Wang Gonghui, Issei Doi

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

[HDS09-07] Landslides caused by the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*Shin-ichiro Hayashi[1], Nobutomo Osanai[1], Takashi Yamada[1], Shin'ya Katsura[1], Takahisa Furuichi[1], Seiji Yanai[2], Yasuharo Murakami[3], Tomoyoshi Miyazaki[4], Yuichiro Tanioka[1], Shigetaka Takiguchi[5], Mayumi Miyazaki[6] (1.Hokkaido University, 2.Ishikawa Prefectural University, 3.Civil Engineering Research Institute for Cold Region, PWRI, 4.Shin Engineering Consultant, Co., Ltd., 5.Ministry of Land, Infrastructure, Transport and Tourism, 6.Pasco Corporation)

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

[HDS09-08] On the coseismic landslides occurring on tephra slopes during the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*Gonghui Wang[1], Gen Furuya[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Toyama Prefectural University)

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

[HDS09-09] Seismological and geotechnical surveys on the landslides induced by the 2018 Hokkaido Eastern Iburi earthquake

*Issei Doi[1], Hikaru Osawa[2], Sumio Matsuura[1] (1.Disaster Prevention Research Institute, Kyoto University, 2.Mountain Science Center, University of Tsukuba)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 304 3F

[H-DS09] Landslides and related phenomena

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Gonghui Wang(Disaster Prevention Research Institute, Kyoto University), Fumitoshi Imaizumi(Faculty of Agriculture, Shizuoka University), Chairperson:Fumitoshi Imaizumi, Chigira Masahiro

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

[HDS09-10] Initiation conditions of debris flows in Ohsawa landslide, Mt. Fuji

★Invited Papers

*Fumitoshi Imaizumi[1], Kazuki Yamamoto[1], Atsushi Ikeda[4], Okihiro Ohsaka[1], Hiroyuki Sugimoto[2], Satoru Suzuki[2], Shinichi Sato[2], Yoshiaki Kashiwabara[3], Naoki Nishimura[3] (1.Faculty of Agriculture, Shizuoka University, 2.Fuji Sabo Office, Ministry of Land, Infrastructure and Transport, 3.Asia Air Survey Co., Ltd., 4.Faculty of Life and Environmental Sciences, Tsukuba University)

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

[HDS09-11] The role of thrust faults with incohesive clayey fault materials to generate deep-seated gravitational slope deformations and catastrophic landslides in the Shimanto accretionary complex

*Noriyuki Arai[1], Masahiro Chigira[1] (1.Disaster Prevention Research Institute,Kyoto University)

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

[HDS09-12] Control effect of huge faults on the structure of surrounding regional rock mass in the whole mountain: implications for the distribution pattern of coseismic landslides

*Chao HUANG[1,2], Yusheng LI[1], Chunhao WU[3], Shujian YI[1,3], Kai LIU[1,4], Gonghui WANG[2] (1.State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, China, 2.Disaster Prevention Research Institute, Kyoto University, Japan, 3.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 4.China Railway Eryuan Engineering Group CO. LTD, China)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 302 3F

[H-TT18] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Nobuhito Ohte(Department of Social Informatics, Graduate School of Informatics, Kyoto University), Gabriel J Bowen(University of Utah), Chairperson:Nobuhito Ohte(Kyoto University)

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

[HTT18-01] Environmental traceability methodology by multi-isoscapes

*Ichiro Tayasu[1], Lei Fujiyoshi[1], Shiho Yabusaki[1], Ki-Cheol Shin[1], Takanori Nakano[1], Makoto Taniguchi[1] (1.Research Institute for Humanity and Nature)

9:15 AM - 9:45 AM JST | 12:15 AM - 12:45 AM UTC

[HTT18-02] Exploring physical and biological connections using isoscapes

★Invited Papers

*Gabriel J Bowen[1] (1.University of Utah)

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

[HTT18-03] Spatial and temporal variations in stable isotopes and soluble ions on high mountain snow surface of Mt. Tateyama, Toyama Prefecture, Japan

*Nozomu Takeuchi[1], Ryo Sugiyama[1] (1.Chiba University)

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

[HTT18-04] Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters in a chert watershed.

*Masami Koshikawa[1], Mirai Watanabe[1], Tomoyoshi Murata[1], Takejiro Takamatsu[1], Shingo Miura[1], Ki-Cheol Shin[2], Takanori Nakano[2] (1.National Institute for Environmental Studies, 2.Research Institute for Humanity and Nature)

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

[HTT18-05] Influences of soil dust, sea salt and anthropogenic activities on ionic and Sr isotopic compositions of wet deposition in Iran

*Yoriko Yokoo[1], Kosuke Asai[1], Sae Horii[1], Ryo Anma[2], Shiva Mehrabani[3], KiCheol Shin[4] (1.Faculty of Science and Engineering, Doshisha University, 2.Tokushima University, 3.Kurdistan University, 4.RIHN)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 302 3F

[H-TT18] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Nobuhito Ohte(Department of Social Informatics, Graduate School of Informatics, Kyoto University), Gabriel J Bowen(University of Utah), Chairperson:Gabriel Bowen(The University of Utah)

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

[HTT18-06] Long-term increasing trend of line-conditioned excess in groundwater

*Masanori Katsuyama[1] (1.Graduate School of Agriculture, Kyoto University)

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

[HTT18-07] Geochemistry of river water in the Okayama and Tottori Prefectures, Japan

*Katsuyuki Yamashita[1], Takahiro Kamei[1], Yuga Kishimoto[1], Masahiko Mori[1], Aya Ooi[2], Ayaka Onishi[2], Yoko Kurihara[2], Hitoshi CHIBA[1], Takanori Nakano[3], Ki-Cheol Shin[4] (1.Graduate School of Natural Science and Technology, Okayama University, 2.Faculty of Science, Okayama University, 3.Ono City, 4.Research Institute for Humanity and Nature)

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

[HTT18-08] Study on groundwater flow system at Oshino Village in Yamanashi Prefecture – Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

*Shiho Yabusaki[1], Makoto Taniguchi[1], Ichiro Tayasu[1], Tomoya Akimichi[1], Noboru Ohomori[2], Ken Gotou[2], Souichirou Watanabe[2], Hitoshi Watanabe[2] (1.Research Institute for Humanity and Nature, 2.Oshino Village)

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

[HTT18-09] The hydrogen and oxygen isotopic compositions of water in the Chikusa River

*Ken'ichi Ohkushi[1], Shiho Yabusaki[2], Ichiro Tayasu[2], Lei Fujiyoshi[2], Takanori Nakano[2], Ki-Cheol Shin[2], Tadashi Yokoyama[3], Hiromune Mitsuhashi[4], Masayuki Itoh[1], Kazuki Yasugi[1] (1.Kobe University, 2.The Research Institute for Humanity and Nature, 3.Ako School for Students with Special Ne, 4.University of Hyogo)

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

[HTT18-10] Dynamics of sulfate and nitrate inferred from stable isotope techniques in Chikusa river watershed, Hyogo Prefecture

*Lei Fujiyoshi[1], Ichiro Tayasu[1], Shiho Yabusaki[1], Takashi F Haraguchi[1], Chikage Yoshimizu[1], Ken'ichi Ohkushi[2], Fumiko Furukawa[2], Masayuki Itoh[2], Yudai Yamamoto[3], Tadashi Yokoyama[4], Hiromune Mitsuhashi[5] (1.The Research Institute for Humanity and Nature, 2.Kobe University, 3.Nagoya University, 4.Hyogo prefectural Ako School for Students with Special Needs, 5.University of Hyogo)

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

[HTT18-11] Chemistry and sulfur and oxygen isotope ratios of sulfate ion of water soluble component of suspended particulate matter at Okayama city.

*Hitoshi CHIBA[1], Tsubasa Yamamoto[1] (1.Graduate School of Natural Science and Technology, Okayama University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 302 3F

[H-TT18] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Nobuhito Ohte(Department of Social Informatics, Graduate School of Informatics, Kyoto University), Gabriel J Bowen(University of Utah), Chairperson:Ichiro Tayasu(Research Institute for Humanity and Nature)

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

[HTT18-12] **Do mountain-climbing mammals protect plants from global warming by their vertical seed dispersal?**

*Shoji NAOE[1], Ichiro Tayasu[2] (1.Forestry and Forest Products Research Institute, Forest Research and Management Organization, 2.Research Institute for Humanity and Nature)

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

[HTT18-13] Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

*Takashi F Haraguchi[1], Ryosuke Koda[2], Ichiro Tayasu[1] (1.Research Institute for Humanity and Nature, 2.RIEAF, Osaka)

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

[HTT18-14] Nutrient supply from forest to river in eastern Toyama: carbon and nitrogen isotopic composition of Epilithic Organic Matter

*JING ZHANG[1], Ryosuke Masuda[1], SAKI KATAZAKAI[1], Tamihisa Ohta[1], OSAMU INAMURA[2], Fumiko Nakagawa[3] (1.University of Toyama, 2.Uozu Aquarium, 3.Nagoya University)

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

[HTT18-15] Investigation on the possibility of the identification of air pollutant sources using stable isotope ratios of lead and strontium

*Shinji Sakurai[1], Takao Nakagiri[1], Kosuke Tanaka[1], Haruhiko Horino[1], Ki-Cheol Shin[2], Ichiro Tayasu[2], Shiho Yabusaki[2] (1.Osaka Prefecture University, 2.Research Institute for Humanity and Nature)

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

[HTT18-16] **Magnesium and zinc stable isotopes in stream ecology**

*Kai Nils Nitzsche[1], Yoshikazu Kato[1], Ki-Cheol Shin[1], Hiromitsu Kamauchi[1], Ichiro Tayasu[1] (1.Research Institute for Humanity and Nature)

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

[HTT18-17] A mechanitic metabolic model of nitrogen stable isotope dynamics in trophic processes

*Reiichiro Ishii[1], Maki Noguchi Aita[2], Eitaro Wada (1.Research Institute for Humanity and Nature, 2.Japan Agency for Marine-Earth Science and Technology)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 302 3F

[H-CG28] Implementing Integrated Research for Sustainable Future

convener:Yukio Himiyama(Emeritus Professor, Hokkaido University of Education), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), Takeshi Sakurai(Graduate School of Agricultural and Life Sciences, The University of Tokyo), Kenichi Abe(Research Institute for Humanity and Nature), Chairperson:Ernan Rustiadi(Bogor Agricultural University), Qinxue Wang(National Institute for environmental Studies), takeshi sakurai

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

[HCG28-01] Implementing Integrated Research for Sustainable Future - a human geoscience perspective

*Yukio Himiyama[1] (1.Emeritus Professor, Hokkaido University of Education)

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

[HCG28-02] **Application of environmental carrying capacity analysis and land cover change scenarios in collaborative spatial planning process: The Jakarta Megacity Case**

★Invited Papers

*ERNAN RUSTIADI[1], Andrea Emma Pravitasari[2], Diar Shiddiq[1], Laode Syamsul Iman[1], Setyardi Pratika Mulya[2], Mia Ermyanila[1], Nur Etika Karyati[1] (1.Center for Regional System Analysis, Planning and Development, Bogor Agricultural University , 2.Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University)

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

[HCG28-03] Does the Market Economy Save the Local Natural Resources While Improving Human Welfare? The Case of 101 Natural Forests in the Middle Hills of Nepal

*Takeshi Sakurai[1], Towa Tachibana[2], Santosh Rayamajhi [3] (1.The University of Tokyo, 2.Chiba University , 3.Tribhuvan University)

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

[HCG28-04] Academic-public-private partnerships for sustainable herding under increasing frequency of climate hazards

*Masato Shinoda[1] (1.Graduate School of Environmental Studies Nagoya University)

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

[HCG28-05] Land use after death and funeral of citizen mainly based on public cemeteries in modern Beijing city

*Haruhiro Doi[1], Yanwei Chai[2], Peiwei Xu[3] (1.Faculty of Education, Oita University, 2.Peking University, 3.Beijing Normal University)

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

[HCG28-06] Restoration and sustainable land management of degraded landscapes in Asia and Africa

★Invited Papers

*OKURO TOSHIYA[1] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

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

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

[S-SS06] Nankai Trough Seismogenic Zone Experiment: Logging and sampling the seismogenic megathrust

convener:Kyuichi Kanagawa(Graduate School of Science, Chiba University), Demian M Saffer(Pennsylvania State University), Masataka Kinoshita(Earthquake Research Institute, University of Tokyo), Chairperson:Kyuichi Kanagawa(Graduate School of Science, Chiba University), Demian Saffer(Department of Geosciences, Pennsylvania State University), Masataka Kinoshita(Earthquake Research Institute, the University of Tokyo)

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

[SSS06-01] Geoscientific information about plate boundary along the Nankai Trough provided by the GNSS-A

★Invited Papers

*Yusuke Yokota[1], Tadashi Ishikawa[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic department, Japan Coast Guard)

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

[SSS06-02] Deep Drilling at the Nankai Trough: IODP NanTroSEIZE Expedition 358 Summary and First Results

★Invited Papers

*Harold Tobin[1], Takehiro Hirose[7], Matt Ikari[5], Kyuichi Kanagawa[10], Gaku Kimura[3], Masataka Kinoshita[8], Hiroko Kitajima[6], Demian M Saffer[4], Asuka Yamaguchi[9], Lena Maeda[2], Nobu Eguchi[2], Sean Toczko[2] (1.Department of Earth and Space Sciences, University of Washington, 2.JAMSTEC-CDEX, 3.Tokyo Un. of Marine Science-Technology, 4.Penn State University, 5.MARUM Un. of Bremen, 6.Texas A&M University, 7.JAMSTEC-KCC, 8.Un. of Tokyo Earthquake Research Institute, 9.Un. of Tokyo AORI, 10.Chiba University)

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

[SSS06-03] Coexistence of soft and hard sediments at deep Nankai accretionary prism, NanTro SEIZE Project, IODP Exp.358

*Arito Sakaguchi[1,2], Michael Strasser[3], Mari Hamahashi[4,5], Takehiro Hirose[2], Hiroko Kitajima[6], Expedition 358 Scientists IODP (1.Yamaguchi Univ., 2.JAMSTEC, 3.University of Innsbruck, 4.University of Tokyo, 5.Nanyang Technological University, 6.Texas A&M University)

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

[SSS06-04] Active and passive seismic experiment during the IODP Exp. 358 deep riser drilling in the Nankai Trough, Japan

*Toshinori Kimura[1], Takashi Tonegawa[1], Kazuya Shiraishi[1], Eiichiro Araki[1], Yasuyuki Nakamura[1], Yuka Kaiho[1], Gou Fujie[1], Seiichi Miura[1], Shuichi Kodaira[1], Noriaki Sakurai[1], Yoshinori Sanada[1], Yukari Kido[1], Masataka Kinoshita[2], Narumi Takahashi[3,1], Yuya Machida[1], Shuhei Nishida[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience)

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

[SSS06-05] Microfabric analysis of damaged zone of principal shear zone in the frontal megathrust in the Nankai Trough

*Gaku Kimura[1], Asuka Yamaguchi[2], Yohei Hamada[3], Suguru Yabe[4] (1.Tokyo University of Marine Science and Technology, 2.Atomosphere and Ocean Research Institute, The University of Tokyo, 3.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 4.Japan Agency for Marine-Earth Science and Technology)

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

[SSS06-06] Seismic Imaging of Mud Diapirs in Northern Kumano Basin, Nankai Trough

*Gregory F Moore[1], Miho Asada[2], Shuichi Kodaira[2], Achim Kopf[3] (1.University of Hawaii at Manoa, 2.JAMSTEC, 3.MARUM)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Kenji Kawai, Sebastian Ritterbex

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

[SIT21-19] Seismological Explorations of Earth's Outer Core: Normal Mode and Body Wave Analyses

★Invited Papers

*Jessica C E Irving[1], Sanne Cottaar[2], Vedran Lekic[3], Wenbo Wu[4] (1.Princeton University, 2.University of Cambridge, 3.University of Maryland, College Park, 4.California Institute of Technology)

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

[SIT21-20] Discussion

*Kenji Kawai[1] (1.University of Tokyo)

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

[SIT21-21] On the 1-D radial convective structure of the Earth’s core inferred from a coupled core-mantle evolution model

*Takashi Nakagawa[1] (1.Department of Earth Sciences, The University of Hong Kong)

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

[SIT21-22] Structural and transport properties of liquid iron-light-element mixtures under outer core conditions

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Inst. of Tech., 2.Ehime Univ.)

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

[SIT21-23] Development of New Technology for Geoneutrino Directional Measurement

*Hiroko Watanabe[1] (1.Research Center for Neutrino Science, Tohoku University)

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

[SIT21-24] Investigation of multi light elements in iron-silicate-water system using high pressure and temperature neutron experiments: Implications for the Earth's evolution

★Invited Papers

*Riko Iizuka-Oku[1], Hirotada Gotou[2], Ko Fukuyama[1], Hiroyuki Kagi[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.The Institute for Solid State Physics, The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Noriyoshi Tsujino, Kenta Ueki

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

[SIT21-25] Low hydrogen contents in the cores of terrestrial planets

★Invited Papers

*Vincent Clesi[1], Mohamed Ali Bouhifd[2], Nathalie Bolfan-Casanova[2], Geeth Manthilake[2], Federica Schiavi[2], Caroline Raepsaet[3], Hélène Bureau[4], Hicham Khodja[3], Denis Andrault[2] (1.Laboratoire de Geologie de Lyon - Terre, Planètes, Environnement, Université Claude Bernard Lyon 1, CNRS, ENS-Lyon, 69622 Villeurbanne, France., 2.Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS UMR 6524, OPGC–IRD, Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France., 3.Laboratoire d'Etude des Eléments Légers, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif sur Yvette Cedex, France., 4.Institut de Minéralogie et de Physique de la Matière et de Cosmochimie, Sorbonne Universités, UMR CNRS-UPMC 7590, 4 place Jussieu, 75252 Paris, France.)

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

[SIT21-26] Discussion

*Taku Tsuchiya[1] (1.Geodynamics Research Center, Ehime University)

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

[SIT21-27] Fe_2S: the most iron-rich Fe-S compound at pressures of the inner core

*Shigehiko Tateno[1,2], Haruka Ozawa[2,3], Kei Hirose[1,4], Toshihiro Suzuki[5] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Institute for Planetary Materials, Okayama University, 3.Nuclear Science and Engineering Center, Japan Atomic Energy Agency, 4.Department of Earth and Planetart Science, The University of Tokyo, 5.Geochemical Research Center, The University of Tokyo)

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

[SIT21-28] First-principles Investigation of Iron Diffusion Properties with Implications to Inner Core Plasticity

★Invited Papers

*Sebastian Ritterbex[1], Taku Tsuchiya[1] (1.GRC Ehime University)

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

[SIT21-29] Dependence of the dipole component dominancy on the Rayleigh number and inner core size in geodynamo simulations

*Yuki Nishida[1], Yuto Katoh[1], Hiroaki Matsui[2], Masaki Matsushima[3], 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)

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

[SIT21-30] Elasticity of Fe-Si Alloy

*Taku Tsuchiya[1], Yu Fukunaga[1] (1.Geodynamics Research Center, Ehime University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP29] Oceanic and Continental Subduction Processes

convener:REHMAN Ur Hafiz(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University), Tatsuki Tsujimori(Tohoku University), Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University), Kazuaki Okamoto(Faculty of Education, Saitama University), Chairperson:Hafiz REHMAN(Kagoshima University), Tatsuki Tsujimori

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

[SMP29-01] Pb-isotope of Fe-Ni alloy associated with serpentinite: Geochemical constraints on the fluid-mediated hyper-reducing environment in mantle wedge

★Invited Papers

*Mayu Kakefuda[1], Tatsuki Tsujimori[1], Katsuyuki Yamashita[2], Yoshiyuki Iizuka[3] (1.Tohoku University, 2.Graduate School of Natural Science and Technology, Okayama University, 3.Institute of Earth Sciences, Academia Sinica)

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

[SMP29-02] PETROCHEMISTRY AND AGE DETERMINATION OF THE NEWLY DISCOVERED ECLOGITE IN THE WESTERN MONGOLIA

*Kosuke Naemura[1], Erdenjargal Choindonjamts[4], Takenori Kato[5], Otgonkhuu Javkhlan[3], Katsuyoshi Michibayashi[2] (1.Nagoya University Museum, 2.Nagoya University Graduate school of environmental studies, 3.Chinese Academy of Geological Sciences, 4.Mongolian Academy of Sciences, 5.Nagoya University Space-Earth Environmental Research)

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

[SMP29-03] **Continental subduction, "*Intraslab UHP Metasomatism*", and the formation of metamorphic diamond**

★Invited Papers

*Yoshihide Ogasawara[1] (1.Department of Earth Sciences, Waseda University)

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

[SMP29-04] Ultrahigh-pressure pseudotachylyte in a marble

★Invited Papers

*Tadao Nishiyama[1], Tomoya Fujimoto[1] (1.Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University)

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

[SMP29-05] Dehydration and Deformation process of subducted large Oceanic Pleateau -case study of the Mikabu blueschist-

*Kazuaki Okamoto[1] (1.Faculty of Education, Saitama University)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP29] Oceanic and Continental Subduction Processes

convener:REHMAN Ur Hafiz(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University), Tatsuki Tsujimori(Tohoku University), Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University), Kazuaki Okamoto(Faculty of Education, Saitama University), Chairperson:Tsai Chin-HO(National Dong Hwa University), Hafiz REHMAN(Kagoshima University)

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

[SMP29-06] Unusually high Nb/Ta ratio of fluid-precipitated jadeites from New Idria serpentinite body, California: Implications for extreme fractionation in slab fluids

*Naoko Takahashi[1], Tatsuki Tsujimori[2], Qing Chang[3], Jun-Ichi Kimura[3] (1.Graduate School of Science, Tohoku Univ., 2.CNEAS, Tohoku Univ., 3.Department of Solid Earth Geochemistry, JAMSTEC)

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

[SMP29-07] The collision process interpreted using the systematic change of metamorphic pattern along theQinling–Dabie–Odesan collisional belt between the North and South Korea-China Cratons

★Invited Papers

*Chang Whan Oh[1,2] (1.Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea, 2.Environmental Science System Research Center, Chonbuk National University,Jeonju, Republic of Korea)

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

[SMP29-08] Contrasting collision processes between northwest and central Himalaya: examination from the "Lesser Himalayan granites” in Pakistan

*Masatsugu Ogasawara[1], Mayuko Fukuyama[2], Rehanul H Siddiqui[3] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Graduate School of Engineering Science, Akita University, 3.Balochistan University of Information Technology, Engineering and Management Sciences)

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

[SMP29-09] New petrologic indications of subduction metamorphism in the Yuli belt, eastern Taiwan

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Dominikus Deka Dewangga[1], Yui Kouketsu[2], Masaki Enami[3] (1.Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2.Department of Earth & Planetary Sciences, Nagoya Univ., 3.Institute for Space-Earth Environmental Research, Nagoya Univ.)

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

[SMP29-10] **The importance of Mn-nodules on the sea floor during subduction for the formation of ophiolitic diamond**

*Richard Wirth[1] (1.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences 3.5 Surface Geochemistry)

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

[SMP29-11] **Along-strike variability of primitive magmas inferred from olivine-hosted melt inclusions, southernmost Andean Southern Volcanic Zone, Chile**

*Derek Weller[1,2], Charles R Stern[2] (1.Earthquake Research Institute, 2.University of Colorado)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP30] Crust-Mantle Connections

convener:Yoshihiko Tamura(Research Institute for Marine Geodynamics, Japan Agency for Maine-Earth Science and Technology), Osamu Ishizuka(Geological Survey of Japan, AIST), Chris Conway(Geological Survey of Japan), Chairperson:Yoshihiko Tamura(JAMSTEC), Chris Conway, Tomoaki Morishita(Kanazawa University)

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

[SMP30-01] **Noble gas and carbon isotopic compositions of petit-spot lavas from southeast of Marcus Island**

★Invited Papers

*Junji Yamamoto[1], Tetsuma Kawano[2], Naoto Takahata[3], Yuji Sano[3] (1.Hokkaido University Museum, 2.Graduate School of Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute)

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

[SMP30-02] A series of cummingtonite-bearing rhyolites in Niijima, Izu-Bonin arc, Japan: petrological and geochemical constraints

★Invited Papers

*Yoji Arakawa[1], Daisuke Endo[2], Junya Oshika[3], Taro Shinmura[4], Kei Ikehata[1] (1.Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Shimane Prefectural Sanbe Nature Museum Sahimeru (Shimane) , 3.Earth Resoueces Faculty, China University of Geosciences, 4.Faculty of Economics, Kumanoto-Gakuen University)

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

[SMP30-03] **Generation of primary andesitic magma in oceanic arcs: Evidence from Kibblewhite Volcano, Kermadec Arc**

★Invited Papers

*Yasuhiro Hirai[1,2], Yoshihiko Tamura[2], Kaj Hoernle[3], Christian Timm[4], Folkmar Hauff[3], Reinhard Werner[3], Bogdan Vaglarov[2], Qing Chang[2], Takashi Miyazaki[2], Jun-Ichi Kimura[2] (1.Graduate School of Natural Science and Technology, Kanazawa University, Japan, 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Kanagawa, Japan, 3.GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany, 4.GNS Science, Lower Hutt, New Zealand)

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

[SMP30-04] Petrogenesis of high-Mg# andesite lavas from Ruapehu volcano, New Zealand

*Chris Conway[1], Katy Chamberlain[2], Yumiko Harigane[1], Daniel Morgan[3] (1.Geological Survey of Japan, 2.Univ. Derby, 3.Univ. Leeds)

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

[SMP30-05] Hydrous felsic magma generated by unmixing of slab-derived supercritical liquid: evidence from Rishiri Volcano, Kuril Arc

★Invited Papers

*Hajime Taniuchi[1], Takeshi Kuritani[2,3], Tetsuya Yokoyama[4,3], Eizo Nakamura[3], Mitsuhiro Nakagawa[2] (1.Department of Natural History Science, Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Science, Faculty of Science, Hokkaido University, 3.Institute for Planetary Materials, Okayama University, 4.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

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

[SMP30-06] Genesis of recent mafic volcanism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of cataclysmic caldera-forming systems?

*Georg F Zellmer[1], Jun-Ichi Kimura[2], Claudine Stirling[3], Gert Lube[1], Phil A Shane[4] (1.Volcanic Risk Solutions, Massey University, Tennent Drive, Palmerston North 4410, New Zealand, 2.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology [JAMSTEC], Natsushima-cho 2-15, Yokosuka 237-0061, Japan, 3.Department of Chemistry, University of Otago, Dunedin 9054, New Zealand, 4.School of Environment, University of Auckland, Auckland 1142, New Zealand)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP30] Crust-Mantle Connections

convener:Yoshihiko Tamura(Research Institute for Marine Geodynamics, Japan Agency for Maine-Earth Science and Technology), Osamu Ishizuka(Geological Survey of Japan, AIST), Chris Conway(Geological Survey of Japan), Chairperson:Chris Conway, Yoshihiko Tamura(JAMSTEC)

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

[SMP30-07] **Introducing an oceanic core complex in the Shikoku Basin: Mado Megamullion**

★Invited Papers

*Yasuhiko Ohara[1,2], Kyoko Okino[3], Norikatsu Akizawa[3], Masakazu Fujii[4], Yumiko Harigane[5], Naoto Hirano[6], Ken-ichi Hirauchi[7], Osamu Ishizuka[5], Shiki Machida[8], Katsuyoshi Michibayashi[9], Alessio Sanfilippo[10], Jonathan E. Snow[11], Hiroyuki Yamashita[12] (1.Hydrographic and Oceanographic Department of Japan, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmosphere and Ocean Research Institute, University of Tokyo, 4.National Institute of Polar Research, 5.Geological Survey of Japan/AIST, 6.Tohoku University, 7.Shizuoka University, 8.Chiba Institute of Technology, 9.Nagoya University, 10.University of Pavia, 11.University of Houston, 12.Kanagawa Prefectural Museum of Natural History)

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

[SMP30-08] Spatial variation of petrological and geochemical characteristics of mantle peridotites in Mado Megamullion, Shikoku Basin

*Norikatsu Akizawa[1], Shiki Machida[2], Kyoko Okino[1], Yasuhiko Ohara[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Hydrographic and Oceanographic Department of Japan)

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

[SMP30-09] **Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres**

★Invited Papers

*Mathieu Rospabe[1,2], Mathieu Benoit[1], Georges Ceuleneer[1] (1.GET, OMP, Univ. of Toulouse, CNRS, IRD, F-31400 Toulouse, France, 2.JAMSTEC, Yokosuka 237-0061, Japan.)

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

[SMP30-10] **Serpentinization and carbonation of dunites in the western part of the Isua Supracrustal Belt, Southwestern Greenland**

*Juan Miguel Ramirez Guotana[1], Tomoaki Morishita[1], Akihiro Tamura[1], Ikuya Nishio[1], Kenichiro Tani[2], Yumiko Harigane[3], Kristoffer Szilas[4], D. Graham Pearson[5] (1.Kanazawa University, 2.National Museum of Nature and Science, Japan, 3.Institute of Geology and Geoinformation Geological Survey of Japan/AIST, 4.University of Copenhagen, 5.University of Alberta)

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

[SMP30-11] **Petrogenesis of fertile abyssal peridotites of the Pujada Ophiolite, SE Mindanao, Philippines**

*Valerie Shayne Vargas Olfindo[1], Betchaida Duetes Payot[1], Gabriel Theophilus Valera[1], Shoji Arai[2], Tomoyuki Shibata[4], Masako Yoshikawa[3] (1.Rushurgent Working Group, National Institute of Geological Sciences, University of the Philippines, 2.Department of Earth Sciences, Kanazawa University, Kakuma, Kanazawa, Ishikawa 920-1192, Japan, 3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, Beppu 874-0903, Japan, 4.Department of Earth and Planetary Systems Science, Hiroshima University, Hiroshima 739-8526, Japan)

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

[SMP30-12] Ultramafic rock in the Hida metamorphic belt: an example of arc plutons

Yohei Ogusu[1], *Tomoaki Morishita[1], Akihiro Tamura[1] (1.Kanazawa University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP31] Supercontinents and Crustal Evolution

convener:Madhusoodhan Satish-Kumar(Department of Geology, Faculty of Science, Niigata University), Tomokazu Hokada(National Institute of Polar Research), Krishnan Sajeev(Centre for Earth Sciences, Indian Institute of Science), Yasuhito Osanai(Division of Evolution of Earth Environments, Faculty of Social and Cultural Studies, Kyushu University), Chairperson:M. Satish-Kumar(Niigata University), Tomokazu Hokada(National Institute of Polar Research)

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

[SMP31-01] Tectonic development of the East Indian cratonic margin and its status in Columbia Supercontinent

★Invited Papers

*Kaushik Das[1] (1.Hiroshima University)

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

[SMP31-02] **Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India**

★Invited Papers

*VINOD O SAMUEL[1] (1.Yonsei University)

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

[SMP31-03] Preliminary paleomagnetic studies on the mafic dykes in Western Dharwar craton, South India.

*Silpa Ammini Sasidharan[1], Madhusoodhan Satish-Kumar[2], Naoto Ishikawa[3], Krishnan Sajeev[4] (1.Graduate School of Science and Technology, Niigata University, 2.Department of Geology, Faculty of Science, Niigata University, 3.Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan, 4.Centre for Earth Sciences, Indian Institute of Science, Bangalore, India)

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

[SMP31-04] Syn-metamorphic boron-bearing fluid infiltrations deduced from tourmaline in the Main Central Thrust zone, eastern Nepal Himalayas

★Invited Papers

*Tetsuo Kawakami[1], Harutaka Sakai[1], Katsushi Sato[1] (1.Graduate School of Science, Kyoto University)

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

[SMP31-05] **Geochemical characteristics of mafic and felsic igneous rocks (1.9-1.75 Ga) in the Lesser Himalaya: Regional variation and its implications for tectonic setting**

*Ryuichi Shinjo[1], Tomoki Amuro[1], Kohei Oura[1], Kazuya Oshiro[1], Shiro Tahara[1], Harutaka Sakai[2] (1.Department of Physics and Earth Sciences, University of the Ryukyus, 2.Faculty of Science, Kyoto University)

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

[SMP31-06] Petrogenesis and tectonic implications of orbicular granodiorite from Yangtze cratonic nucleus

*Yihe Li[1] (1.China University of Geosciences Wuhan)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-CG49] Hard-Rock Drilling Science: From Continental to Deep Sea Drilling, and Oman Project

convener:Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Eiichi TAKAZAWA(Department of Geology, Faculty of Science, Niigata University), Norikatsu Akizawa(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Eiichi Takazawa(Niigata University), Norikatsu Akizawa(AORI The University of Tokyo)

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

[SCG49-06] Melt transport and compositional heterogeneity of the mantle: a case study of peridotite, dunite, and wehrlite from Atlantis Massif

*Norikatsu Akizawa[1], Gretchen L. Früh-Green[2], Akihiro Tamura[3], Chiori Tamura[1], Tomoaki Morishita[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth Sciences, Eidgenössische Technische Hochschule-Zürich, 3.Institute of Science and Engineering, Kanazawa University)

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

[SCG49-07] **Lower crustal accretion processes revealed from the study of gabbroic cores in Holes GT1A and GT2A, the ICDP Oman Drilling Project**

*Sayantani Chatterjee[1], Eiichi TAKAZAWA[1], Katsuyoshi Michibayashi[2], Peter B Kelemen[3], Damon A.H. Teagle[4], Oman Drilling Project Phase I Science Party (1.Department of Geology, Faculty of Sciences, Niigata University, Japan, 2.Department of Earth and Environmental Sciences, Nagoya University, Japan, 3.Lamont Doherty Earth Observatory, Columbia University, USA, 4.Southampton Marine and Maritime Institute, University of Southampton, United Kingdom)

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

[SCG49-08] Petrology of Oman listvenite : Implications for carbon cycle in the subduction zone

*Toma Takahashi[1], Tomoaki Morishita[2], Hiroki Sato[3], Juan Miguel Guotana[2], Tatsuhiko Kawamoto[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 science Party (1.Faculty of Geosciences and Civil Engineering, Kanazawa university, 2.Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa university, 3.Faculty of Science, Kyoto university, 4.Department of Geoscience, Faculty of Science, Shizuoka university, 5.Lamont-Doherty Earth Observatory, Columbia university, 6.School of Ocean and Earth Science, National Oceanography Center Southampton, University of Southampton, 7.School of Geography, Earth and Environmental Sciences, Plymouth University, 8.Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya university, 9.Institute of Science and Technology, Niigata university)

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

[SCG49-09] PGE and Os isotope variation in the gabbros and peridotites from the Oman DP drilling cores in the Samail ophiolite, Oman

*Ryoko Senda[1,2], Katsuhiko Suzuki[2], Tomoaki Morishita[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Damon AH Teagle[7], Jude Ann Coggon[7], Marguerite Godard[8], The Oman DP Science Party (1.Faculty of Social and Cultural Studies, Kyushu University, 2.Research and Development Center for Submarine Resources, JAMSTEC, 3.School of Natural System, Colleage of Science and Technology, Kanazawa University, 4.SDepartment of Geology, Faculty of Science, Niigata University, 5.Department of Earth and Planetary Sciences, Nagoya University, 6.Columbia University, 7.University of Southampton, 8.Géosciences Montpellier)

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

[SCG49-10] Overview of drilling of crust-mantle boundary at CM1&2 sites of Wadi Tayin massif of Oman ophiolite: the ICDP Oman Drilling Project

*Eiichi TAKAZAWA[1], Damon A H Teagle[2], Katsuyoshi Michibayashi[3], Yoshihiko Tamura[4], Jude Ann Coggon[2], Juerg Matter[2], Peter B Kelemen[5], Oman Drilling Project Phase 2 Science Party (1.Department of Geology, Faculty of Science, Niigata University, 2.University of Southampton, 3.Nagoya University, 4.JAMSTEC, 5.Columbia University)

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

[SCG49-11] Petrological observation of core samples drilled from a mantle section of the Oman ophiolite: A preliminary report of the Oman Drilling Project Phase 2

*Yuji Ichiyama[1], Oman Drilling Project Phase 2 Scientific Party (1.Chiba University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-CG49] Hard-Rock Drilling Science: From Continental to Deep Sea Drilling, and Oman Project

convener:Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Eiichi TAKAZAWA(Department of Geology, Faculty of Science, Niigata University), Norikatsu Akizawa(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Tomoaki Morishita(Kanazawa University), Katsuyoshi Michibayashi

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

[SCG49-12] Structural analyses of ultramafic rocks used by X-ray CT core imaging (Oman Drilling Project Phase 2, D/V CHIKYU)

*Katsuyoshi Michibayashi[1], Yuki Kakihata[1], Ikuo Katayama[2], Atsushi Okamoto[3], Keishi Okazaki[4], Peter B Kelemen[5], Eiichi TAKAZAWA[6], Damon A H Teagle[7], Oman Drilling Project Phase 2 Science Party[8] (1.Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 2.Hiroshima University, 3.Tohoku University, 4.KCC, JAMSTEC, 5.Columbia University of New York, 6.Niigata University, 7.Southampton University, 8.ICDP)

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

[SCG49-13] Petrophysical characteristics of serpentinized peridotites of Hole BA1B, BA3A and BA4A

*Kakihata Yuki[1], Katsuyoshi Michibayashi[2], Laura Crispini[3], Bjorn Jamtveit[4], Samuel Barbier[5], Joe Aslin[6], Manuel Menzel[7], Marguerite Godard[8] (1.Graduate School of Science, Shizuoka University, 2.Graduate School of Environmental Studies, Nagoya University, 3.University of Genova, 4.University of Oslo, 5.Claude Bernard University Lyon 1, 6.University of Liverpool, 7.Andalusian Earth Science Institute, 8.Géosciences Montpellier, CNRS, Univ. Montpellier)

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

[SCG49-14] Physical properties of the Moho TZ: Implications from ICDP Oman Drilling Project Phase I & II on-board measurements

*Natsue Abe[1,12], Keishi Okazaki[1], Ikuo Katayama[2], Kohei Hatakeyama[2], Yuya Akamatsu[2], Benoit Ildefonse[3], Ulven Ivar Ole[4], Gilvert Hong[5], Wenlu Zhu[6], Benoit Cordonnier[4], Katsuyoshi Michibayashi[7], Eiichi TAKAZAWA[8], Michell Harris[10], Damon Teagle[11], Peter Kelemen[9], Marguerite Godard[3], Jurg Matter[11], Jude Coggon[11], Oman Drilling Project Scientific Party (1.Japan Agency for Marine-Earth Science and Technology, 2.Hiroshima University, 3.Universitè de Montpellier, 4.University of Oslo, 5.Seoul National University, 6.University of Maryland, 7.Nagoya University, 8.Niigata University, 9.Columbia University, 10.Polymouth University, 11.University of Southampton, 12.Kanazawa University)

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

[SCG49-15] Seismic anisotropy under high pressure conditions of harzburgite collected from Oman Drilling Project Phase II

*Kohei Hatakeyama[1], Ikuo Katayama[1], Natsue Abe[2], The Oman Drilling Project Phase II Science Party (1.Department of earth and planetary systems science, Hiroshima University , 2.JAMSTEC)

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

[SCG49-16] Understanding of the mode of seafloor spreading and the architecture of upper oceanic crust by oceanfloor drilling at off-Hawaii MoHole candidate site

*Susumu Umino[1], Tomoaki Morishita[1], Mikiya Yamashita[2], Osamu Ishizuka[3] (1.Department of Earth Sciences, Kanazawa University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Geological Survey of Japan, AIST)

[E] Oral | B (Biogeosciences)：B-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201A 2F

[B-CG06] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Shingo Kato(RIKEN), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yuki Morono(JAMSTEC), Masanori Kaneko(AIST/GSJ), Shingo Kato(RIKEN)

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

[BCG06-01] Earth as an open system to the Universe, and five multi-layered spheres to produce a habitable planet

*Shigenori Maruyama[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology)

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

[BCG06-02] Holocene Antarctic subglacial weathering and ice-sheet history reconstructed using the $^{10}Be/^{9}Be$ ratios of lake Maruwan Oike sediments

*Adam David Sproson[1], Yusuke Yokoyama[1,2], Yoshinori Takano[2], Yosuke Miyairi[1], Takahiro AZE[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Biogeochemistry, Japan Agency for Marine Science and Technology)

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

[BCG06-03] Chemical speciation and solubility of heavy elements (lead, zinc, copper, arsenic and cadmium) in contaminated soil from Kamegai mine tailing, Toyama, Japan

*Baasansuren Gankhurel[1], Keisuke Fukushi[2], Akitoshi Akehi[1], Yoshio Takahashi[3], Kazuo Kawasaki[4] (1.Graduate School of Natural Science and Technology, Kanazawa University, 2.Instutute of Nature and Environmental Technology, Kanazawa University, 3.Department of Earth and Planetary Science, The University of Tokyo, 4.Graduate School of Science and Engineering for Research, Toyama University)

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

[BCG06-04] High-mass resolution molecular imaging of organic compounds on the Murchison meteorite.

★Invited Papers

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

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

[BCG06-05] Fe(II) oxidation processes at the surface of bacterially colonized iron deposits

★Invited Papers

*Fumito Shiraishi[1], Kohei Nakao[1], Chizuru Takashima[2], Akihiro Kano[3], TAKAAKI ITAI[3] (1.Hiroshima University, 2.Saga University, 3.The University of Tokyo)

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

[BCG06-06] Heme: The distribution and dynamics of a ubiquitous iron-tetrapyrrole molecule

*Yuta Isaji[1], Yoshinori Takano[1], Nanako O. Ogawa[1], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology)

[E] Oral | B (Biogeosciences)：B-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201A 2F

[B-CG06] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Shingo Kato(RIKEN), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yoshinori Takano(JAMSTEC), Keisuke Fukushi, Yohey Suzuki(Univ. Tokyo)

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

[BCG06-07] Diversity and evolution of biosynthetic enzymes for chlorophyll pigments

★Invited Papers

*Yusuke Tsukatani[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

11:00 AM - 11:20 AM JST | 2:00 AM - 2:20 AM UTC

[BCG06-08] **Microdolomites are not MDACs: microbially-derived carbon source for microcrystalline dolomite found within massive gas hydrates and implications for the shallow marine carbon cycle**

★Invited Papers

*Glen Snyder[1], Ryo Matsumoto[1], Naizhong Zhang[1], Yoshihiro Kakizaki[2], Yohey Suzuki[2], Yuji Sano[3], Naoto Takahata[3], Kentaro Tanaka[3], Takumi Imajo[5], Stephen Bowden[4] (1.Gas Hydrate Research Laboratory, Meiji University, 2.University of Tokyo, 3.AORI, University of Tokyo, 4.University of Aberdeen, Scotland, 5.Tokyo University of Marine Science and Technology)

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

[BCG06-09] **Discriminative biogeochemical signatures of methanotrophs inhabiting different chemosynthetic fields in an active mud volcano of the Canadian Beaufort Sea**

*Dong-Hun Lee[1], Yung Mi Lee[2], Jung-Hyun Kim[2], Young Keun Jin[2], Charles Paull[3], Helge Niemann[4,5], Ji-Hoon Kim[6], Kyung-Hoon Shin[1] (1.Hanyang Univ., 2.KOPRI, 3.MBARI, 4.NIOZ and Utrecht Univ., 5.CAGE, UiT , 6.KIGAM)

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

[BCG06-10] Determination of the absolute stereochemistry of the hydroxyl group in 2-hydroxyarchaeol, the main lipid core of methanogenic and methanotrophic archaea

*Noriaki YAMAUCHI[1], Masanori Kaneko[2] (1.Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, 2.National Institute of Advanced Industrial Science and Technology)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[BCG06-11] Mineral-Microbe interaction – Identification of extracellular electron transfer mechanisms by using MetaOmics approach

★Invited Papers

*Shunichi Ishii[1], Shino Suzuki[1], Kenneth H Nealson[2] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.University of Southern California)

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

[BCG06-12] Interactive discussion with the invited speakers

*Yoshinori Takano[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

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

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

convener:Mitsuteru Sato(Department of Cosmoscience, Hokkaido University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Hisayuki Kubota(Hokkaido University), Kozo Yamashita(Ashikaga University, Department of Engineering.), Chairperson:Mitsuteru Sato(Faculty of Science, Hokkaido University), Kozo Yamashita(Department of Technology, Ashikaga Institute of Technology)

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

[MIS05-01] Quasi real-time observation of typhoon and thunderstorms by the system of micro-satellites and ground-based lightning sensors

*Yukihiro Takahashi[4,1], Mitsuteru Sato[1,4], Hisayuki Kubota[4], Kozo Yamashita[2], Tetsuro Ishida[4], Ellison Caparas Castro[3], Purwadi Purwadi[1], Kazuhisa Tsuboki[5], Hiroyuki Yamada[6], Taro Shinoda[5], Loren Joy De Vera Estrebillo[1], Doreena Karmina Abril Pulutan[1] (1.Graduate School of Science, Hokkaido University, 2.Department of Engineering, Ashikaga University, 3.University of the Philippines, Diliman, 4.Faculty of Science, Hokkaido University, 5.Institute for Space-Earth Environmental Research (ISEE), Nagoya University, 6.University of the Ryukyus)

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

[MIS05-02] **Towards the Implementation of the Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project**

★Invited Papers

*Glenn Vincent C. Lopez[1] (1.Advanced Science and Technology Institute)

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

[MIS05-03] **Airborne observation of Super Typhoon Trami in 2018 for understanding the intensity of tropical cyclone in the Philippine Sea**

★Invited Papers

*Hisayuki Kubota[1], Kazuhisa Tsuboki[2], Hiroyuki Yamada[3], Yukihiro Takahashi[1], Taro Shinoda[2], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Kosuke Ito[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Mitsuteru Sato[1] (1.Hokkaido University, 2.Nagoya University, 3.University of the Ryukyus, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Meteorological Research Institute, 6.Meisei Electronic)

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

[MIS05-04] Relation between Lightning and Typhoon Activities (Typhoon LAN) in the Western Pacific Region

*Mitsuteru Sato[1], Yukihiro Takahashi[1], Hisayuki Kubota[1], Kozo Yamashita[2], Jun-Ichi Hamada[3], Joel J. Marciano[4] (1.Department of Cosmoscience, Hokkaido University, 2.Department of Engineering, Ashikaga University, 3.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 4.ASTI, DOST)

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

[MIS05-05] Infrasound multi-site observation of thunders 3: preparation process for SATREPS

★Invited Papers

*Masa-yuki Yamamoto[1] (1.Department of systems engineering, Kochi University of Technology)

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

[MIS05-06] Data Acquisition System for an Infrasound Network for Thunderstorm Monitoring

*Doreena Karmina Abril Pulutan[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Hisayuki Kubota[1], Kozo Yamashita[2], Masa-yuki Yamamoto[3] (1.Department of Cosmosciences, Hokkaido University, 2.Department of Engineering, Ashikaga University, 3.Department of Systems Engineering, Kochi University of Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

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

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

convener:Mitsuteru Sato(Department of Cosmoscience, Hokkaido University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Hisayuki Kubota(Hokkaido University), Kozo Yamashita(Ashikaga University, Department of Engineering.), Chairperson:Yukihiro Takahashi(Hokkaido University), Hisayuki Kubota(Department of Cosmoscience, Hokkaido University)

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

[MIS05-07] Estimation of Lightning Location Using V-POTEKA Lightning Observation Network

*Loren Joy De Vera Estrebillo[1], Mitsuteru Sato[2], Yukihiro Takahashi[2], Hisayuki Kubota[2], Kozo Yamashita[3], Junichi Hamada[4], Joel Marciano[5] (1.Department of Cosmosciences, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Faculty of Engineering, Ashikaga University, 4.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 5.ASTI/DOST)

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

[MIS05-08] **Observation system for thunderstorm development using ground lightning detection network and thermal infrared camera onboard satellite LAPAN-A4 in Indonesia**

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Mitsuteru Sato[1], Kozo Yamashita[3], M. Arif Saifudin[4] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3.Department of Technology, Ashikaga Institute of Technology, Tochigi 3268558, Japan, 4.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat 16310, Indonesia)

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

[MIS05-09] Remote Sensing Water Quality Determination using Multi-spectral Analysis

*Ahmad Shaqeer Mohamed Thaheer[1], Yukihiro Takahashi[1] (1.Hokkaido University)

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

[MIS05-10] Study of cloud effects on atmospheric electric field during lightning activities and snowfall using the 95-GHz cloud radar FALCON-I

★Invited Papers

*Hiroyo Ohya[1], Kota Nakamori[1], Masashi Kamogawa[2], Tomoyuki Suzuki[2], Toshiaki Takano[1], Kazuomi Morotomi[3], Hiroyuki Nakata[1], Kazuo Shiokawa[4] (1.Graduate School of Engineering, Chiba University, 2.Tokyo Gakugei University, 3.Japan Radio Co. Ltd., 4.Nagoya University)

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

[MIS05-11] Preferred environmental conditions of precipitation systems in and around Bangladesh observed by ground-based radars

★Invited Papers

*Fumie Murata[1], Shuhei Azuma[2], Toru Terao[3], Quamrul S.M. Hassan[4] (1.Faculty of Science and Technology, Kochi University, 2.Faculty of Science, Kochi University, 3.Faculty of Education, Kagawa University, 4.Bangladesh Meteorological Department)

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

[MIS05-12] Thundercloud gamma-ray observations at Kashiwazaki aiming at source altitude and beaming measurements and a new trial at Tokyo Skytree in FY2018

★Invited Papers

*Kazuhiro Nakazawa[1], Takahiro Matsumoto[2], Yuuki Wada[2], Alexia Fabiani[1], Teruaki Enoto[3], Kazufumi Okuda[2], Yoshihiro Furuta[4], Yuki Aizawa[2], Takayuki Yuasa[5], Harufumi Tsuchiya[4], Mitsuteru Sato[6], Kazuo Makishima[7] (1.Nagoya University, 2.University of Tokyo, 3.Kyoto University, 4.JAEA, 5.RIKEN, 6.Hokkaido University, 7.Kalvi IPMU, University of Tokyo)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301B 3F

[M-GI29] Near Surface Investigation and Modeling for Groundwater Resources Assessment and Conservation

convener:Jui-Pin Tsai(National Cheng Kung University, Taiwan), Hwa-Lung Yu(National Taiwan University), Ching-Chung Cheng(National Chiao Tung University Taiwan), Jing-Sen Cai(China University of Geosciences), Chairperson:Jui-Pin Tsai(National Cheng Kung University, Taiwan), Hwa-Lung Yu(National Taiwan University, Taiwan)

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

[MGI29-01] Groundwater management for global sustainability

★Invited Papers

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

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

[MGI29-02] **Building the large-scale specific yields over the Zhuoshui river alluvial fan and Minzhu basin with gravimetric technique**

*Ren-Jhih Yang[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Zhen-Yu Wu[1] (1.National Chung Hsing University)

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

[MGI29-03] **Poro-elastic Deformation of a Heterogenous Geologic Medium due to Groundwater Withdrawal**

*Ajit Joshi[1], Masaatsu Aichi[1] (1.Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo)

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

[MGI29-04] **Analytical Solution of a Ditch Drainage System for the restoration of waterlogged site considering a Subsurface Source/Sink**

*SHUBHAM TIWARI[1], BRIJESH KUMAR YADAV[1], RATAN SARMAH[2] (1.Indian Institute of Technology Roorkee, 2.Indian Institute of Technology Ropar)

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

[MGI29-05] **Variable-density flow and mass transport in unsaturated-saturated aquifers under horizontal groundwater flow conditions**

*Jiaqi Liu[1], Tomochika Tokunaga[1] (1.The University of Tokyo)

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

[MGI29-06] A practical approach to evaluating water inflow for underground water-sealed storage cavern

*Jing-Sen Cai[1] (1.China University of Geosciences)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-ZZ Others

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 304 3F

[M-ZZ50] Governance for Trans-boundary Volcanic Disaster

convener:Mayumi Sakamoto(Graduate School of Disaster Resilience and Governance, University of Hyogo), Haruhisa Nakamichi(Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University), MASARU ARAKIDA(Asian Disaster Reduction Center), Chairperson:Mayumi Sakamoto(兵庫県立大学大学院減災復興政策研究科), Haruhisa Nakamichi(京都大学防災研究所), Masaru Arakida(アジア防災センター)

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[MZZ50-01] The development of the European collaborative mechanism of volcanic monitoring systems after 2010 Eyjafjallajokull eruption - from the perspective of European Union law -

*Chizu Arashima[1] (1.KOBE GAKUIN UNIVERSITY)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[MZZ50-02] Preparing for volcanic disasters: Risk communication issues when dealing with international tourists.

★Invited Papers

*Ana Maria Cruz Naranjo[1], Giuseppe Aliperti[1] (1.Kyoto University Disaster Prevention Research Institute)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MZZ50-03] Mitigation of volcanic hazard in Sakurajima, Japan, through the coordinating committee and through communication with the public

*Haruhisa Nakamichi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MZZ50-04] An experimental forecasting technique for the ash hazard from Sakurajima volcano, Japan

*Alexandros Panagiotis Poulidis[1], Tetsuya Takemi[1], Masato Iguchi[1] (1.Disaster Prevention Research Institute, Kyoto University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MZZ50-05] Utilization of Space Technology for Early Warning and Efficiently Response Against Transboundary Disaster

★Invited Papers

*Koji Suzuki[1] (1.Asian Disaster Reduction Center, Research Center for Urban Safety and Security Kobe University)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[MZZ50-06] Discussion -Research Framework for Trans-boudary Disaster

*Mayumi Sakamoto[1] (1.Graduate School of Disaster Resilience and Governance, University of Hyogo)

Wed. May 29, 2019

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS02] Regolith Science

convener:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Akiko Nakamura(Graduate School of Science, Kobe University), Patrick Michel(Observatoire De La Cote D'Azur), Kevin John Walsh(Southwest Research Institute Boulder), Chairperson:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology)

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

[PPS02-01] Moganite in a lunar meteorite as a trace of H_2O ice in the lunar regolith

★Invited Papers

*Masahiro KAYAMA[1] (1.Tohoku University)

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

[PPS02-02] Simulating the Lunar Soil: a Japanese Lunar Soil Simulant FJS-1 and Its Properties

★Invited Papers

*Naohiro Uyama[1], Hiroshi Kanamori[1], Shigeru Aoki[1] (1.Shimizu Corporation)

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

[PPS02-03] Experimental estimation of regolith scattering behavior when a space lander touches on a planetary body

★Invited Papers

*Mitsuhisa Baba[1], Ronald Louis Ballouz[2], Masatsugu Otsuki[1] (1.Japan Aerospace Exploration Agency, 2.The University of Arizona)

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

[PPS02-04] Ray systems in granular cratering

*Tapan Sabuwala[1], Christian Butcher[1], Gustavo Gioia[1], Pinaki Chakraborty[1] (1.Okinawa Institute of Science and Technology Graduate University)

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

[PPS02-05] Scaling of oblique impact cratering onto inclined granular layer

Shinta Takizawa[1], *Hiroaki Katsuragi[1] (1.Graduate School of Environmental Studies, Nagoya University)

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

[PPS02-06] Experimental study on gravitational effects on crater size formed by low-velocity impacts into granular media

*Masato Kiuchi[1], Akiko M Nakamura[2], Koji Wada[3] (1.Japan aerospace exploration agency, Institute of space and astronautical science, 2.Department of Planetology, Kobe University, 3.Planetary Exploration Research Center, Chiba Institute of Technology)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS02] Regolith Science

convener:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Akiko Nakamura(Graduate School of Science, Kobe University), Patrick Michel(Observatoire De La Cote D'Azur), Kevin John Walsh(Southwest Research Institute Boulder), Chairperson:Akiko Nakamura(Graduate School of Science, Kobe University)

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

[PPS02-07] **Impact Ejecta Environment of an Eccentric Asteroid: 3200 Phaethon**

*Jamey Szalay[1], Peter Pokorny[2], Mihaly Horanyi[3], Diego Janches[2], Menelaos Sarantos[2], Ralf Srama[4] (1.Princeton University, 2.NASA/GSFC, 3.University of Colorado Boulder, 4.University of Stuttgart)

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

[PPS02-08] On the Detection of an Ejecta Dust Cloud Around Asteroid (3200) Phaethon by the DESTINY$^+$ Dust Analyzer

*Hiroshi Kimura[1], Masanori Kobayashi[1], Koji Wada[1], Tomoko Arai[1], Hiroki Senshu[1], Masateru Ishiguro[2], Hidekazu Hanayama[3], Ko Ishibashi[1], Takayuki Hirai[1], Fumi Yoshida[1], Peng Hong[1] (1.Planetary Exploration Research Center, 2.Seoul National University, 3.Ishigakijima Astronomical Observatory)

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

[PPS02-09] Close-up thermal and optical observation of asteroid Ryugu

★Invited Papers

*Naoya Sakatani[1], Tatsuaki Okada[1], Satoshi Tanaka[1], Hiroki Senshu[2], Yuri Shimaki[1], Takehiko Arai[3], Toru Kouyama[5], Hirohide Demura[6], Kentaro Suko[6], Tomohiko Sekiguchi[4], Jun Takita[15], Tetsuya Fukuhara[4], Makoto Taguchi[4], Thomas Müller[7], Axel Hargermann[8], Jens Biele[9], Matthias Grott[9], Marco Delbo[10], Seiji Sugita[13], Rie Honda[12], Tomokatsu Morota[11], Manabu Yamada[2], Shingo Kameda[4], ERI TATSUMI[13], Yasuhiro Yokota[1], Hidehiko Suzuki[14], Chikatoshi Honda[6], Kazunori Ogawa[16], Masahiko Hayakawa[1], Moe Matsuoka[1], Yuichiro Cho[13], Hirotaka Sawada[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Chiba Institute of Technology, 3.Ashikaga University, 4.Rikkyo University, 5.National Institute of Advanced Industrial Science and Technology, 6.University of Aizu, 7.Max-Planck Institute for Extraterrestrial Physics, 8.University of Stirling, 9.German Aerospace Center, 10.Observatoire de la Côte d'Azur, CNRS, 11.Nagoya University, 12.Kochi University, 13.University of Tokyo, 14.Meiji University, 15.Hokkaido University for Education, 16.Kobe University)

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

[PPS02-10] **In-Situ Investigation of Asteroid (162173) Ryugu by the Hayabusa2 MASCOT Lander**

★Invited Papers

*Hajime Yano[1], Tra-Mi Ho[2], Ralf Jaumann[3], Jean-Pierre Bibring[4], Karl-Heinz Glassmeier[5], Matthias Grott[3], David Hercik[5], Jens Biele[6], Maximilian Hamm[3], Nicole Schmitz[3], Stefanus Schröder[3], Katharina Otto[3], Christian Krause[6], Laurence Lorda[7], Aurelie Moussi-Soffys[7], Cedric Pilorget[4], Vincent Hamm[4], Lucie Riu[1], Tatsuaki Okada[1], Naoya Sakatani[1], Josef Reill[8], Kaname Sasaki[2], Markus Schlotterer[2], Yuichi Tsuda[1], Stephan Ulamec[6], Friederike Wolff[8], Patrick Michel[9], Marco Delbo[9], Kazunori Ogawa[10], Hiroki Senshu[11], Tetsuo Yoshimitsu[1], Frank Preusker[3], Frank Scholten[3], Stephan Elgner[3], Stefano Mottola[3], Ekkehard Kührt[3], Takanao Saiki[1], Yuya Mimasu[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, Japan, , 2.German Aerospace Center DLR Bremen, Bremen, Germany, 3.German Aerospace Center, Berlin, Germany, 4.Univ. de Paris Sud-Orsay, IAS, Orsay, France, 5.TU Braunschweig, Braunschweig, Germany, 6.German Aerospace Center DLR Cologne, Cologne, Germany, 7.National Centre for Space Studies, CNES, Toulouse, France, 8.German Aerospace Center, DLR, Oberpfaffenhofen, Germany, 9.Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France, 10.Department of Planetology, Graduate School of Science, Kobe University, Kobe, Japan, 11.Planetary Exploration Research Center, Chiba Institute of Technology, Narashino, Japan)

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

[PPS02-11] Evidence of Mass Movement and Boulder Transport on Bennu from NASA's OSIRIS-REx Space Mission

★Invited Papers

*Erica R Jawin[1], Kevin J Walsh[2], Tim McCoy[1], Harold C Connolly[3], Dante S Lauretta[4], Ron L Ballouz[4], Jamie L Molaro[5], Olivier S Barnouin[6], Mike Nolan[4] (1.Smithsonian National Institute, Washington, DC, USA, 2.Southwest Research Institute, Boulder, CO, USA, 3.Dept. of Geology, Rowan University, Glassboro, NJ, USA, 4.Lunar and

Planetary Laboratory, University of Arizona, Tucson, AZ, USA , 5.Planetary Science Institute, Tucson, AZ, USA, 6.The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA)

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

[PPS02-12] Resurfacing processes on small asteroids constrained by crater size distributions on Ryugu, Itokawa, and Eros

*Naofumi Takaki[1], Yuichiro Cho[1], Tomokatsu Morota[3], ERI TATSUMI[1], Kazuo Yoshioka[1], Hirotaka Sawada[5], yokota yasuhiro[2,5], Naoya Sakatani[5], Masahiko Hayakawa[5], Moe Matsuoka[5], Rie Honda[2], Shingo Kameda[4], Manabu Yamada[6], Toru Kouyama[8], Hidehiko Suzuki[10], Chikatoshi Honda[7], Kazunori Ogawa[9], Hideaki Miyamoto[1], Olivier Barnouin[11], Patrick Michel[12], Carolyn Ernst[11], Seiji Sugita[1,6] (1.University of Tokyo, 2.Kochi University, 3.Nagoya University, 4.Rikkyo University, 5.JAXA, 6.Chiba Institute of Technology, Planetary Exploration Res. Center, 7.University of Aizu, 8.AIST, 9.Kobe University, 10.Meiji University, 11.Johns Hopkins University Applied Physics Laboratory, 12.Nice Observatory)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Taishi Nakamoto(Tokyo Institute of Technology)

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

[PPS03-19] The shape of Bennu: Implications for internal structure.

★Invited Papers

*Olivier S Barnouin[1], Micheal G. Daly[2], Eric E Palmer[3], Robert W Gaskell[3], John R. Weirich[3], Catherine L Johnson[4], Manar Al Asad[4], James H Roberts[1], Mark E. Perry[1], Hannah C.M. Sursorney[4], R. Terik Daly[1], Edward B. Bierhaus[5], Jeff A Seabrook[2], Raymond C. Espiritu[1], A. Hari Nair[1], Lilian Nguyen[1], Gregory A Neumann[6], Carolyn M Ernst[1], William V Boynton[7], Micheal C. Nolan[7], Coralie D. Adams[9], Micheal C. Moreau[6], Bashar Rizk[7], Christian Drouet D'Aubigny[7], Erica R. Jawin[8], Kevin J Walsh[10], Patrick Michel[11], Stephen R. Schwartz[7], Ronald L. Ballouz[7], Erwan M Mazarico[6], Daniel J. Scheeres[12], Jay W. McMahon[12], W Bottke[10], Seiji Sugita[13], Naru Hirata[14], Noayuki Hirata[15], Sei-ichiro Watanbe[16], Keara N. Burke[7], Daniella N. DellaGuistina[7], Carinna A. Bennet[7], Dante Lauretta[7] (1.Johns Hopkins University Applied Physics Laboratory, 2.The Centre for Research in Earth and Space Science, York University, Toronto, Ontario, Canada., 3.Planetary Science Institute, Tucson, AZ, USA, 4.Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, Canada., 5.Lockheed Martin Space Systems Company, Denver, CO, USA., 6.NASA Goddard Space Flight Center, Greenbelt, MD, USA., 7.Lunar Planetary Laboratory, University of Arizona, Tucson, AZ, USA., 8.Smithsonian Institution National Museum of Natural History, Washington, DC, USA., 9.KinetX Aerospace, Inc. Simi Valley, CA, USA, 10.Southwest Research Institute, Boulder, CO, USA., 11.Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France., 12.Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA., 13.University of Tokyo, Tokyo, Japan., 14.Aizu University, Aizu-Wakamatsu, Japan., 15.Kobe University, Kobe, Japan., 16.Nagoya University, Nagoya, Japan.)

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

[PPS03-20] Global Geology of Bennu from NASA's OSIRIS-REx Space Mission

★Invited Papers

*Erica R Jawin[1], Kevin J Walsh[2], Tim McCoy[1], Harold C Connolly[3], Dante S Lauretta[4], Ron L Ballouz[4], Olivier S Barnouin[5], C Beddingfield[6], Carina A Bennett[4], Edward B Bierhaus[7], Keara N Burke[4], Ben Clark[8], Michael G Daly[9], Marco Delbo[10], Daniella DellaGiustina[4], Jason P Dworkin[11], Christine Hartzell[12], John Marshall[6], Patrick Michel[10], Jamie L. Molaro[13], Mike Nolan[4], Maurizio Pajola[14], Mark Perry[5], Bashar Rizk[4], Scott Sandford[15], Dan J Scheeres[16], Stephen R Schwartz[4], David Trang[17] (1.Smithsonian National Institute, Washington, DC, USA, 2.Southwest Research Institute, Boulder, CO, USA, 3.Dept. of Geology, Rowan University, Glassboro, NJ, USA, 4.Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA , 5.The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA, 6.SETI Institute, Mountain View, CA, USA, 7.Lockheed Martin Space Systems Company, USA, 8.Space Science Institute, Boulder CO, USA, 9.York University, Canada, 10.Laboratoire Lagrange, Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France, 11.NASA Goddard Space Flight Center, Greenbelt, MD, USA, 12.Department of Aerospace Engineering, University of Maryland, College Park MD, USA, 13.Planetary Science Institute, Tucson, AZ, USA, 14.INAF - Astronomical Observatory of Padova, Italy, 15.NASA Ames Research Center, USA, 16.Dept. of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA, 17.HIGP/University of Hawaii at Manoa, USA)

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

[PPS03-21] Modeling surface mobility mechanisms on a top-shaped near-Earth asteroid

★Invited Papers

*Ronald Ballouz[1], Nicola Baresi[2], Olivier S Barnouin[3], Carina A Bennet[1], Edward B Bierhaus[4], Keara N Burke[1], Harold C Connolly[5], Sarah T Crites[2], Daniella DellaGiustitna[1], Erica Jawin[6], Dante S Lauretta[1], Patrick Michel[7], Derek C Richardson[8], Dan J Scheeres[9], Stephen Schwartz[1], Seiji Sugita[10], Eri Tatsumi[10], Florian Thuillet[7], Kevin Walsh[11] (1.Lunar and Planetary Lab, University of Arizona, Tucson, AZ, USA, 2.Institute of Space and Astronautical Science, Sagamihara, Japan, 3.The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA, 4.Lockheed Martin, Boulder, CO, USA, 5.Department of Geology, Rowan University, Glassboro, NJ, USA, 6.Smithsonian National Museum of Natural History, Washington, DC, USA, 7.UCA-OCA-CNRS, Lagrange Laboratory, Nice, France, 8.Dept. of Astronomy, University of Maryland, College Park, MD, USA, 9.Dept. of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA, 10.University of Tokyo, Tokyo, Japan, 11.Southwest Research Institute, Boulder, CO, USA)

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

[PPS03-22] **Visualization and Analysis of Solar System Small Bodies with NASA's Solar System Treks Project**

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

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

[PPS03-23] Density Distribution within Small Solar System Bodies Based on Smooth Terrain Shape: Asteroid 25143 Itokawa and Comet 67P/Churyumov-Gerasimenko

*Masanori Kanamaru[1], Sho Sasaki[1], Mark Wieczorek[2] (1.Osaka University, 2.Côte d'Azur Observatory)

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

[PPS03-24] Low temperature hydration experiments of cometary analog materials towards the Comet Astrobiology Exploration Sample Return (CAESAR) mission

*Aki Takigawa[1,4], Yuki Kimura[1], Yoshihiro Furukawa[2], Tomoki Nakamura[3] (1.Graduate School of Science, Kyoto University, 2.Institute of Low Temperature Science, 3.Graduate School of Science, Tohoku University, 4.The Hakubi Center for Advanced Research)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Masateru Ishiguro(Seoul National University)

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

[PPS03-25] Overview and current status of DESTINY$^+$ mission

★Invited Papers

*Tomoko Arai[1], Masanori Kobayashi[1], Ko Ishibashi[1], Fumi Yoshida[1], Hiroshi Kimura[1], Takayuki Hirai[1], Hong Peng[1], Manabu Yamada[1], Hiroki Senshu[1], Koji Wada[1], Ralf Srama[2], Harald Kruger[3], Jun-ichi Watanabe[4], Takashi Ito[4], Masateru Ishiguro[5], Tomoki Nakamura[6], Hikaru Yabuta[7], Shogo Tachibana[8], Takashi Mikouchi[8], Shinsuke Abe[9], Katsuhito Ohtsuka[10], Seitaro Urakawa[11], Keiko Nakamura-Messenger[12], Mutsumi Komatsu[13], Shingo Kameda[14], Masato Kagitani[6], Naru Hirata[15], Hirohide Demura[15], Sho Sasaki[16], Takahiro Hiroi[17], Goro Komatsu[18], Hidehiro Kaneda[19], Takaya Inamori[19], Takaya Okamoto[20], Toshifumi Yanagisawa[20], Makoto Yoshikawa[20], Hajime Yano[20], Tatsuaki Okada[20], Takahiro Iwata[20], Takafumi Ootsubo[20], Yasuhiro Kawakatsu[20], Hiroyuki Toyota[20], Kazutaka Nishiyama[20], Takeshi Takashima[20] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.University of Stuttgart, 3.Max Planck Institute, 4.National Astronomical Observatory of Japan , 5.Seoul National Universtiy, 6.Tohoku University, 7.Hiroshima University, 8.The University of Tokyo, 9.Nihon University, 10.Tokyo Meteor Network, 11.Japan Spaceguard Association, 12.NASA , 13.The Graduate University for Advanced Studies, 14.Rikkyo University, 15.Aizu University, 16.Osaka University, 17.Brown University, 18.D'Annunzio University, 19.Nagoya University, 20.JAXA)

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

[PPS03-26] Observational campaign of (3200) Phaethon and (155140) 2005UD in 2017-2018

*Fumi Yoshida[1], Tomoko Arai[1], Ko Ishibashi[1], Peng Hong[1], Ryo Ishimaru[1], DESTINY+ International observation collaborators (1.Planetary Exploration Research Center, Chiba Institute of Technology)

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

[PPS03-27] Rotationally-resolved spectroscopic observations of Phaethon - 2005 UD, and their fragments detected by lunar impact flashes.

*Shinsuke Abe[1], Nicholas Moskovitz[2], Fumi Yoshida[3], Katsutoshi Ohtsuka[4], Ito Takashi[5], Ryota Fuse[1], Masahisa Yanagisawa[6], Ryuhei Yamada[7] (1.Department of Aerospace Engineering, College of Science and Technology, Nihon University, 2.Lowell Observatory, 3.Planetary Exploration Research Center, Chiba Institute of Technology, 4.Tokyo Meteor Network, 5.National Astronomical Observatory of Japan, 6.The University of Electro-Communications, 7.The University of Aizu, Department of Computer Science and Engineering)

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

[PPS03-28] Thermal Radiation Pressure Force on Regolith Particles of Atmosphereless Bodies

*Yoonsoo P. Bach[1], Masateru Ishiguro[1] (1.Department of Physics and Astronomy, Seoul National University)

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

[PPS03-29] A kilometre-sized Kuiper belt object revealed by OASES stellar occultation observations

*Ko Arimatsu[1,2], Kohji Tsumura[3], Fumihiko Usui[4], Shinnaka Yoshiharu[5], Kohei Ichikawa[3,6,7], Takafumi Ootsubo[8], Takayuki Kotani[2,9], Takehiko Wada[8], Koichi Nagase[8], Jun-ichi Watanabe[2] (1.Astronomical Observatory, Graduate School of Science, Kyoto University, 2.National Astronomical Observatory of Japan, 3.Frontier Research Institute for Interdisciplinary Science, Tohoku University, 4.Center for Planetary Science, Graduate School of Science, Kobe University, 5.Laboratory of Infrared High-resolution Spectroscopy, Koyama Astronomical Observatory, Kyoto Sangyo University, 6.Department of Astronomy, Columbia University, 7.Department of Physics and Astronomy, University of Texas at San Antonio, 8.Department of Space Astronomy and Astrophysics, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 9.Astrobiology Center, National Institutes of Natural Sciences)

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

[PPS03-30] AKARI/IRC near-infrared asteroid spectroscopic survey: AcuA-spec

*Fumihiko Usui[1], Sunao Hasegawa[2], Takafumi Ootsubo[2], Takashi Onaka[3,4] (1.Kobe University, 2.ISAS/JAXA, 3.The University of Tokyo, 4.Meisei University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Patrick Espy(Norwegian University of Science and Technology), Astrid Maute(National Center for Atmospheric Research, US)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PEM09-01] **Vertical Coupling from the Atmosphere to Geospace at Arrival Heights in Antarctica**

★Invited Papers

*Xinzhao Chu[1] (1.University of Colorado Boulder)

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

[PEM09-02] Vertical structure of terdiurnal tides in the Antarctic MLT region: 15 years observation over Syowa

*Huixin Liu[1], Masaki Tsutsumi[2], Hanli Liu[3] (1.Earth and Planetary Science Division, Kyushu University, Japan, 2.National Institute for Polar Research, Japan, 3.National Center for Atmospheric Research, US)

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

[PEM09-03] **3D Investigation of gravity waves propagation by Continuous Doppler sounding**

*Jaroslav Chum[1], Katerina Podolska[1] (1.Institute of Atmospheric Physics of the Czech Academy of Sciences)

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

[PEM09-04] **Observations of MLT dynamics using meteor radars and meteor radar networks**

★Invited Papers

*Gunter Stober[1], Vivien Matthias[2], Sven Wilhelm[1], Dimitry Pokhotelov[1], Alexander Kozlovsky[3], Evgenia Belova[4], Johan Kero[4], Chris Hall[5], Masaki Tsutsumi[6] (1.Leibniz Institute of Atmospheric Physics, 2.Potsdam Institute for Climate Impact Research, Earth System Analysis - Research Domain 1, Potsdam, Germany, 3.Sodankylä Geophysical Observatory, Sodankylä, FIN-99600, Finland, 4.Swedish Institute of Space Physics, Box 812, 98128 Kiruna, Sweden, 5.Tromsø Geophysical Observatory UiT-the Arctic University of Norway, Tromsø, Norway, 6.National Institute of Polar Research, Tokyo, Japan)

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

[PEM09-05] Ionospheric Variability Associated with the Quasi-6-day Planetary Wave

★Invited Papers

*Yosuke Yamazaki[1] (1.GFZ German Research Centre for Geosciences)

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

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

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Yuichi Otsuka, Yosuke Yosuke Yamazaki(GFZ Potsdam, Germany)

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[PEM09-06] Results of FORMOSAT-3/COSMIC to the most recent developments on FORMOSAT-7/COSMIC-2

★Invited Papers

*JANN-YENQ Liu[1] (1.Center for Astronautical Physics and Engineering; Graduate Institute of Space Science, National Central University, Taiwan)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[PEM09-07] A morphological study on the relationship between electron density fluctuations and magnetic fluctuations observed by low altitude satellites in low and middle latitudes

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

4:05 PM - 4:25 PM JST | 7:05 AM - 7:25 AM UTC

[PEM09-08] Observations of the Thermosphere and Ionosphere by the NASA GOLD Mission

★Invited Papers

*Stanley C Solomon[1], Alan G. Burns[1], Richard W. Eastes[2], William E. McClintock[2] (1.National Center for Atmospheric Research, 2.University of Colorado)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[PEM09-09] Temporal and spatial evolutions of storm enhanced density in the mid- and low-latitude regions as seen in the variation of global total electron content

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

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[PEM09-10] **Tidal Forcing Effects on the Zonal Variation of Solstice Equatorial Plasma Bubbles**

*Loren Chang[1], Jude Salinas[1], Yi-Chung Chiu[1], Pei-yun Chiu[1], Charles Lin[2] (1.Institute of Space Science and Engineering, Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2.Department of Earth Science, National Cheng Kung University, Taiwan)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Hiroshi Hasegawa(Institute of Space and Astronautical Science, JAXA)

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

[PEM11-01] **A Case Study Based on Ground Observations of the Conjugate Ionospheric Response to Interplanetary Shock in Polar Regions**

*He Fang[1], Zejun HU[1], Hongqiao HU[1] (1.Polar Research Institute of China)

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

[PEM11-02] **Effects of Solar Illumination on the Auroral Electrojet Intensity**

*Shinichi Ohtani[1], Jesper W Gjerloev[1] (1.The Johns Hopkins University Applied Physics Laboratory)

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

[PEM11-03] Quasi-persistent multiple mesoscale field-aligned currents in the duskside auroral oval

*Yoshihiro Yokoyama[1], Satoshi Taguchi[1], Toshihiko Iyemori[2], Keisuke Hosokawa[3] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Kyoto University, 3.Department of Communication Engineering and Informatics, University of Electro-Communications)

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

[PEM11-04] Generation of dispersive Alfvenic turbulence in magnetosphere-ionosphere feedback coupling

*Tomo-Hiko Watanabe[1], Masatoshi Kaneyama[1], Shinya Maeyama[1] (1.Graduate School of Science, Nagoya University)

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

[PEM11-05] Aspects of simulating magnetosphere-ionosphere coupling via field-aligned current

*Astrid I Maute[1], Arthur D Richmond[1], Gang Lu[1] (1.High Altitude Observatory, National Center for Atmospheric Research, Boulder CO, 80301, USA)

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

[PEM11-06] **Revisiting the energy conversion process of Birkeland current generation**

*Akimasa Yoshikawa[1] (1.Department of Earth and Planetary Sciences, Kyushu University)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Shinji Saito(ISEE, Nagoya University), Yusuke Ebihara(RISH, Kyoto University)

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

[PEM13-11] Nonlinear Damping of Oblique Whistler Mode Waves Via Landau Resonance

*Yikai HSIEH[1], Yoshiharu Omura[1] (1.Reserach Institute for Sustainable Humanosphere, Kyoto University)

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

[PEM13-12] Instantaneous Frequency Analysis on Nonlinear EMIC Emissions: Arase Observation

*Masafumi Shoji[1], Yoshizumi Miyoshi[1], Yoshiharu Omura[2], Lynn M Kistler[1,3], Yasumasa Kasaba[4], Shoya Matsuda[5], Yoshiya Kasahara[6], Ayako Matsuoka[5], Reiko Nomura[7], Keigo Ishisaka[8], Atsushi Kumamoto[4], Fuminori Tsuchiya[4], Satoshi Yagitani[6], Mariko Teramoto[1], Kazushi Asamura[5], Takeshi Takashima[5], Iku Shinohara[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Research Institute for Sustainable Humanosphere, Kyoto University, 3.Institute for the Study of Earth Oceans and Space, University of New Hampshire, 4.Tohoku University, 5.Institute of Space and Astronautical Science, 6.Kanazawa University, 7.National Astronomical Observatory of Japan, 8.Toyama Prefecture University)

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

[PEM13-13] Rapid Precipitation by EMIC Rising-tone Emissions of Relativistic Electrons Observed by the Van Allen Probes Mission

*Satoko Nakamura[1], Yoshiharu Omura[1], Craig Kletzing[2], Daniel Baker[3] (1.Research Institute for Sustainable Humanosphere, Kyoto University., 2.Department of Physics and Astronomy University of Iowa , 3.The Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado)

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

[PEM13-14] Plasmaspheric EMIC waves excited through mode conversion from equatorial noise under existence of M/Q=2 ions

*Yoshizumi Miyoshi[1], Shoya Matsuda[2], Satoshi Kurita[1], koji nomura[1], Kunihiro Keika[3], Masafumi Shoji[1], Naritoshi Kitamura[3], Yoshiya Kasahara[4], Ayako Matsuoka[2], Iku Shinohara[2], Kazuo Shiokawa[1], Shinobu Machida[1], Ondrej Santolik[5], Scott Boardsen[6], Richard Horne[7], Wygant John[8] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.JAXA, 3.University of Tokyo, 4.Kanazawa University, 5.CAS, 6.NASA, 7.British Antarctic Survey, 8.University of Minnesota)

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

[PEM13-15] Generation Mechanism of Non-thermal Continuum Radiation

*Yoshiharu Omura[1], Miroslav Horky[1,2] (1.Reserach Institute for Sustainable Humanosphere, Kyoto University, 2.Department of Space Physics, Institute of Atmospheric Physics, Czech Academy of Sciences)

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

[PEM13-16] Influence of kappa distributions on the sweep rate of whistler mode chorus waves

*Danny Summers[1] (1.Memorial University of Newfoundland)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Yusuke Ebihara(RISH, Kyoto University), Shinji Saito(ISEE, Nagoya University)

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

[PEM13-17] The Impacts of Substorms on the Ring Current

★Invited Papers

*Jasmine Kaur Sandhu[1], I. J. Rae[1], M. Gkioulidou[2], C. Forsyth[1], G. D. Reeves[3], M. P. Freeman[4], K. R. Murphy[5], M.-T. Walach[6], H. E. Spence[7] (1.Mullard Space Science Laboratory, University College London, UK., 2.Applied Physics Laboratory, John Hopkins University, USA., 3.Los Alamos National Laboratory, USA., 4.British Antarctic Survey, UK., 5.University of Maryland, USA., 6.Lancaster University, UK., 7.University of New Hampshire, USA.)

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

[PEM13-18] Dipolarization in the Inner Magnetosphere: Comparison between Geosynchronous Orbit and Further Inside

★Invited Papers

*Shinichi Ohtani[1], Tetsuo Motoba[1], Matina Gkioulidou[1], Kazue Takahashi[1] (1.The Johns Hopkins University Applied Physics Laboratory)

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

[PEM13-19] Substorm-associated particle injection near/at geosynchronous orbit: Observations from ERG and GOES

*Tzu-Fang Chang[1,2], Chio-Zong Cheng[2], Sunny Wing-Yee Tam[2], Chih-Yu Chiang[2], Yoshizumi Miyoshi[1], Tomoaki Hori[1], Takefumi Mitani[3], Takeshi Takashima[3], Ayako Matsuoka[3], Mariko Teramoto[1], Iku Shinohara[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 2.Institute of Space and Plasma Sciences, National Cheng Kung University, Tainan, Taiwan, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan)

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

[PEM13-20] Substorm -like energetic electron injection observed at the plasma sheet boundary in the inner magnetosphere

*Iku Shinohara[1], Nagai Tsugunobu[1], Takefumi Mitani[1], Nana Higashio[2], Satoshi Kasahara[3], Yoichi Kazama[4], Shiang-Yu Wang[4], Sunny Tam[5], Ayako Matsuoka[1], Kazushi Asamura[1], Shoichiro Yokota[6], Takeshi Takashima[1], Yoshizumi Miyoshi[7] (1.Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science, 2.Japan Aerospace Exploration Agency, 3.The University of Tokyo, 4.Academia Sinica/Institute of Astronomy and Astrophysics, 5.National Cheng Kung University, 6.Osaka University, 7.Nagoya University/Institute for Space-Earth Einvironment Research)

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

[PEM13-21] Magnetic field disturbances associated with the magnetic dipolarization observed by Arase (ERG) in the inner magnetosphere

*Ayako Matsuoka[1], Masahito Nose[2], Yoshizumi Miyoshi[2], Iku Shinohara[1], Mariko Teramoto[2], Reiko Nomura[3], Akiko Fujimoto[4], Yoshimasa Tanaka[5], Manabu Shinohara[6], Yoshiya Kasahara[7], Yasumasa Kasaba[8], Keigo Ishisaka[9], Shoya Matsuda[1], Masafumi Shoji[2], Tomoko Nakagawa[10], Yoichi Kazama[11], Shiang-Yu Wang[11], Satoshi Kasahara[12], Shoichiro Yokota[13], Takefumi Mitani[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.RISE, National Astronomical Observatory of Japan, 4.School of Computer Science and Systems Engineering, Kyushu Institute of Technology, 5.National Institute of Polar Research, 6.National Institute of Technology, Kagoshima College, 7.Information Media Center, Kanazawa University, 8.Planetary Plasma and Atmospheric Research Center, Tohoku University, 9.Faculty of Engineering, Toyama Prefectural University, 10.Faculty of Engineering, Tohoku Institute of Technology, 11.Academia Sinica Institute of Astronomy and Astrophysics, 12.School of Science, The University of Tokyo, 13.School of Science, Osaka University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Yoshizumi Miyoshi(ISEE, Nagoya University), Yusuke Ebihara(RISH, Kyoto University)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PEM13-22] Statistical Property of Long Lasting Poloidal Pc 4-5 Waves and Relation with Particle Dynamics in the Inner Magnetosphere: Van Allen Probes Observations

★Invited Papers

*Kazuhiro Yamamoto[1], Masahito Nose[2], Kunihiro Keika[3], Charles W. Smith[4], Robert J. MacDowall[5], Donald G. Mitchell[6], Hyomin Kim[7], John Wygant[8] (1.Graduate School of Science, Kyoto University, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Graduate School of Science, the University of Tokyo, 4.Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 5.Solar System Exploration Division, Goddard Space Flight Center, 6.The Johns Hopkins University Applied Physics Laboratory, 7.Center for Solar Terrestrial Research, New Jersey Institute of Technology, 8.School of Physics and Astronomy, University of Minnesota)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PEM13-23] Subauroral Polarization Streams: Indication of Magnetosphere–Ionosphere Coupling

★Invited Papers

*Fei He[1,2,3], Xiao-Xin Zhang[4], Wenbin Wang[5], Zhonghua Yao[1,2,3], Yong Wei[1,2,3], Zhi-Peng Ren[1,2,3], Xinan Yue[1,2,3], Weixing Wan[1,2,3] (1.Institute of Geology & Geophysics, CAS, 2.Institutions of Earth Science, CAS, 3.College of Earth and Planetary Sciences, UCAS, 4.National Center for Space Weather, CMA, 5.High Altitude Observatory, NCAR)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[PEM13-24] Simultaneous Arase-ground observations of a purple and green auroral arc

*Kazuo Shiokawa[1], Masahito Nose[1], Satoshi Tsuchiya[1], Yuki Takagi[1], Shun Imajo[1], Yoshimasa Tanaka[2], Yoshizumi Miyoshi[1], Keisuke Hosokawa[3], Yoichi Kazama[4], Shiang-Yu Wang[4], Sunny W.Y. Tam[4], Kazushi Asamura[5], Satoshi Kasahara[6], Shoichiro Yokota[7], Tomoaki Hori[1], Kunihiro Keika[6], Ayako Matsuoka[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Polar Research, 3.The University of Electro-Communications, 4.National Cheng Kung University, 5.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 6.University of Tokyo, 7.Osaka University)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[PEM13-25] Multiple Satellite Observations of Oxygen Torus in the Inner Magnetosphere

*Masahito Nose[1], Ayako Matsuoka[2], Atsushi Kumamoto[3], Yoshiya Kasahara[4], J Goldstein[5,6], Mariko Teramoto[1], Fuminori Tsuchiya[3], Shoya Matsuda[2], Masafumi Shoji[1], Shun Imajo[1], Oimatsu Satoshi[7], Kazuhiro Yamamoto[7], Yuki Obana[8], Reiko Nomura[9], Akiko Fujimoto[10], Iku Shinohara[2], Yoshizumi Miyoshi[1], W S Kurth[11], C A Kletzing[11], C W Smith[12], R J MacDowall[13] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Graduate School of Science, Tohoku University, 4.Information Media Center, Kanazawa University, 5.Space Science and Engineering Division, Southwest Research Institute, 6.University of Texas at San Antonio, 7.Graduate School of Science, Kyoto University, 8.Faculty of Engineering, Osaka Electro-Communication University, 9.National Astronomical Observatory of Japan, 10.Kyushu Institute of Technology, 11.Department of Physics and Astronomy, University of Iowa, 12.Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 13.Solar System Exploration Division, Goddard Space Flight Center)

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

[PEM13-26] Study of characteristics of storm-time Pc5 ULF waves excited by the drift-bounce resonance with ring current ions based on the global drift-kinetic simulation

*Tomotsugu Yamakawa[1], Kanako Seki[1], Takanobu Amano[1], Yoshizumi Miyoshi[2], Naoko Takahashi[1] (1.Department of Earth and Planetary Science, School of Science, The University of Tokyo, 2.ISEE, Nagoya University)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 104 1F

[A-AS01] High performance computing for next generation weather, climate, and environmental sc iences

convener:Hiromu Seko(Meteorological Research Institute), Takemasa Miyoshi(RIKEN), Chihiro Kodama(Japan Agency for Marine-Earth Science and Technology), Masayuki Takigawa(Japan Agency for Marine-Earth Science and Technology), Chairperson:Hiromu Seko(Meteorological Research Institute), Chihiro Kodama(Japan Agency for Marine-Earth Science and Technology)

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

[AAS01-01] Data Assimilation Studies using Big Observation Data in the Projects of Post K and BDA

*Hiromu Seko[1], Masaru Kunii[2], Yohei Sawada[1], Kozo Okamoto[1], Sho Yokota[1], Kosuke Ito[3], Kazuki Shimoji[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency, 3.University of the Ryukyus)

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

[AAS01-02] **High-resolution Numerical Weather Simulation with a Large Domain for Extreme Heavy Rainfall Events**

*Tsutao OIZUMI[1,2], Kazuo Saito[4,3], le duc[1], Junshi Ito[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, 3.The Atmosphere and Ocean Research Institute, 4.Japan Meteorological Business Support Center)

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

[AAS01-03] A Numerical Case Study on a Tornado that Formed in a Quasi Linear Convective System

★Invited Papers

*Eigo Tochimoto[1], Hiroshi Niino[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

[AAS01-04] Improving the observation operator for Phased Array Weather Radar in the SCALE-LETKF system

*Arata Amemiya[1], Takumi Honda[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

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

[AAS01-05] Data assimilation and forecast experiments for the record-breaking rainfall event in Japan in July 2018 with NICAM-LETKF at 112-km and 28-km resolution

*Koji Terasaki[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

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

[AAS01-06] Model Parameter Estimation with Data Assimilation Using NICAM-LETKF

★Invited Papers

*Shunji Kotsuki[1], Yousuke Sato[2], Koji Terasaki[1], Hasashi Yashiro[1], Hirofumi Tomita[1], Masaki Satoh[3], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science, 2.Graduate School of Engineering, Nagoya University, 3.Atmosphere and Ocean Research Institute, the University of Tokyo)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 104 1F

[A-AS01] High performance computing for next generation weather, climate, and environmental sc iences

convener:Hiromu Seko(Meteorological Research Institute), Takemasa Miyoshi(RIKEN), Chihiro Kodama(Japan Agency for Marine-Earth Science and Technology), Masayuki Takigawa(Japan Agency for Marine-Earth Science and Technology), Chairperson:Masayuki Takigawa(Japan Agency for Marine-Earth Science and Technology), Takemasa Miyoshi(RIKEN Advanced Institute for Computational Science)

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

[AAS01-07] 3D debris flow simulations by using smoothed particle hydrodynamics (SPH) method

*Shoji Ueta[1], Natsuki Hosono[2], Yosuke Alexandre Yamashiki[1] (1.Kyoto University, 2.JAMSTEC)

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

[AAS01-08] **Regional atmospheric data assimilation coupled with an ocean mixed layer model: a case of typhoon Soudelor (2015)**

*Kohei Takatama[1], Takumi Honda[1], Takemasa Miyoshi[1] (1.RIKEN)

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

[AAS01-09] Effective Radiative Forcing and Climate Response to Short-Lived Climate Pollutants Under Different Scenarios

Hua Zhang[1], *Bing Xie[1], Zhili Wang[1] (1.China Meteorological Administration)

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

[AAS01-10] **The NICAM–SPRINTARS simulation of the long-range transport of black carbon using the K computer**

★Invited Papers

*Yousuke Yamashita[1], Masayuki Takigawa[1], Daisuke Goto[2], Hisashi Yashiro[3], Masaki Satoh[4,1], Yugo Kanaya[1], Fumikazu Taketani[1], Takuma Miyakawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Environmental Studies, 3.RIKEN Advanced Institute for Computational Science (AICS), 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AAS01-11] High-resolution, ensemble simulations of intense tropical cyclones and their stochasticity during the El Niños of 1997 and 2015

*Yohei Yamada[1], Chihiro Kodama[1], Masaki Satoh[1,2], Masuo Nakano[1], Tomoe Nasuno[1], Masato Sugi[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, The university of Tokyo, 3.Meteorological Research Institute, Japan Meteorological Agency)

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

[AAS01-12] **NICAM results of the project DYAMOND for global storm-resolving model intercomparison**

★Invited Papers

*Masaki Satoh[1], Ryosuke Shibuya[2], Chihiro Kodama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.JAMSTEC)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 105 1F

[A-OS08] ECS-Kuroshio and Ryukyu Current System -Observation, modeling and theory-

convener:Hirohiko Nakamura(Kagoshima University, Faculy of Fisheries), Xiao-Hua Zhu(Second Institute of Oceanography), Chairperson:Hirohiko Nakamura(Kagoshima University), Jae-Hun Park(Inha University)

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[AOS08-01] Downstream Evolution of the Kuroshio Velocity Structure and Transport

★Invited Papers

*Magdalena Andres[1], Sen Jan[2] (1.Woods Hole Oceanographic Institution, 2.National Taiwan University)

2:10 PM - 2:25 PM JST | 5:10 AM - 5:25 AM UTC

[AOS08-02] **Non-seasonal variability of the Kuroshio shelf intrusion and its associated changes in the ocean environment over the East China Sea during 1993-2017**

*Jiwon Kang[1], Hanna Na[1] (1.School of Earth and Environmental Sciences, Seoul National University, Republic of Korea)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[AOS08-03] The temporal and spatial variability of the Kuroshio in the East China Sea and its associated mechanisms

*Yanzhou Wei[1] (1.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[AOS08-04] The Joint Kuroshio–Ryukyu Current System Study and a rapid report about mooring observations southeast of Miyakojima

*Xiao-Hua Zhu[1], Hirohiko Nakamura[2], Jae-Hun Park[3], Ruixiang Zhao[1], Ayako Nishina[2], Chuanzheng Zhang[1], Chanhyung Jeon[4], Hanna Na[5], Ze-Nan Zhu[1], Hong Sik Min[6] (1.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China, 2.Faculty of Fisheries, Kagoshima University, Kagoshima, Japan, 3.Department of Ocean Sciences, Inha University, Incheon, South Korea, 4.Department of Marine Science and Biological Engineering, Inha University, Incheon, Korea, 5.School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea, 6.Ocean Circulation and Climate Research Center, Korea Institute of Ocean Science and Technology, Busan, Korea)

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

[AOS08-05] Relationship of the Kuroshio with the current fields in the East China Sea from observations and model results

*Hong Sik Min[1], Chorong Hwang[1], Dong Guk Kim[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Jae-Hun Park[4], Chanhyung Jeon[4], Hanna Na[5], Naoki Hirose[6] (1.Korea Institute of Ocean Science & Technology, 2.Kagoshima University, 3.Second Institute of Oceanography, 4.Inha University, 5.Seoul National University, 6.Kyushu University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 105 1F

[A-OS08] ECS-Kuroshio and Ryukyu Current System -Observation, modeling and theory-

convener:Hirohiko Nakamura(Kagoshima University, Faculy of Fisheries), Xiao-Hua Zhu(Second Institute of Oceanography), Chairperson:Jae-Hun Park(Inha University), Hirohiko Nakamura(Kagoshima University)

3:35 PM - 3:55 PM JST | 6:35 AM - 6:55 AM UTC

[AOS08-06] Separating Small-Scale Oceanic Internal Waves and Vortical Motions

★Invited Papers

*Ren-Chieh Lien[1] (1.University of Washington, Seattle, WA, USA)

3:55 PM - 4:10 PM JST | 6:55 AM - 7:10 AM UTC

[AOS08-07] Structure and variability of the Kuroshio current in the Tokara Strait

*Zhao-Jun Liu[1], Hirohiko Nakamura[2], Xiao-Hua Zhu[1], Ayako Nishina[2], Xinyu Guo[3], Menghong Dong[1] (1.Second Institute of Oceanography, China, 2.Kagoshima University, Japan, 3.Ehime University, Japan)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[AOS08-08] **Near-inertial waves advected by the Kuroshio from observation and simulation**

*CHANHYUNG JEON[1], Jae-Hun Park[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Dong Guk Kim[4], Hong Sik Min[4], Sok Kuh Kang[4], Hanna Na[5], Naoki Hirose[6], Youngseok Choi[1] (1.Inha University, 2.Kagoshima University, 3.Second Institute of Oceanography, 4.Korea Institute of Ocean Science and Technology, 5.Seoul National University, 6.Kyushu University)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[AOS08-09] Turbulent mixing and near-inertial internal waves induced by the Kuroshio over seamounts in the Tokara Strait

*Takeyoshi Nagai[1], Daisuke Hasegawa[2], Eisuke Tsutsumi[3], Hirohiko Nakamura[4], Ayako Nishina[4], Tomoharu Senjyu[3], Takahiro Endoh[3], Takeshi Matsuno[3], Ryuichiro Inoue[5], Amit Tandon[6] (1.Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Kyushu University, Research Institute for Applied Mechanics, 4.Faculty of Fisheries Kagoshima University, 5.Ocean Circulation Research Group, Japan Agency for Marine-Earth Science and Technology, 6.Mechanical Engineering Department & SMAST, University of Massachusetts Dartmouth)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[AOS08-10] Microstructure and mooring observations of enhanced mixing in the Kerama Gap

*Ryuichiro Inoue[1], Hirohiko Nakamura[2], Takahiro Tanaka[3], Shinzou Fujio[4], Daigo Yanagimoto[4], Ichiro Yasuda[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kagoshima University, Faculy of Fisheries, 3.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 4.The University of Tokyo, Atmosphere and Ocean Research Institute)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301A 3F

[A-OS11] Continental-Oceanic Mutual Interaction: Planetary scale Material Circulation

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

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

[AOS11-01] Explorations and current understandings for subsurface ocean of icy bodies

★Invited Papers

*Jun Kimura[1] (1.Osaka University)

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

[AOS11-02] **Climate predictability for societal applications including AI/ML**

*Swadhin Behera[1], Manali Pal[2], J.V. Ratnam[1], Rajib Maity[2], Takeshi Doi[1], Yushi Morioka[1], Masami Nonaka[1] (1.Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001, 2.Indian Institute of Technology, Kharagpur, India)

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

[AOS11-03] Re-entry of giant-impact fragments and early evolution of the Earth's ocean

*Takanori Sasaki[1] (1.Department of Astronomy, Kyoto University)

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

[AOS11-04] Modeling of Extreme Freshwater Discharge and influence from Japanese First-Class Rivers to Coastal zones

*Ryusuke Kuroki, Yosuke Alexandre Yamashiki[1], Sergey Varlamov[2], Yasumasa Miyazawa[2], Racault Fanny Marie[3], Hoshin Vijai Gupta[4] (1.Kyoto University, 2.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan, 3.Plymouth Marine Laboratory, Plymouth, United Kingdom, 4.University of Arizona)

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

[AOS11-05] Establishment of new curriculum at Biosphere 2

*Kenji Miki[1], Takao Doi[2], Yosuke Yamashiki[3], Masahiro Terada[2] (1.Kyoto University Graduate School of Agriculture, 2.Kyoto University Unit of Synergetic Studies for Space, 3.Graduate School of Advanced Integrated Studies in Human Survivability)

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

[AOS11-06] Development of the highly precise high-speed photometry technique with the photometer mounted with PIRKA telescope

*Nami Kimura[1] (1.Hokkaido University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301A 3F

[A-OS11] Continental-Oceanic Mutual Interaction: Planetary scale Material Circulation

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

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

[AOS11-07] **The Drivers of early Archean Earth's Hydrology: Resolving the Faint Young Sun's Paradox**

★Invited Papers

*Vladimir Airapetian[1], Guillaume Gronoff[2], Michael Way[3], Meng Jin[4] (1.NASA Goddard Space Flight Center/SEEC and American University, 2.NASA LaRC/SSAI, 3.NASA GISS/SEEC, 4.SETI)

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

[AOS11-08] Experimental study on elementary hydrological process of rainfall in a forested continental hinterland

*Shigeki Murakami[1] (1.Kyushu Research Cente, Forestry and Forest Products Research Institute)

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

[AOS11-09] Radiological Assessment of Martian and Terrestrial Surface during Young Sun

*Yosuke Alexandre Yamashiki[1], Hiroyuki Maehara[6], Yuta Notsu[3], Tatsuhiko Sato[2], Airapetian Vladimir[7], Shota Notsu[3], Ryusuke Kuroki[1], keiya murashima[5], Hiroaki Sato[4], Hina Bando[5], Kosuke Namekata[3], Takanori Sasaki[3], Scott Thomas[8], Nogami Daisaku[3], Kazunari Shibata[9] (1.Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2.Japan Atomic Energy Agency, 3.Graduate School of Science, Kyoto University, 4.School of Engineering, 5.School of Science, 6.National Astronomical Observatory of Japan, 7.NASA / Goddard Space Flight Center, 8.University of Bristol , 9.Kwasan Astronomical Observatory, Kyoto University)

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

[AOS11-10] **Evaluation of scintillator detection materials for application within environmental radiation monitoring**

*Peter George Martin[1], D. Connor[1], M. Lowden[1], T. B. Scott[1] (1.School of Physics, University of Bristol, Bristol, UK)

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

[AOS11-11] The important factors for future human space activity in terms of space medicine

*Masahiro Terada[1], Yosuke Yamashiki[1], Kenji Miki[1], Satoko Tsujihiro[1], Takao Doi[1] (1.Kyoto University, Unit of Synergetic Studies for Space)

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

[AOS11-12] Storm Surge Response to Freshwater Outflow from Typhoons on the Ibaraki Coast

*Josko Troselj[1], Nobuhito Mori[1] (1.Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University)

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

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

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Noboru Okuda(Research Institute for Humanity and Nature)

3:40 PM - 4:00 PM JST | 6:40 AM - 7:00 AM UTC

[AHW22-01] **Coral Skeleton $\delta^{15}N$ as a Tracer of Historic Nutrient Loading to a Coral Reef in Maui, Hawaii**

★Invited Papers

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

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

[AHW22-02] **The Use of Ammonium and Trace Metals in Identifying Low Redox Environment Zone at Indonesian Coastal Alluvial Groundwater**

*Anna Fadliah Rusydi[1,4], Mitsuyo - Saito[2], Seiichiro - Ioka[3], Shin-ichi - Onodera[1] (1.Graduate School of Integrated Arts and Sciences, Hiroshima University, Japan, 2.Graduate School of Environmental and Life Sciences, Okayama University, Japan, 3.Institute of Regional Innovation, Hirosaki University, Japan, 4.Research Center for Geotechnology, Indonesian Institute of Sciences, Indonesia)

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

[AHW22-03] Spatial and temporal variation in submarine groundwater discharge (SGD) on a beach scale in a temperate coastal island: a multi-tracer approach

*Mitsuyo Saito[1], Shin-ichi Onodera[2], Yusuke Tomozawa[2], Kazuyoshi Asai[3] (1.Graduate School of Environmental and Life Science, Okayama University, 2.Graduate School of Integrated Arts and Sciences, Hiroshima University, 3.Geo Science Laboratory)

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

[AHW22-04] **Phosphorus discharge via groundwater into the lake, based on lacustrine groundwater discharge (LGD) and alluvial plain sediment**

*Shin-ichi Onodera[1], Mitsuyo Saito[2], Guangzhe Jin[3], Anna Fadliah Rusydi[1], Yusuke Tomozawa[1], Kunyang Wang[1], Syuhei Ban[4], Noboru Okuda[5] (1.Graduate School of Integrated and Arts Sciences, Hiroshima University, 2. Graduate School of Environmental and Life Science, Okayama University, 3.Guangdong Ocean University, 4.The University of Shiga Prefecture, 5.Research Institute for Humanity and Nature)

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

[AHW22-05] **Geochemical controls and health implications of water chemistry in Benoue River Basin, North Cameroon: Insights from Major ions**

*Sharon Bih Kimbi[1,2], Wilson Y Fantong[3], Samuel N Ayonghe[2], Robert Kringel[4], Shin-ichi Onodera[1] (1.Graduate School of Integrate Arts and Sciences, Hiroshima University, 2.Department of Environmental Science, Faculty of science, University of Buea, 3.Institute of Mining and Geological Research (IRGM), 4.Federal Institute for Geoscience and Natural Resources Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR) PRESS NO & SW)

[E] 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 | 103 1F

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Takeshi Hayashi(Faculty of Education and Human Studies, Akita University)

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

[AHW23-12] Drought Analysis based on Copulas and Poisson Process

*Pei-Yu Wu[1], Gene Jiing-yun You[1] (1.National Taiwan University, Department of Civil Engineering)

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

[AHW23-13] **Snow melt dynamics in snowfall dominated mountain regions in Shonai**

*Alexander Brandt[1,3], Muhammad Fraz Ismail[2], Larry Maximo Lopez Caceres[1], Wolfgang Bogacki[2] (1.Yamagata University, 2.Hochschule Koblenz, 3.UGAS)

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

[AHW23-14] Study on transport of particulate organic matter in a small river with forest and paddy filed by using carbon isotopes ($\delta^{13}C$ and $\Delta^{14}C$)

*Seiya Nagao[1], Ryunosuke Tahara[2], Shinya Ochiai[1], Akiko Goto[3], Takashi Hasegawa[3] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University, 3.Institute of Science and Engineering, Kanazawa University)

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

[AHW23-15] **Sources of Shallow Groundwater Salinity in the Ganges Delta of Bangladesh**

*Masudur Rahman[1,2], Tomochika Tokunaga[1] (1.Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo, 5-1-5, Kashiwa-no-ha, Kashiwa-shi, Chiba 277-8563, Japan, 2.Environmental Science Discipline, Life Science School, Khulna University, Khulna 9208, Bangladesh)

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

[AHW23-16] **Groundwater chemistry in the Gunii Khooloi basin, Southern Gobi Region of Mongolia using multivariate analysis**

*Batdemberel BAYANZUL[1,2], Isao Machida[3], Kengo Nakamura[2], Noriaki Watanabe[2], Takeshi Komai[2] (1.School of Geology and Mining Engineering, Mongolian University of Science and Technology, 2.Graduate School of Environmental Studies, Tohoku University, 3.Groundwater research group, Advanced Industrial Science and Technology)

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

[AHW23-17] **Temporal observation of molybdenum concentrations in rivers from Erdenet mining area, Mongolia**

*Solongo Tsetsgee[1], Keisuke Fukushi[1], Altansukh Ochir[2], Takahashi Yoshio[3], Ariuntungalag Yunden[2], Enkhjin Odgerel[2], Noriko Hasebe[1] (1.Kanazawa University, 2.National University of Mongolia, 3.The University of Toyko)

[E] 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 | 103 1F

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Keisuke Fukushi

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

[AHW23-18] Solid-water interaction of Mn and As near the bottom of Lake Biwa. –Implications for the spatio-temporal change of these elements for past 40 years-

★Invited Papers

*TAKAAKI ITAI[1], SACHIKA NATORI[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

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

[AHW23-19] **Sources, pathways and treatment of contaminants in surface water: Applicability in developing countries**

*Mst. Shamsun Nahar[1] (1.Earth Consultant Co. Ltd, Toyama, Japan)

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

[AHW23-20] **Numerical simulations (COMSOL) of γ-Fe_2O_3 nanohybrids for transport (3D) and arsenic removal in homogeneous porous media**

*Ajay Kumar[1], Himanshu Joshi[1], Anil Kumar[1] (1.INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, INDIA)

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

[AHW23-21] **Transport processes of suspended solids in the Kumaki River inferred from atmospheric radionuclides**

*Shinya Ochiai[1], Ryunosuke Tahara[2], Tetsuya Matsunaka[1], Seiya Nagao[1] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[AHW23-22] Using tritium in Japanese precipitation for tritium-tracer transit time studies across Asia

*Maksym Gusyev[1], Yoshito Kikumori[1], Terumasa Nishihara[2], Takeshi Hayashi[3], Kimpei Ichiyanagi[4], Naofumi Akata[5], Tomoki Oda[6], Uwe Morgenstern[7], Michael Stewart[7] (1.International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), 2.Civil Engineering Research Institute for Cold Region, PWRI, 3.Akita University, 4.Kumamoto University, 5.National Institute for Fusion Science (NIFS), 6.University of Tokyo, 7.GNS Science, New Zealand)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Misako Kachi(Earth Observation Research Center, Japan Aerospace Exploration Agency)

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

[ACG34-01] Current Status and Future Plan of the Global Change Observation Mission - Water (GCOM-W) and Advanced Microwave Scanning Radiometer 2 (AMSR2)

*Misako Kachi[1], Takashi Maeda[1], Nodoka Ono[1], Hideyuki Fujii[1], Marehito Kasahara[1], Naoto Ebuchi[1,2] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.Institute of Low Temperature Science, Hokkaido University)

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

[ACG34-02] Testing and Evaluation for JPSS-1 Algorithms using Algorithm Development Library Block 2.1

*Bigyani Das[1,2], Weizhong Chen[1,2], Thomas S King[1,2], Walter Wolf[2] (1.IMSG, 2.STAR/NESDIS/NOAA)

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

[ACG34-03] Remote Sensing of Atmospheric and Surface Properties using Hyperspectral satellite Sensors

*Xu Liu[1] (1.NASA Langley Research Center)

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

[ACG34-04] **RADIOMETRIC UNIFORMITY AND STABILITY OF GROUND SITE CHARACTERIZATION FOR INSAT-3D**

*Shailesh Parihar[1], R. Bhatla[1], A. K. Mitra[2] (1.Banaras Hindu University, Varanasi, India, 2.India Meteorological Department, New Delhi, India)

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

[ACG34-05] Vicarious calibration activities of ASTER Thermal Infrared Radiometer (TIR) for Earth environmental observation

*Satoru Yamamoto[1], Hideyuki Tonooka[2], Soushi Kato[3], Kazuki Ayuzawa[2], Tsuneo Matsunaga[4] (1.Japan Space Systems, 2.Ibaraki University, 3.Remote Sensing Technology Center of Japan, 4.National Institute for Environmental Studies)

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

[ACG34-06] **Overview of Vegetation Lidar MOLI**

★Invited Papers

*Haruhisa Shimoda[1], Toshiyoshi Kimura[2], Rei Mituhashi [2], Junpei Muruoka [2], Daisuke Sakaizawa[2], Tadashi Imai [2], Kazuhiro Asai[3] (1.Tokai University, 2.JAXA, 3.Tohoku Institute of Technology)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 303 3F

[A-CG35] Projection and detection of global environmental change

convener:Michio Kawamiya(Japan Agency for Marine-Earth Science and Technology), Hiroaki Tatebe(Japan Agency for Marine-Earth Science and Technology), Kaoru Tachiiri(Japan Agency for Marine-Earth Science and Technology), Chairperson:Hiroaki Tatebe

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

[ACG35-01] **Sour and anoxic Sea of Japan in the near future**

*Chen-Tung Arthur Chen[1], Hon-Kit Lui[1], Masao Ishii[2] (1.National Sun Yat Sen University, 2.Japan Meteorological Agency)

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

[ACG35-02] **Decadal predictions of the variable ocean carbon uptake**

★Invited Papers

*Hongmei Li[1], Tatiana Ilyina[1], Wolfgang A. Müller[1,2], Peter Landschützer[1] (1.Max Planck Institute for Meteorology, Bundesstraße 53, 20146 Hamburg, Germany, 2.Deutscher Wetterdienst, Bernhard-Nocht-Straße 76, 20359 Hamburg, Germany)

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

[ACG35-03] Air-sea CO_2 flux variations in the tropical Pacific simulated with two ESMs embedded an ocean data assimilation system

*Michio Watanabe[1], Hiroaki Tatebe[1], Hiroshi Koyama[1], Tomohiro Hajima[1], Masahiro Watanabe[2], Michio Kawamiya[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, the University of Tokyo)

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

[ACG35-04] **A Study of Decadal Ocean Deoxygenation and Heat Uptake from a suite of OMIP Simulations**

*Yohei Takano[1], Jerry Tjiputra[2], Jörg Schwinger[2], Matthias Gröger[3], Sarah Berthet[4], Roland Séférian[4], Andrew Yool[5], Julien Palmieri[5], Michio Watanabe[6], Irene Stemmler[1], Tatiana Ilyina[1] (1.Max Planck Institute for Meteorology, 2.Norwegian Research Centre, 3.Swedish Meteorological and Hydrological Institute, 4.Centre National de Recherche Météorologique, Unite mixte de recherche 3589 Météo-France/CNRS, 5. National Oceanography Centre, 6.Japan Agency for Marine-Earth Science and Technology)

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

[ACG35-05] **Role of large-scale environmental variability in changing storm climate**

*Nilima Aditya Natoo[1] (1.University of Bremen, Germany)

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

[ACG35-06] The forced response of the climate system: The case of climatic teleconnections

*Tamas Bodai[1], Matyas Herein[2], Gabor Drotos[3] (1.University of Reading, 2.Eotvos University Budapest, 3.Universitat de les Illes Balears)

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 303 3F

[A-CG35] Projection and detection of global environmental change

convener:Michio Kawamiya(Japan Agency for Marine-Earth Science and Technology), Hiroaki Tatebe(Japan Agency for Marine-Earth Science and Technology), Kaoru Tachiiri(Japan Agency for Marine-Earth Science and Technology), Chairperson:Kaoru Tachiiri(Japan Agency for Marine-Earth Science and Technology), Michio Kawamiya(JAMSTEC)

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

[ACG35-07] Guiding Mother Earth: taking stock of progress to a long-term temperature goal

★Invited Papers

*Myles Robert Allen[1] (1.Environmental Change Institute, School of Geography and the Environment and Department of Physics, University of Oxford)

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

[ACG35-08] **Uneven distributions of four hazard indicators of climate change with the Paris Agreement's goals**

*Hideo Shiogama[1] (1.Center for Global Environmental Research, National Institute for Environmental Studies)

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

[ACG35-09] Understanding the centennial-scale human-natural interactions using an integrated terrestrial model MIROC-INTEG under ISIMIP2 project

*Yusuke Satoh[1], Julien Boulange[1], Naota Hanasaki[1], Kumiko Takata[1], Yadu Pokhrel[3], Ted Veldkamp[2,4], Peter Burek[2], Tokuta Yokohata[1] (1.National Institute for Environmental Studies, 2.International Institute for Applied Systems Analysis, 3.Department of Civil and Environmental Engineering, Michigan State University, 4.Institute for Environmental Studies (IVM), VU Amsterdam)

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

[ACG35-10] Radiative forcing of the physiological CO_2 response

*Victor Brovkin[1], Veronika Gayler[1], Sonia I Seneviratne[2], Pierre Gentine[3] (1.Max Planck Institute for Meteorology, Hamburg, Germany, 2.ETH, Institute for Atmospheric and Climate Science, Zurich, Switzerland, 3.Columbia University, Earth and Environmental Engineering, New York, USA)

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

[ACG35-11] Progress of MIROC-ES2 simulations in CMIP6 and the analysis of the biogeochemical feedbacks

*Tomohiro Hajima[1], Shingo Watanabe[1], Michio Kawamiya[1], Kaoru Tachiiri[1], Hiroaki Tatebe[1], Akihiko Ito[2], Kumiko TAKATA[2], Michio Watanabe[1], Maki Noguchi[1], Akitomo Yamamoto[1], Akinori Ito[1], Manabu Abe[1], Rumi Ohgaito[1], Dai Yamazaki[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Environmental Studies, 3.Institute of Industrial Science, the University of Tokyo)

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

[ACG35-12] The impact of long-term historical warming on the global terrestrial gross primary production

*Irina Melnikova[1], Takahiro Sasai[1] (1.Tohoku University)

[E] Oral | H (Human Geosciences)：H-GM Geomorphology

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

[H-GM03] Geomorphology

convener:Tsuyoshi Hattanji(Faculty of Life and Environmental Sciences, University of Tsukuba), Masayuki Seto(Fukushima Future Center for Regional Revitalization, Fukushima University), Chairperson:Thomas Parkner, Tsuyoshi Hattanji

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

[HGM03-01] Surface structure as a control for gully complex development in the Mackey`s block, North Island, New Zealand

*Thomas Parkner[1] (1.University of Tsukuba, Graduate School of Life and Environmental Sciences)

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

[HGM03-02] Model Linking Landslides and River Evolution of Incisional Channel Created by River Erosion

*Chia-Ting Kao[1], Gene Jiing-yun You[1] (1.National Taiwan University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HGM03-03] **A semi-automated method for extracting channels and channel profiles from LiDAR-derived digital elevation models**

*Pinliang Dong[1] (1.University of North Texas)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HGM03-04] Laboratory experiments on the landform development

*Shunji Ouchi[1] (1.Faculty of Science and Engineering, Chuo University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HGM03-05] Characteristics of lake sediment from southern part of Mongolia and comparison to meteorological data

*Uyangaa Udaanjargal[1], Noriko Hasebe[1], Keisuke Fukushi[1], Tanaka Yukiya[2], Davaadorj Davaasuren[4], Makoto Sambo[1], Baasansuren Gankhurel[1], Nagayoshi Katsuta[3], Shinya Ochiai[1], Tuvshin Gerelmaa[4] (1.Kanazawa University, 2.Kyunghee University, 3.Gifu University, 4.National University of Mongolia)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HGM03-06] **Evaluation of geomorphological changes on Kujukuri beach based on UAV SfM**

*Mergen Kungaa[1], Toshihiko Sugai[1], Natsuki Sasaki[1], Taiga Kimori[1], Taro Funatsu (1.Tokyo University, Graduate School of Frontier Sciences, Department of Natural Environmental Studies)

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 304 3F

[H-DS10] Natural hazards impacts on human society, economics and technological systems

convener:ELENA PETROVA(Lomonosov Moscow State University, Faculty of Geography), Hajime Matsushima(Research Faculty of Agriculture, Hokkaido University), Chairperson:Elena Petrova, Hajime Matsushima

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HDS10-01] People's lives utilizing coastal dunes ecosystem service

★Invited Papers

*Kaneko Korehisa[1] (1.Hokuso Creature Association)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HDS10-02] Survey on the Impact of Sea wall on the Vegetation of Coastal sand dune

*XIANGMEI ZHONG[1], Hajime Matsushima[2], Akira Suzuki[3], Yoshihiko Hirabuki[4], Kouji Kimura[5] (1.Graduate school of Agriculture, Hokkaido University, 2.Research Faculty of Agriculture, Hokkaido University, 3.Kita-no-satohama Hana-no-kanehashi Network, 4.Faculty of Liberal Arts, Tohoku Gakuin University, 5.Snow Brand Seed Co., Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HDS10-03] Greening on the seawall: challenge to conversion from gray to green infrastructure.

★Invited Papers

*Hajime Matsushima[1], Akira Suzuki[2], Kouji Kimura[4], Xiangmei Zhong[5], Yoshihiko Hirabuki[3] (1.Research Faculty of Agriculture, Hokkaido University, 2.Kita-no-satohama Hana-no-kakehashi Network, 3.Faculty of Liberal Arts, Tohoku Gakuin University, 4.Snow Brand Seed Co., Ltd., 5.Graduate school of Agriculture, Hokkaido University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HDS10-04] Distribution Characteristics of Informal Green Space and Its Extension of perspective into Green Infrastructure

*minseo kim[1], Katsunori Furuya[1] (1.Chiba University Graduate School of Horticulture)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HDS10-05] DISASTER ANALYSIS OF LIGHTNING STRIKE DENSITY BASED ON LANDFORM FOR REDUCING VICTIMS IN WONOSOBO, INDONESIA

*Astry Zulky Permatasari[1], Gagad Nur Ridho[1], Yan Abdi Rahmanu[1], Emilya Nurjani[1] (1.Gadjah Mada University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HDS10-06] Development of Cost Competitive Unmanned Aerial Vehicle for Search and Rescue

*Aditya Keshav Natoo

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301B 3F

[H-DS10] Natural hazards impacts on human society, economics and technological systems

convener:ELENA PETROVA(Lomonosov Moscow State University, Faculty of Geography), Hajime Matsushima(Research Faculty of Agriculture, Hokkaido University), Chairperson:Hajime Matsushima, Elena Petrova

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HDS10-07] **Seasonal variations of atmospheric hazard impacts on infrastructure**

★Invited Papers

*ELENA PETROVA[1] (1.Lomonosov Moscow State University, Faculty of Geography)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HDS10-08] Assessment of water supply function and measures for chemical release accidents triggered by major earthquakes

*Lisa Ito[1], Toyohiko Nakakubo[2], Naoya Kojima[1], Akihiro Tokai[1] (1.Graduate School of Engineering, Osaka University, 2.Faculty of Core Research, Ochanomizu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HDS10-09] Development of disaster risk management plan of a thermal power plant: Spearheading the paradigm shift from disaster management to disaster risk management of NATECH in India

*Repaul Kanji[1], Madan Mohan Rout[2], Ankur Srivastava[3] (1.Gujarat Institute of Disaster Management, Gandhinagar, Gujarat, India, 2.Institute of Seismological Research, Gandhinagar, India, 3.Indian Institute of Technology Delhi, India)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HDS10-10] **Applying Transfer Learning to Improve Machine Learning Impact Model at Extremes**

*Peter Lawrence Watson[1], Manos Anagnostou[1], David Wanik[1] (1.University of Connecticut)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HDS10-11] rescEU, the European Union Civil Protection System UCPM and the future role of Geosciences in natural disaster reduction

*Andreas Nikolaus Kueppers[1] (1.GFZ - Deutsches Geoforschungszentrum - Helmholtz Zentrum Potsdam)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HDS10-12] The Probability of Satellite Anomalies by a Disastrous Solar Flare

*Daikichi SEKI[1,2,3] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2.Centre for the Study of Existential Risk, University of Cambridge, 3.Astronomical Observatory, Kyoto University)

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301B 3F

[H-DS10] Natural hazards impacts on human society, economics and technological systems

convener:ELENA PETROVA(Lomonosov Moscow State University, Faculty of Geography), Hajime Matsushima(Research Faculty of Agriculture, Hokkaido University), Chairperson:Elena Petrova, Hajime Matsushima

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[HDS10-13] Management and Maintenance for Disaster prevention park in Tokyo Metropolitan Government

★Invited Papers

*Masayshi Kikuchi[1] (1.Tokyo Metropolitan Park Association)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[HDS10-14] Rebuilding Tourism after the Great East Japan Earthquake and Examining Post-Disaster Tourism in Kamaishi City

*Satoshi Sasaki[1], Kiyotatsu Yamamoto[2], Kaoruko Sasaki[3] (1.Iwate University, 2.The University of Tokyo, 3.Hokkaido University)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[HDS10-15] Population Change in Ishinomaki City, Miyagi Prefecture, with a Focus on the Area around the Earthquake Ruins

*Ryo Nishisaka[1], Katsunori Furuya[1] (1.Chiba University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[HDS10-16] The Way of Seeing the Atomic Bomb Dome and the Relationship with Viewers' Attributes

*yasuhara arisa[1], Kiyotatsu Yamamoto[1], Akio Shimomura[1] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[HDS10-17] Flood Disaster Risk Analysis at Ratnapura in Sri Lanka

*Tsuchida Ryo[1], Kaoru Takara[1] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 101 1F

[H-TT21] Non-destructive techniques applied to stone cultural heritage

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Celine Elise Thomachot-Schneider(Groupe d'etude des environnements naturels, anthropiques et archeologiques - Universite de Reims-Champagne-Ardenne (France)), Wonsuh Song(Waseda University), Miguel Gomez-Heras(Universidad Autonoma de Madrid), Chairperson:Wonsuh Song, Chiaki Oguchi

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HTT21-01] Study on creation of 3D model by SfM photogrammetry: An example of Taya Cave

Kisara Shimizu[1], *Chiaki T. Oguchi[1], Yasuhiko TAMURA[2], Yuichi S. Hayakawa[3], Takuro Ogura[4], OGATA KEISUKE[5] (1.Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University, 2.The Exective Committee for the Preservation of Taya Cavern, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Graduate School of Frontier Sciences, The University of Tokyo, 5.Tsurumi University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HTT21-02] **TLS measurement data and 3D printing of an artificial cave for geotechnical and educational applications**

*Yuichi S. Hayakawa[1,2], Takuro Ogura[4,5], Yasuhiko Tamura[2], Chiaki T. Oguchi[3], Kisara Shimizu[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Center for Spatial Information Science, The University of Tokyo, 3.Saitama University, 4.Graduate School of Frontier Science, The University of Tokyo, 5.Graduate School of Environmental Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HTT21-03] Conservation restoration of the world heritage of Okinawa Prefecture, Sonohyan-utaki Ishimon - Situation after 30 years since filling with mortar and applying silicone resin.

*Wonsuh Song[1], Tadateru Nishiura[2], Chiaki T. Oguchi[3] (1.Waseda University, 2.Kokushika Univeristy, 3.Saitama University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HTT21-04] Application of portable XRF analysis for provenance of seabed worked stone in coastal are of Kochi Prefecture

★Invited Papers

*Wataru Tanikawa[1], Go-Ichiro Uramoto[2], Masafumi MURAYAMA[2], Yohei Hamada[1], Yuhji Yamamoto[2], Osamu Tadai[3] (1.Japan Agency for Marine-Earth Science and Technology, Kochi Instutute for Core Sample Research, 2.Kochi University, Center for Advanced Marine Core Research, 3.Marine Works Japan LTD.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HTT21-05] pXRF analyses on Assyrain sculptures

★Invited Papers

*Ryo Anma[1], Ki-Cheol Shin[2], Chikako Watanabe[3], Akihiro Tuji[4] (1.Graduate School of Technology, Industrial and Social Sciences, Tokushima University, 2.Research Institute for Humanity and Nature, 3.Faculty of International Studies, Osaka Gakuin University, 4.National Museum of Nature and Science)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HTT21-06] Discussion

*Chiaki T. Oguchi[1] (1.Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT26] New perspectives on the geodynamics of East Asia

convener:Timothy B Byrne(University of Connecticut), Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo), Jonny Wu(University of Houston), Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Jonny Wu, Okino Kyoko

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SIT26-01] How to solve controversies in Cenozoic tectonics in western Pacific margin

*Gaku Kimura[1] (1.Tokyo University of Marine Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SIT26-02] Plio-Pleistocene plate interactions associated the Philippine Sea Plate

*Timothy B Byrne[1], Gaku Kimura[3], Jonny Wu[2] (1.University of Connecticut, 2.University of Houston, 3.Tokyo University of Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SIT26-03] A regional mylonite zone between the Mesozoic metamorphic basement and the subducted Miocene covered schists in eastern Range of Taiwan: A possible Plio-Pleistocene transform fault between Eurasia and the Philippine Sea plate

*Gong-Ruei Ho[1], Jian-Cheng Lee[1], Timothy B Byrne[2], En-Chao Yeh[3] (1.Institute of Earth Sciences, Academia Sinica, 2.Department of Geography, University of Connecticut, 3.Department of Earth Sciences, National Taiwan Normal University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SIT26-04] **Coeval exhumation or subduction channel extrusion of the high pressure Yuli belt? Insights from the Shoufeng fault in eastern Taiwan**

*Jian-Cheng Lee[1,5], Gong-Ruei Ho[1,5], Timothy B Byrne[2], Yuan Hsi Lee[3,5], En-Chao Yeh[4,5] (1.Academia Sinica, 2.Univerity of Connecticut, 3.National Chung Cheng University, 4.National Taiwan Normal University, 5.The Yuli Exhumation Study team (YES Team))

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SIT26-05] Metamorphic temperature variation across the Yuli belt: a clue about exhumation of high-pressure rocks?

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Yui Kouketsu[2], Masaki Enami[3] (1.Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2.Department of Earth & Planetary Sciences, Nagoya Univ., 3.Institute for Space-Earth Environmental Research, Nagoya Univ.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SIT26-06] **Thermal state, slab metamorphism and interface seismicity in Mariana based on 3-D modeling**

*Yingfeng Ji[1,2,3], Shoichi Yoshioka[3,4] (1.Center of Excellence in Tibetan Plateau Earth Science, Chinese Academy of Sciences, 2.Key laboratory of continental collision and plateau uplift, Institute of Tibetan Plateau, Chinese Academy of Sciences, 3.Research Center for Urban Safety and Security, Kobe University, 4.Graduate School of Science, Kobe University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT26] New perspectives on the geodynamics of East Asia

convener:Timothy B Byrne(University of Connecticut), Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo), Jonny Wu(University of Houston), Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo), Tim Byrne

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SIT26-07] **A tomography-led plate reconstruction of NE Asia during the late Cretaceous**

*Jonny Wu[1], Yi-An Lin[1], Nicolas Flament[2], Tsung-Jui Wu[1], Yiduo Liu[1] (1.University of Houston, 2.University of Wollongong)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SIT26-08] Geodynamic models of late Mesozoic intraoceanic subduction offshore NE Asia caused by growing Izanagi plate

*Lorenzo Colli[1], Jonny Wu[1], Yi-An Lin[1] (1.University of Houston)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SIT26-09] **Early Cretaceous to Paleocene magmatism in the Sikhote-Alin area and their implications for Paleo-Pacific plate subduction and continental evolution**

*Tsung-Jui Wu[1], Jonny Wu[1], Igor Alexandrov[2], Thomas Lapen[1] (1.Department of Earth and Atmospheric sciences, University of Houston, Houston, U.S., 2.Far East Geological Institute, Russian Academy of Sciences, Vladivostok, Russia)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SIT26-10] Processes of subduction initiation revealed by P-T paths of amphibolite and blueschist tectonic blocks in serpentinite mélange: An example from the Kamuikotan high-P/T metamorphic rocks in Hokkaido, northern Japan

*Toru Takeshita[1], Ayumi S. Okamoto, Wonji Shin[1], Mizuho Ando[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University)

4:30 PM - 4:50 PM JST | 7:30 AM - 7:50 AM UTC

[SIT26-11] Metamorphism in the Sanbagawa belt of SW Japan as a record of subduction processes

★Invited Papers

*Simon Richard Wallis[1] (1.University of Tokyo)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[SIT26-12] Subduction and exhumation of the high pressure metamorphic rocks: What we know and what we need to know.

*Timothy B Byrne[1] (1.University of Connecticut)

[E] Oral | S (Solid Earth Sciences)：S-GC Geochemistry

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GC40] Volatile Cycles in the Deep Earth - from Subduction Zone to Hot Spot

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Takeshi Hanyu(Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Gray E Bebout(Lehigh University), Chairperson:Takeshi Hanyu, Gray Bebout(Lehigh University), Yuji Sano, Hirochika Sumino

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[SGC40-01] Continental growth, crustal recycling, and global water cycle

★Invited Papers

*Jun Korenaga[1] (1.Department of Geology and Geophysics, Yale University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SGC40-02] Role of volatiles in magma genesis of ascending mantle plume

*Eiichi Takahashi[1], Jintuan Wang[1], Li Li[1] (1.Guangzhou Institute of Geochemistry, Chinese Academy of Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SGC40-03] DH partitioning experiment among high-pressure polymorph of olivine

*Asami Sano-Furukawa[1], Shoichi Itoh[2], Toru Inoue[3], Masamichi Noda[3] (1.J-PARC center, Japan Atomic Energy Agency, 2.Kyoto University, 3.Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SGC40-04] **Formation of Fe-rich volatile-bearing phases in the deep lower mantle and the implications for deep Earth volatile cycles**

*Li Zhang[1], Hongsheng Yuan[1], Eiji Ohtani[2], Lianjie Man[1], Duck Young Kim[1], Dmitry Popov[3], Yue Meng[3], Eran Greenberg[4], Vitali Prakapenka[4] (1.Center for High Pressure Science and Technology Advanced Research (HPSTAR), 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.HPCAT, X-ray Science Division, Argonne National Laboratory, 4.GeoSoilEnviroCARS, University of Chicago)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SGC40-05] Estimation of the origin of Pitcairn Island OIB by Independent Component Analysis

*Takahiro Ozawa[1], Hikaru Iwamori[1,2,3], Takeshi Hanyu[2], Morihisa Hamada[2], Kenji Shimizu[4], Ushikubo Takayuki[4], Jun-Ichi Kimura[2], Q. Chang[2], Hitomi Nakamura[5], Motoo Ito[4] (1.Tokyo Institute of Tokyo, 2.Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology, 3.Earthquake Research Institute, The University Tokyo, 4.Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 5.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

[E] Oral | S (Solid Earth Sciences)：S-GC Geochemistry

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GC40] Volatile Cycles in the Deep Earth - from Subduction Zone to Hot Spot

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Takeshi Hanyu(Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Gray E Bebout(Lehigh University), Chairperson:Takeshi Hanyu, Gray Bebout(Lehigh University), Yuji Sano, Hirochika Sumino

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SGC40-06] Tracing recycled volatiles in MORB with halogens

★Invited Papers

*Ray Burgess[1], Lorraine Ruzie-Hamilton[1], Patricia Clay[1], Bastian Joachim[2], Christopher Ballentine[3] (1.School of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL UK, 2.Institute for Mineralogy and Petrography, University of Innsbruck, Innrain, 52A-6020, Innsbruck, Austria, 3.Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN UK)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SGC40-07] Volatile composition in ocean island basalts

*Takeshi Hanyu[1] (1.Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SGC40-08] Halogen heterogeneity in the subcontinental lithospheric mantle

*Hirochika Sumino[1], Masahiro Kobayashi[2], Ray Burgess[3], Chris J Ballentine[4] (1.Department of Basic Science, Graduate School of Arts and Sciences, University of Tokyo, 2.Tokyo Metropolitan Industrial Technology Research Institute, 3.School of Earth and Environmental Sciences, University of Manchester, 4.Department of Earth Sciences, University of Oxford)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SGC40-09] Efficiency of Deep Carbon Subduction: Input, Metamorphic Records, and Bearing on Estimated Sources of Arc Volcanic Gases

*Gray E Bebout[1,2], Gabe S Epstein[2], Brian M House[3] (1.Institute for Planetary Materials, Okayama University, 2.Lehigh University, 3.University of California, San Diego)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SGC40-10] Helium isotope variations in subduction-type volcanic hydrothermal systems

*Yuji Sano[1], Takanori Kagoshima[1], Naoto Takahata[1], Tetsuji Onoue[2], Tomo Shibata[3], Tobias P Fischer[4] (1.Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Earth and Environmental Sciences, Kumamoto University, 3.Institute for Geothermal Sciences, Kyoto University, 4.Department of Earth and Planetary Sciences, University of New Mexico)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | IC 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Hitoshi Hirose, Yoshiyuki Tanaka

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[SCG48-01] Variability of the space-time evolution of slow slip events off the Boso Peninsula, central Japan, from 1996 to 2018

★Invited Papers

*Jun'ichi Fukuda[1] (1.Earthquake Research Institute, University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG48-02] Cumulative slip distribution of short-term slow slip events in the western Shikoku area, southwest Japan based on tilt change measurements

*Hitoshi Hirose[1,2], Wakako Tamura[2], Takeshi Kimura[3] (1.Research Center for Urban Safety and Security, Kobe University, 2.Graduate School of Science, Kobe University, 3.National Research Institute for Earth Science and Disaster Resilience)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG48-03] Shallow undersea SSEs off the western Japan monitored by the GNSS-A

*Yusuke Yokota[1], Tadashi Ishikawa[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic department, Japan Coast Guard)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG48-04] Co- and Post-seismic deformation due to the 2016 moderate earthquake sequence at the Chaman fault

*Fumiko Matsumoto[1], Masato Furuya[1] (1.Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG48-05] An attempt to quantify transient fluid flow during slow slip event using GNSS and gravity data-1st report

*Yusuke Umemiya[1], Yoshiyuki Tanaka[1] (1.The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Kazushige Obara(Earthquake Research Institute, University of Tokyo), Aitaro Kato(Earthquake Research Institute, University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG48-06] Interplay between long-term SSE and ETS facilitated by different underground environment

*Kazushige Obara[1] (1.Earthquake Research Institute, The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG48-07] **Determination of sVLFE epicenters around the subducted Kyushu-Palau Ridge from coda interferometry**

*Takashi Tonegawa[1], Yusuke Yamashita[2], Aki Ito[1], Masanao Shinohara[3], Daisuke Suetsugu[1], Tsutomu Takahashi[1], Yasushi Ishihara[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[4] (1.JAMSTEC, 2.DPRI, Kyoto University, 3.ERI, The University of Tokyo, 4.Kagawa University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG48-08] Detection of slow earthquakes in the microseism frequency band (0.05–1.0 Hz) by large-scale waveform stacking

*Koki Masuda[1], Satoshi Ide[1], Kazuaki Ohta[2] (1.Department of Earth an Planetary Science, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG48-09] Source characteristics of low-frequency earthquakes in Nankai subduction zone inferred from analysis of large event dataset

*Natalia Poiata[1], Mariano Supino[1,2], Gaetano Festa[2], Jean-Pierre Vilotte[1], Kazushige Obara[3] (1.Institut de Physique du Globe de Paris, 2.Università degli Studi di Napoli “ Federico II ”, Napoli, Italy, 3.Earthquake Research Institute, University of Tokyo, Japan)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG48-10] **High-frequency radiation prior to semi-volcanic low-frequency earthquake in Eastern Shimane, SW Japan, illuminated by “0.1 manten” Hyper Dense Seismic Observation**

*Aitaro Kato[1], Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3] (1.Earthquake Research Institute, the University of Tokyo, 2.Kyushu University, 3.Kyoto University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG48-11] Variation of Focal Mechanisms of Low Frequency Earthquakes in Parkfield

*Miki Aso[1,3], Naofumi Aso[2], Satoshi Ide[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Tokyo Institute of Technology, School of Science , 3.OYO RMS Corporation)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Satoshi Ide(Graduate School of Science, University of Tokyo), Kazuaki Ohta

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SCG48-12] Mapping seismic data to slow slip using machine learning

★Invited Papers

*Bertrand Rouet-Leduc[1], Claudia Hulbert[2], Ian McBrearty[1], Paul Johnson[1] (1.Los Alamos National Laboratory, USA, 2.Ecole Normale Superieure, France)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG48-13] Revealing the slow earthquake activity in the Japan Trench and its relation to the 2011 Tohoku-Oki earthquake

*Tomoaki Nishikawa[1], Takanori Matsuzawa[2], Kazuaki Ohta[1], 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, Tohoku University, 4.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG48-14] Tremor and slow slip associated with afterslip of the 2011 Tohoku earthquake

*Kazuaki Ohta[1], Yoshihiro Ito[1], Ryota Hino[2], Shukei Ohyanagi[1], Takanori Matsuzawa[3], Masanao Shinohara[4], Hajime Shiobara[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Science, Tohoku University, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Earthquake Research Institute, the University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG48-15] High definition imaging of the Japan Trench by OBS Array of Arrays: Does shallow tectonic tremor occur in the plate interface?

*Shukei Ohyanagi[1], Kazuaki Ohta[2], Yoshihiro Ito[2], Ryota Hino[3], Yusaku Ohta[3], Ryosuke Azuma[3], Masanao Shinohara[4], Kimihiro Mochizuki[4], Toshinori Sato[5], Yoshio Murai[6] (1.Kyoto University, Graduate School of Science, 2.Kyoto University, Disaster Prevention Research Institute, 3.Tohoku University, 4.Tokyo University, Earthquake Research Institute, 5.Chiba University, 6.Hokkaido University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG48-16] The activity of small repeating earthquakes after the 2011 Tohoku-oki earthquake: an examination based on the S-net and land networks

*Naoki Uchida[1], Ryota Takagi[1], Satoshi Hirahara[1], Takashi NAKAYAMA[1], Toru Matsuzawa[1], Sachiko Tanaka[2], Youichi Asano[2] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2.National Research Institute for Earth Science and Disaster Resilience)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201A 2F

[M-IS07] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Misato Fukagawa(名古屋大学大学院 理学研究科), Kosuke Fujishima(ELSI 地球生命研究所)

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[MIS07-01] METEOROID AND DEBRIS IMPACT FLUX IN LOW EARTH ORBIT WITNESSED BY THE TANPOPO CAPTURE PANELS ONBOARD THE ISS IN 2015-2017

*Hajime Yano[1], K. Yamamoto[2], E. Minakami[2], M. Eitel[1,3], S. Sasaki[4], J. Imani[5], K. Okudaira[6], M. Higashide[7], E. Imai[8], Y. Kawaguchi[9], Yoko Kebukawa[10], H. Mita[11], M. Nishi[12], T. Noguchi[13], Makoto Tabata[14], A. Tsuchiyama[12], Hikaru Yabuta[15], K. Arai[8], H. Hashimoto[1], Kensei Kobayashi[10], A. Yamagishi[16] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Hosei University, 3.University of Stuttgart, 4.Tokyo University of Technology, 5.Yuki Seimitsu, Co. Ltd., 6.University of Aizu, 7.JAXA/Aerospace Research and Development Directorate, 8.Nagaoka University of Technology, 9.Chiba Institute of Technology, 10.Yokohama National University, 11.Fukuoka Institute of Technology, 12.Kyoto University, 13.Kyushu University, 14.Chiba University, 15.Hiroshima University, 16.Tokyo University of Pharmacy and Life Science)

3:50 PM - 4:10 PM JST | 6:50 AM - 7:10 AM UTC

[MIS07-02] Growth and transport of dust, ice, and organics in the inner part of protoplanetary disks

★Invited Papers

*Satoshi Okuzumi[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[MIS07-03] Model Prediction of Complex Organic Molecules in Protoplanetary Disks

*Hideko Nomura[1], Catherine Walsh[2], Tom J. Millar[3] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.School of Physics and Astronomy, University of Leeds, 3.School of Mathematics and Physics, Queen’s University Belfast)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[MIS07-04] Abiotic synthesis of organic matters in environments simulating asteroids and the catalytic effect of minerals on amino acid formation

*Walaa Elmasry[1], Yoko Kebukawa[1], Kensei Kobayashi[1] (1.Yokohama National University)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[MIS07-05] Peptide Formation from amino acid precursors under simulated submarine hydrothermal environments

*Kensei Kobayashi[1], Keisuke Naito[1], Koki Naito[1], Soushi Kuramoto[1], Ei-ichi Imai[2], MITA Hajime[3], Yoko Kebukawa[1] (1.Yokohama National University, 2.Nagaoka University of Technology, 3.Fukuoka Institute of Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 104 1F

[M-GI30] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Takemasa Miyoshi(RIKEN), Chairperson:Takemasa Miyoshi(RIKEN Advanced Institute for Computational Science), Shin'ya Nakano(情報・システム研究機構 統計数理研究所)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI30-01] Recent progresses and applications of geomagnetic data assimilation

★Invited Papers

*Julien Aubert[1], Vincent Lesur[1], Alexandre Fournier[1], Gauthier Hulot[1] (1.Institut de Physique du Globe de Paris, France)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI30-02] Accounting for non-locality of vertical error correlation within ETKF through eigen-spectral localization

★Invited Papers

*Daisuke Hotta[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI30-03] Data assimilation experiments with MODIS LAI observations and the dynamic global vegetation model SEIB-DGVM over Siberia

★Invited Papers

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Yohei Sawada[1,2], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science, 2.Meteorological Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI30-04] Inversion of the ocean vertical diffusivity from steady-state tracer distributions by using an adjoint method

★Invited Papers

*Akira Oka[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI30-05] Nonlinear data assimilation with 4DEnVar using iterative weather forecast model

*Sho Yokota[1], Ko Koizumi[1], Masaru Kunii[2,1], Kosuke Ito[3,1] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Numerical Prediction Division, Forecast Department, Japan Meteorological Agency, 3.University of the Ryukyus)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MGI30-06] Development of Data Assimilation System for Atmospheric Density to Improve Satellite's Orbit Prediction Accuracy

*Hiroshi Kato[1], Hideaki Hinagawa[1], Kyohei Akiyama[1], Yuki Akiyama[1], Masaya Nakano[2], Daichi Obinata[2], Shinichi Nakamura[1] (1.Japan Aerospace Exploration Agency, 2.FUJITSU LIMITED)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 104 1F

[M-GI30] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Takemasa Miyoshi(RIKEN), Chairperson:Shinichi Miyazaki(Kyoto University), Yosuke Fujii

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI30-07] An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS

★Invited Papers

*Shun Ohishi[1], Tsutomu Hihara[2], Hidenori AIKI[1], Joji Ishizaka[1], Yasumasa Miyazawa[2], Misako Kachi[3] (1.Nagoya University, 2.JAMSTEC, 3.JAXA)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI30-08] Validation of JCOPE-T DA ocean assimilation product

*Tsutomu Hihara[1], Sergey Varlamov[1], Yasumasa Miyazawa[1], Toru Miyama[1], Misako Kachi[2], Hiroshi Murakami[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Aerospace Exploration Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI30-09] **Do surface lateral flows matter for land data assimilation?: Implication for hyper-resolution land modeling and observation**

*Yohei Sawada[1] (1.Meteorological Research Institute)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI30-10] Geodynamo data assimilation for candidate models of IGRF13-SV from Japan team

*Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hisayoshi Shimizu[1], Hiroaki TOH[5] (1.Ocean Hemisphere Research Institute, Earthquake Research Institute,The University of Tokyo, 2.The Institute of Statistical Mathematics, 3.Faculty of Science, Kyushu University, 4.School of Science, Tokyo Institute of Technology, 5.Graduate School of Science, Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI30-11] A pilot study of geomagnetic data assimilation into a geodynamo model

*Shin ya Nakano[1], Takuto Minami[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5], Hisayoshi Shimizu[2] (1.The Institute of Statistical Mathematics, 2.Earthquake Research Institute, the University of Tokyo, 3.Faculty of Science, Kyushu University, 4.School of Science, Tokyo Institute of Technology, 5.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI30-12] Bayesian parameter estimation of a physics-based model of postseismic crustal deformation

★Invited Papers

*Jun'ichi Fukuda[1], Kaj Johnson[2] (1.Earthquake Research Institute, University of Tokyo, 2.Department of Earth and Atmospheric Sciences, Indiana University)

Thu. May 30, 2019

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Huixin Liu(Kyushu University, Japan), Stan Solomon(National Center for Atmospheric Research, US)

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[PEM09-11] Assimilation products of thermospheric and ionospheric measurements by the NASA Ionopsheric Connection Explorer

★Invited Papers

*Thomas J Immel[1], Chihoko Cullens[1], Yen-Jung Wu[1], Gary Bust[2], Jeffrey Forbes[3], Scott L England[4] (1.University of California, Berkeley, 2.Johns Hopkins University, 3.University of Colorado, 4.Virginia Tech)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[PEM09-12] petitSat - A 6U CubeSat to examine the link between MSTIDS and ionospheric plasma density enhancements

*Jeffrey Klenzing[1], Ryan L Davidson[2], Gregory D Earle[3], Alexa J Halford[4], Sarah L Jones[1], Carlos Martinis[5], Nikolaos Paschalidis[1], Robert F Pfaff[1], Jonathon M Smith[1,6] (1.NASA Goddard Space Flight Center, Greenbelt, MD, USA, 2.Utah State University, Logan, UT, USA, 3.Virginia Tech, Blacksburg, VA, USA, 4.The Aerospace Corporation, Chantilly, VA, USA, 5.Boston University, Boston, MA, USA, 6.Catholic Universtiy of America, Washington, DC, USA)

9:35 AM - 9:55 AM JST | 12:35 AM - 12:55 AM UTC

[PEM09-13] A three-dimensional ionospheric electrodynamics model

★Invited Papers

*Astrid I Maute[1], Arthur D Richmond[1] (1.High Altitude Observatory, National Center for Atmospheric Research, Boulder CO, USA.)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[PEM09-14] **Spatial Fluctuation of TEC Index: A new index of ionospheric irregularities**

*Guanyi Ma[1], Takashi Maruyama[2] (1.National Astronomical Observatories, Chinese Academy of Sciences, 2.National Institute of Information and Communications Technology)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[PEM09-15] Coupling of lower thermosphere planetary wave energy into the ionosphere

*Patrick J Espy[1,2], Nora Stray[1,2,3], Robert Hibbins[1,2] (1.Norwegian University of Science and Technology, Trondheim, Norway, 2.Birkeland Centre for Space Science, Bergen, Norway, 3.Teknova AS, Tordenskjolds Gate 9, 4612 Kristiansand, Norway)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Jann-Yenq Liu(National Central University, Taiwan), Loren Chang(National Central University, Taiwan)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM09-16] Modulation of Lightning Occurrence by the Solar Wind

*Omar Angelo Nava[1], Daniel Emmons[1], Robert Loper[1] (1.Air Force Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM09-17] Long Term Mesopause Temperature Variations resolved by SD-WACCM, MSISE-00,TIMED SABER and Local Observations in Irkutsk (52.29o, 104.29o), Russia

*Yi Chung Chiu[1], Loren Chang[1], Yi Duann[1], ALEXEI DMITRIEV[1], Irina Medvedeva[2], Konstantin Ratovsky[2], Jia Yue[3] (1.Institute of Space Science, National Central University, 2.Russian Academy of Sciences, Russian Federation, 3.Hampton University, USA)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM09-18] ISS-IMAP observation of the mesospheric disturbances generated by tropical cyclones

*Akinori Saito[1], Takeshi Sakanoi[2], Septi Perwitasari[4], Yuta Hozumi[3], Ryota Okada[1], Ryo Murakami[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 3.University of Electro-Communications, 4.Space and Upper Atmospheric Sciences Group, National Institute of Polar Research)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM09-19] A fast acoustic wave detected in GNSS total electron content after the foreshock of the 2011 Tohoku Earthquake

*Yoshihiro Kakinami[1], Hiroaki Saito[2], Tetsuo Yamamoto[3], Chia-Hung Chen[4], Masa-yuki Yamamoto[2], Kensuke Nakajima[5], JANN-YENQ Liu[6] (1.Hokkaido Information University, 2.Kochi University of Technology, 3.Hokkaido University, 4.National Cheng Kung University, 5.Kyushu University, 6.National Central University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM09-20] **Study of quiet-time high-latitude thermospheric winds using a Fabry-Perot interferometer at Tromsoe: Averages and exceptional events**

*Heqiucen XU[1], Kazuo Shiokawa[1], Shin-ichiro Oyama[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM09-21] **The longitudinal differences of lunar tidal characteristics between East Asian and American sectors during stratospheric sudden warming events: 2009-2018.**

*Jing Liu[1], Donghe Zhang[1] (1.Peking University)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Shin'ya Nakano(情報・システム研究機構 統計数理研究所), Motoharu Nowada(Shandong University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM11-07] **Nightside Distorted Transpolar Arcs and Their Possible Formation Process Model**

*Nowada Motoharu[1], Jun Yang[1], Benoit Hubert[2], Qiu-Gang Zong[3], Quan-Qi Shi[1], Yong-Fu Wang[3], Xu-Zhi Zhou[3], Zhao Hua-Yu[3] (1.Shandong University at Weihai, 2.Université de Liège, 3.Peking University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM11-08] Ionospheric Conductivity Dependence of the Subauroral Polarization Streams Observed by the SuperDARN HF Radars

Yuting Zhang[1], *Nozomu Nishitani[1], Tomoaki Hori[1], Simon G. Shepherd[2], William A. Bristow[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Thayer School of Engineering, Dartmouth College, 3.University of Alaska Fairbanks)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM11-09] Ionospheric convection modeling based on convolution with a localized vector-valued basis function

*Shin ya Nakano[1], Tomoaki Hori[2], Kanako Seki[3], Nozomu Nishitani[2] (1.The Institute of Statistical Mathematics, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Graduate School of Science, University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM11-10] **Occurrence Statistics and Driving Mechanisms of Ionospheric ULF Waves Observed by SuperDARN Radars**

★Invited Papers

*Xueling Shi[1], Joseph B. H. Baker[1], John Michael Ruohoniemi[1], Dong Lin[1], Michael Hartinger[1,2] (1.Virginia Tech, 2.Space Science Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM11-11] Magnetic Field Oscillations Observed by Swarm Satellites in the Nightside Upper Ionosphere During Low-latitude Pi2 Pulsations

*Khan-Hyuk Kim[1], Jae-Hee Park[1] (1.School of Space Research, Kyung Hee Univ.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM11-12] Magnetospheric Multiscale observations of ULF waves and correlated low-energy ion monoenergetic acceleration

*Bin Li[1], De-sheng Han[2], Ze-jun Hu[1], Jian-jun Liu[1], Lei Dai[3] (1.Polar Research Institute of China, 2.Tongji University, 3.National Space Science Center, Chinese Academy of Sciences)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Kunuhiro Keika(東京大学大学院理学系研究科), Shin'ya Nakano(情報・システム研究機構 統計数理研究所), Motoharu Nowada(Shandong University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM11-13] Statistical study on warm plasma in the magnetotail based on two-component fits of distribution functions

*Kunihiro Keika[1], Ryuta Asami[1], Masahiro Hoshino[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM11-14] Analysis on anisotropy variations for pitch angle distributions of electrons with various parameters at dipolarization sites in the inner plasma sheet

*Kaiti Wang[1], Zhuo-Ren Lang[2], Ching-Huei Lin[3], Tohru Hada[4], Toshi Nishimura[5] (1.Tamkang Univ., 2.National Cheng Kung Univ., 3.Chien-Hsin Univ. of Sci. & Tech., 4.Kyushu Univ., 5.Boston Univ.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM11-15] Study of slow-mode shock formation in the symmetric magnetic reconnection based on hybrid simulations

*Nehpreet Kaur Walia[1], Kanako Seki[1], Takanobu Amano[1] (1. Department of Earth & Planetary Science, Graduate School of Science, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM11-16] Reconstruction of the electron diffusion region of magnetotail reconnection seen by the Magnetospheric Multiscale spacecraft

*Hiroshi Hasegawa[1], Richard E. Denton[2], Rumi Nakamura[3], Kevin J. Genestreti[4], Takuma Nakamura[3], Kyoung Joo Hwang[5], Tai D. Phan[6], Roy B. Torbert[4], Jim L. Burch[5], Barbara L. Giles[7], Dan J. Gershman[7], Chris T. Russell[8], Bob J. Strangeway[8], Per Arne Lindqvist[9], Yuri V. Khotyaintsev[10], Robert E. Ergun[11], Naritoshi Kitamura[12], Yoshifumi Saito[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Dartmouth College, 3.Space Research Institute, Austrian Academy of Science, 4.University of New Hampshire, 5.Southwest Research Institute, 6.University of California Berkeley, 7.NASA Goddard Space Flight Center, 8.University of California Los Angeles, 9.Royal Institute of Technology, 10.Swedish Institute of Space Physics, 11.University of Colorado, 12.University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM11-17] **MMS observations of the dense high speed flow in the magnetotail**

*Mingyu Wu[1], Tielong Zhang[1] (1.Harbin Insitute of Technology, Shenzhen)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM11-18] The spatio-temporal development of lightning-induced electron precipitation events

★Invited Papers

*Robert C Moore[1], Dooyoung Kim[1] (1.University of Florida)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Naritoshi Kitamura(東京大学大学院理学系研究科), Yuka Sato(日本工業大学)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM11-19] Energy flow, dynamo and field-aligned current during a substorm

*Yusuke Ebihara[1], Takashi Tanaka[2] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.Kyushu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM11-20] **Electron flux and field-aligned current associated with Pc5 auroral arc pulsations observed onboard THEMIS and DMSP satellites**

*Natsuo Sato[1], Akira S Yukimatu[1,2], Yoshimasa Tanaka[1,2], Tomoaki Hori[3], Akira Kadokura[1,2], Tohru Sakurai[4], Desheng Han[5], Yuzhang Ma[6], Qinghe Zhang[6] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Nagoya University, 4.Tokai University, 5.Tongji University, 6.Shandong University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM11-21] Multiple spots of enhanced electron precipitation near the equatorward boundary of the cusp

*Satoshi Taguchi[1], Satoshi Kose[1], Kohei Takasu[1], Morio Tanaka[1], Keisuke Hosokawa[2], Yasunobu Ogawa[3] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Department of Communication Engineering and Informatics, University of Electro-Communications, 3.National Institute of Polar Research)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM11-22] Statistical study of auroral/resonant-scattering 427.8-nm emission observed at subauroral latitudes over 14 years

*Kazuo Shiokawa[1], Yuichi Otsuka[1], Martin Connors[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Athabasca University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM11-23] Antarctic large area network observation of auroral phenomena using unmanned system: Conjugate auroral event studies (2)

*Akira Kadokura[1], Hisao Yamagishi[1], Masaki Okada[1], Yasunobu Ogawa[1], Yoshimasa Tanaka[1], Ryuho Kataoka[1], Herbert Akihito Uchida[1], Yuichi Otsuka[2] (1.National Institute of Polar Research, 2.Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM11-24] **Dawn-Dusk Asymmetry in Dayside and Nightside auroral Ovals: Surveys of auroral emissions based on the all-sky imagers in Arctic and Antarctic**

★Invited Papers

*Zejun Hu[1] (1.Polar Research Institute of China)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Naritoshi Kitamura(東京大学大学院理学系研究科), Yuka Sato(日本工業大学), Masaki Nishino(名古屋大学宇宙地球環境研究所)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM11-25] Enhancement of 10MeV protons associated with a change of magnetic field configuration at geosynchronous orbit

*Takahiro Obara[1] (1.Planetary Plasma and Atmospheric Research Center,Tohoku University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM11-26] Solar-cycle variations of >30 keV proton flux enhancements under the inner radiation belt

*ALLA SUVOROVA[1] (1.National Central University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM11-27] Auroral Imaging with Commercial DSLR Cameras near Athabasca, Canada

*Martin G Connors[1,2], Ian Schofield[1], Mike Noble[2], Alister Ling[2], Ryuho Kataoka[3], Ken Murata[4], Kazunori Yamamoto[4] (1.Athabasca University, 2.Edmonton Centre, Royal Astronomical Society of Canada, 3.National Institute for Polar Research, 4.National Institute for Communications Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM11-28] PARM: Investigation of precipitating high-energy electrons into the auroral ionosphere with sounding rockets

*Kazushi Asamura[1], Yoshizumi Miyoshi[2], Keisuke Hosokawa[3], Takefumi Mitani[1], Taku Namekawa[1,5], Takeshi Sakanoi[4], Naoshi Yagi[4], Mizuki Fukizawa[4], Genki Ishizawa[4], Satoshi Kasahara[5], Shin Sugo[5], Oya Kawashima[5], Reiko Nomura[6], Masahito Nose[2], Mariko Teramoto[2], Yasunobu Ogawa[7], Shinji Saito[2], Ryoichi Fujii[8] (1.ISAS / JAXA, 2.ISEE, Nagoya University, 3.The University of Electro-Communications, 4.Tohoku University, 5.The University of Tokyo, 6.NAOJ / NINS, 7.NiPR / ROIS, 8.ROIS)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM11-30] Development of a miniaturized X-ray imager for GEOspace X-ray imager (GEO-X)

*Kumi Ishikawa[1], Yuichiro Ezoe[2], Masaki Numazawa[2], Daiki Ishi[2], Maiko Fujitani[2], Ryota Otsubo[2], Aoto Fukushima[2], Hikari Suzuki[2], Tatsuya Yuasa[2], Hiroshi Nakajima[3], Junko Hiraga[4], Yoshizumi Miyoshi[5], Satoshi Kasahara[6], Kazuhisa Mitsuda[1] (1.Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science , 2.Tokyo Metropolitan University, 3.Kanto Gakuin University, 4.Kwansei Gakuin University, 5.Nagoya University, 6.The university of Tokyo)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-EM15] Study of coupling processes in solar-terrestrial system

convener:Mamoru Yamamoto(Research Institute for Sustainable Humanosphere, Kyoto University), Yasunobu Ogawa(National Institute of Polar Research), Satonori Nozawa(Institute for Space-Earth Environment Research), Akimasa Yoshikawa(Department of Earth and Planetary Sciences, Kyushu University), Chairperson:Mamoru Yamamoto

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM15-01] Status of Equatorial MU Radar project in 2019

*Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Tatsuhiro Yokoyama[1], Toshitaka Tsuda[1] (1.Research Institute for Sustainable Humanosphere, Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM15-02] Recent Progress and Current Status of EISCAT_3D in 2018-2019

*Hiroshi Miyaoka[1], Yasunobu Ogawa[1], Satonori Nozawa[2], Koji Nishimura[1], Shin-ichiro Oyama[2], Takuji Nakamura[1], Ryoichi Fujii[2], Craig James Heinselman[3] (1.National Institute of Polar Research, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.European Incoherent Scatter Scientific Association)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM15-03] Current status of the ground-based multi-point network observation of the upper atmosphere, ionosphere, and magnetosphere by the PWING Project and the Optical Mesosphere Thermosphere Imagers (OMTIs)

*Kazuo Shiokawa[1], Yuichi Otsuka[1], PWING Team (1.Institute for Space-Earth Environmental Research, Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM15-04] Development of MAGDAS project: Search for global electromagnetic coupling from polar to equatorial ionosphere

*Akimasa Yoshikawa[1], Taisei Kabasawa[2], Teiji Uozumi[3], Akiko Fujimoto[4], Shuji Abe[3] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Graduate school of Sciences, Kyushu Univerity, 3.International center for Space weather science and education, Kyushu University, 4.Kyushu Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM15-05] IUGONET data analysis system for a study of coupling processes in the solar-terrestrial system

*Atsuki Shinbori[1], Yoshimasa Tanaka[2], Norio Umemura[1], Shuji Abe[3], Masahito Nose[1], Satoru UeNo[4] (1.Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2.National institute of Polar Research, 3.International Center for Space Weather Science and Education Kyushu University, 4.Observatory, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM15-06] Discussion on large-scale research project "Study of coupling processes in solar-terrestrial system" (1)

*Mamoru Yamamoto[1] (1.Research Institute for Sustainable Humanosphere, Kyoto University)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-EM15] Study of coupling processes in solar-terrestrial system

convener:Mamoru Yamamoto(Research Institute for Sustainable Humanosphere, Kyoto University), Yasunobu Ogawa(National Institute of Polar Research), Satonori Nozawa(Institute for Space-Earth Environment Research), Akimasa Yoshikawa(Department of Earth and Planetary Sciences, Kyushu University), Chairperson:Satonori Nozawa

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[PEM15-07] Numerical Experiments on Stratosphere-Troposphere Two-Way Dynamical Coupling in the Tropics through Organizations of Moist Convective Systems

★Invited Papers

*Shigeo Yoden[1], Hai Bui[2], Takahiro Banno[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Geophysical Institute, University of Bergen)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM15-08] Future development of numerical simualtion of equatorial plasma bubbles

*Tatsuhiro Yokoyama[1] (1.Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM15-09] Characteristics of CME- and CIR-driven ion upflows in the polar ionosphere

*Yasunobu Ogawa[1], Kanako Seki[2], Kunihiro Keika[2], Yusuke Ebihara[3] (1.National Institute of Polar Research, 2.School of Science, the University of Tokyo, 3.Research Institute for Sustainable Humanosphere, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM15-10] SuperDARN Hokkaido Pair of (HOP) radars and mid-latitude SuperDARN: today and future

*Nozomu Nishitani[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM15-11] Simultaneous observation of Ionospheric Incoherent Scatter and Field Aligned Irregularities using adaptive signal processing techniques by the PANSY radar at Antarctic Syowa Station (39.6°E, 69.0°S)

*Taishi Hashimoto[1], Akinori Saito[2], Koji Nishimura[3], Masaki Tsutsumi[3], Kaoru Sato[4], Toru Sato[1] (1.Graduate School of Informatics, Kyoto University, 2.Graduate School of Science, Kyoto University, 3.National Institute of Polar Research, 4.Graduate School of Science, The University of Tokyo)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-EM15] Study of coupling processes in solar-terrestrial system

convener:Mamoru Yamamoto(Research Institute for Sustainable Humanosphere, Kyoto University), Yasunobu Ogawa(National Institute of Polar Research), Satonori Nozawa(Institute for Space-Earth Environment Research), Akimasa Yoshikawa(Department of Earth and Planetary Sciences, Kyushu University), Chairperson:Yasunobu Ogawa

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM15-12] Mini/Micro Satellite Constelaltion for the study of LAI coupling

*Koichiro Oyama[1,2,3] (1.Institute of Plasma and Space Sciences,National Cheng Kung Univ., Taiwan, 2.International Ceneter for Space Weather Sudy and Education, Kyushu Univ.,, 3.CoLtd. Asia Space Environment Research Consortium, Japan)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM15-13] Statistical study of daily and seasonal variation of the equatorial anomaly in Asia based on satellite-ground beacon experiment

*Yuki Sakamoto[1], Mamoru Yamamoto[1], Kornyanat Hozumi[2] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.National Institute of Information and Communications Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM15-14] Latest installation of FM-CW radar in Peru

*Akiko Fujimoto[1], Akihiro Ikeda[2], Akimasa Yoshikawa[3] (1.Kyushu Institute of Technology, 2.National Institute of Technology,Kagoshima College, 3.Kyushu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM15-15] **Understanding the OH Meinel Band Emissions on the Terrestrial Planets**

*Konstantinos S. Kalogerakis[1] (1.Center for Geospace Studies, SRI International, Menlo Park, California, U.S.A.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM15-16] Statistical study of Sporadic Sodium Layer (SSL) observed at Tromsø

*Satonori Nozawa[1], Takuo T. Tsuda[2], Norihito Saito[3], Toru Takahashi[4], Takuya Kawahara[5], Yasunobu Ogawa[4], Hitoshi Fujiwara[6], Satoshi Wada[3], Youhei Ogawa[1], Chris Hall[7], Asgeir Brekke[7] (1.Institute for Space-Earth Environment Research, 2.The University of Electro-Communications, 3.RIKEN Center for Advanced Photonics, 4.National Institute of Polar Research, 5.Faculty of Engineering, Shinshu University, 6.Faculty of Science and Technology, Seikei University, 7.UiT The Arctic University of Norway)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM15-17] Discussion on large-scale research project "Study of coupling processes in solar-terrestrial system" (2)

*Mamoru Yamamoto[1] (1.Research Institute for Sustainable Humanosphere, Kyoto University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 104 1F

[A-AS02] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Kosuke Ito(University of the Ryukyus), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Chairperson:Sachie Kanada(Nagoya University), Akiyoshi Wada(Meteorological Research Institute)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AAS02-01] A GRAPES-based mesoscale EPS for TC forecasting: configuration and performance

*Xubin Zhang[1] (1.Institute of Tropical and Marine Meteorology, CMA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AAS02-02] **Evaluation of operational Ensemble based Global Forecast System prediction for Tropical Cyclones over the North Indian Ocean**

*Medha Deshpande[1], Radhika Kanase[1], R P M Krishna[1], Emmanuel Rongmie[1], P Mukhopadhyay[1] (1.IITM, Pune, INDIA)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS02-03] Structural Changes Preceding Rapid Intensification in Tropical Cyclones as shown in a Large Ensemble of Idealized Simulations

*Yoshiaki Miyamoto[1], David S Nolan[2] (1.Faculty of Environment and Information Studies, Keio University, 2.Rosenstiel School of Marine and Atmospheric Science, University of Miami)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AAS02-04] Potential impacts of tropical cyclone inner-core convective activity on the predictability of rapid intensification

*Masashi Minamide[1], Derek J. Posselt[1] (1.Jet Propulsion Laboratory, california institute of technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS02-05] A link between high-speed solar wind streams and rapid intensification of tropical cyclones

*Paul Prikryl[1,2], Lidia Nikitina[2], Vojto Rušin[3] (1.Physics Department, University of New Brunswick, Fredericton, NB, Canada, 2.Geomagnetic Laboratory, Natural Resources Canada, Ottawa, ON, Canada, 3.Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovak Republic)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS02-06] Influence of Tropical Lower Stratospheric Cooling on Extreme Deep Convective Activity and Tropical Cyclones

*Kunihiko Kodera[1], Nawo Eguchi[2], Rei Ueyama[3], Beatriz M Funatsu[4], Chantal Claud[5] (1.Meteorological Research Institute, 2.Kyushu University, 3.NASA Ames Research Center, 4.Université de Nantes, 5.Ecole Polytechnique)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 104 1F

[A-AS02] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Kosuke Ito(University of the Ryukyus), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Chairperson:Yoshiaki Miyamoto, Kosuke Ito(University of Ryukyus)

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[AAS02-07] A change in the inner-core structure of Typhoon Trami (2018) as observed through upper-tropospheric aircraft reconnaissance of T-PARCII

★Invited Papers

*Hiroyuki Yamada[1], Kazuhisa Tsuboki[2], Taro Shinoda[2], Hisayuki Kubota[3], Yukihiro Takahashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Tadayasu Ohigashi[5], Kosuke Ito[1], Munehiko Yamaguchi[6], Tetsuo Nakazawa[6] (1.University of the Ryukyus, 2.Nagoya University, 3.Hokkaido University, 4.Meisei Electric, 5.National Research Institute for Earth Science and Disaster Resilience, 6.Meteorological Research Institute, Japan Meteorological Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS02-08] **Dramatic changes in the inner-core structure of Typhoon Jebi (2018) at landfall and relationship between a mesovortex and strong wind gusts**

*Udai Shimada[1], Ryo OYAMA[1], shingo shimizu[2] (1.Meteorological Research Institute, 2.National Research Institute for Earth Science and Disaster Prevention)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS02-09] **Revisiting Asymmetric CAPE in Sheared Tropical Cyclones**

*Qingqing Li[1] (1.NUIST Nanjing University of Information Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS02-10] **Observed rainfall asymmetry of tropical cyclone in the process of making landfall in Guangdong, South China**

*Guanhuan Wen[1] (1.Guangzhou Institute of Tropical and Marine Meteorology, China Meteorological Administation)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS02-11] Volumetric Detection of Tornadic Vortices Associated with Typhoon Nanmadol (2017) Using PAWR and Deep Learning

*Toru Adachi[1], Naoki Ishitsu[2], Kenichi Kusunoki[1], Hanako Inoue[1], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3] (1.Meteorological Research Institute, 2.Alpha Denshi/Meteorological Research Institute, 3.East Japan Railway Company)

[E] 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 | 104 1F

[A-AS02] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Kosuke Ito(University of the Ryukyus), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Chairperson:Sachie Kanada(Nagoya University), Yoshiaki Miyamoto

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AAS02-12] Evaluation of the monthly Potential of the 2018 typhoon activity and the effect of the positive PMM and SST of the eastern northwestern Pacific

*Takahiro Ishiyama[1], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AAS02-13] **Contributions of different time scale variations to tropical cyclogenesis over the western North Pacific**

*Xi Cao[1] (1. Institute of Atmospheric Physics, Chinese Academy of Sciences)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AAS02-14] Binary interaction between TC Chanthu (2016) and a nearby cold low

*Kosuke Ito[1], Miyabi Higa[1], Johnny Chan[2] (1.University of the Ryukyus, 2.City University of Hong Kong)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AAS02-15] **Response of landfalling North Indian Ocean cyclonic disturbances to warming climate and associated environmental parameters**

*JAGABANDHU PANDA[1], KASTURI SINGH[1] (1.Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, India)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS02-16] **Rainfall contribution of North Indian Ocean cyclonic disturbances over India in a warming climate**

*KASTURI SINGH[1], JAGABANDHU PANDA[1] (1.Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, India)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS02-17] Analysis of typhoon tracks and associated precipitation amount over western Japan: A case study with Typhoon Nancy and Typhoon Jebi

*Sridhara Nayak[1], Tetsuya Takemi[1] (1.Disaster Prevention Research Institute, Kyoto University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 105 1F

[A-OS07] Climate variability and predictability on subseasonal to decadal timescales

convener:Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Doug Smith(Met Office), Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Chairperson:V Ramaswamy(NOAA GFDL), Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS07-01] Seasonal Predictions of Tropical Cyclones in 2018 using GFDL and NICAM High-Resolution Global Models

★Invited Papers

*Hiroyuki Murakami[1,2], Masuo Nakano[3], V Ramaswamy[1], Thomas Delworth[1], Sarah Kapnick[1], Rich Gudgel[1], Takashi Mochizuki[3], Takeshi Doi[3], Yushi Morioka[3] (1.Geophysical Fluid Dynamics Laboratory, 2.University Corporation for Atmospheric Research, 3.JAMSTEC)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS07-02] **Future change of tropical cyclone-induced waves in the Indian Ocean; An analysis based on super-high-resolution MRI-AGCM3.2 climate model**

*Bahareh Kamranzad[1,2], Nobuhito Mori[1] (1.Disaster Prevention Research Institute, Kyoto University, 2.Hakubi Center for Advanced Research, Kyoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS07-03] The ocean-coupled global cloud-resolving modeling era

★Invited Papers

*Tomoki Miyakawa[1] (1.Atmosphere and Ocean Research Institute University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS07-04] Westerly Wind Burst (WWB)/Easterly Wind Surge (EWS)-like stochastic forcing and the effects on ENSO prediction by the SINTEX-F system

*Takeshi Doi[1], Swadhin Behera[1], Toshio Yamagata[1] (1.JAMSTEC)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS07-05] **The life-cycle of annual waves in the Pacific Ocean as identified by a seamless diagnosis for the energy flux**

*Hidenori AIKI[1], Takahiro Shimura[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Graduate School for Environmental Studies, Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS07-06] Development of weakly coupled atmosphere-ocean data assimilation system and the evaluation of the coupled reanalysis in JMA/MRI

★Invited Papers

*Yosuke Fujii[1], Chiaki Kobayashi[1], Toshiyuki Ishibashi[1], Yuhei Takaya[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 105 1F

[A-OS07] Climate variability and predictability on subseasonal to decadal timescales

convener:Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Doug Smith(Met Office), Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS07-07] Decadal variability and predictability of the North Atlantic Oscillation

★Invited Papers

*Rosemary Eade[1,2], David Stephenson[2], Doug Smith[1], Adam Scaife[1,2], Leon Hermanson[1], Nick Dunstone[1] (1.Met Office Hadley Centre, 2.University of Exeter)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS07-08] Seasonal to multi-year climate predictability in a climate model MIROC6

*Takahito Kataoka[1], Hiroaki Tatebe[1], Hiroshi Koyama[1], Takashi Mochizuki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS07-09] Identifying the early 2000s hiatus associated with internal climate variability

*Xin-Gang Dai[1], Ping Wang[2] (1.Institute of Atmospheric Physics, Chinese Academy of Sciences, 2.Chinese Academy of Meteorological Sciences)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS07-10] Decadal Evolution of the Surface Energy Budget during the Fast Warming and Global Warming Hiatus Periods in the ERA-Interim

*XIAOMING HU[1] (1.Sun Yat-sen University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS07-11] **The role of ocean variability for multi-year droughts in Australia**

*Andrea Taschetto[1,2], Alex Sen Gupta[1,2], Caroline C Ummenhofer[3], Matthew H England[1,2] (1.Climate Change Research Centre, University of New South Wales, Sydney, Australia, 2.ARC Centre of Excellence for Climate Extremes, University of New South Wales, Sydney, Australia, 3.Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS07-12] Decadal variability and predictability in the Southern Ocean - implications for interpreting recent observed trends

★Invited Papers

*Liping Zhang[1,2], Thomas L Delworth[2], William Cooke[2,3], Xiaosong Yang[2,3] (1.Princeton University, 2.Geophysical Fluid Dynamics Laboratory, 3.UCAR)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 105 1F

[A-OS10] Atlantic climate variability, and its global impacts and predictability

convener:Ingo Richter(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Hiroki Tokinaga(Research Institute for Applied Mechanics, Kyushu University), Noel S Keenlyside(Geophysical Institute Bergen), Carlos R Mechoso(University of California Los Angeles), Chairperson:Hiroki Tokinaga(京都大学白眉センター), Ingo Richter

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS10-01] Atlantic impacts on the tropical Pacific climate in the 2000s

*Takashi Mochizuki[1], Masahiro Watanabe[2], Masahide Kimoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere-Ocean Research Institute, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS10-02] Recent acceleration of Arabian Sea warming induced by the Atlantic-western Pacific trans-basin multidecadal variability

*Cheng Sun[1] (1.Beijing Normal University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS10-03] **Westward Wind Changes over the Tropical and Mid-latitude Pacific in the Past Three Decades Driven by the Inter-basin Teleconnections**

★Invited Papers

*Xichen Li[1] (1.Institute of Atmospheric Physics)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS10-04] On the Usefulness of the Atlantic Multidecadal Oscillation Index for Identifying Origins of North Atlantic Sea Surface Temperature Variability

*Jing Sun[1,2], Mojib Latif[1,3], Wonsun Park[1], Taewook Park[1,4] (1.GEOMAR Helmholtz Centre for Ocean Research Kiel, 2.Ocean University of China, 3.University of Kiel, 4.Korea Polar Research Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS10-05] Atlantic Multidecadal SST Signal Modulated by the Low-Frequency Mixed Layer Depth Variability

*Ayako Yamamoto[1], Hiroaki Tatebe[1], Masami Nonaka[1] (1.Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS10-06] A High-Resolution Future Wave Climate Projection for the Northwestern Atlantic

*Adrean Webb[1], Tomoya Shimura[1], Nobuhito Mori[1] (1.Kyoto University, Disaster Prevention Research Institute)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 105 1F

[A-OS10] Atlantic climate variability, and its global impacts and predictability

convener:Ingo Richter(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Hiroki Tokinaga(Research Institute for Applied Mechanics, Kyushu University), Noel S Keenlyside(Geophysical Institute Bergen), Carlos R Mechoso(University of California Los Angeles), Chairperson:Ingo Richter, Hiroki Tokinaga(京都大学白眉センター)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS10-07] Tropical Atlantic Impact on ENSO predictability

★Invited Papers

*Belen Rodriguez-Fonseca[1,2], Irene - Polo[1], Elsa - Mohino[1], Teresa - Losada[1], Marta - Martin-Rey[5], Roberto - Mechoso[3], Noel - Keenlyside[4] (1.Department of Physics of the Earth and Astrophysics, UCM, Madrid, Spain, 2.Institute of Geosciences, IGEO, UCM-CSIC, Madrid, Spain, 3.Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, USA, 4.Geophysical Institute, University of Bergen, Norway, 5.Instituto de Ciencias del Mar, Barcelona, Spain)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS10-08] **Interannual variability of Antarctic Intermediate Water in the tropical North Atlantic**

*Yao Fu[1], Chunzai Wang[1], Peter Brandt[2,3], Richard J. Greatbatch[2,3] (1.State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, 2.GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany , 3.Christian-Albrechts-Universität zu Kiel, Kiel, Germany)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS10-09] **Understanding the mechanisms of the Atlantic meridional climate variability**

*Hyacinth C Nnamchi[1], Riccardo Farneti[2], Noel S Keenlyside[3], Fred Fred Kucharski[2], Mojib Latif[1] (1.GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, 2.Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 3.Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS10-10] The corss-equatorical gradient variability: The role of heat, momentum, and freshwater flux

*Takahito Kataoka[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS10-11] Generation mechanisms of the Benguela Nino with a focus on local amplification

*Tomoki Tozuka[1], Ryo Kobayashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS10-12] **Seasonal energy analysis for baroclinic waves in equatorial Atlantic through a diagnostic scheme for energy flux**

*Qingyang Song[1], Hidenori AIKI[1] (1.Institute of space-earth environmental research, Nagoya University)

[E] 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 | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Adina Paytan(University of California, Santa Cruz)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AHW22-06] Biodiversity increases integrated trophic position of macroinvertebrate communities in coastal food webs: testing the vertical diversity hypothesis

*Noboru Okuda[1], Jin'ichi Karube[2], Yoichiro Sakai[3], Tomohiro Takeyama[4], Ichiro Tayasu[1], Chikage Yoshimizu[1], Toshi Nagata[5] (1.Research Institute for Humanity and Nature, 2.Kindai University, 3.Lake Biwa Environmental Research Institute, 4.Okayama University of Science, 5.University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AHW22-07] The analysis of the community composition of riverine bacteria and microalgae in relation to nutrient status and diversity: the case in irrigation season in the Yasu River, Japan

*Tohru Ikeya[1], Takuya Ishida[1], Yoshitoshi Uehara[1], Satoshi Asano[2], Ichiro Tayasu[1], Noboru Okuda[1], Masayuki Ushio[3,4,5], Shohei Fujinaga[4], Chia-Ying Ko[6], Elfritzson Martin Peralta[7], Naoto F. Ishikawa[8], Tomoya Iwata[9] (1.Research Institute for Humanity and Nature, 2.Lake Biwa Environmental Research Institute, 3.Hakubi Center, Kyoto University, 4.Center for Ecological Research, Kyoto University, 5.PRESTO, Japan Science and Technology Agency, 6.National Taiwan University, 7.University of Santo Tomas, 8.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 9.Faculty of Life and Environmental Sciences, Yamanashi University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AHW22-08] Multiple stressors and protection efforts in highly urbanized watersheds in the Philippines

*Elfritzson M. Peralta[1,3], Leocris S. Batucan Jr.[4,6], Alexis E. Belen[2,3], Irisse Bianca B. De Jesus[1,3], Takuya Ishida[5], Chia-Ying Ko[7], Yuki Kobayashi[5], Tohru Ikeya[5], Yoshitoshi Uehara[5], Tomoya Iwata[8], Adelina S. Borja[9], Jonathan Carlo A. Briones[1,2,3], Francis S. Magbanua[4], Rey Donne S. Papa[1,2,3], Noboru Okuda[5] (1.Research Center for the Natural and Applied Sciences, University of Santo Tomas, PH, 2.Department of Biological Sciences, University of Santo Tomas, PH, 3.The Graduate School, University of Santo Tomas, PH, 4.Institute of Biology, University of the Philippines Diliman, PH, 5.Research Institute for Humanity and Nature, JP, 6.Academia Sinica and Department of Life Science, National Taiwan Normal University, TW, 7.Institute of Fisheries Science and Department of Life Science, National Taiwan University, TW, 8.Faculty of Life and Environmental Sciences, University of Yamanashi, JP, 9.Resource Management and Development Department, Laguna Lake Development Authority, PH)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AHW22-09] Ammonium contamination of shallow groundwater beneath vegetable fields in Central Vietnam

★Invited Papers

*Maeda Morihiro[1], Takuya Fujimura[1], Van Ngoc Tuong Hoang[2], Daisuke Inoue[3], Hidetaka Chikamori[1], Fujio Hyodo[1] (1.Okayama University, 2.Hue University, 3.Osaka University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AHW22-10] Modelling nutrient and organic waste behaviour in a tropical wetland in Singapore under projected anthropogenic scenarios

*Swee Yang Edmund Low[1], Dong Eon Kim[1], Canh Tien Trinh Nguyen[1], Yixiong Cai, Shie-Yui Liong[1] (1.National University of Singapore)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AHW22-11] Benthic macroinvertebrate assemblages and water quality reflect the impacts of land use and land cover in Marikina Watershed, Philippines

*Julie - An N. Gregorio[1,2], Elfritzson M. Peralta[3,5], Irisse Bianca B. de Jesus[3,5], Tohru Ikeya[6], Jonathan Carlo A. Briones[3,4,5], Rey Donne S. Papa[3,4,5], Francis S. Magbanua[1], Noboru Okuda[6] (1.Institute of Biology, University of the Philippines, Diliman, Quezon City, 1101 Philippines, 2.Institute of Environmental Science and Meteorology, University of the Philippines, Diliman, Quezon City 1101 Philippines, 3.Research Center for the Natural and Applied Sciences, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 4.Department of Biological Sciences,

University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 5.The Graduate School, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 6.Research Institute for Humanity and Nature, 457-4 Motoyama, Kamigamo, Kyoto, 603-8047, Japan)

[E] 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 | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Yasumoto Jun(University of the Ryukyus, Faculty of Agriculuture Department of Regional Agricultural Engineering)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AHW22-12] **Characterization, distribution and degradation of environmental plastics in inland river system of Mongolia**

*Batdulam Battulga[1], Masayuki Kawahigashi[1], Bolormaa Oyuntsetseg[2] (1.Department of Geography, Tokyo Metropolitan University, Tokyo, 192-0397, Japan , 2.Department of Chemistry, National University of Mongolia, Ulaanbaatar, 210646, Mongolia)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AHW22-13] Multi-site and multi-approach sediment transport modeling in tropical watersheds

★Invited Papers

*Assefa M Melesse[1], Alemu Osore Aga[2], Hagos Gebreselassie[2] (1.Florida International University, 2.Addis Ababa University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AHW22-14] Calculation of SS concentration coefficients of river water for each land use by a simple watershed model.

*Seiko Yoshikawa[1], Donglai Ma[1,2], Tadamasa Saito[1,3], Kenji Matsumori[4], Yuko Itoh[5], Masahiro Kobayashi[5] (1.Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization, 2.Graduate Scool, Tsukuba University , 3.Faculty of Agriculture, Ibaraki University , 4.Western Region Agricultural Research Center, National Agriculture and Food Research Organization, 5.Forestry and Forest Products Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AHW22-15] Evaluation of long term variation in water balance and discharge of sediment and nitrogen in the urbanized catchment of Yamato River, using SWAT model

*Kunyang Wang[1,2], Yuta Shimizu[3], Shin-ichi Onodera[1], Mitsuyo Saito[4], Yusuke Tomozawa[1] (1.Graduate School of Integrated Arts and Science, Hiroshima University, 2.Capital Normal University, 3.National Agriculture and Food Research Organization, 4.Okayama University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AHW22-16] Causal correlation between water-use of the Tedori River and coastal erosion of Chirihama Nagisa Driveway, Ishikawa, Japan

*Toshihiko Momose[1] (1.Ishikawa Prefectural University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AHW22-17] Role of suspended solids on elemental dynamics in the Selenga River system

★Invited Papers

*Masayuki Kawahigashi[1], Orgilbold Myangan[2], Bolormaa Oyuntsetseg[2] (1.Tokyo Metropolitan University, 2.National University of Mongolia)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Yoshikawa Seiko(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AHW22-18] Relationship between topographical characteristics in catchment area and dissolved iron concentration of river in permafrost area

*Yuto Tashiro[1], Muneoki Yoh[1], Takayuki Shiraiwa[2], Takeo Onishi[3] (1.Tokyo University of Agriculture and Technology, 2.Hokkaido University, 3.Gifu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AHW22-19] Water Source Zones and Hydrochemical Properties of Fluoride Water in Mt. Meru Watershed, Tanzania

*Shinji Nakaya[1], Ryogo Takada[1], Jun Yasumoto[2], Junichi Yoshitani[1], Innocent Lugodisha[3], Zuberi Dominicus Lwimbo[3], Hans Komakech[4], Thomas Reuben Mollel[5] (1.Department of Water Environment and Civil Engineering, Faculty of Engineering, Shinshu University, Japan, 2.Department of Regional Agriculture Engineering, University of the Rykuyus, Japan, 3.School of Materials, Energy, Water and Environmental Sciences, NM-AIST, Tanzania, 4.WISE-Future, NM-AIST, Tanzania, 5.SGSS and Institute of resources assessment-UDSM, Tanzania)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AHW22-20] Development and Application of a System for Measurement of Total Load of Water Quality

★Invited Papers

*Keiji Takase[1], Yuko Itoh[2] (1.Ishikawa Prefectual University, 2.Forestry and Forest Products research Institute, Japan)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AHW22-21] Water infiltration and uptake around a Japanese cypress growing on a flat upland

*Masahiro Kobayashi[1], Shin-ichi Onodera[2], Yuko Itoh[1], Tadashi Sakata[1] (1.Forestry and Forest Products Research Institute, 2.Graduate School of Integrated and Arts Sciences, Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AHW22-22] Innovative Rainfall Simulator Design for Moving Storm Scenarios with Different Storm Patterns

*RAVI KUMAR MEENA[1], SUMIT SEN[2] (1.M.Tech Student, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India, 2. Associate Professor, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301A 3F

[A-GE28] Subsurface Mass Transport, Material Cycle, and Environmental Assessment

convener:Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo), Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Yasushi Mori(Graduate School of Environmental and Life Science, Okayama University), Chairperson:Yuki Kojima(Gifu University), Shoichiro Hamamoto(The University of Tokyo), Yasushi Mori(Okayama University), Hirotaka Saito(Tokyo University of Agriculture and Technology)

9:00 AM - 9:25 AM JST | 12:00 AM - 12:25 AM UTC

[AGE28-01] **Humic substances in deep sedimentary groundwater**

★Invited Papers

*Takumi Saito[1] (1.School of Engineering, The University of Tokyo)

9:25 AM - 9:40 AM JST | 12:25 AM - 12:40 AM UTC

[AGE28-02] Nano-Bubble Retention in Saturated Porous Media under Different Solution Chemistry

*Shoichiro Hamamoto[1], Takuya Sugimoto[1], Takato Takemura[2], Taku Nishimura[1], Scott A Bradford[3] (1.Department of Biological and Environmental Engineering, The University of Tokyo, 2.College of Humanities and Sciences, Nihon University, 3.U. S. Salinity Laboratory)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[AGE28-03] **Geochemical Investigation of Metals and Trace Elements around the Abandoned Cu – Ni Mine Site in Selibe Phikwe, Botswana**

*Fiona Segolame Motswaiso[1], Kengo - Nakamura[1], Noriaki - Watanabe[1], Takeshi - Komai[1] (1.Tohoku Univeristy Graduate School of Environmental Studies)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[AGE28-04] Removal of Arsenic (III) From Aqueous Solution Using Pumice and Zeolite Supported Zero-Valent Iron Nanoparticle

*Shashi Ranjan[1], Brijesh kumar yadav[1], Himanshu Joshi[1] (1.Indian Institute of Technology Roorkee)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[AGE28-05] **Unsaturated Hydraulic Conductivity Estimation from Multi-step Centrifuge Outflow**

*Thanh Long Bui[1], Yasushi Mori[1] (1.Graduate School of Environmental and Life Science, Okayama University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301A 3F

[A-GE29] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Institute for Geo-Resources and Environment, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University), Chairperson:Ming Zhang(AIST), Hirotaka Saito(Tokyo University of Agriculture and Technology), Yonghong Hao(Tianjin Normal University)

10:50 AM - 11:05 AM JST | 1:50 AM - 2:05 AM UTC

[AGE29-01] Input-Output Analysis of Taiwan's Food-Energy-Water Risk

*CHU-CHUN YAO[1], Gene Jiing-yun You[1] (1.National Taiwan University)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AGE29-02] **Groundwater potential analysis using the multiple spatiotemporal remote sensing approach in fractured rock of mountainous region**

*Jung-Jun Lin[1,2], Yuei-An Liou[1], Chien-Chung Ke[2], Su-Yun Chi[2], Jia-Hung Liang[3] (1.National Central Univ., 2.Sinotech Engineering Consultants, Inc., 3.Ministry of Economic Affairs)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[AGE29-03] Estimating Soil Water Content with Color Calibration Method in the Image of Remote Sensing by Unmanned Aerial Vehicle

*Hong-Yi Li[1], Hong-Ru Lin[1], Jyun-Lin Chen[1], Shao-Yang Huang[1], Jet-Chau Wen[1] (1.National Yunlin University of Science and Technology)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[AGE29-04] **Characterizing Geotechnical Properties of Drinking Water Sludge Blended with Graded Crushed Clay Brick for Road Subgrade: Effects of Gradation and Mixing Proportion of Crushed Clay Brick on CBR and Water Permeability**

*Muhammad Rashid Iqbal[1], Akihiro Matsuno[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[AGE29-05] Investigation and Evaluation of the Multiple-liquefaction Site at the Southern Taiwan

*Chih-Sheng KU[1] (1.I-Shou University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301A 3F

[A-GE29] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Institute for Geo-Resources and Environment, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University), Chairperson:Ken Kawamoto(Saitama University), Jet- Chau Wen(National Yunlin University of Science and Technology, Taiwan)

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[AGE29-06] Investigating the Reproducibility of Hydraulic Tomography Estimates with Time-Variable Boundary Conditions

*Jian-Dao Li[1], Jyun-Lin Chen[1], Hong-Ru Lin[1], Shao-Yang Huang [1], Tian-Chyi Jim Yeh[2], Jet-Chau Wen[1] (1.National Yunlin University of Science and Technology, 2.The University of Arizona)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[AGE29-07] **Applying river pollution index and QUAL2K model for water quality assessment and management in Ke-Ya river, Taiwan**

*Hong-Syuan Li[1], Yu-Chih Lin[1] (1.Department of Environmental Engineering & Health, Yuanpei University of Medical Technology)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[AGE29-08] Environmental assessment at CDW disposal sites in Vietnam: Case study in Thanh Tri landfill, Hanoi

*Thanh Ha Ngo[1], Akihiro Matsuno[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[AGE29-09] **Modeling Study on the Impacts of Groundwater Pumping to Regional Hydroclimatology in 37 World Major Aquifers**

*Pat J.-F. Yeh[1] (1.Monash University Malaysia)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[AGE29-10] CHRATERIZING BURIED WASTE COMPOSITION AT CONSTRUCTION AND DEMOLITION WASTE (CDW) DISPOSAL SITE IN VIETNAM: A CASE STUDY IN THANH TRI LANDFILL IN HANOI

*Tselmeg Aldarjav[1], Akira Kato[1], Akihiro Matsuno[1], Ken Kawamoto[1,2] (1.Graduate School of Science and Engineering, Saitama University, Japan , 2.International Institute for Resilient Society, Saitama University, Japan)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Kentaroh Suzuki

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG34-07] GCOM-C “Shikisai” FIRST YEAR OBSERVATIONS

★Invited Papers

*Hiroshi Murakami[1], Masahiro Hori[1], Risa Miyazaki[1], Toshiyuki Kobayashi[1], Takashi M. Nagao[1], Kazunori Ogata[1], Rigen Shimada[1], Junichi Takaku[2] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.Remote Sensing Technology Center of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG34-08] Algorithm improvement for GCOM-C/SGLI Above Ground Biomass Standard product.

*KAJIWARA Koji[1], Yoshiaki HONDA[1] (1.Chiba University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG34-09] Common retrieval of Atmospheric Aerosol Properties for geostationary and polar-orbital Satellite Imaging Sensors: Himawari8/AHI and GCOM-C/SGLI results

*Yoshida Mayumi[1], Maki Kikuchi[1], Takashi M. Nagao[1], Hiroshi Murakami[1], Keiya Yumimoto[2] (1.Japan Aerospace Exploration Agency, 2.Kyusyu University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG34-10] Cloud optical properties from various ground and satellite instruments evaluated during an intensive campaign

*Alessandro Damiani[1], Hitoshi Irie[1], Takashi Horio[1], Tamio Takamura[1], Rei Kudo[2], Pradeep Khatri[3], Hironobu Iwabuchi[3], Ryosuke Masuda[3], Takashi M. Nagao[4] (1.CEReS, Chiba University, 2.Meteorological Research Institute, Japan Meteorological Agency, 3.Graduate School of Science, Tohoku University, 4.Earth Observation Research Center, JAXA)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG34-11] Issues in aerosol-cloud-climate interaction: Needs for future satellite mission

★Invited Papers

*Kentaroh Suzuki[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG34-12] Impact of aerosol vertical profile and optical parameters on the accuracy of satellite AOD retrieval

*Jing Li[1], Chong Li[1] (1.Peking University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG34-13] Statistical validation of drop size distribution estimated by GPM/DPR

*Nobuhiro Takahashi[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG34-14] Impact study of DPR SLH nudging method for data assimilation in the JMA Local NWP system

★Invited Papers

*Yasutaka Ikuta[1] (1.Japan Meteorological Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG34-15] Precipitation Extremes Monitoring using Global Satellite Mapping of Precipitation (GSMaP) Product

*Takuji Kubota[1], Tashima Tomoko[1], Riko Oki[1], Tomoaki Mega[2], Tomoo Ushio[2] (1.Earth Observation Research Center,Japan Aerospace Exploration Agency, 2.Department of Aerospace Engineering, Tokyo Metropolitan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG34-16] Estimation of cloud water content over land using satellite-based passive microwave observations with a coupled land and atmosphere assimilation method

*Rie Seto[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG34-17] Ensemble-Based Data Assimilation of GPM/DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

*Shunji Kotsuki[1], Koji Terasaki[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG34-18] **An ecohydrological land reanalysis by integrating simulation and satellite observations**

*Yohei Sawada[1], Tosiyuki Nakaegawa[1], Kozo Okamoto[1], Takeshi Iriguchi[1], Hideyuki Fujii[2] (1.Meteorological Research Institute, 2.Japan Aerospace Exploration Agency)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Tsuneo Matsunaga

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG34-19] How GOSAT has survived in-orbit anomalies and calibrated radiance spectra for 10 years.

★Invited Papers

*Akihiko Kuze[1], hiroshi Suto[1], Kei Shiomi[1], Nobuhiro Kikuchi[1], Makiko Hashimoto[1], Fumie Kataoka[2] (1.Japan Aerospace Exploration Agency, 2.RESTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG34-20] Estimating regional anthropogenic methane emissions with GOSAT satellite retrievals and ground-based observations

*Shamil Maksyutov[1], Aki Tsuruta[2], Rajesh Janardanan[1], Fenjuan Wang[1], Akihiko Ito[1], Motoki Sasakawa[1], Toshinobu Machida[1], Isamu Morino[1], Yukio Yoshida[1], Johannes Kaiser[3], Greet Janssens-Maenhout[4], Ed Dlugokencky[5], Tsuneo Matsunaga[1] (1.National Institute for Environmental Studies, 2.Finnish Meteorological Institute, 3.Deutscher Wetterdienst, 4.European Commission, Joint Research Centre , 5.National Oceanic and Atmospheric Administration, Global Monitoring Division)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG34-21] The Status and the Future Plan of GOSAT-2 Level 2 and 4 Products

★Invited Papers

*Tsuneo Matsunaga[1], Isamu Morino[1], Yukio Yoshida[1], Makoto Saito[1], Hibiki M Noda[1], Hirofumi Ohyama[1], Akihide Kamei[1], Fumie Kawazoe[1], Ryoichi Imasu[2], Teruyuki Nakajima[4], Takashi Nakajima[5], Naoko Saitoh[3], Makiko Hashimoto[4] (1.Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies, 2.The University of Tokyo, 3.Chiba University, 4.Japan Aerospace Exploration Agency, 5.Tokai University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG34-22] A preliminary initial check of the cloud discrimination products by CAI-2 onboard GOSAT-2

*Yoshiaki Ishihara[1], Yu Oishi[2], Haruma Ishida[3], Takashi Nakajima[4] (1.NIES, 2.NARO, 3.JMA, 4.Tokai Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG34-23] **Drought monitoring and evaluation performance of temperature vegetation drought index (TVDI) over Eurasia**

*Fengmei Yao[1], Siqi Shi[1], Jiahua Zhang[2] (1.UCAS University of Chinese Academy of Sciences, 2.Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG34-24] **IMPACT OF CHANGE IN LAND USE AND LAND COVER PATTERN ON LAND SURFACE TEMPERATURE AND THERMAL COMFORT USING MICRO-SCALE AREA MODEL: CASE STUDY OF AN EDUCATIONAL CAMPUS.**

*DILJIT KUMAR NAYAK[1], MANJU MOHAN[1] (1.IIT DELHI)

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301B 3F

[H-TT19] Geographic Information Systems and Cartography

convener:Takashi Oguchi(Center for Spatial Information Science, The University of Tokyo), Yuji Murayama(Graduate School of Life and Environmental Sciences), Yoshiki Wakabayashi(Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University), Chairperson:Yuji Murayama, Yoshiki Wakabayashi

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HTT19-01] **A study on geographical changes in main roads and coastlines in the 200 years in Japan**

*Yuki IWAI[1], Yuji Murayama[1] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HTT19-02] Comparative analysis of foreign tourists' spatial behavior in Tokyo using locational data from the photo-sharing service of Flickr

*Bochra Bettaieb[1], Yoshiki Wakabayashi[1] (1.Tokyo Metropolitan University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HTT19-03] Neighborhood Walkability and its Potential Associations with Residents' Walking Habits

★Invited Papers

*Ikuho Yamada[1], Keiichiro Sanada[2] (1.Faculty of Science and Engineering, Chuo University, 2.Graduate School of Science and Engineering, Chuo University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HTT19-04] **THE STUDY OF USING PARTICLE FILTER METHOD COMBINED INDOOR MAGNETIC MAP AND PEDESTRIAN DEAD RECKONING FOR INDOOR POSITIONING.**

*Yu-Chun Chen[1] (1.Department of Land Economics, National Chengchi University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HTT19-05] Assessing the Agriculture Sustainability based on Geospatial Technique in a Tropical Mountain Area : A Case Study in Kotmale Catchment in Sri Lanka.

*DM Sanjeewa Lasantha Bandara[1], Takehiro Morimoto [2] (1.Division of Spatial Information Science, Graduate School of Life and Environmental Sciences, University of Tsukuba, 2.Faculty of Life and Environmental Sciences, University of Tsukuba)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HTT19-06] **Spatial Evaluation of Potential Tsunami Vertical Evacuation: A Case Study of the Western Coastal Belt in Sri Lanka**

*Ranagalage Mahinda Manjula[1], Yuji Murayama[1] (1.Division of Spatial Science, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan)

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301B 3F

[H-TT19] Geographic Information Systems and Cartography

convener:Takashi Oguchi(Center for Spatial Information Science, The University of Tokyo), Yuji Murayama(Graduate School of Life and Environmental Sciences), Yoshiki Wakabayashi(Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University), Chairperson:Takashi Oguchi, Ikuho Yamada(Chuo University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HTT19-07] A Framework for Assessing the Spatial Distribution of Vulnerability of Communities to Landslides in Tropical Mountainous Region: A Case study from Kegalle District – Sri Lanka.

★Invited Papers

*Nimala Chinthake Perera[1] (1.SANASA CAMPUS - SRI LANKA, IHRA - UNIVERSITY OF COLOMBO - SRI LANKA)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HTT19-08] Applications of WebGIS to Educating Disaster Risk Reduction for Chinese and Japanese Students

*Jiali SONG[1], Takashi Oguchi[2], Hiroyuki Yamauchi[2], Takuro Ogura[1] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Center for Spatial Information Science, The University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HTT19-09] Solar System Treks - GIS that provides interactive visualization and analysis for planetary science and exploration

★Invited Papers

*Emily Law[1], Brian Hamilton Day[2] (1.NASA Jet Propulsion Laboratory, 2.NASA Ames Research Center)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HTT19-10] **Landslide Recognition using Remote Sensing Images and PCANet**

*Yimei Wei[1], Takashi Oguchi[1] (1.Graduate School of Frontier Science, the University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HTT19-11] Estimating the fractional vegetation cover using fixed-wing drone and multiple vegetation indices

★Invited Papers

*Kotaro Iizuka[1] (1.Center for Spatial Information Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HTT19-12] Topographic surveys in Ny-Alesund, Svalbard, and improvement of mapping methods

*Jaeyong Lee[1], Takashi Oguchi[2] (1.Department of Environmental Studies, Graduate School of Frontier Sciences, The University of Tokyo, 2.Center for Spatial Information Science, The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT25] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Graduate School of Science, Osaka University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), William F McDonough(University of Maryland College Park), George Helffrich(Earth-Life Science Institute, Tokyo Institute of Technology), Chairperson:George Helffrich(ELSI, Tokyo Institute of Technology), Hidenori Terasaki

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT25-01] **High-pressure Equation of State of Schreibersite $Fe_{2.15}Ni_{0.85}P$: Implications for the Martian Core**

*Xuejing He[1], Jiazeng Guo[2], Xiang Wu[3], Shengxuan Huang[1], Fei Qin[1], Xiangping Gu[4], Shan Qin[1] (1.Peking Univ., 2.Nanyang Normal Univ., 3.China Univ. of Geosciences, 4.Central South Univ.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT25-02] Bottom-up solidification versus top-down solidification of the liquid core of the relatively small planetary bodies

*Satoru Urakawa[1], Hidenori Terasaki[2] (1.Department of Earth Sciences, Okayama University, 2.Department of Earth and Space Science, Osaka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT25-03] P-wave velocity of Fe_3S under high pressure and temperature

*Seiji Kamada[1,2], Hidenori Terasaki[3], Hiroshi Fukui[4,5], Tatsuya Sakamaki[2], Hiroshi Uchiyama[6], Satoshi Tsutsui[6], Eiji Ohtani[2], Alfred Q.R. Baron[5] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.Department of Earth and Space Science, Graduate School of Science, Osaka University, 4.Graduate School of Material Science, University of Hyogo, 5.RIKEN, 6.JASRI)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT25-04] The sound velocity of liquid Fe-Ni-S-Si alloys under Mercury's core condition

*Iori Yamada[1], Hidenori Terasaki[1], Asaka Kamiya[1], Ryo Tsuruoka[1], Yuji Higo[2], Akihiko Machida[3] (1.Graduate School of Science, Osaka University, 2.Japan Synchrotron Radiation Research Institute, 3.National Institute for Quantum and Radiological Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT25-05] In situ observation of Rayleigh–Taylor instability growth of liquid Fe-Si using laser shock

*Hidenori Terasaki[1], Tatsuhiro Sakaiya[1], Keisuke Shigemori[2], Hiroki Kato[2], Yoichiro Hironaka[2], Tadashi Kondo[1] (1.Graduate School of Science, Osaka University, 2.Institute of Laser Engineering, Osaka University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT25] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Graduate School of Science, Osaka University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), William F McDonough(University of Maryland College Park), George Helffrich(Earth-Life Science Institute, Tokyo Institute of Technology), Chairperson:William McDonough(University of Maryland / Tohoku University), Eiji Ohtani(Tohoku University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SIT25-06] *P-V-T* equation-of-state of liquid Fe from *ab-initio* simulations to the TPa regime

*Gerd Steinle-Neumann[1], Fabian Wagle[1] (1.Bayerisches Geoinstitut, University of Bayreuth, Germany)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SIT25-07] ***Ab initio* study of Iron-Nickel alloys in Super-Earths cores**

*Francois Soubiran[1], Razvan Caracas[1] (1.Ecole normale superieure de Lyon, Laboratoire de Géologie de Lyon, Université Lyon 1, CNRS UMR 5276, Lyon, France)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT25-08] **Impurity effect on the iron's transport properties at Earth's core conditions: A key constraint for the evolution of the Earth's core**

*Youjun Zhang[1], Mingqiang Hou[2], Nilesh Salke[2], Jung-Fu Lin[3] (1.Sichuan University, 2.HPSTAR, 3.University of Texas at Austin)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SIT25-09] Melting in the Fe-FeO system to 214 GPa

*Kenta Oka[1], Yuto Kidokoro, Kei Hirose[1], Yoichi Nakajima[2], Guillaume Morard[3], Guillaume Fiquet[3], Nicolas Coudurier[3] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Priority Organization for Innobation and Excellence, 3.Sorbonne Université)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SIT25-10] B2 phase in the inner core: constraints from high pressure experiments

*Eiji Ohtani[1], Daijo Ikuta[1], Seiji Kamada[2], Tatsuya Sakamaki[1], Naohisa Hirao[3] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2.Frontier Institute for Interdisciplinary Research, Tohoku University, 3.SRring-8, Japan Synchrotron Research Institute)

[E] Oral | S (Solid Earth Sciences)：S-VC Volcanology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC34] Connecting magma dynamics in vent-conduit system with surface expression of volcanic eruption

convener:Takahiro Miwa(National research institute for earth science and disaster prevention), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Takahiro Miwa, Jacopo Taddeucci

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC34-01] An experimental basis for estimating particle properties following volcanic ash emissions

★Invited Papers

*Adrian Hornby[1], Ulrich Kueppers[1], Hanna Horsch[2], Paul Ayris[1], Nick Varley[3], Daniele Andronico[4], Boris Behncke[4], Yan Lavallée[5], Jackie E Kendrick[5], James Utley[5], Amy Hughes[5], David Damby[6], Benedikt Maurer[1], Marlin Juchem[1], Donald B Dingwell[1] (1.Ludwig-Maximilians-Universität München, DE, 2.Hazen Research, Golden, USA, 3.University of Colima, MX, 4.INGV Catania, IT, 5.University of Liverpool, UK, 6.USGS Cascades Volcano Observatory, USA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC34-02] **Vapor transport in shallow intruded magmas: insights from diktytaxitic texture**

*Ryosuke Sakurai[1], Michihiko Nakamura[2], Satoshi Okumura[2], Mayumi Mujin[2], Takayuki Nakatani[2] (1.Division of Earth and Planetary Materials Science, Faculty of Science, Tohoku University, 2.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC34-03] First observation of nanolites and ultrananolites in alkaline volcanic glasses (Eifel, Germany)

*Marija Putak Juricek[1], Michihiko Nakamura[2], Mayumi Mujin[2], Hans-Ulrich Schmincke[3], Mari Sumita[3], Nobuyoshi Miyajima[1] (1.BGI, 2.Tohoku Univ., 3.GEOMAR)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC34-04] Textural Study of Pumice Clasts from The Youngest Toba Tuff Eruption

*Gabriela Nogo Retnaningtyas Bunga Naen[1], Atsushi Toramaru[1], Tomoharu Miyamoto[1], Haryo Edi Wibowo[2] (1.Department Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Nishiku, 744, Motooka, Fukuoka, 819-0395, Japan, 2.Geological Engineering Department, Universitas Gadjah Mada, 55284, Yogyakarta, Indonesia)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC34-05] **Oomurodashi volcano: Past effusive and phreatomagmatic activity revealed by submarine and subaerial deposits**

*Iona McIntosh[1], Kenichiro Tani[2], Alexander Nichols[3], Qing Chang[1], Jun-Ichi Kimura[1] (1.Japan Agency for Marine-Earth Science and Technology, Yokosuka, 2.National Museum of Nature and Science, Tsukuba, 3.University of Canterbury, Christchurch, New Zealand)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC34-06] Mechanism of volatile transport from mafic to silicic magma upon mixing

*Shumpei Yoshimura[1], Akiko Matsumoto[1], Mitsuhiro Nakagawa[1] (1.Department of Earth and Planetary Sciences, Hokkaido University)

[E] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC34] Connecting magma dynamics in vent-conduit system with surface expression of volcanic eruption

convener:Takahiro Miwa(National research institute for earth science and disaster prevention), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Nobuo Geshi(GSJ/AIST), Adrian Hornby(Ludwig-Maximilians-University Munich)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC34-07] The in-flight grain size distribution of lapilli and bombs from Strombolian explosions

*Jacopo Taddeucci[1], Piergiorgio Scarlato[1], Elisabetta Del Bello[1], Tullio Ricci[1], Ulrich Kueppers[2], Bruce Houghton[3] (1.Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, 2.Department of Earth and Environmental Sciences. Ludwig-Maximilians-Universität (LMU). Munich, Germany, 3.Department of Earth Sciences, University of Hawai‘i at Mānoa, Honolulu, USA)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC34-08] **Pyrrotite oxidation as a proxy for air entrainment in eruption columns**

*Keiko Matsumoto[1], Michihiko Nakamura[2] (1.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology, 2.Faculty of Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC34-09] **Thermal signals in volcano monitoring: combining MODIS-MIROVA data with ground-based measurements at Aso Volcano, Japan**

*Corrado CIGOLINI[1], Akihiko Yokoo[2], Diego Coppola[1], Marco Laiolo[1] (1.Department of Earth Sciences, University of Torino, Italy, 2.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Kyoto University, Japan)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC34-10] Magma transfer processes in the NE Japan arc: insights from crustal ambient noise tomography combined with volcanic eruption records

*Georg F Zellmer[1], Kai-Xun Chen[2], Yuancheng Gung[2], Ban-Yuan Kuo[3], Takeyoshi Yoshida[4] (1.Massey University, Palmerston North, New Zealand, 2.National Taiwan University, Taipei, Taiwan, 3.Academia Sinica, Taipei, Taiwan, 4.Tohoku University, Sendai, Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC34-11] **STRATIGRAPHY RENEWAL, MAGMA CHAMBER STRATIFICATION, AND CONDUIT PROCESS OF THE 1815 TAMBORA CALDERA FORMING ERUPTION**

*Indranova Suhendro[1], Atsushi Toramaru[1], Yasuo Miyabuchi[2], Tomoharu Miyamoto[1] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Japan, 2.Faculty of Advanced Science and Technology, Kumamoto University, Kurokami 2-40-1, Chuo-ku, Kumamoto 860-8555, Japan)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Kimihiro Mochizuki(Earthquake Research Institute, University of Tokyo), Ryuta Arai

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG48-17] Three-dimensional seismic structure of the shallow plate boundary in the northern Hikurangi margin from NZ3D OBS data

*Ryuta Arai[1], Shuichi Kodaira[1], Richard Kellett[2], Valerie Stucker[2], Dan Bassett[2], Stuart Henrys[2], Koichiro Obana[1], Nathan Bangs[3], Dan Barker[2], Rebecca Bell[4], Kimihiro Mochizuki[5], Gou Fujie[1], Seiichi Miura[1], Bill Fry[2], team NZ3D (1.Japan Agency for Marine-Earth Science and Technology, 2.GNS Science, 3.University of Texas Institute for Geophysics, 4.Imperial College London, 5.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:45 AM JST | 12:15 AM - 12:45 AM UTC

[SCG48-18] **Using earthquake focal mechanisms to investigate slow slip driving forces in the northern Hikurangi**

★Invited Papers

*Emily Warren-Smith[1], Bill Fry[1], Laura Wallace[1] (1.GNS Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG48-19] Seismological structural changes around source regions of slow earthquakes in Nankai subduction zone inferred from broadband receiver functions

*Yasunori Sawaki[1], Yoshihiro Ito[2], Kazuaki Ohta[2], Takuo Shibutani[2], Tomotaka Iwata[2] (1.Graduate School of Science, Kyoto University , 2.Disaster Prevention Research Institute, Kyoto University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG48-20] Slip tendency maps for compressional and extensional stress states on a shallow decollement in Nankai Trough

*Yoshitaka Hashimoto[1], Shigeyuki Sato[1], Gregory F Moore[2], Masataka Kinoshita[3], Gaku Kimura[4], Ayumu Miyakawa[5], Kazuya Shiraishi[6], Yasuhiro Yamada[6] (1.Kochi University, 2.University of Hawaii, 3.University of Tokyo, 4.Tokyo University of Marine Science and Technology, 5.AIST, 6.JAMSTEC)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG48-21] Permeability and its anisotropy on creeping Chihshang Fault, Taiwan

*Tyas Dwi Aprilniadi[1], Wen-Jie Wu[1], Li-Wei Kuo[1], Jian-Cheng Lee[2], Jia-Jyun Dong[3] (1.Department of Earth Sciences, National Central University, 2.Institute of Earth Sciences, Academia Sinica, 3.Graduate Institute of Applied Geology, National Central University)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Simon Wallis(Nagoya University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG48-22] Short fluid infiltration events in the low permeable metamorphic rocks triggered by crustal fracturing at amphibolite–granulite facies conditions

*Diana Mindaleva[1], Masaoki Uno[1], Fumiko Higashino[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1] (1.Graduate school of environmental studies, Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG48-23] Generation of high fluid pressure at the base of the shallow mantle wedge—evidence from serpentinite of the Sanbagawa belt, SW Japan

*Simon Richard Wallis[1], Yui Kouketsu[2], Mari Yokota[1,2] (1.University of Tokyo, 2.Nagoya University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG48-24] **Overpressured subduction plate boundary caused by infiltration of mantle-derived fluids: Evidence from helium isotope analysis on veins in subduction mélange**

*Naoki Nishiyama[1], Kohtaro Ujiie[1], Hirochika Sumino[2] (1.University of Tsukuba, 2.The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG48-25] **Geological and rheological conditions of subduction plate boundary between the seismogenic zone and the ETS zone in warm-slab environments**

*Kohtaro Ujiie[1], Kazuya Noro[1], Norio Shigematsu[2], Ake Fagereng[3], Naoki Nishiyama[1], Christopher Tulley[3], Haruna MASUYAMA[1], Yasushi Mori[4] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, 2.Research Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, Japan, 3.Cardiff University, 4.Kitakyushu Museum of Natural History and Human History)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG48-26] Temperature variation in tectonic mélanges of the Shimanto Belt, SW Japan

*Tsai-Wei Chen[1], Donald M Fisher[1], Andrew J Smye[1], Yoshitaka Hashimoto[2] (1.Penn State Univ., 2.Kochi Univ.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG48-27] Frictional properties of opal gouge at low-temperature hydrothermal conditions and their implications for seismogenic faulting along subduction-zone megathrusts

*Kyuichi Kanagawa[1], Tomoya Nakanishi[2], Morito Kuwana[3], Michiyo Sawai[1], Takehiro Hirose[4] (1.School of Science, Chiba University, 2.Graduate School of Science and Engineering, Chiba University, 3.Faculty of Science, Chiba University, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Takahiro Hatano, Takehito Suzuki

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG48-28] **Rate and State Dependent Friction Law and Static Friction Force**

*Hiroshi Matsukawa [1] (1.Aoyama Gakuin University)

2:00 PM - 2:30 PM JST | 5:00 AM - 5:30 AM UTC

[SCG48-29] **Stable sliding, slow and silent slip events and laboratory earthquakes across the brittle ductile transition**

★Invited Papers

*Alexandre Schubnel[1], Aubry Jérôme[1], François Passelègue[2] (1.Laboratoire de Géologie, ENS, PARIS, France, 2.EPFL, Switzerland)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG48-30] Dramatic velocity weakening of dry quartz friction at relatively slow slip velocities

*Akito Tsutsumi[1], Hirotaka Iida[2], Yuko Onoe[1] (1.Graduate School of Science, Kyoto University, 2.Geothermal Engineering. Co. Ltd.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG48-31] Rupture nucleation processes accompanying tremor and slow slip in gel friction experiments

*Tetsuo Yamaguchi[1] (1.Graduate school of Engineering, Kyushu University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG48-32] Solution Orbit for k and epsilon Model for Turbulent Flow in Porous Media

*Takehito Suzuki[1] (1.Department of Physics and Mathematics, Aoyama Gakuin University)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Naofumi Aso, Takahiro Hatano

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SCG48-33] **Modelling precursory seismicity in the laboratory using a roughness derived rate and state friction model**

★Invited Papers

*Paul A Selvadurai[1], Percy Galvez[2], Stefan Wiemer[1], P. Martin Mai[2] (1.Swiss Seismological service, ETH Zurich, Switzerland, 2.King Abdullah University of Science and Technology, Thuwal, Saudi Arabia)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG48-34] Exponential dependence on perturbation stress of earthquake nucleation

*Saito Takuya[1], Takahiro Hatano[1] (1.The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG48-35] Stochastic modeling of slow earthquakes comparable to observations

*Naofumi Aso[1], Ryosuke Ando[2], Satoshi Ide[2] (1.Tokyo Institute of Technology, 2.University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG48-36] Migration of aqueous fluid near the subducting plate interface

*Manabu Morishige[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG48-37] EnKF estimation of frictional properties and slip evolution on a LSSE fault and the changing slip deficit rate on a megathrust fault

*Kazuro Hirahara[1,2] (1.Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University , 2.Riken, AIP center)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-CG50] Intraslab and intraplate earthquakes

convener:Saeko Kita(International Institute of Seismology and Earthquake Engineering, BRI), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(Bavarian Geoinstitute, University of Bayreuth), Ryo Okuwaki(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Saeko Kita(Building Research Insitute), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(University of Bayreuth), Ryo Okuwaki(筑波大学), Thomas Ferrand(UC San Diego)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG50-01] On a reversely-dipping low-velocity layer in the Tohoku-slab beneath the forearc: unbending induced fluid pathway?

★Invited Papers
Cancelled

*Hitoshi Kawakatsu[1], HyeJeong Kim[1] (1.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG50-02] Evidence for transient fluid pathways in the mantle of the subducting Nazca slab from seismological observations and modeling of the Poisson's ratio

★Invited Papers

*Wasja Bloch[1,2], Timm John[2], Jörn Kummerow[2], Bernd Schurr[1], Pablo Salazar[3,4], Serge A. Shapiro[2] (1.GeoForschungszentrum GFZ, Potsdam, Germany, 2.Freie Universität Berlin, Germany, 3.Universidád Católica del Norte, Antofagasta, Chile, 4.National Research Center for Integrated Natural Disasters Management (CIGIDEN), Santiago, Chile)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG50-03] Numerical simulation of water transportation along subducting slabs and implications for intraslab earthquakes

★Invited Papers

*Atsushi Nakao[1], Hikaru Iwamori[1,2,3], Tomoeki Nakakuki[4], Yujiro Suzuki[1], Takashi Nakagawa[5], Hitomi Nakamura[2,3,6,7] (1.Earthquake Research Institute, University of Tokyo, 2.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.Department of Earth and Planetary Systems Science, Hiroshima University, 5.Department of Earth Sciences, The University of Hong Kong, 6.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 7.Ocean Resource Research Center for Next Generation, Chiba Institute of Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG50-04] Subduction of serpentinized fracture zone and intraslab earthquakes in southern Mexico

★Invited Papers

*Marina Manea[1,2] (1.Computational Geodynamics Laboratory, Geosciences Center, National Autonomous University of Mexico, 2.Institute of Astronomy, Romanian Academy)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG50-05] Reaction-induced embrittlement of the lower continental crust

*Alexandre Schubnel[1], Sarah Incel[2], Julien Gasc[1], Nadège Hilairet[5], Yanbin Wang[3], Feng Shi[3], Loic Labrousse[4] (1.Laboratoire de Géologie, ENS, 2.University of Oslo, 3.GCECARS, University of Chicago, 4.ISTEP, Sorbonne Université, 5.UMET, Université de Lille)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG50-06] Transformation-induced, melt-enhanced faulting in orthoenstatite: implications for global intermediate-depth earthquakes

Feng Shi[1], Jianguo Wen[2], Tony Yu[1], Lupei Zhu[3], *Yanbin Wang[1] (1.Center for Advanced Radiation Sources, University of Chicago, Chicago, IL, USA, 2.Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, USA, 3.Department of Earth & Atmospheric Sciences, Saint Louis University, St. Louis, MO, USA)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-CG50] Intraslab and intraplate earthquakes

convener:Saeko Kita(International Institute of Seismology and Earthquake Engineering, BRI), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(Bavarian Geoinstitute, University of Bayreuth), Ryo Okuwaki(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Saeko Kita(Building Research Insitute), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(University of Bayreuth), Ryo Okuwaki(筑波大学), Thomas Ferrand(UC San Diego)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG50-07] The Isolated M7.9 Deep Earthquake of 30 May 2015 Under the Present Bonin Wadati-Benioff Zone: Evidence from the New ISC-EHB Earthquake Catalogue (1930-2015) and CMT Focal Mechanisms

*Stephen Kirby[1], E. Robert Engdahl[2], Emile Andre Okal[3] (1.United States Geological Survey, Menlo Park, 2.University of Colorado, 3.Northwestern University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG50-08] What Can M_W –4 Lab-Quakes Teach Us About Deep-Focus Earthquakes?

★Invited Papers

*Julien Gasc[1], Julien Fauconnier[1], Clémence Daigre[1], Arefeh Moarefvand[1], Damien Deldicque[1], Blandine Gardonio[1], Alexandre Schubnel[1], Pamela Burnley[2] (1.Laboratoire de Géologie, ENS-CNRS, Paris, FRANCE, 2.University of Nevada Las Vegas, Las Vegas, USA)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG50-09] Deep intraslab earthquake rupture due to grain size assisted thermal runaway

*Marcel Thielmann[1], Thibault Duretz[2] (1.Bavarian Geoinstitute, University of Bayreuth, Germany, 2.Université de Rennes, Rennes, France)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG50-10] Fault model of the 2012 off-Miyagi intraslab earthquake doublet and its implication for rheological signature of incoming Pacific plate

*Tatsuya Kubota[1], Ryota Hino[2], Syuichi Suzuki[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Graduate School of Science, Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG50-11] Source-rupture process of the intraplate earthquake; its diversity related to the fault geometry and damaged fault zone

*Ryo Okuwaki[1], Yuji Yagi[1] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG50-12] **Aftershocks of the NEXT Cascadia Intraslab Earthquake**

*Paul Bodin[1,2] (1.University of Washington Seattle, 2.Pacific Northwest Seismic Network)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-CG51] Role of volatiles on Earth and planetary dynamics

convener:Takayuki Ishii(Bavarian Research Institute, University of Bayreuth), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), Michihiko Nakamura(Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University), Bjorn Mysen(Geophysical Laboratory, Carnegie Inst. Washington), Chairperson:Michihiko Nakamura, Eiji Ohtani(Tohoku University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG51-01] Constraining the degassing rate of the mantle since 3 Ga using the deficit of xenon-129 in the ancient atmosphere

★Invited Papers

*Bernard Marty[1], David Bekaert[1], Michael Broadley[1] (1.Centre de Recherches Pétrographiques et Géochimiques/ CNRS - Universite de Lorraine France)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG51-02] **Investigating volatile cycles in the terrestrial mantle by incorporating He and Ar isotopes into geodynamical models of mantle convection**

★Invited Papers

*Rosie Ellen Jones[1], Peter van Keken[2], Jonathan M Tucker[2], Chris J Ballentine[1] (1.Department of Earth Sciences, University of Oxford, Oxford, UK, 2.Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, USA)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG51-03] Fluid circulation in the forearc mantle wedge inferred from the dihedral angle in an olivine-H_2O-NaCl system

*Yongsheng HUANG[1], Takayuki Nakatani[1], Michihiko Nakamura[1], Catherine McCammon[2] (1.Graduate School of Science, Tohoku University, 2.Byerisches Geoinstitut, University of Bayreuth)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG51-04] The oxygen fugacity of serpentinites: implications for subduction zone redox evolution

*Lisa Eberhard[1], Dan Frost[1], Catherine McCammon[1] (1.BGI)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG51-05] Experimental study of the effect of composition on water solubility in natural silicate melts

*Shigeru Yamashita[1] (1.Institute for Planetary Materials, Okayama University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG51-06] Deep mantle volatile cycle and plate tectonics: Impact to the climate evolution

*Takashi Nakagawa[1], Shintaro Kadoya[2], Eiichi Tajika[3] (1.Department of Earth Sciences, The University of Hong Kong, 2.Department of Earth and Space Sciences, University of Washington, 3.Department of Earth and Planetary Sciences, The University of Tokyo)

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-CG51] Role of volatiles on Earth and planetary dynamics

convener:Takayuki Ishii(Bavarian Research Institute, University of Bayreuth), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), Michihiko Nakamura(Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University), Bjorn Mysen(Geophysical Laboratory, Carnegie Inst. Washington), Chairperson:Takayuki Ishii(Bavarian Research Institute, University of Bayreuth), Bjorn Mysen(Carnegie Institution of Washington)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG51-07] The nature of water induced small degree melts in the deep mantle

★Invited Papers

*Daniel James Frost[1], Pierre Condamine[3], Davide Novella[2], Rong Huang[1] (1.University of Bayreuth, 2.University of Cambridge, 3.Université de Lorraine)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG51-08] **Phase separation of hydrous Vesuvius melt: vesicle nucleation or spinodal decomposition?**

★Invited Papers

*Anja Allabar[1], Marcus Nowak[1] (1.University of Tuebingen)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG51-09] Role of water on dynamics in the lower mantle and core-mantle boundary regions

*Eiji Ohtani[1], Takayuki Ishii[2], Liang Yuan[1], Daijo Ikuta[1], Tomoo Katsura[2], Dan Frost[2] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2.Bavarian Research Institute, University of Bayreuth)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG51-10] Stability of Fe-bearing hydrous phases and element partitioning in the system MgO-Al_2O_3-Fe_2O_3-SiO_2-H_2O in Earth's lowermost mantle

*Hongsheng Yuan[1], Li Zhang[1], Eiji Ohtani[2], Yue Meng[3], Eran Greenberg[4], Vitali B. Prakapenka [4] (1.Center for High Pressure Science and Technology Advanced Research, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.HPCAT, X-Ray Science Division, Argonne National Laboratory, 4.Center for Advanced Radiation Sources, University of Chicago)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG51-11] **Laboratory Micro-Seismicity during Serpentinite Deformation as a Potential Analogue for Lower Wadati-Benioff Plane Seismicity**

*Julien Gasc[1,3], Nadège Hilairet[2], Tony Yu[3], Yanbin Wang[3], Thomas P. Ferrand[1], Alexandre Schubnel[1] (1.Laboratoire de Géologie, CNRS - ENS, Paris, FRANCE, 2.Unité Matériaux et Transformations, CNRS - Lille University, Villeneuve d'Ascq, FRANCE, 3.GeoSoilEnviro-CARS, University of Chicago, Argonne IL, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG51-12] Water transport and mixing in the whole-mantle scale convection

*Takeo Kaneko[1], Tomoeki Nakakuki[1], Masanori Kameyama[2], Hikaru Iwamori[3] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.Geodynamics Research Center, Ehime University, 3.Earthquake Research Institute, University of Tokyo)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS03] Evolution and variability of the Asian monsoon in Cenozoic global climate changes

convener:Masanobu Yamamoto(Faculty of Environmental Earth Science, Hokkaido University), Ryuji Tada(Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo), Chairperson:Masanobu Yamamoto(Hokkaido University), Tomohisa Irino, Yoshimi Kubota(National Science Museum), Ryuji Tada(The University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS03-01] **Reconstruction of Indian summer monsoon variability during the last 1,460,000 years**

*Masanobu Yamamoto[1], Steven Clemens[2] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Department of Earth, Environmental and Planetary Sciences, Brown University)

2:00 PM - 2:20 PM JST | 5:00 AM - 5:20 AM UTC

[MIS03-02] Pleistocene Seawater $\delta^{18}O$ reconstructions from the Indian and East Asian Monsoon Regions

★Invited Papers

*Steven C Clemens[1], Masanobu Yamamoto[2] (1.Brown University, 2.Hokkaido University)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[MIS03-03] The Monsoon Erosion Pump

★Invited Papers
Cancelled

*Liviu Giosan[1] (1.Woods Hole Oceanographic Institution)

2:40 PM - 3:00 PM JST | 5:40 AM - 6:00 AM UTC

[MIS03-04] East Asian winter monsoon intensity in the Pleistocene based on seasonal land snail shell stable isotope ratios

★Invited Papers

*David L Dettman[1,3], Xin Wang[2], Mi Wang[2], Junhui Zhang[2] (1.University of Arizona, Geosciences Dept., Environmental Isotope Lab., 2.Lanzhou University, Key Laboratory of Western China's Environmental Systems, College of Earth and Environmental Sciences, 3.Shimane University, Estuary Research Center)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS03-05] Reconstruction of ventilation history of the Japan Sea based on physical properties data collected during IODP Exp. 346

*Tomohisa Irino[1], Liviu Giosan[2], Ryuji Tada[3], Ken Ikehara[4] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Woods Hole Oceanographic Institution, 3.Graduate School of Science, University of Tokyo, 4.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS03] Evolution and variability of the Asian monsoon in Cenozoic global climate changes

convener:Masanobu Yamamoto(Faculty of Environmental Earth Science, Hokkaido University), Ryuji Tada(Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo), Chairperson:Ryuji Tada(The University of Tokyo), Yoshimi Kubota(National Science Museum), Masanobu Yamamoto(Hokkaido University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS03-06] The spatial-temporal patterns of Indian monsoonal variations during the past 80 kyr recorded in NGHP-02 Hole 19B, western Bay of Bengal: Implications from chemical and mineral properties

*Yuki Ota[1,2,3,4], Hodaka Kawahata[4], Junichiro Kuroda[4,3], Atsushi Suzuki[2], Daisuke Araoka[2], Asuka Yamaguchi[4], Ayako Abe-Ouchi[4] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

3:45 PM - 4:05 PM JST | 6:45 AM - 7:05 AM UTC

[MIS03-07] **400,000 years millennial scale temperature and rainfall in East Asia deduced from paired Mg/Ca and oxygen isotope of planktic foraminifera from the East China Sea**

★Invited Papers

*Yoshimi Kubota[1], Steven Clemens[2], Kyung-Eun Lee[3], Ann Holbourn[4], Etsuko Wakisaka[5], Keiji Horikawa[5], Ryuji Tada[6], Katsunori Kimoto[7] (1.National Museum of Nature and Science, 2.Brown University, 3.Korea Maritime and Ocean University, 4.Christian-Albrechts-University, 5.University of Toyama, 6.The University of Tokyo, 7.Japan Agency for Marine-Earth Science and Technology)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MIS03-08] Onset and evolution of millennial-scale variability of East Asian Monsoon recorded in the Japan Sea sediments: New data with new interpretation

*Ryuji Tada[1], Tomohisa Irino[2], Arisa Seki[3], Masafumi Murayama[4], Kaz Mitake[1], Masayuki Ikeda[5] (1.Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo, 2.Faculty of Environmental Earth Science, Hokkaido University, 3.Faculty of Science, Shinshu University, 4.Faculty of Agriculture and Marine Science, 5.Shizuoka University)

4:20 PM - 4:40 PM JST | 7:20 AM - 7:40 AM UTC

[MIS03-09] Interhemispheric linkages of Australian and Asian monsoons on a warmer-than-modern Earth

★Invited Papers

*Ann E Holbourn[1], Wolfgang Kuhnt[1], Janika Joehnck[1], Sebastian Beil[1], Julia Luebbers[1], Kenji Marc Raymond Matsuzaki[2], Yair Rosenthal[3], Denise Kulhanek[4], IODP Expedition 363 Scientists (1.University of Kiel, 2.University of Tokyo, 3.Rutgers University, 4.Texas A&M University)

4:40 PM - 5:00 PM JST | 7:40 AM - 8:00 AM UTC

[MIS03-10] **Miocene evolution of the Asian Monsoon from climate and productivity proxies in the Bay of Bengal and South China Sea**

★Invited Papers

*Wolfgang Kuhnt[1], Julia Luebbers[1], Ann Holbourn[1], Karlos GD Kochhann[2], Steven C Clemens[3], Clara T Bolton[4], Yoichi Usui[5] (1.University of Kiel, 2.UNISINOS University, 3.Brown University, 4.Aix-Marseille Université, 5.Japan Agency for Marine-Earth Science and Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS04] Interdisciplinary studies on pre-earthquake processes

convener:Katsumi Hattori(Department of Earth Sciences, Graduate School of Science, Chiba University), JANN-YENQ Liu(Institute of Space Science, National Central University, Taiwan), Dimitar Ouzounov(Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA), Qinghua Huang(Peking University), Chairperson:Jann-Yenq Liu(National Central University, Taiwan), Toshiyasu Nagao

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS04-01] Application of blind source separation method in seismo-magnetic data analysis

★Invited Papers

*Peng Han[1], Yi Zhong[1], Yuanyuan Zhou[1], Yonghui Ma[2], Chengliang Xie[3], Katsumi Hattori[4], Chie Yoshino[4] (1.Southern University of Science and Technology, Shenzhen, China, 2.Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China, 3.China University of Geosciences (Beijing), Beijing, 100083, China, 4.Chiba University, Chiba, Japan)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS04-02] Rn flux anomaly and local seiemicity around Asahi station,Boso,Japan

*Haruna Kojima[1], Katsumi Hattori[2], Chie Yoshino[2], Michikuni Shimo[3], Toshiharu Konishi[4], Ryuichi Furuya[5] (1.Graduate School of Science and Engineering,Chiba University, 2.Department of Earth Sciences,Graduate School of Science,Chiba University, 3.Fujita Hearth University, 4.OHYO KOKEN KOGYO Co.,Ltd, 5.COM SYSTEM ,INC.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS04-03] Geochemical evidence for the occurrence of 2018 Hualien earthquake triggered by earlier earthquake swarm

*Ching-Chou Fu[1], Lou-Chuang Lee[1], Cheng-Horng Lin[1], Vivek Walia[2], Dimitar Ouzounov[3] (1.Institute of Earth Sciences, Academia Sinica, 2.National Center for Research on Earthquake Engineering, NARL, Taiwan, 3.Chapman University, One University Drive, Orange, CA, USA)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS04-04] Temporal Variation and Statistical Assessment of b value

*weiyun xie[1], Katsumi Hattori[1], Peng Han[2] (1.chiba university, 2. Southern University of Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS04-05] The S-K characteristics of the borehole areal strains associated with the Ms 8.0 Wenchuan and Ms 7.0 Lushan earthquakes

★Invited Papers

*Kaiguang Zhu[1], Zining Yu[1], Chenquan Chi[1], Mengxuan Fan[1], Kaiyan Lii[1] (1.Jilin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS04-06] The Relationship between Earthquakes and Lightning Events of the globe during 2009-2017

*Ching-Chung Cheng[1], JANN-YENQ Liu[1,2,3] (1.Graduate Institute of Space Science, National Central University, TAIWAN, 2.Center for Astronautical Physics and Engineering, National Central University, TAIWAN, 3.Center for Space and Remote Sensing Research, National Central University, TAIWAN)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS04] Interdisciplinary studies on pre-earthquake processes

convener:Katsumi Hattori(Department of Earth Sciences, Graduate School of Science, Chiba University), JANN-YENQ Liu(Institute of Space Science, National Central University, Taiwan), Dimitar Ouzounov(Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA), Qinghua Huang(Peking University), Chairperson:Peng Han, Katsumi Hattori

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS04-07] 3D-Tomography of the Ionospheric Anomalies Preceding the 2011 Tohoku-Oki (M_w9.0) Earthquake

*Ihsan Naufal Muafiry[1,2], Kosuke Heki[1] (1.Hokkaido University, Japan, 2.Universitas Esa Unggul, Indonesia)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS04-08] Statistical Analysis of Pre-seismic Ionospheric Electron Density Anomalies and Investigation of Precursor

*Sanaka Saito[1], Chie Yoshino[1], Katsumi Hattori[1] (1.Chiba University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS04-09] Spatial clustering of pre-earthquake anomalies as an indicator of the preparation/activation zone

*Dimitar Ouzounov[1], Sergey Pulinets[2], Tiger Liu[3], Katsumi Hattori[4] (1.Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA, 2.Space Research Institute, RAS, Moscow, Russia, 3.National Central University, Taoyuan City, Taiwan, 4. Chiba University, Chiba, Japan)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS04-10] **Application of the ionospheric parameters on the seismic research**- -Seismic-ionospheric effect detected from China Seismo-Electromagnetic Satellite

★Invited Papers

*Rui Song[1], Hattori Katsumi[2], Xuemin Zhang[3] (1.Graduate School of Science and Engeering, Chiba University, 2.Graduate School of Science, Chiba University, 3.Institute of Earthquake Science, China Earthquake Administration)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS04-11] ROC curve analyses on the ionospheric TEC of M>=6.0 earthquakes in Japan during 1998-2015

★Invited Papers

*JANN-YENQ Liu[1], Yuh-Ing Chen[2], Pei-Jung Lee[1] (1.Center for Astronautical Physics and Engineering; Graduate Institute of Space Science, National Central University, Taiwan, 2.Graduate Institute of Statistics, National Central University, Taiwan)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS04-12] FORMOSAT-5/AIP observes seismo-ionospheric precursors

*JANN-YENQ Liu[1], Chi-Kuang Chao[1] (1.Center for Astronautical Physics and Engineering; and Graduate Institute of Space Science, National Central University, TAIWAN)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 202 2F

[M-IS06] Conservation of geoparks, natural geosites and cultural heritage: weathering process and damage assessment

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Tetsuya Waragai(Graduate School of Science and Engineering, Nihon University), Kuniyasu Mokudai(Tohoku Gakuin University), Magdalini Theodoridou(School of Engineering, Cardiff University), Chairperson:Tetsuya Waragai(日本大学大学院　理工学研究科), Kuniyasu Mokudai(Japan Geoservicee)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS06-01] Geopark's response to conservation of geosites from natural hazards

*Kuniyasu Mokudai[1], Shuichi Hasegawa[2] (1.Japan Geoservice Incorporated, 2.Kagawa Univ.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS06-02] Physical and mechanical properties for damage assesment of Taya Cave rocks, central Japan

*Chiaki T. Oguchi[1], Yurina Akimoto[2], Yasuhiko TAMURA[3], Kaisei Sakane[1] (1.Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University, 2.Faculty of Engineering, Saitama University, 3.The Exective Committee for the Preservation of TAYA CAVERN)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS06-03] Interdisciplinary approaches on conservation of underground geoheritage for community development of Taya Cave and its adjacent area

★Invited Papers

*Yasuhiko TAMURA[1,2], Chiaki T. Oguchi[4], Yuichi S. Hayakawa[5,2], Takuro Ogura[2], OGATA KEISUKE[6], Masashi MORITA[3] (1.The Executive Committee for the Preservation of TAYA CAVERN , 2.The University of Tokyo, Center for Spatial Information Science, 3.Yokohama National University, Institute of Urban Innovation, 4.Saitama University, Graduate School of Science and Engineering, 5.Hokkaido University, Faculty of Environmental Earth Science, 6.Tsurumi University, The Department of Cultural Properties)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS06-04] **Italian underground cultural heritage: from monitoring to enhancement**

★Invited Papers

*Mario Parise[1], Tiziana Vitolo[2], Roberta Varriale[2] (1.Univ. Aldo Moro, Dept. Earth and Environmental Sciences, Bari, Italy, 2.CNR-ISSM, Italy)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS06-05] Possibility of insolation weathering of sandstone blocks composing Angkor temples, Cambodia

*Tetsuya Waragai[1] (1.Graduate School of Science and Engineering, Nihon University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS06-06] **Durability evaluation of pyroclastic rocks used in the historical built environment of Hungary**

*Luigi Germinario[1,2], Ákos Török[1] (1.Budapest University of Technology and Economics, Hungary, 2.Saitama University, Japan)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201A 2F

[M-IS07] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Hikaru Yabuta(Hiroshima University), Seiji Sugita(東京大学大学院 理学系研究科), Misato Fukagawa(名古屋大学大学院 理学研究科), Kosuke Fujishima(ELSI 地球生命研究所)

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[MIS07-06] How to find and characterize nearby habitable exoplanets

★Invited Papers

*Norio Narita[1] (1.Astrobiology Center)

9:20 AM - 9:40 AM JST | 12:20 AM - 12:40 AM UTC

[MIS07-07] **Organic Matter Preserved in Mudstones of a 3-Billion-Year-Old Lake Deposit in Gale Crater, Mars**

★Invited Papers

*Jennifer L Eigenbrode[1], Roger E Summons[2], Andrew Steele[3], Caroline Freissinet[4], Maëva Millan[5], Rafael Navarro-González[6], Paul Mahaffy[1] (1.NASA Goddard Space Flight Center, 2.Massachusetts Institute of Technology, 3.Carnegie Institution of Washington, 4.Institut Pierre Simon Laplace, CNRS, 5.Georgetown University, 6.Universidad Nacional Autónoma de México)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[MIS07-08] **The third year sample return of Tanpopo: Capture and Exposure Experiment of Micrometeorite and Microbes on Exposure Facility of International Space Station**

*Akihiko Yamagishi[1], Hirofumi Hashimoto[2], Hajime Yano[2], Shin-ichi Yokobori[3], Kensei Kobayashi[4], Hajime Mita[5], Hikaru Yabuta[6], Masumi Higashide[7], Makoto Tabata[8], Hideyuki Kawai[8], Eiichi Imai[9] (1.Tokyo University of Pharmacy and Life Science, Department of Molecular Biology, 2.ISAS/JAXA, Sagamihara, Japan, 3.Tokyo University of Pharmacy and Life Science, Tokyo, Japan, 4.Yokohama National University, Yokohama, Japan, 5.Fukuoka Institute of Technology, Fukuoka, Japan, 6.Hiroshima University, Hirosima, Japan, 7.Japan Aerospace Exploration Agency (JAXA), Tokyo, Japan, 8.Chiba University, Chiba, Japan, 9.Nagaoka University of Technology, Nagaoka, Japan)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[MIS07-09] Theoretical search for photosynthetic pigments applicable around low temperature stars: Modulation of physical-chemical properties by central metals

*Yu Komatsu[1,2], Kenji Takizawa[1,3] (1.Astrobiology Center, 2.National Astronomical Observatory of Japan, 3.National Institute for Basic Biology)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[MIS07-10] Effects of the formation of hydrocarbon aerosols on the climate stability of Earth-like planets and their habitability

*Yasuto Watanabe[1], Eiichi Tajika[1], Kazumi Ozaki[2], Peng Hong[3] (1.The University of Tokyo, 2.Toho University, 3.Chiba Institute of Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201A 2F

[M-IS07] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Kosuke Fujishima(ELSI 地球生命研究所), Misato Fukagawa(名古屋大学大学院 理学研究科), Seiji Sugita(東京大学大学院 理学系研究科), Hikaru Yabuta(Hiroshima University)

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[MIS07-11] the emergence of iron-sulfur protometabolism

★Invited Papers

*Sheref Mansy[1] (1.University of Trento)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[MIS07-12] Life-water-mineral interactions and their products

★Invited Papers

*Fumito Shiraishi[1] (1.Hiroshima University)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[MIS07-13] How much can we learn about ancient cells from sequence analysis? New metrics on an old problem.

*Shawn E McGlynn[1], Sarah J Berkemer[2,3] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Bioinformatics Group, Department of Computer Science, Interdisciplinary Center for Bioinformatics, University of Leipzig, 3.Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[MIS07-14] Scientific significance of searching living cells on Mars surface by Life Detection Microscope (LDM)

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[MIS07-15] Civilization-bearing planets in the Milky-Way Galaxy; 50 necessary conditions must be satisfied in order

*Shigenori Maruyama[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 302 3F

[M-AG38] Satellite Land Physical Processes Monitoring at Medium/High/Very High Resolution

convener:Jean-Claude Roger(University of Maryland College Park), Shinichi Sobue(Japan Aerospace Exploration Agency), Eric Vermote(NASA Goddard Space Flight Center), Chairperson:Jean-Claude Roger, Eric Vermote

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[MAG38-01] 15-years of LSA-SAF/Eumetsat satellite-derived albedo products: method for retrieval validation, and recent advances using neural networks during spectral integration

*Florian Pinault[1], Dominique Carrer[1], Xavier Ceamanos[1], Gabriel Lellouch[1], Catherine Meurey[1], Suman Moparthy[1], Chloé Vincent[1], Sandra Coelho[2], Isabel Trigo[2] (1.Météo France, CNRM-GAME, UMR3589, Toulouse, France, 2.IPMA, Lisbon, Portugal)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[MAG38-02] **Toward a Consistent Land Long Term Climate Data Records from Large Field of View Polar Orbiting Earth Observation Satellites**

*Eric Vermote[1], Jean-Claude Roger[1,2], Belen Franch[1,2], Christopher Justice[2], Ivan Csiszar[3], Sadashiva Devadiga[1], Edward Masuoka[1] (1.NASA Goddard Space Flight Center, 2.University of Maryland, Dept. of Geographical Sciences, 3.NOAA/NESDIS/STAR)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[MAG38-03] **LaSRC Cloud Detection Algorithm for Landsat 8 and Sentinel-2 Data**

*Sergii Skakun[1], Eric Vermote[2], Jean-Claude Roger[1] (1.University of Maryland College Park, 2.NASA Goddard Space Flight Center)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[MAG38-04] **Aerosol models for the validation of Surface Reflectances for MODIS, VIIRS, Landsat-8, Sentinel-2 from LaSRC**

*Jean-Claude Roger[1,2], Eric Vermote[2], Sergii Skakun[1,2], Belen Franch[1,2], Georgia Doxani[4], William Rountree[1,2], Ferran Gascon[4], chris justice[1], oleg dubovik[3], Brent holben[2] (1.University of Maryland, College Park, USA, 2.NASA Goddard Space flight Center, Greenbelt, USA, 3.LOA, University of Lille, Villeneuve d'Ascq, France, 4.ESA, Frascati, Italy)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[MAG38-05] Quantity and spatial distribution of aboveground biomass carbon in Colombia’s forest

*Pedro Rodriguez-Veiga[1,2], Adriana Paola Barbosa-Herrera[3], Edersson Cabrera[3], Gustavo Galindo[3], Valentin Louis[1], Pilar Lozano[3], Pacheco-Pascagaza Ana Maria[1], Indira Pachon-Cendales[3], Salinas Nelso Ricardo[3], Heiko Balzter[1,2] (1.Centre for Landscape and Climate Research, University of Leicester, Leicester, UK, 2.NERC National Centre for Earth Observation (NCEO), Leicester, UK, 3.Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), Bogota, Colombia)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201B 2F

[M-AG38] Satellite Land Physical Processes Monitoring at Medium/High/Very High Resolution

convener:Jean-Claude Roger(University of Maryland College Park), Shinichi Sobue(Japan Aerospace Exploration Agency), Eric Vermote(NASA Goddard Space Flight Center), Chairperson:Sergii Skakun(University of Mrayland, USA), Eric Vermote

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[MAG38-06] Introduction of GCOM-C/SGLI Leaf Area Index & Fraction of Absorbed Photosynthetically Active Radiation products

*Toshiyuki Kobayashi[1], Yoshiaki HONDA[2], Yuhsaku Ono[2], Hideki Kobayashi[3], Wei Yang[2], Shin Nagai[3], Tomoko Akitsu[4], Kenlo Nasahara[4], Risa Miyazaki[1], Masahiro Hori[1], Hiroshi Murakami[1] (1.Japan Aerospace Exploration Agency, 2.Center for Environmental Remote Sensing, Chiba University, 3.Japan Agency for Marine-Earth Science and Technology, 4.University of Tsukuba)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[MAG38-07] **35-years of Land Surface Albedo and 15-years of Down-Welling Short-Wave Radiation Retrievals from Satellites through the EUMETSAT/LSA-SAF and ECMWF/C3S projects**

*Dominique Carrer[1], Florian Pinault[1], Iskander Benhadj[2], Xavier Ceamanos[1], Sandra Coelho[3], Gabriel Lellouch[1], Catherine Meurey[1], Suman Moparthy[1], Else Swinnen[2], Chloé Vincent[1], Isabel Trigo[3] (1.Meteo France, CNRM, France, 2.VITO, Belgium, 3.IPMA, Portugal)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MAG38-08] **Integrating the satellite-based biophysical model and environmental zonation scheme to estimate rice yield gap in Northeast China**

*Jiahua Zhang[1,3], Jingwen Wang[1,2,3] (1.Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 2.University of Chinese Academy of Sciences, 3.Aerospace Information Research Institute, Chinese Academy of Sciences)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MAG38-09] Landsat-based Phenological Classification Mapping in Japan

*Narumasa Tsutsumida[1], Shin Nagai[2], Pedro Rodriguez-Veiga[3,4,1], Tomoaki Miura[5] (1.Graduate School of Global Environmental Studies, Kyoto Univeristy, 2.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 3.Centre for Landscape and Climate Research, University of Leicester, 4. National Centre for Earth Observation, University of Leicester, 5.Department of Natural Resources and Environmental Management University of Hawaii at Manoa)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MAG38-10] **Incorporating satellite-retrieved canopy nitrogen content into the biophysical process model for estimating crop yield and N fertilizer recommendation**

*Jingwen Wang[1,2,3], Jiahua Zhang[1,3] (1.Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 2.University of Chinese Academy of Sciences, 3.Aerospace Information Research Institute, Chinese Academy of Sciences)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-AG Applied Geosciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 202 2F

[M-AG40] CTBT IMS Technologies for Detecting Nuclear Explosion and Their Applications to Earth Science

convener:Nurcan Meral Ozel(Comprehensive Nuclear-Test-Ban Treaty Organization), Hiroyuki Matsumoto(Japan Agency for Marine-Earth Science and Technology), Yosuke Naoi(Japan Atomic Energy Agency), Chairperson:Nurcan Meral Özel(Comprehensive Nuclear-Test-Ban Treaty Organization), Hiroyuki Matsumoto(JAMSTEC), Noriko Kamaya(ERI, University of Tokyo)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MAG40-01] Japanese Contributions and Collaborations for IMS Technologies and the Verification Regime

*Nurcan Meral Ozel[1], David Jepsen[1], Naoko Nakashima[1], Hideaki Komiyama[1], Hiroyuki Matsumoto[1,2] (1.Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MAG40-02] Review: Researches on detection of nuclear tests by seismic waves in Japan

★Invited Papers

*Noriko Kamaya[1] (1.Earthquake Research Institute, the University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MAG40-03] Waveform Analysis on Induced Earthquakes after the 2017 Nuclear Test and Detected Mining Events in DPRK

*Masashi Motohashi[1], Takanari Fujii[1], Takayuki Otsu[1] (1.Japan Weather Association)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MAG40-04] Submarine volcanoes and where to find them: Harnessing IMS hydroacoustic data

★Invited Papers

*Dirk Metz[1] (1.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MAG40-05] **Importance of noble gas monitoring in CTBT verification technology and observation results in Takasaki radionuclide monitoring station**

*Yoichi Yamamoto[1], Yuichi Kijima[1], Yutaka Tomita[1] (1.Japan Atomic Energy Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MAG40-06] ATM analysis results on radioxenons detected in Japan

*Yuichi Kijima[1], Yoichi Yamamoto[1], Yutaka Tomita[1] (1.Japan Atomic Energy Agency)

[E] Oral | U (Union)：Union

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 101 1F

[U-01] JpGU-AGU-EGU Great Debate: Impact of research assessment and going forward

convener:Kazuaki Hori(Department of Geography, Graduate School of Environmental Studies, Nagoya University), Denis-Didier Rousseau(CNRS - ENS), Jonathan L Bamber(member), Chairperson:Yasuhiro Murayama(NICT)

Research assessment mainly based on indices that can be easily quantified such as the number of papers and citations, impact factor, research grant, is spreading among researchers and institutions. However, as typified by DORA (The Declaration on Research Assessment), there has been a movement to review and improve this situation. In this great debate, we discuss the impact of research assessment on researchers, research institutes, research funding agencies, publishers, and even society, based on the current problems of research assessment.

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC

[U01-01] Panel discussion about research assessment

*Kazuaki Hori[1] (1.Department of Geography, Graduate School of Environmental Studies, Nagoya University)

Panel discussion about research assessment

*Kazuaki Hori[1]

1. Department of Geography, Graduate School of Environmental Studies, Nagoya University

Research assessment mainly based on indices that can be easily quantified such as the number of papers and citations, impact factor, research grant, is spreading among researchers and institutions.

However, as typified by DORA (The Declaration on Research Assessment), there has been a movement to review and improve this situation.

In this JpGU-AGU-EGU great debate, we discuss the impact of research assessment on researchers, research institutes, research funding agencies, publishers, and even society, based on the current problems of research assessment.

We will invite experts on the issues. Please join discussions and exhange opinions concerning research assessment.

Keywords: research assessment, scientific research, open science

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | U (Union)：Union

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 101 1F

[U-02] Advancing workplace: progress, challenges and strategies for improvement

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Claudia Jesus-Rydin(European Research Council), Chairperson:Rie Hori, Chiaki Oguchi

We are inviting contributions form participants who is interested or has had personal experience in dealing with diversity issues, such as first-hand reports from role models (researchers at different stages of their carriers), as well as perspective views from leaders of research or educational institutions. We welcome submissions from researchers and students working in Japan, both Japanese and foreign, as well as from JpGU2019 participants from other countries. Contributions to this session will be synthesized to highlight the current state of workplace diversity in Japan, and to develop successful strategies and practices for improvement and maintaining diversity in Geosciences. This session is co-sponsored by the Union Symposium US 4 of EGU 2019 "Promoting and supporting equality of opportunities in geosciences" in order to share and exchange current status information with the EGU / AGU community.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[U02-01] Managing Diversity and Inclusiveness

*Jessica Federman[1] (1.California State University, Dominguez Hills)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[U02-02] Adina Paytan 12:36 PM (0 minutes ago)
to me **Where Have All the Women Gone?**

★Invited Papers

*Adina Paytan[1] (1.University of California Santa Cruz)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[U02-03] Gender balance and diversity in the ocean and geosciences: IODP, research cruise, and laboratories

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[U02-04] Problem in paternity leave

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[U02-05] Challenges in teaching interactive lectures with high student diversity using student response systems

★Invited Papers

*Thomas Parkner[1], Verena Pietzner[2] (1.University of Tsukuba, 2.University of Oldenburg)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[U02-06] **The AGU Ethics and Equity Center: New Resources for Advancing Workplace Excellence**

Brooks Hanson[1], Christine McEntee[1], Robin Elizabeth Bell[1], *Billy M Williams[1] (1.American Geophysical Union)

Managing Diversity and Inclusiveness

*Jessica Federman[1]

1. California State University, Dominguez Hills

There is considerable interest in understanding the ways in which diversity can improve work processes and organizational outcomes (Gonzalez & DeNisi, 2009; Homan, Hollenbeck, Humphrey, van Knippenberg, Ilgen, & Van Kleef, 2008) as well as identifying how to attract, retain, and integrate diverse populations in various fields of science (Thomas & Ely, 1996). A promising area of research that's resolved to meet this objective is focused on creating work environments where diverse individuals feel included (Bilimoria, Joy, & Liang, 2008; Roberson, 2006), otherwise known as inclusiveness. The current paper discusses several studies and bodies of work that provide a collection of tools to retain and promote the notion of inclusiveness for underrepresented minorities in geoscience fields and in general, promote diversity in the workplace. The paper focuses on theory and empirical work on inclusiveness, diversity and discrimination in employment and highlights contextual and conceptual tools that address the needs of various fields (including cultural and geographically different environments) and the evolvement and progress of this literature moving forward.

Keywords: Mentoring , Diversity, Inclusiveness

©2019. Japan Geoscience Union. All Right Reserved.

Adina Paytan <apaytan@ucsc.edu> 12:36 PM (0 minutes ago) to me **Where Have All the Women Gone?**

*Adina Paytan[1]

1. University of California Santa Cruz

The representation of women in STEM (*Science, Technology, Engineering and Mathematics*) matters. Diversity in the workforce contributes to creativity, productivity, innovation, and success. The STEM fields in general and Earth Sciences in particular have long been plagued by the under-representation of women. Men tend to dominate in the field, and the numbers of women simply aren't growing the way one would hope. Although women iin most countries earn just over 40% of the bachelor's degrees in the field, they accounted on avarage for just 20% of faculty in 2015, with considerablle differences between countries. The troubling disparity has been attributed to a number of factors; including deeply embedded culture based psychological barriers and failures by elementary and high schools to spark girls' interests in math and science. In colleges, the reasons for high attrition rates of women from STEM majors often cite insufficient support, and a lack of female role models. At the department, college, or institutional level emerging research suggest that a "chilly climate" environment where gender stereotypes, bias and inequality prevail. Lack of mentoring and supportive policies (particularly for work–life balance) also contribute to the "leaky pipeline" a metaphor for the greater likelihood for women to leave STEM fields at every point, from recruitment to attrition after graduation; because of a significant amount of barriers. Institutional changes in policy and structure including increasing awareness and training to reducing bias, along with strategies like implementing mentoring programs and fostering social accountability, are some of the possible solutions. While some progress has been made and we are on the right track there is still a distance to the mark line and mountains to climb along the way.

Keywords: Women in Science, Leaky pipeline, Role Models

©2019. Japan Geoscience Union. All Right Reserved.

Gender balance and diversity in the ocean and geosciences: IODP, research cruise, and laboratories

*Natsue Abe[1]

1. R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology

Approximately 600 people from all over the world participated in the workshop in order to prepare scientific targets for the next decade of the Integrated Ocean Drilling Program (IODP) [1] held in Bremen in 2009 [2], of which about 30% were women. Meanwhile, among the 100 participants from Japan, there were only 6 women (6% !!). Why is there a big gap between Japan and other countries? Did this gap shrink over the past 10 years?

My research field is mainly in ocean science now. Female researchers were 17 –33 % of the science parties among my 8 times participations on drilling expeditions. However, even in the United States, people have been straggling to increase female researchers in this field [3]. Our outreach activities always include some contents targeting to female students [4]. Women for one ocean [4] has established among Japanese scientists, and start working and supporting for female workers in the ocean science.

I will talk about the international projects especially in the ocean sciences that I experienced through my career and diversity situation in overseas' research laboratory. Then I would like to have a discussion on why gender balance and diversity are difficult to progress in Japan.

References

[1] IODP: http://www.iodp.org/

[2] IODP INVEST workshop: https://www.marum.de/en/Research/INVEST.html

[3] Women in Oceanography: A Decade later. (E.S. Kappel, Ed). Oceanography, vol. 27, 2015. https://doi.org/10.5670/oceanog.2014.106

[4] https://joidesresolution.org/women-in-geoscience-and-technics-heather/

[5] Women in One Ocean: https://oceanwomenjp.wixsite.com/website

Keywords: gender balance, diversity, IODP

©2019. Japan Geoscience Union. All Right Reserved.

Problem in paternity leave

*Yukihiro Takahashi[1]

1. Department of Cosmosciences, Graduate School of Science, Hokkaido University

I took childcare leave in 1999 and 2004 for half year and three months, respectively. At that time only 75 ppm of men took this leave for more than 3 months. Still only about 5 percent men take it (including very short one) now. There is a list of reasons why they didn’ t take it on the government web page. However, I think one of the most essential reason that cannot appear on such research is the lack of international common sense related to the gender issues.

Keywords: childcare leave, gender gap

©2019. Japan Geoscience Union. All Right Reserved.

Challenges in teaching interactive lectures with high student diversity using student response systems

*Thomas Parkner[1], Verena Pietzner[2]

1. University of Tsukuba, 2. University of Oldenburg

Interactive teaching is becoming increasing popular in higher education, as students who engage in the learning process learn more. Student response systems - also called clickers –are an engagement tool, which promotes such interactivity as students increase their engagement in lectures. In a globalizing world, student diversity has become greater in many institutions, while publications on clickers focus on courses with similar student background. In this study, the effect of clickers on the learning climate in lectures with high student diversity is analyzed to differentiate the clicker effect.

A questionnaire was developed containing 29 questions on learning climate categorized in the seven dimensions comprehensibility, opportunity to participate, subject relevance, class participation, willingness to participate, own performance, and satisfaction. In the first session of each lecture, students were asked to describe their ideal geoscience lectures. In the following session set, effects of clickers on learning climate was compared to lectures without clicker usage. Typically three of such sets were evaluated by the students per lecture followed by the final evaluation of the whole lecture. Statistical analyses were performed using the Mann–Whitney U test and Kruskal–Wallis H test.

For each clicker session, the question difficulty was staggered from recall questions, over conceptual understanding questions, over application questions, to critical thinking questions. The clicker sessions were performed at the end of the sessions with question numbers ranging between 7 and 12 questions.

In total 174 students participated in 12 undergraduate geoscience lectures at the University of Tsukuba. In terms of student type, students were classified into degree students in the Integrated Life & Environmental Sciences program in English (with majors in geoscience, biology and agro-biological resource science) from 34 countries with 64.9%, into geoscience in the Japanese program with 14.4%, and into exchange students with 20.7%. 59.4% of the students were female and 40.6% male.

In general, sessions with clicker usage were rated better in all dimensions. Using clicker, students ($n = 806$) feel more satisfied ($U = 71746.5$, $Z = -2.876$, $p = 0.004$), and they ($n = 805$) sense a higher relevance of the topics ($U = 73455.5$, $Z = -2.269$, $p = 0.023$). In addition, they ($n = 786$) think they have more possibilities to actively take part in the lecture ($U = 69468.0$, $Z = -2.446$, $p = 0.014$), and they ($n = 785$) also use this possibility significantly higher than in lectures without clicker ($U = 69432.5$, $Z = -2.403$, $p = 0.016$).

Gender-specific differences for the initial lecture and the usage of clickers became evident. For ideal lectures, student views differed tendentially in three dimensions. For female students ($n=82$), topic relevance is significantly more important ($U = 1717.000$, $Z = -1.903$, $p = 0.057$) than for male students ($n=52$). In addition, the participation of the whole class ($U = 1733.500$, $Z = -1.838$, $p = 0.066$) as well as the own participation ($U = 1763.500$, $Z = -1.697$, $p = 0.090$) is more important for female students. Gender differences were also shown for the usage of clickers. In sessions with clickers, female students ($n=239$) rate the dimensions of comprehension ($U = 14649.500$, $Z = -2.752$, $p = 0.006$) and course participation ($U = 15432.500$, $Z = -2.022$, $p = 0.043$) significantly higher than males ($n =147$). In sessions

©2019. Japan Geoscience Union. All Right Reserved.

without clicker, no gender-specific differences were found.

Comparing degree students enrolled in the English and Japanese program significant differences were identified. Regarding comprehension (U = 5426.500, Z = -2.415, p = 0.016) and own participation (U = 5761.000, Z = -1.799, p = 0.072), the students in the English program (n =235) rated the lectures with clicker better than the students in the Japanese program (n =58). In contrast, the students in the Japanese program rated the possibility to participate (U = 5403.000, Z = -2.157, p = 0.031) as well as the course participation (U = 5352.500, Z = -2.251, p = 0.024) significantly higher. Exchange students were less satisfied when clickers were used, possibly due to the difficulty to answer questions correctly.

These results on the learning climate in lectures with high student diversity indicate the clickers are not a guarantor for positive effects on learning climate. Aligning question difficulty with student level is a challenging task for lectures with high student diversity.

Keywords: student diversity, student response systems

©2019. Japan Geoscience Union. All Right Reserved.

The AGU Ethics and Equity Center: New Resources for Advancing Workplace Excellence

Brooks Hanson[1], Christine McEntee[1], Robin Elizabeth Bell[1], *Billy M Williams[1]

1. American Geophysical Union

Issues associated with ethics, equity and diversity in the Earth and space sciences, including the issue of harassment and its impact on women scientists, are now well known and documented. Building on its earlier work of establishing an updated AGU Ethics Policy which defines harassment as scientific misconduct, the American Geophysical Union (AGU) has taken additional significant steps over the past 12 months to further advance ethics and equity practices, including steps to help prevent harassment. This presentation will highlight the unique role that professional societies can take to help change the culture in science, technology engineering and math (STEM) fields, and the AGU actions and results to-date, including the introduction of a new Ethics and Equity Resource Center, and the establishment of a formal coalition of more than fifty scientific societies in the U.S. to help address harassment and associated issues in science. Progress to date and remaining challenges to advance ethics and equity-related practices, and to track the impact of these changes, will be discussed.

Keywords: Ethics, Diversity, Harassment, Inclusion, Work climate, Equity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor), Chairperson:Sushil Atreya

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS04-01] Recent results from the MAVEN mission

*Dave A Brain[1,4], Bruce Jakosky[1], Janet Luhmann[2], Gina DiBraccio[3] (1.University of Colorado, 2.University of California Berkeley, 3.NASA Goddard Space Flight Center, 4.University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS04-02] From Clouds to Aurora to Atmospheric Escape: Highlights from MAVEN's Imaging UltraViolet Spectrograph

★Invited Papers

*Nicholas McCord Schneider[1], MAVEN/IUVS Science Team (1.LASP, University of Colorado Boulder)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS04-03] Variation in Martian Crustal Magnetic Field Cusp Topology

*Tristan David Weber[1], David Brain[1], Shaosui Xu[2], David Mitchell[2], Jasper Halekas[3] (1.University of Colorado, Boulder, 2.Space Sciences Laboratory, UC Berkeley, 3.University of Iowa, Iowa City)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS04-04] The Induced Global Looping Magnetic Field on Mars

*Lihui Chai[1], Weixing Wan[1], Yong Wei[1], Tielong Zhang[2], Willi Exner[3], Markus Fraenz[4], Eduard Dubinin[4], Moritz Feyerabend[3], Uwe Motschmann[3], Yingjuan Ma[5], J. S. Halekas[6] (1.Institute of Geology and Geophysics Chinese Academy of Sciences, 2.Space Research Institute, Austrian Academy of Sciences, Graz, Austria, 3.Institute for Theoretical Physics, TU Braunschweig, Braunschweig, Germany, 4.Max Planck Institute for Solar System Research, Goettingen, Germany, 5.Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Los Angeles, CA, USA, 6.Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS04-05] First Observation of Magnetic Pulsations on Martian Surface

*Peter J Chi[1], Christopher T Russell[1], Steve Joy[1], Don Banfield[2], Catherine L Johnson[3,4], Yingjuan Ma[1], Anna Mittelholz[3], Yanan Yu[1] (1.University of California Los Angeles, 2.Cornell University, 3.University of British Columbia, 4.Planetary Science Institute)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS04-06] Retrieval of vertical aerosol and gas profiles considering multiple scattering from Martian limb observations by MRO/CRISM

*Yasumasa Kasaba[1], Masashi Toyooka[2], Shohei Aoki[3], Arnaud Mahieux[3,4], Hiromu Nakagawa[2], Hironobu Iwabuchi[2] (1.Planetary Plasma and Atmospheric Research Center (PPARC), Tohoku University, 2.Dep. Geophysics, Tohoku University, 3.Planetary Aeronomy, Belgian Institute for Space Aeronomy, Belgium , 4.University of Texas at Austin, USA)

Recent results from the MAVEN mission

*Dave A Brain[1,4], Bruce Jakosky[1], Janet Luhmann[2], Gina DiBraccio[3]

1. University of Colorado, 2. University of California Berkeley, 3. NASA Goddard Space Flight Center, 4. University of Tokyo

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission has been making science observations from Mars orbit since November, 2014, with the science goal of assessing the role that loss of atmospheric gas to space has played in changing the Martian climate through time. To achieve this objective, MAVEN measures the energetic inputs to the Martian upper atmosphere from the Sun (“drivers”), the properties of the regions of the upper atmosphere from which escaping particles are drawn (“reservoirs”), and the different escape processes as they occur today (“escape”). These data, and the models used to help understand them, allow us to constrain the influence of escape on the evolution of the Martian atmosphere over time. In this presentation we will summarize the main findings of MAVEN over more than 4 years of science observations, with an emphasis on recent results released over the past year. We will then present the status and future science plans for the mission as the spacecraft’s orbit is changed to prepare for increased relay activities in the coming months and years.

Keywords: Mars, Climate, Atmospheric Escape

©2019. Japan Geoscience Union. All Right Reserved.

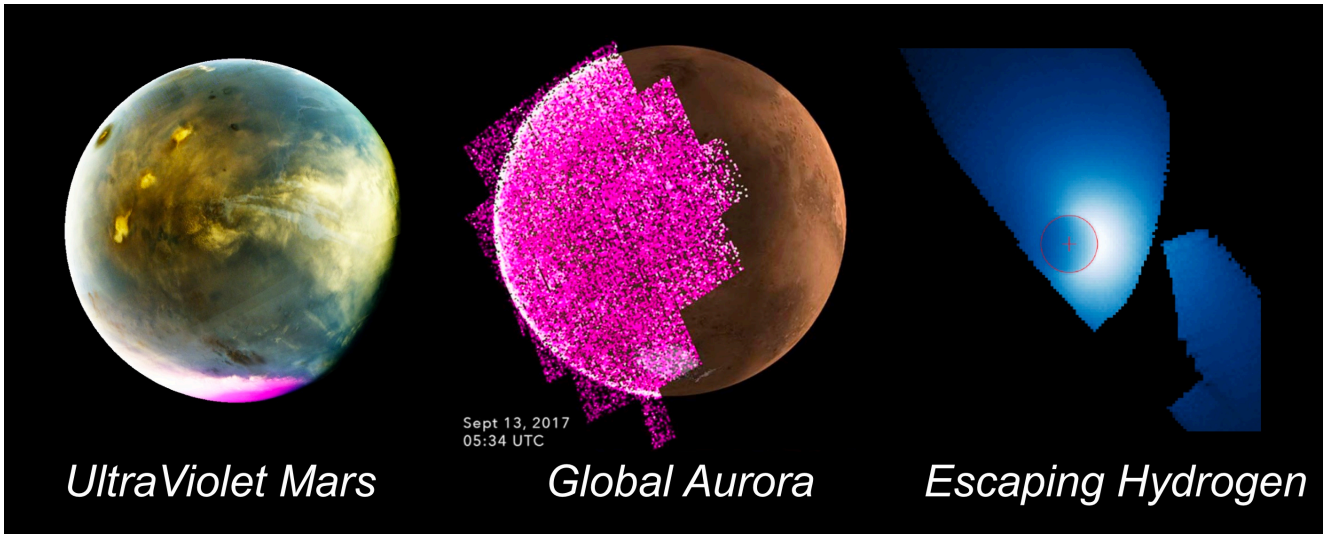
From Clouds to Aurora to Atmospheric Escape: Highlights from MAVEN's Imaging UltraViolet Spectrograph

*Nicholas McCord Schneider[1], MAVEN/IUVS Science Team

1. LASP, University of Colorado Boulder

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission's Imaging Ultraviolet Spectrograph (IUVS) observes Mars in the far and mid ultraviolet (110-340 nm), investigating lower and upper atmospheric structure and indirectly probing neutral atmospheric escape. The instrument is among the most powerful spectrographs sent to another planet, with several key capabilities: separate Far-UV & Mid-UV channels for stray light control; a high-resolution echelle mode to resolve deuterium and hydrogen emission; internal instrument pointing and scanning capabilities to allow complete mapping and nearly continuous operation; and optimization for airglow studies. After four Earth years in orbit (two Mars years), IUVS has assembled a large quantity of data and provided insights on present-day processes at Mars including dayglow, nightglow, aurora, meteor showers, clouds, and solar-planetary interactions. In this presentation, we will highlight key results obtained by IUVS, including: (1) dust storm and cloud activity from a synoptic perspective; (2) a surprisingly high level of auroral activity of three types; (3) long-term tracking of seasonally-modulated escape of hydrogen. We will present an overview of these results and a discussion of their implications for understanding Mars atmospheric dynamics and evolution.

Keywords: mars, atmosphere, ultraviolet, aurora, escape, clouds



©2019. Japan Geoscience Union. All Right Reserved.

Variation in Martian Crustal Magnetic Field Cusp Topology

*Tristan David Weber[1], David Brain[1], Shaosui Xu[2], David Mitchell[2], Jasper Halekas[3]

1. University of Colorado, Boulder, 2. Space Sciences Laboratory, UC Berkeley, 3. University of Iowa, Iowa City

The Martian magnetic field environment is complex. Crustal magnetic fields interact with the incoming interplanetary magnetic field (IMF) to produce a dynamic topological system that in turn constrains the motion of charged particles. The inflow of energetic electrons and the outflow of ionospheric particles are both channeled through regions of vertically oriented field referred to as magnetic "cusps". These cusp regions are consequently host to a range of energetic processes including field-aligned currents and aurora, and may be the source of substantial quantities of ion escape at Mars.
Here we present an analysis of variability in crustal cusps, using electron pitch-angle distributions and energy distributions measured by MAVEN to study how cusp topology varies with upstream solar wind conditions. We find that increased solar wind pressure causes an increase in the spread of open cusp regions on both the dayside and nightside of the planet, and that changes in IMF direction control which cusps preferentially open to the solar wind. Finally, we then pair these results with direct measurements of particle flux to begin an analysis of energy deposition and ion outflow in cusp regions.

Keywords: Martian Magnetosphere, Magnetic Topology, Martian Ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

The Induced Global Looping Magnetic Field on Mars

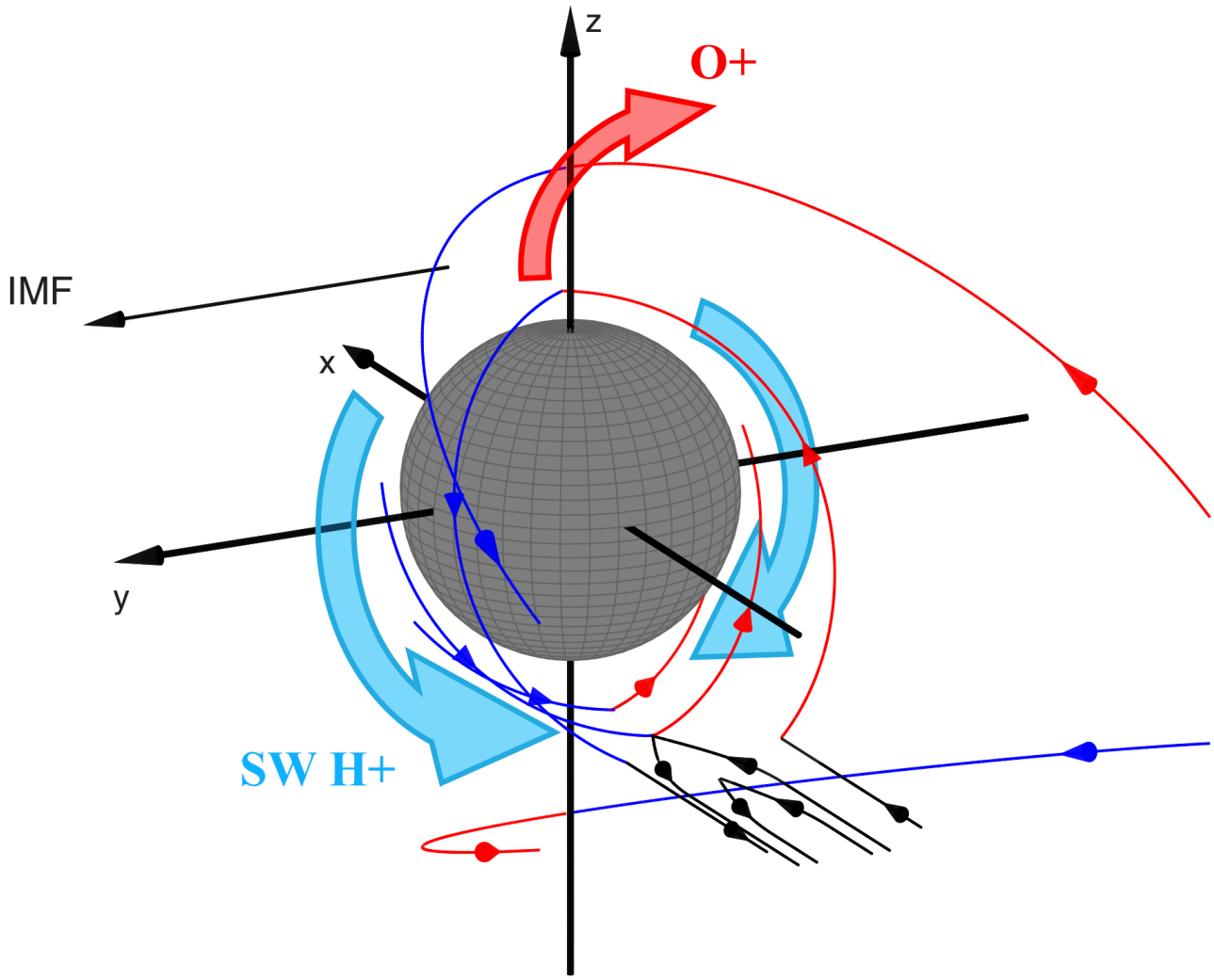
*Lihui Chai[1], Weixing Wan[1], Yong Wei[1], Tielong Zhang[2], Willi Exner[3], Markus Fraenz[4], Eduard Dubinin[4], Moritz Feyerabend[3], Uwe Motschmann[3], Yingjuan Ma[5], J. S. Halekas[6]

1. Institute of Geology and Geophysics Chinese Academy of Sciences, 2. Space Research Institute, Austrian Academy of Sciences, Graz, Austria, 3. Institute for Theoretical Physics, TU Braunschweig, Braunschweig, Germany, 4. Max Planck Institute for Solar System Research, Goettingen, Germany, 5. Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Los Angeles, CA, USA, 6. Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA

Magnetic fields inconsistent with draped IMFs and crustal fields have been observed on Mars. Considering the discovery of a global looping magnetic field around the Venusian magnetotail and the similarities in the solar wind interactions between Mars and Venus, we use MAVEN observations to investigate the global looping field on Mars and its formation mechanism. It is found that a global looping field also exists on Mars; therefore, this type of global looping field is a common feature of unmagnetized planetary bodies with ionospheres and it should also exist on Titan and near-Sun comets. The comparison of the looping fields on Mars and Venus shows that the looping field is stronger on Mars. Solar wind azimuthal flows around the magnetotail towards the -E magnetotail polar region (X_MSE<0,Y_MSE=0,Z_MSE}<-1R_M) are observed. We illustrate that the looping field can be formed by bending the draped field lines with these azimuthal flows, and that these azimuthal flows are associated with heavy ion plumes along the +E direction that are expected to be stronger on Mars than Venus. The current system associated with the looping field and its possible connection with the nightside ionosphere formations and ion escapes on Mars and Venus are discussed.

Keywords: Mars, Venus, induced magnetosphere, looping magnetic field

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

First Observation of Magnetic Pulsations on Martian Surface

*Peter J Chi[1], Christopher T Russell[1], Steve Joy[1], Don Banfield[2], Catherine L Johnson[3,4], Yingjuan Ma[1], Anna Mittelholz[3], Yanan Yu[1]

1. University of California Los Angeles, 2. Cornell University, 3. University of British Columbia, 4. Planetary Science Institute

Landed in the western Elysium Planitia on Mars on November 26, 2018, InSight is the first Mars surface mission that carries a magnetometer. One of the research topics that can be investigated by using the InSight FluxGate (IFG) magnetometer observations is ultra-low-frequency (ULF) magnetic pulsations. Past and ongoing Mars orbiter missions have observed several types of magnetic pulsations near the planet, but whether any of them can reach the Martian surface is an open question. We study the initial IFG data to examine whether and what types of magnetic pulsations are present on the Martian surface. We have found continuous pulsations (Pc) with frequencies at ~10 mHz occurring mostly near midnight. Pc at lower frequencies (of the order of 1 mHz) has also been found in the local morning. The data from the Temperature and Wind for InSight Subsystem (TWINS) confirm that these ULF oscillations in the IFG data are not caused by the wind-driven motion of the lander. Data from the Mars-orbiting MAVEN spacecraft show that the ~10-mHz magnetic pulsations observed by InSight are different from the upstream waves in the foreshock region but may be induced by the oscillations in the tail plasma sheet. The observed continuous pulsations on the Martian surface near midnight are distinct from what are typically observed on the Earth's surface at the same local hours. The different field and plasma environment at Mars raises interesting questions regarding how the magnetic pulsations in the induced magnetosphere propagate to the surface.

Keywords: Mars, NASA InSight mission, surface magnetic field, induced magnetosphere, solar wind interaction with Mars

©2019. Japan Geoscience Union. All Right Reserved.

Retrieval of vertical aerosol and gas profiles considering multiple scattering from Martian limb observations by MRO/CRISM

*Yasumasa Kasaba[1], Masashi Toyooka[2], Shohei Aoki[3], Arnaud Mahieux[3,4], Hiromu Nakagawa[2], Hironobu Iwabuchi[2]

1. Planetary Plasma and Atmospheric Research Center (PPARC), Tohoku University, 2. Dep. Geophysics, Tohoku University, 3. Planetary Aeronomy, Belgian Institute for Space Aeronomy, Belgium , 4. University of Texas at Austin, USA

Mars must somehow have lost most of its atmosphere and water. The evolution of the Mars environment is thought to have proceeded by atmospheric escape to space. In the last decades, there have been a renewed interest from lower to upper atmosphere to understanding the Martian climate. Vertical profiles of atmospheric gases and aerosols are thus the primary information for key processes in energy and mass transport into the upper atmosphere from below. Thanks to the aggressive explorations by MRO and MEx missions, there have been a lot of dataset of limb-viewing observations that can add new restrict the history of the Martian environment. However, these limb datasets haven't started on the retrieval due to their computational costs in the process of radiative transfer calculations.

JACOSPAR is a fast RT code that considers multiple scattering that simulates the radiance and Jacobians in the fully spherical geometry, which has been developed for the terrestrial atmosphere. We have newly developed the retrieval code by applying JACOSPAR for Martian limb observation. For the first step to apply JACOSPAR to Martian limb observation, we modified two points for RT simulations to be optimized. First, we implemented a uniform distribution of line of sight within the field of view (FOV) in order to reduce the resultant variance of the calculated radiance along line of sight in the FOV. Second, we also optimized the threshold of Russian roulette method for the efficient calculation in the Monte Carlo simulation.

The evaluation results of Jacobians calculated by JACOSPAR showed the agreements accurate within 2% and 10% for absorption and scattering, respectively, in almost cases. In order to evaluate our retrieval code and its proper implementations, we have applied our retrieval code for the MRO/CRISM limb observations. We conducted spectral fitting to retrieve vertical profiles of number density of CO#CO,H#O,dust,andwatericefor the observed spectra by CRISM in the altitude range from 0 to 20 km. Here we newly attempted to retrieve the mean radius, and its variance of aerosols for the two cases of difference a priori conditions for the variance of aerosols' radius of 0.5 and 1.2. We, however, still found the discrepancy of spectral slope and intensity between retrieved spectra and measured spectra. It is also noted that the repetitive variations of fitting profiles do not converge during the iterations. The possible explanation for the discrepancy of the spectral slope and intensity might be due to the treatments of aerosol properties. One of the solutions is to apply modified-gamma distribution for size distribution function, instead of log-normal distribution function applied for this study.

More precise and accurate treatment of size distribution function is required as a next step. The repetitive variations of fitting profiles might be caused by the sensitivity of the retrieval. The detailed evaluation of the retrieval sensitivity should also be required for the future work.

Keywords: Mars, Retrieval , atmosphere, vertical profile

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor), Chairperson:Hideaki Miyamoto, Tomohiro Usui

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS04-07] **MODELING MORE COMPLEX EARLY MARTIAN ATMOSPHERES AND DETERMINING THE RESULTING PRECIPITATION AND EROSION RATES**

*Ramses M Ramirez[1,2] (1.Earth-life Science Institute, 2.Tokyo Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS04-08] GCM simulations of the present and past water environment on Mars

*Takeshi Kuroda[1,2], Arihiro Kamada[1], Katsushige Toriumi[1], Yasumasa Kasaba[1], Naoki Terada[1], Hiromu Nakagawa[1] (1.Faculty of Science, Tohoku University, 2.National Institute of Information and Communications Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS04-09] Cold-based glaciation at Pavonis Mons, Mars: Evidence for moraine deposition during glacial advance

★Invited Papers

*Reid Parsons[1,2], Tomohiro Kanzaki[3], Ryodo Hemmi[1], Hideaki Miyamoto[3] (1.University Museum, University of Tokyo, 2.Earth and Geographic Science Dept., Fitchburg State University, 3.Dept. of Systems Innovation, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS04-10] Possible Earth-like tectonic scenario on Mars; a mineralogical and geochemical perspective

*Trishit Ruj[1], Gene W Schimdt[2], Goro Komatsu[2], Kenji Kawai[1] (1.Department of Earth and Planetary Science, School of Science, UTokyo, Japan, 2.International Research School of Planetary Sciences,

Università d'Annunzio, Italy)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS04-11] Hydration state of the Martian lithosphere constrained from gravity and topography

*James Daniel Paul Moore[1], Jon Wade[2], Anthony B Watts[2], Richard M Palin[3], Lars M Hansen[2], Brendan Dyck[4], Jun Muto[6], Andrew J Smye[5], Adam D Switzer[1] (1.Earth Observatory of Singapore, 2.University of Oxford, 3.Colorado School of Mines, 4.Simon Fraser University, 5.Penn State, 6.Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS04-12] SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES – PROSPECTS FOR LIFE

*Sergey Bulat[1] (1.NRC KI - Petersburg Nuclear Physics Institute, Saint-Petersburg-Gatchina, Russia)

MODELING MORE COMPLEX EARLY MARTIAN ATMOSPHERES AND DETERMINING THE RESULTING PRECIPITATION AND EROSION RATES

*Ramses M Ramirez[1,2]

1. Earth-life Science Institute, 2. Tokyo Institute of Technology

The early Mars climate problem remains one of the most interesting ones in planetary science. In particular, the high degree of fluvial surface erosion, as exemplified by modified craters and large winding ancient valley networks, suggests that early Mars may have exhibited a more Earth-like climate in the past. However, climate models have always struggled to simulate the warmer and wetter conditions that were apparently required to explain these observations, given that early Mars (~3.8 Ga) received less than 1/3 the solar insolation that reaches our planet today. One possibility is that warm climate conditions on early Mars were maintained by a multi-bar CO_2-rich atmosphere (with H_2O vapor), mirroring conditions that may have been true during the early days of Earth and Venus. However, climate models have repeatedly shown that a dense CO_2 atmosphere alone is insufficient to generate warm conditions.

This inability of climate models to warm planets using the conventional greenhouse gases (i.e. CO_2 and H_2O) had prompted us and other groups to consider additional warming from secondary absorbers, such as H_2 and CH_4. Both CO_2-H_2 and CO_2-CH_4 atmospheres have been shown to generate above-freezing mean surface temperatures, which are high enough to explain the existence of geological features that were most likely carved by running water.

However, these previous calculations were performed by single-column radiative convective climate models that can only compute mean-averaged planetwide properties and are unable to spatially resolve atmospheric and surface parameters. Such models are also unable to evaluate the effects of oceans on climate, or compute precipitation and the resulting erosion rates to compare with those inferred from observations. On the other end, 3-D models, although quite complex, are very expensive computationally and are unable to explore parameter space as fully and completely as can simpler models. For best results, 3-D models also require a level of knowledge about the planet that, although available for present Earth, is simply unavailable for early Mars, which necessarily results in making many assumptions that cannot be tested or verified as with any other model.

Here, I present my advanced 2-D non-grey energy balance model, which provides a nice compromise between complexity and speed for this problem. It contains 36 latitude bands, clouds, topography, the ice-albedo feedback, and accurate radiative transfer directly computed from detailed single-column climate modeling calculations. Ocean sizes can be varied and planetary parameters, including eccentricity and obliquity can be computed. A typical simulation takes less than a minute. I present some preliminary results (Figure 1).

We will present simulation results for CO_2-H_2 and CO_2-CH_4 atmospheres of various H_2 (0 -20%) and CH_4 (0- 10%) concentrations, pressures (0 –3 bar), while varying ocean size given various literature estimates. From these simulations, we will compute atmospheric and surface temperatures as a function of latitude, yielding precipitation rates, and the resultant erosion rates as a function of latitude. These latitudinal erosion rates will be compared against those inferred for observations. Should such erosion rates be too

©2019. Japan Geoscience Union. All Right Reserved.

high, we can conclude that the resultant climates are too wet/warm. Likewise, should they be too low, the climates are not wet enough. Thus, for the first time we will be able to constrain realistic atmospheric compositions using a relatively complex model that may satisfy the available atmospheric and geologic constraints, providing a glimpse into what the ancient atmosphere could have actually been like. We will also discuss the implications of our results and give hypotheses that can be tested by upcoming and future missions searching for ancient geology and even life.

Keywords: early Mars, life, climate, atmospheres, erosion

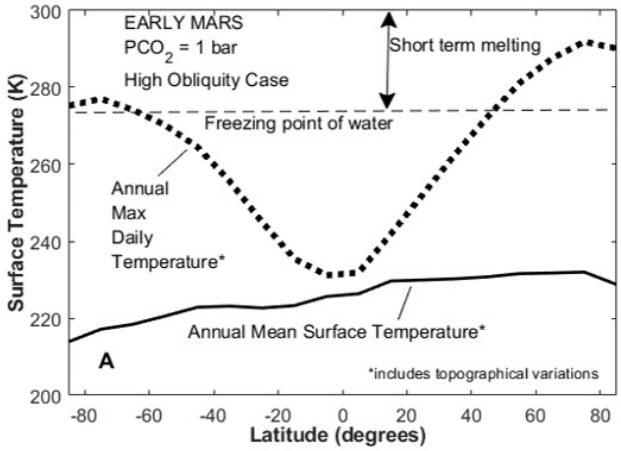


Figure 1: Computed surface temperatures per latitude band, which agrees well with the similar 1-bar case from the 3-D model of Wordsworth et al. 2015 Fig.1.

©2019. Japan Geoscience Union. All Right Reserved.

GCM simulations of the present and past water environment on Mars

*Takeshi Kuroda[1,2], Arihiro Kamada[1], Katsushige Toriumi[1], Yasumasa Kasaba[1], Naoki Terada[1], Hiromu Nakagawa[1]

1. Faculty of Science, Tohoku University, 2. National Institute of Information and Communications Technology

Though the current Mars is a dry planet, the ancient Mars is thought to have been a water-rich planet like the present Earth. There are many topographic evidences of past liquid water flow, which should be hints for the past climate on Mars. Most of the liquid water is thought to have escaped into space, but even on the present Mars, some water environments have been found as the permanent north polar cap, underground ice, and possibly salty liquid water.

On the present Mars, water vapor exists in the atmosphere with the mixing ratio of up to hundreds of ppmv from surface up to ~100 km altitude, and water ice clouds also exist in low-latitudes around aphelion (northern summer) with the infrared opacity of up to ~0.2 and winter polar regions. The north polar ice sheet is thought to be the main source of atmospheric water, as well as possibly the underground water. Also the detection and mapping of HDO/H2O ratio in the atmospheric water could be hints for the history and movement of water. Our Mars global climate model (MGCM), DRAMATIC, has simulated such water environment consistently with the available observations, and the detailed investigations are ongoing with high-resolution (horizontal resolution of ~67 km) simulations.

Moreover, we have simulated the paleoclimate on Mars using a MGCM for paleoclimate (PMGCM), with a dense CO2 atmosphere with the surface pressure of up to a few bars. Radiative effects of water vapor may contribute the warming, and the existence of liquid ocean and lakes contributes the supply of water in the atmosphere. Our PMGCM simulation with ocean/lakes estimated the distributions of fluvial and sediment discharges from the precipitation and snow accumulations, and showed the agreements with the observed valley networks with several exceptions.

Keywords: Mars, water cycle, water environment, paleoclimate, global climate model

©2019. Japan Geoscience Union. All Right Reserved.

Cold-based glaciation at Pavonis Mons, Mars: Evidence for moraine deposition during glacial advance

*Reid Parsons[1,2], Tomohiro Kanzaki[3], Ryodo Hemmi[1], Hideaki Miyamoto[3]

1. University Museum, University of Tokyo, 2. Earth and Geographic Science Dept., Fitchburg State University, 3. Dept. of Systems Innovation, University of Tokyo

The three large volcanoes in the Tharsis region of Mars: Arsia, Pavonis, and Ascraeus Montes all have fan-shaped deposits (FSDs) on their northern or western flanks consisting of a combination of parallel ridges, knobby/hummocky terrain, and a smooth, viscous flow-like unit. The FSDs are hypothesized to have formed in the Amazonian during a period of high spin-axis obliquity which redistributed polar ice to the equatorial Tharsis region resulting in thick (>2 km), flowing ice deposits.

The ridged units in the FSDs are hypothesized to be deposited during glacial recession based on their similarity to terrestrial analogs in the Dry Valleys of Antarctica [1] and Iceland [2,3]. Crater age dates [4] suggest glacial recession took place slowly over hundreds of millions of years, but that recession episodically halted for a period of about a million years [4] in order to deposit an individual ridge. However, the 120 kyr periodicity in obliquity [5-7] is the most likely climate signal to influence the redistribution of ice and glacial dynamics. Therefore, there is an inconsistency between the million-year timescale attributed to ridge formation and the climate variation timescale. To investigate the process of ridge formation, we conducted numerical simulations of ice accumulation and flow using temperature and mass balance assumptions associated with Amazonian global circulation models [8] and laboratory experiments of ice sublimation under martian conditions [9].

We find that ice flow ceases during glacial retreat due to the reduction in ice thickness associated with the slow sublimation (0.5 mm/yr) of buried ice. Laboratory experiments of sublimation of buried ice supports this model assumption [9] as does the presence of remnant ice deposits within the Pavonis FSD. Because ice flow has ceased during glacial retreat, there is no mechanism to advect surface debris to form a ridge.

The model results, when combined with topography observations of a long sequence of ridges located interior of the Pavonis FSD, show that the ridged units were more likely deposited during one or more periods of glacial advance (instead of retreat) when surface temperature variations caused by 120 kyr periodicity obliquity oscillations propagated through the ice deposit resulting in a fluctuating ice flow rate. A model-derived ice flow rate of 3 cm/yr during glacial advance can deposit an average interior ridge in less than 100 kyrs if the supraglacial debris layer is two or more meters thick.

The pattern in ridge spacing observed at Pavonis Mons is more consistent with ridge deposition occurring during glacial advance. These ridges were overrun by the advancing ice, but remained preserved due to the cold temperatures at the glacier bed. Evidence supporting the preservation of ridges underneath an ice sheet comes from intersecting ridge sequences at Arsia and Pavonis [10], as well as the superposition of remnant ice (the smooth unit) on top of ridges.

Our hypothesis links the dominant, 120 kyr periodicity in obliquity to the time interval between adjacent ridges. By measuring the spacing between these ridges and dividing by the obliquity periodicity, we constrain the velocity of glacial margin to be between 0.2 and 4 cm/Earth yr - in close agreement with the

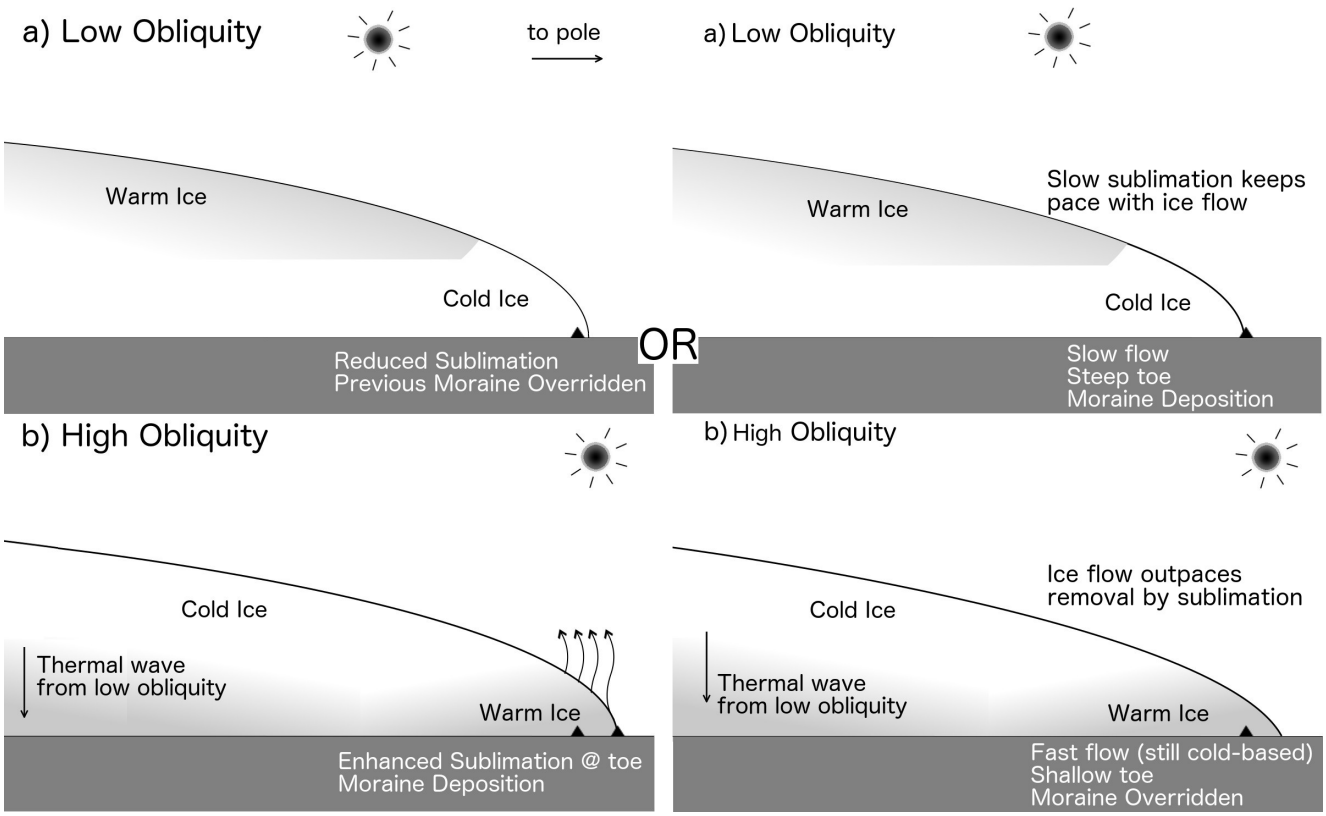
©2019. Japan Geoscience Union. All Right Reserved.

numerical simulation. Furthermore, a comparison with a simulation conducted under terrestrial gravity confirms the prediction of steeper ice margins on Mars during glacial advance which may contribute to ridge deposition via mass wasting, although invoking mass wasting is not required by our hypothesis so long as the supraglacial debris layer is >2 m thick. This re-interpretation of the FSD ridged unit suggests that the timescale of FSD formation (and perhaps the duration of the Amazonian high obliquity period) was shorter than previously reported.

References:

[1] Head, J. W., & D. R. Marchant (2003), *Geology*, *31*(7).
[2] Lucchitta, B. (1981), *Icarus*, *45*, 264–303.
[3] Williams, R. (1978), in *Geol. Soc. Am.*, vol. 10, p. 517.
[4] Kadish, S. et al. (2014), *PSS*, *91*, 52–59.
[5] Ward, W. (1992), *Mars*, pp. 298–320, Univ. of Ariz. Press, Tuscon.
[6] Laskar, J. et al. (2004), *Icarus*, *170*, 343–364.
[7] Schorghofer, N. (2008), *GRL*, *35*, L18201.
[8] Forget, F. et al. (2006), *Science*, *311*, 368–371.
[9] Chevrier, V., et al. (2008), *Icarus*, *196*(2), 459 –476.
[10] Shean, D. E., et al. (2005), *JGR*, *110*(E05001).

Keywords: Mars, Glaciation, Climate



©2019. Japan Geoscience Union. All Right Reserved.

Possible Earth-like tectonic scenario on Mars; a mineralogical and geochemical perspective

*Trishit Ruj[1], Gene W Schimdt[2], Goro Komatsu[2], Kenji Kawai[1]

1. Department of Earth and Planetary Science, School of Science, UTokyo, Japan, 2. International Research School of Planetary Sciences, Università d'Annunzio, Italy

The southern highlands of Mars preserve a series of Noachian aged (Eoarchean equivalent to Earth) grabens with multiple orientations and morphologies (Ruj et al., 2018). We have found traces of a 3000 km long succession of grabens (with individual grabens ranging from 30 to 1200 km) in the Noachis Terra and Terra Sabaea region around the western boundary of the massive Hellas basin. However, the origin of these grabens is neither confirmed to be a result of Earth-like plate tectonics or related to giant impacts such as Hellas, Argyre and Isidis. Here, after preparing the geological map, we present our preliminary observation (using remotely sensed datasets) on the mineralogy of the rocks and the geochemistry of the crust associated with the grabens. The hyperspectral analysis of several CRISM (Compact Reconnaissance Imaging Spectrometer, onboard the Mars Reconnaissance Orbiter) observations indicates the presence of olivine, pyroxene (clino), plagioclase, phyllosilicates and hydrated sulfates. GRS (Gamma Ray Spectrometer onboard on Mars Odyssey) observation of the area shows a higher abundance of Potassium (K) and Thorium (Th) than their average global distribution. Plagioclase, olivine and pyroxene are the main constituents of basalts and the GRS derived geochemistry confirms the existence of this alkali basalt type with a higher abundance of Potassium (K). Meanwhile, Thorium (Th) content is higher than the surroundings, indicating the presence of granitic composition rocks which are typically found within continental rift zones on Earth associated with bimodal volcanism.

Keywords: Mars, Tectonics, Martian mineralogy

©2019. Japan Geoscience Union. All Right Reserved.

Hydration state of the Martian lithosphere constrained from gravity and topography

*James Daniel Paul Moore[1], Jon Wade[2], Anthony B Watts[2], Richard M Palin[3], Lars M Hansen[2], Brendan Dyck[4], Jun Muto[6], Andrew J Smye[5], Adam D Switzer[1]

1. Earth Observatory of Singapore, 2. University of Oxford, 3. Colorado School of Mines, 4. Simon Fraser University, 5. Penn State, 6. Tohoku University

Widespread aqueous alteration of the Martian crust suggests that metamorphic hydration reactions may have played a critical role in the sequestration of water early during the planet’s history. The presence of hydrous phases in the Martian crust reduce its bending strength, and we show that observations of the Martian gravity anomaly may be used to constrain the fate of Martian surface water.

Using the gravity anomalies associated with notable topographic features, such Olympus Mons, as well as the global gravity and topography, we construct yield strength envelopes for hydrous and anhydrous end-member crustal sections, and derive the predicted elastic thicknesses, Te, a proxy for the long-term lithospheric strength of Mars. We also use spherical harmonic coefficients that describe the Martian gravity anomaly and topography fields to quantify the role of isostasy in contributing to crustal and upper mantle structure. Power spectra of these fields reveal that the gravity effect of topography and its flexural compensation contributes significantly to the observed free-air gravity anomaly spectra for spherical harmonic degree $8 < n < 50$, corresponding to wavelength $300 < \lambda < 3000$ km. The best-fit global average is for an elastic plate (flexure) model with T_e of ~126 km. All isostatic models under-predict the spectra at $2 < n < 5$, and we interpret the low-order Martian gravity field, at least in part, to be the result of processes that formed the Northern Basin. By comparing the observed Martian T_e to that predicted for our metamorphic mineral assemblages, we iterate on the water content until convergence. In short, we show the bending strength of Mars places constraints on the amount of hydration of the Martian crust, which in turn we use to calculate the planetary water budget. Notably, the stiffer flexural response of Olympus Mons is consistent with its younger age and eruption predominantly into a dry environment.

Keywords: Mars, Flexure, Gravity

©2019. Japan Geoscience Union. All Right Reserved.

SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES –PROSPECTS FOR LIFE

*Sergey Bulat[1]

1. NRC KI - Petersburg Nuclear Physics Institute, Saint-Petersburg-Gatchina, Russia

The objective was to search for microbial life in the subglacial freshwater Antarctic Lake Vostok by analyzing the uppermost water layer entered the borehole following successful lake unsealing at the depth 3769m from the surface. The samples included the drillbit frozen and re-cored borehole-frozen water ice. The study aimed to explore the Earth’ s subglacial Antarctic lake and use the results to prospect the life potential in recently discovered subglacial very likely hypersaline South Pole ice cap Martian lake (liquid water reservoir) [1] as well as similar subglacial hypersaline lakes (reservoirs) in Canadian Arctic [2].

The Lake Vostok is a giant (270 x 70 km, 15800 km2 area), deep (up to 1.3km) freshwater liquid body buried in a graben beneath 4-km thick East Antarctic Ice Sheet with the temperature near ice melting point (around -2.5°C) under 400 bar pressure. It is extremely oligotrophic and poor in major chemical ions contents (comparable with surface snow), under the high dissolved oxygen tension (in the range of 320 –1300 mg/L), with no light and sealed from the surface biota about 15 Ma ago [3].

The water frozen samples studied showed very dilute cell concentrations - from 167 to 38 cells per ml. The 16S rRNA gene sequencing came up with total of 53 bacterial phylotypes. Of them, only three phylotypes passed all contamination criteria. Two phylotypes were reported before [4] - hitherto-unknown and phylogenetically unclassified phylotype w123-10 likely belonging to *Parcubacteria* Candidatus *Adlerbacteria* and 3429v3-4 showing below-genus level (93.5%) similarity with *Herminiimonas glaciei* of *Oxalobacteraceae* (*Beta-Proteobacteria*) –water-inhabited ultramicrobacterium isolated from a deep Greenland ice core. The new third finding (the phylotype 3698v46-27) proved to be conspecific with several species of *Marinilactobacillus* of *Carnobacteriaceae* (*Firmicutes*). All three bacterial phylotypes may represent ingenious microbial communities in the subglacial Lake Vostok.

Two newly discovered (RES) subglacial hypersaline lakes (5 and 8.3km2 areas) in the Canadian Arctic are settled in bedrock throughs beneath 560 and 740m ice cap with modeled temperature below -10.5°C [2] and isolated by a glacier for at least 120 Ky ago. The biology is not yet studied (lakes are not unsealed), but the life potential is rather high (while dissimilar to the Lake Vostok). Their estimated salinity (140-160 psu) is in a range of that observed for brine-rich water body beneath Taylor Glacier (–7.8°C, 125 psu) and the ice-covered Lake Vida (–13°C, 200 psu) in Antarctica, both inhabited by active unique microbial communities.

The just discovered (RES) 20km-wide subglacial lake beneath the South Pole ice cap on Mars [1] should be ultra-hypersaline because it is buried beneath a 1.5km water ice cap with modeled temperature -68° C. It is well below known low-temperature limits supporting terrestrial microbial cell propagation and metabolism as well (-18°C and -33°C, respectively [5]). Such conditions may indicate zero-level life potential for this lake from the Earth-bound point of view, but its exploration may give us surprises.

©2019. Japan Geoscience Union. All Right Reserved.

In general, all three subglacial lakes (complexes) –two Earth-bound and one Martian, may host unique life forms never met before but their exploration (unsealing) is challenging as it happened with the Lake Vostok.

The reported study was partly funded by RFBR according to the research project №18-55-16004.

References:

[1] Orosei et al 2018 Science 361_490-3

[2] Rutishauser et al 2018 Sci Adv 4_eaar4353

[3] Bulat et Petit 2015 Encyclopedia of Astrobiology, Vol 1, pp.1-6 (Ch. 1765-2)

[4] Bulat 2016 Phil Trans Royal Soc A Math Phys Eng Sci 374 (2059)_20140292

[5] Rummel et al 2014 Astrobiology 14_887-968

Keywords: Antarctica, Subglacial Lake Vostok, Subglacial Mars South Pole ice cap lake, Subglacial hypersaline Canadian lakes, Bacterial 16S rRNA genes, Astrobiology

©2019. Japan Geoscience Union. All Right Reserved.

SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES – PROSPECTS FOR LIFE

Sergey Bulat[1]
[1]*NRC 'Kurchatov Institute' - Petersburg Nuclear Physics Institute, St. Petersburg-Gatchina, Russia*. E-mail: bulat@omrb.pnpi.spb.ru

Keywords:
Antarctica, subglacial Lake Vostok, Mars, subglacial South Pole ice cap lake, subglacial hypersaline Canadian lakes, Lake Vostok unsealing, frozen water, life, extremophiles, bacteria, 16S rRNA genes, astrobiology

Introduction:
The objective was to search for microbial life in the subglacial freshwater Antarctic Lake Vostok by analyzing the uppermost water layer entered the borehole following successful lake unsealing at the depth 3769m from the surface. The samples included the drillbit frozen and re-cored borehole-frozen water ice. The study aimed to explore the Earth's subglacial Antarctic lake and use the results to prospect the life potential in recently discovered subglacial very likely hypersaline South Pole ice cap Martian lake (liquid water reservoir) [1] as well as similar subglacial hypersaline lakes (reservoirs) in Canadian Arctic [2].
The Lake Vostok is a giant (270 x 70 km, 15800 km2 area), deep (up to 1.3km) freshwater liquid body buried in a graben beneath 4-km thick East Antarctic Ice Sheet with the temperature near ice melting point (around -2.5°C) under 400 bar pressure. It is extremely oligotrophic and poor in major chemical ions contents (comparable with surface snow), under the high dissolved oxygen tension (in the range of 320 – 1300 mg/L), with no light and sealed from the surface biota about 15 Ma ago [3].
The water frozen samples studied showed very dilute cell concentrations - from 167 to 38 cells per ml. The 16S rRNA gene sequencing came up with total 53 bacterial phylotypes. Of them, only three phylotypes passed all contamination criteria. Two phylotypes were reported before [4] - hitherto-unknown and phylogenetically unclassified phylotype w123-10 likely belonging to *Parcubacteria* Candidatus *Adlerbacteria* and 3429v3-4 showing below-genus level (93.5%) similarity with *Herminiimonas glaciei* of *Oxalobacteraceae* (*Beta-Proteobacteria*) – water-inhabited ultramicrobacterium isolated from a deep Greenland ice core. The new third finding (the phylotype 3698v46-27) proved to be conspecific with several species of *Marinilactobacillus* of *Carnobacteriaceae* (*Firmicutes*). All three bacterial phylotypes may represent ingenious microbial communities in the subglacial Lake Vostok.
Two newly discovered (RES) subglacial hypersaline lakes (5 and 8.3km2 areas) in the Canadian Arctic are settled in bedrock throughs beneath 560 and 740m ice cap with modeled temperature below -10.5°C [2] and isolated by a glacier for at least 120 Ky ago. The biology is not yet studied (lakes are not unsealed), but the life potential is rather high (while dissimilar to the Lake Vostok). Their estimated salinity (140-160 psu) is in a range of that observed for brine-rich water body beneath Taylor Glacier (−7.8°C, 125 psu) and the ice-covered Lake Vida (−13°C, 200 psu) in Antarctica, both inhabited by active unique microbial communities.
The just discovered (RES) 20km-wide subglacial lake beneath the South Pole ice cap on Mars [1] should be ultra-hypersaline because it is buried beneath 1.5km water ice cap with modeled temperature -68°C. It is well below known low-temperature limits supporting terrestrial microbial cell propagation and metabolism as well (-18°C and -33°C, respectively [5]). Such conditions may indicate zero-level life potential for this lake from the Earth-bound point of view, but its exploration may give us surprises.
In general, all three subglacial lakes (complexes) – two Earth-bound and one Martian, may host unique life forms never met before but their exploration (unsealing) is challenging as it happened with the Lake Vostok.
The reported study was partly funded by RFBR research project №18-55-16004.

References:
[1] Orosei et al 2018 Science 361_490-3
[2] Rutishauser et al 2018 Sci Adv 4_eaar4353
[3] Bulat et Petit 2015 Encyclopedia of Astrobiology, Vol 1, pp.1-6 (Ch. 1765-2)

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 201B 2F

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University), Chairperson:Yang-Yi Sun

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM14-01] New In-situ Ion Composition and Velocity Observations in the Topside Ionosphere from the Swarm-E Ion Mass Spectrometer

★Invited Papers

*Andrew W Yau[1] (1.University of Calgary)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM14-02] **Spatial-time features and dynamics of ionospheric disturbances during magnetic storms in 2015-2018**

★Invited Papers

*Oksana Mandrikova[1], Nadezhda Fetisova[1], Yurii Polozov[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Kamchatka State Technical University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM14-03] Estimating 2D neutral wind patterns using line-of-sight data from multiple Scanning Doppler Imagers

*Heikki Vanhamaki[1], Shin-ichiro Oyama[1,2], Mark Conde[3], Anita Aikio[1], Lei Cai[4], Ilkka Virtanen[1] (1.University of Oulu, Finland, 2.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 3.Geophysical Institute, University of Alaska Fairbanks, US, 4.KTH Royal Institute of Technology, Sweden)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM14-04] **Comparison of empirical models for the location of the ionospheric middle-latitude trough in the nighttime**

*Sarah Park[1], Khan-Hyuk Kim[1] (1.School of Space Research, Kyung Hee University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM14-05] Research on nonlinear cross-modulation of power line emission and other very low frequency radiations in the ionosphere

*Ling Yang[1], Jing Wu[1], Qiang Guo[1] (1.Beihang University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM14-06] Ionospheric variation induced by 21 August 2017 total solar eclipse detected by Global Ionospheric Specification

*CHIYEN LIN[1,2], JANN-YENQ Liu[1,2,3], Charles Lin[4] (1.Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2.Graduate Institute of Space Science, National Central University, Taiwan, 3.Center for Space and Remote Sensing Research, National Central University, Taiwan, 4.Department of Earth Science, National Cheng Kung University, Taiwan)

New In-situ Ion Composition and Velocity Observations in the Topside Ionosphere from the Swarm-E Ion Mass Spectrometer

*Andrew W Yau[1]

1. University of Calgary

The imaging and rapid-scanning ion mass spectrometer (IRM) onboard the polar-orbiting Swarm-E (e-POP) satellite is a new type of ion mass spectrometer that combines the techniques of hemispherical electrostatic deflection and ion time-of-flight analysis, with the unique capability of measuring simultaneously both the ion composition distribution and the detailed ion velocity distributions of individual ion species. We present several new observation results of the low, mid, and high-latitude topside ionosphere (300-1500 km altitude), from both detailed and statistical analyses of IRM data acquired in the first five years of the Swarm-E mission (since the launch in September 2013). These include the enhancement of minor ion composition at high latitudes, including N+ and molecular ions; localized regions of heavy ion up-flows and down-flows in the F-region auroral ionosphere; and bi-directional light ion flows at mid-latitudes; among others. We discuss the implications of these observation results in the context of both magnetosphere-ionosphere and ionosphere-thermosphere coupling.

Keywords: ionosphere, ion composition, ion mass spectrometer

©2019. Japan Geoscience Union. All Right Reserved.

Spatial-time features and dynamics of ionospheric disturbances during magnetic storms in 2015-2018

*Oksana Mandrikova[1], Nadezhda Fetisova[1], Yurii Polozov[1,2]

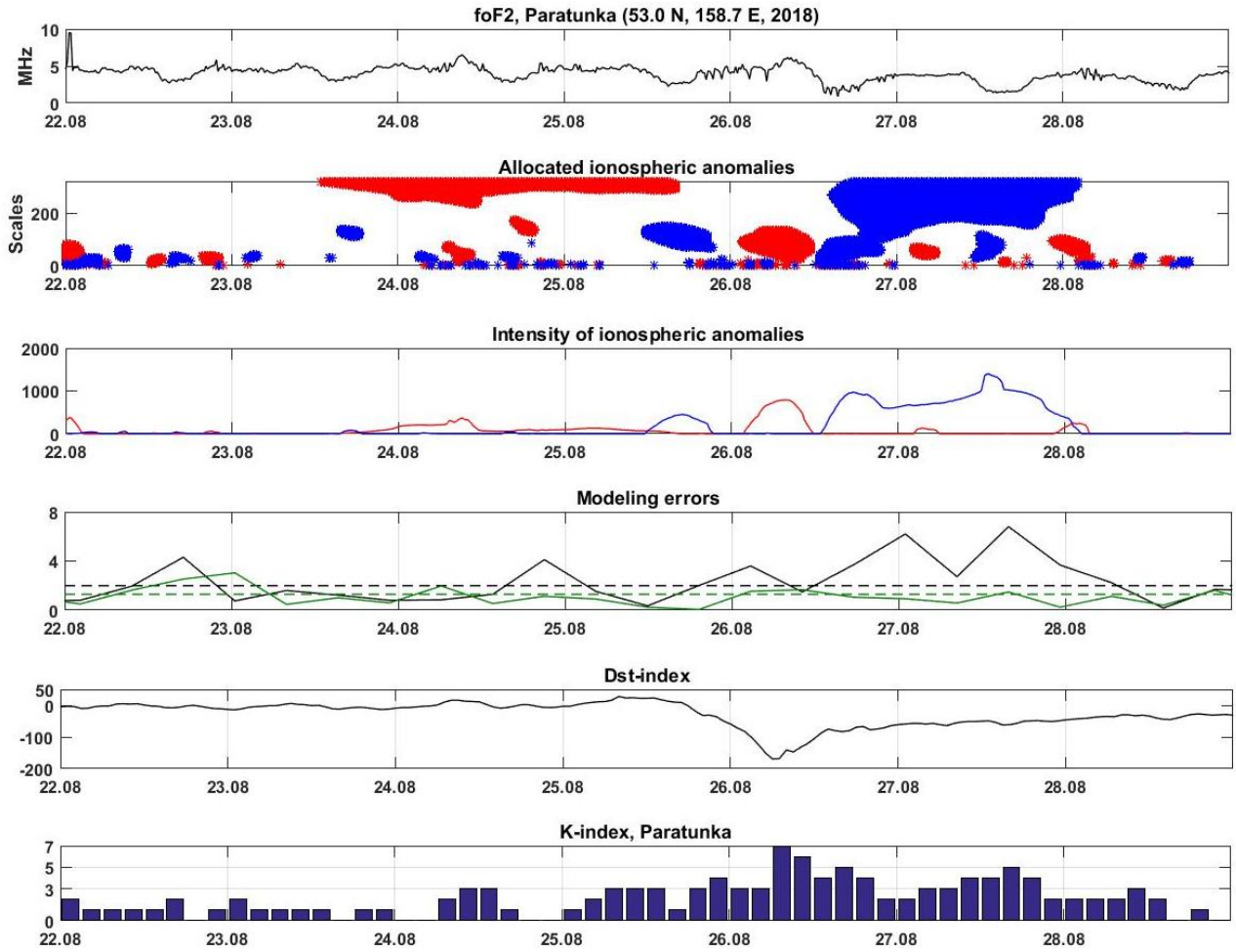
1. Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2. Kamchatka State Technical University

Ionospheric disturbances are formed as a result of ionosphere reaction to the increase in solar and geomagnetic activity (solar flares, coronal emissions, geomagnetic storms and substorms).They can have different intensity and duration and lead to the occurrences of positive and negative ionospheric storms. The ionospheric storm dynamics has complex spatial-time characteristics, depending on geographic location (polar and auroral zones, mid-latitude and equatorial regions), geomagnetic storm force, local time, and other factors. Ionospheric storms have negative impact on modern technical systems; therefore, their timely detection and prediction are an important task. In spite of the intensive development of technical tools and data analysis methods, the question of effective solution of this problem remains open [ex. 1].
In the paper, we modeled and analyzed the ionospheric parameter time course according to the ground station network (the resource http://wdc.nict.go.jp was used). Spatial-time features and dynamics of ionospheric disturbances were studied during magnetic storms which occured in 2015-2018. In the paper, a method proposed by the authors was used to model and to analyze ionospheric data. The method is based on wavelet transform [1]. The method allowed us to study the ionospheric parameter dynamics in detail, to detect ionospheric disturbances and to estimate their characteristics (Fig.1). The method was implemented numerically and adapted for real-time (as data are recorded). Comparison with the traditional approaches [2, 3] (median methods, IRI model) showed high efficiency of the proposed method and the possibility to apply it for on-line analysis of ionospheric data and to detect of ionospheric disturbances.

1. Mandrikova O.V., Fetisova N.V., Polozov Y.A., Solovev I.S., Kupriyanov M.S. Method for modeling of the components of ionospheric parameter time variations and detection of anomalies in the ionosphere coupling of the high and mid latitude ionosphere and its relation to geospace dynamics // Earth, Planets and Space. 2015. Vol. 67. No 1. pp. 131-146. DOI: 10.1186/s40623-015-0301-4
2. Mikhailov A., et al. A method for foF2 monitoring over Spain using the El Arenosillo digisonde current observations // Annals of Geophysics. 1999. Vol. 42 (4). doi:10.4401/ag-3748.
3. Bilitza D. International Reference Ionosphere 2007: Improvement sand new parameters / D. Bilitza, B.W. Reinisch // Advances in space research. 2008. Vol. 42. P. 599-609.

Keywords: Ionosphere, data analysis, ionospheric disturbances

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Estimating 2D neutral wind patterns using line-of-sight data from multiple Scanning Doppler Imagers

*Heikki Vanhamaki[1], Shin-ichiro Oyama[1,2], Mark Conde[3], Anita Aikio[1], Lei Cai[4], Ilkka Virtanen[1]

1. University of Oulu, Finland, 2. Institute for Space-Earth Environmental Research, Nagoya University, Japan, 3. Geophysical Institute, University of Alaska Fairbanks, US, 4. KTH Royal Institute of Technology, Sweden

We present a new analysis technique for estimating 2D neutral wind pattern using data from a single Scanning Doppler Imager (SDI) or a combination of SDIs, incoherent scatter radars (ISR) and Fabry-Perot interferometers (FPI) within overlapping field-of-views. Neutral wind plays an important role in ionospheric electrodynamics and Ionosphere-Thermosphere coupling, by for example affecting the Joule heating rates and plasma transport. However, reliable and extensive measurements of the neutral wind are rather difficult to obtain.

Pointwise measurements can be obtained with ISRs or FPIs, but these measurements can not provide 2D latitude-longitude maps of the neutral wind pattern needed in mesospheric studies. A Scanning Doppler Imager can measure the line-of-sight (LOS) component of the neutral wind in dozens of directions simultaneously. However, further modeling is needed to convert the LOS velocities into 2D velocity maps. Unfortunately these maps are far from unique, as perpendicular velocities (e.g. rotation around the measurement site) are not visible in the LOS data. This can be mitigated by combining data from several nearby SDIs, or a combination of SDIs, FPIs and ISRs.

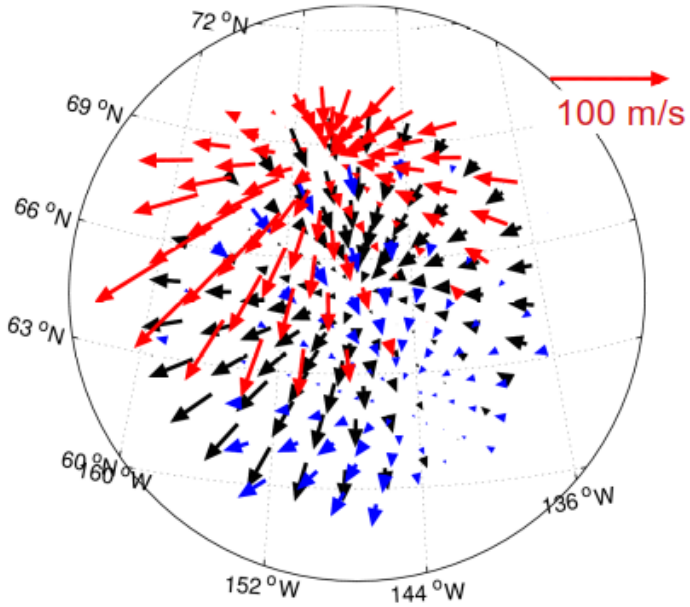
Our analysis technique is based on fitting the LOS data with special vector basis functions called Spherical Elementary Current Systems (SECS). In this approach the wind is naturally divided into curl-free and divergence-free components, and there is no need to provide any explicit boundary conditions on the wind pattern.

We present several synthetic test scenarios as well as first results using data from SDIs located in Alaska. Using the synthetic test scenarious we further estimate optimal locations for 2 or 3 SDIs that could be located around the future EISCAT_3D radar system in northern Scandinavia.

Keywords: Ionosphere, Thermosphere, Neutral wind

©2019. Japan Geoscience Union. All Right Reserved.

Line-of-sight velocity from 3 SDIs



Neutral wind pattern

→ ?

©2019. Japan Geoscience Union. All Right Reserved.

Comparison of empirical models for the location of the ionospheric middle-latitude trough in the nighttime

*Sarah Park[1], Khan-Hyuk Kim[1]

1. School of Space Research, Kyung Hee University

The middle-latitude ionization trough is a region of depleted plasma density in the ionosphere located at the equatorward edge of the auroral oval in the nighttime. Numerous studies have shown that trough locations shift equatorward under disturbed geomagnetic conditions. Many empirical models were developed to predict the trough location as a function of magnetic latitude (MLAT) and geomagnetic activity. Using the DMSP F15 data obtained in the nighttime sector of MLT = 1700-0130 hrs from February 2000 to January 2005, we identified 7735 middle-latitude troughs and statistically examined the trough location under different geomagnetic conditions. Unlike previous studies, we found that the middle-latitude trough minimum in the plasma density are distributed in a broad range of magnetic latitudes from ~40˚N to ~72˚N around 1700-2200 MLT in the Northern Hemisphere and from ~28˚S to ~76˚S around 2000-0130 MLT in the Southern Hemisphere depending on geomagnetic conditions. Trough locations at low latitudes and high latitudes, which appear under extremely disturbed (Kp > 6) and quiet (Kp < 1) geomagnetic conditions, respectively, are not well expected from previous empirical models. In this study, we develop an empirical model, in which trough locations can be expected under extreme geomagnetic conditions, and compare it with previous models.

Keywords: Ionospheric middle-latitude trough, Empirical model of the trough location

©2019. Japan Geoscience Union. All Right Reserved.

Research on nonlinear cross-modulation of power line emission and other very low frequency radiations in the ionosphere

*Ling Yang[1], Jing Wu[1], Qiang Guo[1]

1. Beihang University

By analyzing the observation data on electric field intensity from DEMETER satellite, we found that there exists a special type of line radiation events in the ionosphere above China. Their time-frequency power spectrums have several parallel lines with the center frequency 19.8 kHz, interval 50 Hz/100 Hz, and bandwidth 10 Hz. This phenomenon mostly occurs above central and eastern regions of China, which are the magnetic conjugate point of NWC transmitter in Australia (21.81˚S, 114.16˚E) [1]. The 19.8 kHz-spectral line is considered from the transmitter, which generates signal with center frequency 19.8 kHz and frequency band 200 Hz.

We applied bicoherence spectral analysis [2] to the spectrum of these events and found that they are likely to be generated by the wave radiated from NWC transmitter nonlinearly cross-modulated by 50 Hz-power line emission (PLE) from Chinese power grid. We further used the theory of interaction of plane radio waves for the theoretical analysis on such nonlinear cross-modulation. This phenomenon indicates that radiation from ground power grid can not only directly propagate into the ionosphere, but also interact with other waves in the ionosphere and further change their original state.

Reference: [1] J. Macnae. (2015) *Geophysics*, 80, E343-E353. [2] D. B. Graham, et al. (2014) *Geophys. Res. Lett.*, 41, 1367-1374.

Keywords: power line emission, nonlinear cross-modulation, ionosphere, bicoherence spectral analysis

©2019. Japan Geoscience Union. All Right Reserved.

Ionospheric variation induced by 21 August 2017 total solar eclipse detected by Global Ionospheric Specification

*CHIYEN LIN[1,2], JANN-YENQ Liu[1,2,3], Charles Lin[4]

1. Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2. Graduate Institute of Space Science, National Central University, Taiwan, 3. Center for Space and Remote Sensing Research, National Central University, Taiwan, 4. Department of Earth Science, National Cheng Kung University, Taiwan

On 21 August 2017, a total solar eclipse passed through the continental United States (CONUS) from the west to the east coast. Total Electron Content (TEC) measurements from thousands ground-based GNSS (Global Navigation Satellite System) receiving stations over CONUS observe the ionospheric horizontal variation induced by the moon shadow. Meanwhile, Global Ionospheric Specification (GIS) is an ionospheric data assimilation product based on Gauss-Markov Kalman filter, to assimilate slant TEC observed from ground-based GPS receivers and space-based RO instrumentations into background model International Reference Ionosphere (IRI-2016) to provide the continuity ionospheric three-dimensional (3D) electron density distribution. In this study, GIS assimilates about 1000 ground-based GNSS receiving stations data over the CONUS to reconstruct 3D electron density distribution during the obscuration period. Comparison of integrated TEC, N_mF_2, and h_mF_2 for the eclipse day and the day before the eclipse day, the assimilation analysis results demonstrate that not only electron density is depleted and also the peak height is uplifted during the solar eclipse. These results also indicate that the GIS electron density can study ionospheric 3D structural variation.

Keywords: Data Assimilation, Ionosphere, Solar Eclipse

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 201B 2F

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University), Chairperson:CHI-YEN LIN

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM14-07] Spatial gradients in the ionospheric delays (TECs) and scintillations associated with plasma bubbles

★Invited Papers

*Susumu Saito[1], Takayuki Yoshihara[1] (1.Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM14-08] Temporal and spatial variation of GPS TEC and phase scintillation during substorms and auroral breakups

*Paul Prikryl[1,2], James M. Weygand[3], Reza Ghoddousi-Fard[4], P. Thayyil Jayachandran[1], David R. Themens[1], Anthony M. McCaffrey[1], Bharat S. R. Kunduri[5], Emma Spanswick[6], Yongliang Zhang[7], Akira Sessai Yukimatu[8] (1.Physics Dept. of University of New Brunswick, Canada, 2.Geomagnetic Laboratory Natural Resources Canada, 3.Earth Planetary and Space Sciences, University of California, USA, 4.Canadian Geodetic Survey Natural Resources Canada , 5.Bradley Dept. of Electrical and Computer Engineering, Virginia Tech, USA, 6.Dept. of Physics and Astronomy of University of Calgary, Canada, 7.Johns Hopkins University Applied Physics Laboratory, USA, 8.National Institute of Polar Research, Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM14-09] IGS ROTI Maps extension toward Southern Hemisphere and low latitudes

*Iurii Cherniak[1,2], Irina Zakharenkova[2], Andrzej Krankowski[2] (1.COSMIC Program Office, University Corporation for Atmospheric Research, 2.University of Warmia and Mazury in Olsztyn)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM14-10] Durations of ionospheric gradients and plasma bubbles as ionospheric threats to GBAS

*MAHO NAKAMURA[1], Susumu Saito[1], Takayuki Yoshihara[1] (1.Electronic Navigation Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM14-11] Ionospheric Space Weather Data Product of FORMOSAT-7/COSMIC-2

★Invited Papers

*Charles Lin[1], P. K. Rajesh[1], CHIYEN LIN[2,3], Chia-Hung Chen[1], Jia-Ting Lin[1] (1.Department of Earth Sciences, National Cheng Kung University, 2.Center for Astronautical Physics and Engineering, National Central University, Taoyuan 32001, Taiwan, 3.Graduate Institute of Space Science, National Central University, Taoyuan 32001, Taiwan)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM14-12] **Vertical structure of ionosphere perturbed by large earthquake and tsunami**

*Yang-Yi Sun[1], XiangXiang Yan[1], Tao Yu[1], JANN-YENQ Liu[2] (1.China University of Geosciences (Wuhan), 2.National Central University)

Spatial gradients in the ionospheric delays (TECs) and scintillations associated with plasma bubbles

*Susumu Saito[1], Takayuki Yoshihara[1]

1. Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology

Spatial gradients in the ionospheric delays (equivalently ionospheric total electron contents: TECs) are the threat to the differential GNSS systems such as the ground-based GNSS augmentation system (GBAS), because they decorrelates the ionosphere induced errors between the reference and user stations. Another important issues is the scintillations associated with small-scale (a few hundred meters for GPS L1 signals at 1.57542 GHz) plasma irregularities. While the spatial gradient in the ionospheric delay may result in differential correction errors, the scintillation may result in increased noise of pseudo-range measurements, and in the worst case, cycle-slips and signal lock-off. Although both are associated plasma bubbles, they may not always occur simultaneously, partly because they are associated withplasma irregularities with different scale sizes.

In this study, correlation between the ionospheric spatial variation measured by a set of GNSS stations locate at the New Ishigaki Airport (24.3N, 124.2E) and the amplitude scintillation index (S4) observed near the airport are analyzed. The GNSS stations at the airport are separated by 0.1 - 2.3 km. The ionospheric delay differences are estimated based on the carrier-phase double differences with sophisticated methods originally developed for integrity monitors for GBAS. S4 index is estimated by a dedicated GNSS scintillation receiver. It was shown that the ionospheric delay gradients are not always enhanced when scintillation index is enhanced, though they are positively correlated. Further analysis of their correlations with different scale sizes by different combinations of GNSS receivers for ionospheric delay gradient estimation will be conducted, and the results will also be reported at the meeting.

Keywords: plasma bubble, spatial gradients in TEC, scintillations

©2019. Japan Geoscience Union. All Right Reserved.

Temporal and spatial variation of GPS TEC and phase scintillation during substorms and auroral breakups

*Paul Prikryl[1,2], James M. Weygand[3], Reza Ghoddousi-Fard[4], P. Thayyil Jayachandran[1], David R. Themens[1], Anthony M. McCaffrey[1], Bharat S. R. Kunduri[5], Emma Spanswick[6], Yongliang Zhang[7], Akira Sessai Yukimatu[8]

1. Physics Dept. of University of New Brunswick, Canada, 2. Geomagnetic Laboratory Natural Resources Canada, 3. Earth Planetary and Space Sciences, University of California, USA, 4. Canadian Geodetic Survey Natural Resources Canada , 5. Bradley Dept. of Electrical and Computer Engineering, Virginia Tech, USA, 6. Dept. of Physics and Astronomy of University of Calgary, Canada, 7. Johns Hopkins University Applied Physics Laboratory, USA, 8. National Institute of Polar Research, Japan

Ionospheric structure caused by precipitation of energetic particles can adversely affect the GPS signals resulting in phase scintillation and cycle slips (loss of lock). GPS phase scintillation has been found correlated with auroral emission intensity, particularly with rapid changes in auroral forms and their brightness [1,2,3]. Total electron content (TEC) enhancements that were observed during substorm expansion phase within the night side downward (R1) current appear to be associated with enhanced precipitating particle fluxes [4]. Such TEC enhancements cause phase scintillation, which is most intense just after substorm onsets and auroral breakups. Phase scintillation index is computed for sampling rate of 50 Hz by specialized GPS scintillation receivers from the Canadian High Arctic Ionospheric Network (CHAIN). A proxy scintillation index is obtained from dual frequency measurements of geodetic-quality GPS receivers sampling at 1 Hz, which include globally distributed receivers of RT-IGS network that are monitored by the Canadian Geodetic Survey in near-real-time. Temporal and spatial changes of TEC and phase scintillation are investigated in the context of equivalent ionospheric currents derived from ground magnetometer network using the spherical elementary current method [5,6]. The relation of phase scintillation with auroral emission observed by THEMIS all-sky imagers and the far-ultraviolet scanning imager SSUSI onboard the DMSP satellites is also examined. In general, GPS phase scintillation is mapped to regions of strong westward electrojet (upward R2 currents or the interface with downward R1 currents) and to the poleward edge of the eastward electrojet (upward R1 currents). Following substorm onsets and auroral breakups, strong phase scintillation associated with TEC enhancements are mapped mainly to the upward R2 current or the equatorward edge of the downward R1 current at or near the Harang discontinuity region [7].

[1] Kinrade J., et al., J. Geophys. Res., 118, 2490–2502, 2013. https://doi.org/10.1002/jgra.50214
[2] Semeter J., et al., Geophys. Res. Lett., 44, 9539–9546, 2013. https://doi.org/10.1002/2017GL073570
[3] Mushini S., et al., Space Wea., 16, 838–848, 2018. https://doi.org/10.1029/2018SW001919
[4] Weygand J.M., et al., Abstract SA41B-3484, presented at 2018 AGU Fall Meeting
[5] Amm O., and A. Viljanen, Earth Planets Space, 51, 431–440, 1999. doi:10.1186/BF03352247
[6] Weygand J.M., et al., J. Geophys. Res., 116, A03305, 2011. doi:10.1029/2010JA016177
[7] Weygand J.M., et al., J. Geophys. Res.. 113, A04213, 2008. doi:10.1029/2007JA012537

Keywords: Polar and auroral ionosphere (Ionospheric irregularities, Ionospheric currents, Energetic particles), Auroral substorms, GPS total electron content and phase scintillation

©2019. Japan Geoscience Union. All Right Reserved.

IGS ROTI Maps extension toward Southern Hemisphere and low latitudes

*Iurii Cherniak[1,2], Irina Zakharenkova[2], Andrzej Krankowski[2]

1. COSMIC Program Office, University Corporation for Atmospheric Research, 2. University of Warmia and Mazury in Olsztyn

The International GNSS Service (IGS) has accepted for official release a new ionospheric product to characterize ionospheric irregularity and intensity as derived from multi-site ground-based GPS observations. This product routinely generated by multi-step processing of carrier phase delays in dual-frequency GPS signals and transferred to the IGS CDDIS database. These ROTI maps allow regular monitoring of ionospheric irregularities over the Northern Hemisphere where there is the highest concentration of the GNSS users. This product represents changes of the GPS-based index ROTI (Rate of TEC Index) and has a polar projection within a range of 50˚-90˚N in geomagnetic latitude and 00-24 magnetic local time and based on measurements with 30 s sampling rate from about 700 GPS representative stations located at high and middle latitudes of the Northern Hemisphere.As the highest concentration of the GNSS users is within the American, European and Asian sectors, initially it focused on the Northern Hemisphere auroral, and midlatitude regions. But plasma irregularities that occurred at high, middle, and low latitudes have different physical mechanisms of their origin and development. For investigation of the ionospheric irregularities climatology, study of the ionospheric responses for Space Weather events, processes derived from below, this actual ROTI Map product is required to be extended to low latitudes and the Southern hemisphere polar and midlatitudes.

Recently, a number of the ground-based receivers within the global and regional networks grew significantly. It offers an excellent opportunity to extend the current IGS ROTI maps product toward global coverage. We present initial results of improved ROTI maps product performance to characterize ionospheric irregularities exited by different types of geophysical processes and space weather events. The new ROTI maps product can be a valuable tool for retrospective analysis of plasma irregularities impact on the GNSS positioning in the “worst case” examination domain.

The research is supported by the National Science Centre, Poland, through grants 2017/25/B/ST10/00479 and 2017/27/B/ST10/02190.

Keywords: GPS, ionosphere, ionospheric irregularities, ROTI, IGS

©2019. Japan Geoscience Union. All Right Reserved.

Durations of ionospheric gradients and plasma bubbles as ionospheric threats to GBAS

*MAHO NAKAMURA[1], Susumu Saito[1], Takayuki Yoshihara[1]

1. Electronic Navigation Research Institute

Ground-Based Augmentation System (GBAS) of global navigation satellite systems (GNSS) is now being widely deployed in the world. Ionospheric disturbances are one of the threats to GBAS operation because it is based on the differential GNSS (DGNSS) technique with L1 single frequency signals.In 2017, The International Civil Aviation Organization (ICAO) Asia-Pacific (APAC) region has defined the ionospheric threat model that can be used in the low magnetic latitude part of the region [1]. The threat model is being optimized for the transition region from low to mid-latitude regions over Japan by collecting more data using Japanese dense GNSS network (the GNSS Earth Observation NETwork: GEONET) [2,3,4].

Steep ionospheric delay gradients of which widths are several tens kilometers or less are one of the ionospheric threats in GBAS, because steep ionospheric gradients with small spatial scales may not be detected neither by GBAS ground stations nor by an airborne receiver when the gradient stands between the GBAS ground station and airplanes. From the viewpoint of GBAS operations, it is important to know how long such gradient events would last to predict the duration of GBAS operation outage. Therefore, clarifying durations of steep but small ionospheric gradients is important for GBAS operations. Though the duration of the ionospheric delay depletions associated with plasma bubbles have been studied extensively, the duration of the steep gradients have not been studied well.

In this paper, we extracted the steep ionospheric gradients caused by plasma bubbles from the ionospheric delay differences between some pairs of stations using the single-frequency-carrier-phase based and code-aided (SF-CBCA) technique [5] and GEONET data. Once the plasma bubbles candidates and the satellites which is affected by the ionospheric disturbances are selected, ionospheric delay variations of each receiver derived by dual-frequency measurements for estimation of the durations for each ionospheric gradient. The analyses of durations of steep ionospheric gradients which could be the threat for GBAS operations will be reported.

[1] S. Saito, S. Sunda, J. lee, S. Pullen, S. Supriadi, T. Yoshihara, M. Terkildsen, Frederic Lecat, “Ionospheric delay gradient model for GBAS in the Asia-Pacific region”, ICAO APANPIRG Ionospheric Studies Task Force, GPS solute, DOI 10.1007/s10291-017-0662-1, 2017.
[2] S. Saito, T. Yoshihara, S. Fujita, “Absolute gradient monitoring for GAST-D with a single-frequency carrier-phased based and code-aided technique”, 25th International Technical Meeting of the Satellite Division of The Institute of Navigation, Nashville TN, September 17-21, 2012.
[3] S. Saito and T. Yoshihara, “Evaluation of extreme ionospheric total electron content gradient associated with plasma bubbles for GNSS Ground-Based Augmentation System”, Radio Sci., 52, doi:10.1002/2017RS006291.
[4] M. Nakamura, S. Saito, T. Yoshihara, “Study of the spatial scale of plasma bubbles for ionospheric threat model for GBAS”, ION ITM 2018, 763-770, Reston, VA, January 2018.
[5] S. Fujita, T. Yoshihara and S. Saito, “Determination of ionosphere gradient in short baselines by using single frequency measurements”, Journal of Aeronautics, Astronautics and Aviation, Series A, Vol.42, No. 4 pp.269-276(2010).

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: ionosphere, ionospheric threat model, plasma bubble, ionospheric gradient, GNSS, GBAS

©2019. Japan Geoscience Union. All Right Reserved.

Ionospheric Space Weather Data Product of FORMOSAT-7/COSMIC-2

*Charles Lin[1], P. K. Rajesh[1], CHIYEN LIN[2,3], Chia-Hung Chen[1], Jia-Ting Lin[1]

1. Department of Earth Sciences, National Cheng Kung University, 2. Center for Astronautical Physics and Engineering, National Central University, Taoyuan 32001, Taiwan, 3. Graduate Institute of Space Science, National Central University, Taoyuan 32001, Taiwan

FORMOSAT-7/COSMIC-2 (F7/C2) will provide unprecedented number of ionosphere observations in the mid- and low-latitude regions where the ionosphere is highly variable due to its interactions with planetary waves, solar oscillations, and lunar tides overlapping on top of the original ionospheric climatological electron density morphologies. To study the strong day-to-day variability of the ionosphere there, we have developed a global ionospheric data assimilation model using radio occultation observations together with auxiliary observations from ground-based GNSS stations. The assimilation system is capable of producing day-to-day and hour-to-hour ionospheric electron density maps three dimensionally for the study. With the advance given by the newly developed data assimilation model, we re-examine the wave-4 variations on daily basis, as well as the migrating tidal variations during the stratospheric sudden warming events. Additionally, electron density profiles from the aided Abel inversion of radio occultation observations will also be provided which is expected to give more reliable electron density profile around 200-300 km altitude compared with traditional Abel inversion. The abovementioned ionosphere products from the F7/C2 observations will be available six months after launch.

Keywords: FORMOSAT-7/COSMIC-2, Space Weather

©2019. Japan Geoscience Union. All Right Reserved.

Vertical structure of ionosphere perturbed by large earthquake and tsunami

*Yang-Yi Sun[1], XiangXiang Yan[1], Tao Yu[1], JANN-YENQ Liu[2]

1. China University of Geosciences (Wuhan), 2. National Central University

The FORMOSAT-3/COSMIC (F3/C) radio occultation (RO) technique vertically scans the atmosphere from 0 to 800 km altitude. Here we first show the ionospheric electron density structures which were perturbed by the wavefront of the M_W7.8 Nepal earthquake that occurred on 25 April 2015. Next, we show the acoustic resonance due to the 2008 Mw8.0 Wenchuan earthquake and 2011 Mw9.0 Tohoku earthquake and tsunami. The mean wavelet spectra derived from dozens of atmospheric and ionospheric RO sounding profiles within six hours after the earthquake illustrate that the atmospheric oscillations with the vertical wavelength ranging from 0.5 to 60 km appear at the altitudes from the lower atmosphere to the ionosphere. The vertical wavelength estimated from the atmospheric gravity wave dispersion relation is compared with the observed vertical wavelength. The small-scale gravity waves may not be easy to reach the upper ionosphere. These RO-observed long-lasting atmospheric and ionospheric oscillations may consist of the earthquake/tsunami wavefront and its residual oscillatory tail or acoustic resonance. The results suggest that the RO technique is a powerful tool which is suitable for probing earthquake/tsunami-induced oscillations in the atmosphere, and allow a more comprehensive understanding of the excitation, propagation, and dissipation of earthquake/tsunami-induced gravity waves in the entire atmosphere.

Keywords: coseismic traveling ionospheric disturbance, wavefront, resonance, radio occultation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Kazuo Yoshioka(The University of Tokyo), Mitsunori Ozaki(Kanazawa University)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[PCG21-01] Current status and instrument development plan for future lunar exploration missions

★Invited Papers

*Makiko Ohtake[1] (1.Japan Aerospace Exploration Agency)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[PCG21-02] Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3] (1.The university of Tokyo, 2.ISAS/JAXA, 3.Osaka University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[PCG21-03] Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1] (1.The university of tokyo, 2.Osaka University, 3.Nagoya University, 4.ISAS / JAXA)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[PCG21-04] A high-voltage pulsed power supply for on-site mass spectrometry in future solar system explorations

*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2] (1.Graduate School of Science, Osaka University, 2.ISAS/JAXA)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[PCG21-05] Development of DESTINY$^+$ Dust Analyzer and its expected science return

*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3]
(1.Chiba Institute of Technology, Planetary Exploration Research Center, 2.University of Stuttgart, 3.Max Planck Institute for Solar System Research)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

Discussion

Current status and instrument development plan for future lunar exploration missions

*Makiko Ohtake[1]

1. Japan Aerospace Exploration Agency

Currently JAXA is planning a series of lunar exploration missions as a part of the international space exploration program. The goal of this program is to accomplish a Mars human exploration mission(s) after developing the required technology by doing. lunar exploration missions. In the initial stage of the program, JAXA is studying the following two lunar exploration missions.

1) Lunar polar exploration to evaluate the possibility of utilizing lunar polar water ice as a fuel resource for future lunar exploration. This mission will use pinpoint landing technology, which will be developed and demonstrated by the Smart Lander for Investigating the Moon (SLIM), for landing in a very limited and difficult area suitable for polar-ice investigation.

2) A lunar sample return mission (Human Enhanced Robotic Architecture for Lunar Exploration and Science; HERACLES), which will employ a lunar Gateway (Lunar Orbital Platform-Gateway) and will demonstrate the capability to return from the lunar surface that is required for a human landing mission on the Moon. This mission will bring back 15 kg of lunar samples and is capable of exploring tens of kilometers of the lunar surface by rover.

These missions are still before the pre-project phase, and the instruments that will be carried on these missions haven’t been selected. Recently, teams for conducting preliminary study of candidate instruments for the lunar polar exploration mission were selected based on proposals. And JAXA is planning to announce a request for information for the HERACLES instruments. Also, study teams for these missions in JAXA identified several key technologies to realize the missions and started to develop them (e.g., a rover system, a surface-drilling system, and night-survival technology). For efficient and optimal development of these technologies, the requirements and engineering limitations are being discussed among scientists and engineers, and iterative development is fundamental. This presentation will discuss the current status of the lunar polar exploration mission and the HERACLES mission including identified key technologies. A development plan for these technologies will also be discussed to accelerate discussion and interaction among people from different fields.

Keywords: Moon, Lunar polar exploration, HERACLES, international space exploration program

©2019. Japan Geoscience Union. All Right Reserved.

Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3]

1. The university of Tokyo, 2. ISAS/JAXA, 3. Osaka University

In-situ observation is important in solar system exploration because of the difficulty in returning samples from a gravitational celestial body. Especially, in-situ mass spectrometry of celestial surface material is indispensable to understand the evolution of the moon and planets since mass spectra bring us various information such as the isotope composition. For the purpose of in-situ material analysis, mass spectrometers are used for recent planetary explorations. In addition, observations by lunar explorer in recent years reports the result of remote sensing suggesting the existence of H_2O in the moon polar permanent shadow, but the existence is ambiguous since the observations have problems such as difficulty in discriminating between H_2O and OH. The need for a mass spectrometer to demonstrate the presence of water by in situ observation is increasing.

Mass spectrometers on planetary explorers must be compact and lightweight, but mass spectrometers that have both the compactness and high mass resolution have not been developed yet. Therefore, we are developing a compact and moderately high mass resolution TOF-MS (Time-Of-Flight Mass Spectrometer) for measuring neutral particles on the moon and planets.

TOF-MS accelerates ions with an electric field. The accelerated ions fly at a fixed distance and the mass information is obtained from their flight time. In general, the flight path of ions must be long for realizing high mass resolution. In order to increase flight distance without enlarging equipment, a reflectron type TOF- MS, which reflects ions by electric field is adopted. Since the ion trajectory is dispersed as the ion flight distance increases, the detection efficiency decreases when the number of reflection increases. Therefore, our new reflectron type TOF-MS is equipped with a triple reflection mode with high mass resolution and a single reflection mode with high sensitivity. These measurement modes can be switched electrically depending on the observation targets. Simulation results show that the mass resolution is 360 in the triple reflection mode and 180 in the single reflection mode. Currently, we are manufacturing a test model whose size and potential are optimized.
In this presentation we will report the design of our new reflectron type TOF-MS that is optimized by analytical calculation and numerical simulation.

Keywords: Solar System Exploration, Mass Spectromete

©2019. Japan Geoscience Union. All Right Reserved.

Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1]

1. The university of tokyo, 2. Osaka University, 3. Nagoya University, 4. ISAS / JAXA

Previous mass spectrometry in solar system explorations has advanced our knowledge and understanding on the formation and evolution of planets, as well as the dynamics of space environment surrounding planets, moons, and other small bodies. Nonetheless, there are many important topics remaining to be addressed by higher-resolution mass spectrometry. Here we report our design of Orbitrap, which is a kind of Fourier-transform mass spectrometer, showing high mass resolution (m/dm ~ 10000) based on numerical simulations. We propose a simple and miniaturized ion storage unit in front of the multi-reflectron region, utilizing the potential drop by the electron beam for ionization. Such a high-resolution mass spectrometer will provide significant information on elemental and isotopic compositions in, on, and around planets and other solar system objects. For instance, discrimination between N_2(28.0062 u) and CO(27.9949 u) in the Martian atmosphere, which is essential for discussing atmospheric escape in the present and past, will be enabled.

Keywords: Mass Spectrometer, High Mass Resolution, Orbitrap

©2019. Japan Geoscience Union. All Right Reserved.

A high-voltage pulsed power supply for on-site mass spectrometry in future solar system explorations

*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2]

1. Graduate School of Science, Osaka University, 2. ISAS/JAXA

Isotope-ratio mass spectrometric analyses have been frequently utilized in laboratories for not only the earth planetary science but also other scientific and industrial fields. In the planetary science, such mass analyses of meteorites and returned samples provide detailed information regarding the origin and evolution. Recently on-site measurements by lander and rover missions including high-resolution mass spectrometry have opened the door to a new era of the planetary science. We argue that the on-site mass analysis is capable of directly determining the age of bodies and asteroids and the presence of water. For Japanese future lander and rover missions, we are now developing high-resolution mass spectrometers. Although high-performance mass spectrometers occupy the much room of laboratories, it is possible to develop the mass spectrometers for space applications because the key components including ion optics and electronics are in principle fabricated within the acceptable ranges in terms of the size, weight, and power consumption. In addition, we have already developed several spaceborne mass analyzers for the space plasma observation and have succeeded in mass analyses in space. After conducting the concept design of the mass spectrometers for landers and rovers, we conclude that the feasibilities are enough for the ion optics and almost all the components of the electronics. However, we have estimated relatively low feasibility for the high-voltage pulsed power supply which mostly determine the performance of the time-of-flight mass spectrometers. The laboratory high-voltage pulsed power supplies contain a 'black box' module as the key component that consumes much power. Therefore, we have started reconstructing a high-voltage pulsed power supply for spaceborne time-of-flight mass spectrometers. We have developed evaluation boards of the high-voltage pulsed power supply for reflectron-type multi-turn-type mass spectrometers, which is planned to be utilized in future Japanese landing missions. In this presentation, we will report the instrumentation and test results.

Keywords: High-voltage pulsed power supply, Mass spectrometry, Isotope

©2019. Japan Geoscience Union. All Right Reserved.

Development of DESTINY$^+$ Dust Analyzer and its expected science return

*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3]

1. Chiba Institute of Technology, Planetary Exploration Research Center, 2. University of Stuttgart, 3. Max Planck Institute for Solar System Research

Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science (DESTINY$^+$) led by Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science (JAXA/ISAS) will be launched in 2023. In addition to its two main engineering missions such as advancement of the electrical propulsion in space and acquisition of the fast flyby technique to the solar system small body, DESTINY$^+$ set two scientific missions to perform fast flyby observation of an active asteroid, 3200 Phaethon, and dust observation during interplanetary cruising and Phaethon flyby phases. In this presentation, we will introduce the dust analyzer for DESTINY$^+$ (DDA) and its expected science return.

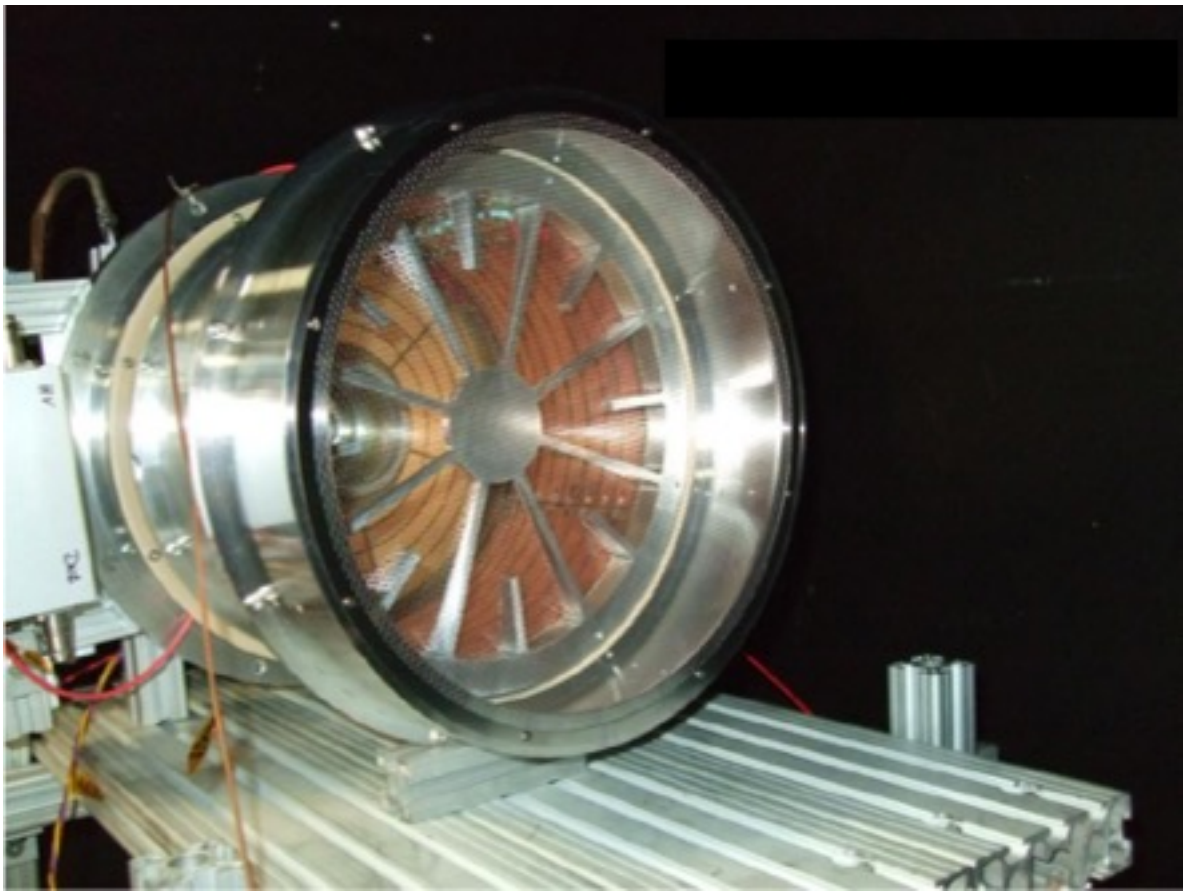
DDA is an dust impact detector equipped with time-of-flight mass spectrometer (TOF-MS) which is the technologically advanced model of the dust analyzer (CDA) onboard the NASA's Saturn explorer, Cassini. DDA has been under development by a dust group at University of Stuttgart who developed CDA. Planetary Exploration Research Center at Chiba Institute of Technology (CIT/PERC) plays a role in interface adjustment between the spacecraft and DDA, operation planning, leading the DDA’s dust science, and so on.

Hypervelocity impact, >~1 km/s, of micrometeoroid on the target plate of the DDA sensor generates a plasma cloud composed of positive and negative ions and electrons. The applied electric field inside the sensor separates positive or negative particles from the other according to its polarity, and directs the separated ions into an ion collector. Then one can obtain TOF mass spectra and estimate the chemical composition of detected dust particles. The past dust analyzers had historically employed the positive ion detection mode in which the impact target is positively biased, however, DDA will have two sensor heads tuned for analyzing positive and negative ions respectively in order to reveal the chemical composition of dust particles with a wide variety of atomic and molecular species at the same observation condition. Another upgrade of DDA is a two-axes gimbal for aiming the sensor head towards the direction from which more incident of dust particles is expected.

During the interplanetary cruising phase between Earth and Venus orbit for about 2 years, DDA will observe the interplanetary dust originated from asteroids and comets and the interstellar dust incoming from outside the Solar System. At the Phaethon flyby, DDA will try to detect and analyze the ejected dust particles from Phaethon itself due to bombardment of the interplanetary dust.

Keywords: Interplanetary dust, Interstellar dust, 3200 Phaethon, Impact ionization, TOF-MS, Dust analyzer

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Satoshi Kasahara , Mitsunori Ozaki(Kanazawa University)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[PCG21-06] Satellite mission: PhoENiX (Physics of Energetic and Non-thermal plasmas in the X (= magnetic reconnection) region)

★Invited Papers

*Noriyuki Narukage[1], Mitsuo Oka[2], Yasushi Fukazawa[3], Keiichi Matsuzaki[4], Shin Watanabe[4], Taro Sakao[4], Sin-nosuke Ishikawa[5], Kouichi Hagino[6], Ikuyuki Mitsuishi[5], Tsunefumi Mizuno[3], Iku Shinohara[4], Masumi Shimojo[1], Shinsuke Takasao[5], Hiroshi Tanabe[7], Munetaka UENO[8], Tadayuki Takahashi[9], Takeshi Takashima[4], Masayuki Ohta[4] (1.National Astronomical Observatory of Japan, 2.Space Sciences Laboratory, The University of California, Berkeley, 3.Hiroshima University, 4.Japan Aerospace Exploration Agency, 5.Nagoya University, 6.Tokyo University of Science, 7.The University of Tokyo, 8.Kobe University, 9.Kavli Institute for the Physics and Mathematics of the Universe)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[PCG21-07] Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3] (1.Department of Solar System Sciences, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Hokkaido Information University, 3.Graduate School of Science, Kyoto University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[PCG21-08] SS-520-3 Sounding Rocket Experiment Targeting the Ion Outflow in the Polar Cusp / Aurora

*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3] (1.Department of Solar System Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Institute of Polar Research, 3.Research Institute for Sustainable Humanosphere, Kyoto University)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[PCG21-09] **Development of the chip implemented as high-speed current detection circuits for particle sensors**

*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1] (1.JAXA, 2.Kyoto University)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[PCG21-10] GEO-X (GEOspace X-ray imager) : Imaging the dayside solar wind-terrestrial magnetosphere interaction

★Invited Papers

*Yuichiro Ezoe[1], Yoshizumi Miyoshi[2], Satoshi Kasahara[3], Ryu Funase[3], Harunori Nagata[4], Hiroshi Nakajima[5], Kumi Ishikawa[6], Atsushi Yamazaki[6], Hiroshi Hasegawa[6], Junko Hiraga[7], Masaki Fujimoto[6], Kazuhisa Mitsuda[6], Munetaka Ueno[8], Hiroyuki Koizumi[3], Yasuhiro Kawakatsu[6], Takahiro Iwata[6], Hironori Sahara[1] (1.Tokyo Metropolitan University, 2.Nagoya University, 3.University of Tokyo, 4.Hokkaido University, 5.Kanto Gakuin University, 6.ISAS/JAXA, 7.Kansei Gakuin University, 8.Kobe University)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

Discussion

Satellite mission: PhoENiX (Physics of Energetic and Non-thermal plasmas in the X (= magnetic reconnection) region)

*Noriyuki Narukage[1], Mitsuo Oka[2], Yasushi Fukazawa[3], Keiichi Matsuzaki[4], Shin Watanabe[4], Taro Sakao[4], Sin-nosuke Ishikawa[5], Kouichi Hagino[6], Ikuyuki Mitsuishi[5], Tsunefumi Mizuno[3], Iku Shinohara[4], Masumi Shimojo[1], Shinsuke Takasao[5], Hiroshi Tanabe[7], Munetaka UENO[8], Tadayuki Takahashi[9], Takeshi Takashima[4], Masayuki Ohta[4]

1. National Astronomical Observatory of Japan, 2. Space Sciences Laboratory, The University of California, Berkeley, 3. Hiroshima University, 4. Japan Aerospace Exploration Agency, 5. Nagoya University, 6. Tokyo University of Science, 7. The University of Tokyo, 8. Kobe University, 9. Kavli Institute for the Physics and Mathematics of the Universe

We are planning a new solar satellite mission, "*PhoENiX*", for understanding of particle acceleration during magnetic reconnection, which are ubiquitous features exhibited by a wide range of plasmas in the universe. The main observation targets of this mission are solar flares, which are generated by magnetic reconnection and accelerate plasma particles. The sun is a unique target in the sense that it can be investigated in great detail with good spatial, temporal and energy resolutions.
The scientific objectives of this mission are (1) to identify particle acceleration sites, (2) to investigate temporal evolution of particle acceleration, and (3) to characterize properties of accelerated particles, during solar flares. In order to achieve these science objectives, the *PhoENiX* satellite is planned to be equipped with three instruments of (1) Photon-counting type focusing-imaging spectrometer in soft X-rays (up to ~10 keV) to observe the contexts of particle accelerations (e.g., shocks, plasmoids, flows, etc.), (2) Photon-counting type focusing-imaging spectrometer in hard X-rays (up to ~30 keV) to identify the accelerated particles, and (3) Spectropolarimeter in soft gamma-rays (spectroscopy is available in the energy range of from > 20 keV to < 600 keV; spectropolarimetry is available from > 60 keV to < 600 keV) to detect the anisotropy of accelerated particles. We plan to realize *PhoENiX* satellite mission around next solar maximum (around 2025).
The basic developments of key technologies for these instruments have been completed. The soft X-ray imaging spectroscopy is planned to be realized with the combination of high-precision glass-polished X-ray mirrors and high-speed CMOS cameras. The hard X-ray imaging spectroscopy consists of high-precision electroforming X-ray mirrors and CdTe cameras. The soft gamma-ray spectropolarimeter is a redesigned instrument of *Hitomi* / Soft Gamma-ray Detector (SGD) that has Compton cameras with active shields. Some of these technologies required for the X-ray imaging spectroscopy have been demonstrated by *FOXSI* sounding rocket series launched in 2012, 2014 and 2018. The *FOXSI* successfully obtained the focusing imaging spectroscopic data of the solar corona in X-rays (from ~0.5 keV to ~15 keV).
In this presentation, we explain the details of science goal and objectives, and instruments of *PhoENiX* mission.

Keywords: PhoENiX, Particle Acceleration, Magnetic Reconnection, Solar Flare, X-rays, Imaging Spectroscopy

©2019. Japan Geoscience Union. All Right Reserved.

Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3]

1. Department of Solar System Sciences, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Hokkaido Information University, 3. Graduate School of Science, Kyoto University

The lower ionosphere is known as a unique region where charged particles and neutral particles co-exist. The charged particles tend to move in a direction different from neutral particles, because of a difference in those behaviors against the electromagnetic force. For example, the dynamo current and polarization electric field existing in this region are attributed to a difference in a collision frequency between ion and electron with neutral particles. Characteristic phenomena such as traveling ionospheric disturbance and equatorial spread F are generated due to the diversity of the particles in this region. The momentum transfer between the charged and neutral particles plays an important role in generating these phenomena. Sounding rocket is the most suitable platform which enables us to make in-situ measurement of the particles in this region because low-altitude satellite cannot be in orbit for a long time period because of the atmospheric drag. Thus, it is desirable to make a direct measurement of charged and neutral particles by using instrument on the sounding rocket to further understand such unresolved phenomena.

Chemical release experiment, such as Lithium Ejection System (LES) or Trimethyl Aluminum (TMA) instruments, have been adapted for sounding rocket experiment to get information on neutral wind in the lower ionosphere. In contrast, no instruments to measure a drift of the ionospheric ions is now available in Japan. Only a few studies on the neutral-ion coupling based on the simultaneous measurements on the rocket are available in the literature. Therefore, our understanding of interaction between charged and neutral particles in the weakly ionized plasma has not made much progress because of a lack of observational data. Unfortunately, it is very difficult to reproduce a coupling between charged and neutral particles on the ground, and direct measurements by sounding rocket or low altitude satellite is only the way to provide quantitative information.

Under such a background, we have started developing an ion drift velocity analyzer which enables us to estimate the ion drift velocity and density in the lower ionosphere. It is well known that Ion Drift Meter (IDM) or Retarding Potential Analyzer (RPA) had been installed on low-altitude satellite, such as Dynamic Explorer-2 and Atmospheric Explorer series. Our instrument will be required to have both of these functions. It will also be possible to make simultaneous measurement of the ion drift and neutral wind in the sounding rocket experiment if the present instrument is successfully developed and installed on the sounding rocket together with chemical release experiment. Then, we will be able to conduct quantitative discussion on the coupling between charged and neutral particles.

As the first step of the instrument development, a numerical simulation to design the internal structure was started. The instrument consists of RPA section in the front and multiple sector anodes in the end. Accuracy to estimate incident direction, speed, and temperature of thermal ions is evaluated from the simulation result. The prototype model is to be manufactured after we obtain a confident prospect that the instrument provides the ion density and velocity in a good accuracy. Then, we will put the prototype instrument in the vacuum chamber and evaluate its performance by generating ion drift. The latest status of our instrument development will be explained in the presentation.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: ionosphere, ion drift, ion-neutral coupling, sounding rocket

©2019. Japan Geoscience Union. All Right Reserved.

SS-520-3 Sounding Rocket Experiment Targeting the Ion Outflow in the Polar Cusp / Aurora

*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3]

1. Department of Solar System Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. National Institute of Polar Research, 3. Research Institute for Sustainable Humanosphere, Kyoto University

In order to achieve collective understanding of the microphysics and its role (scale coupling) in the global scale to mesoscale phenomena in the polar ionosphere, Japan-Norway sounding rocket experiment program is now in progress. Although Japanese sounding rocket SS-520-3 was planned to be launched from Ny-Ålesund, Svalbard in Spitsbergenin December 2017, the launch was postponed due to mal-function of the timer equipment that was found during the final stage of the integration test. Since the timer equipment problem has already been completely fixed, SS-520-3 Payload Instrument team desires the earliest possible launch of the sounding rocket.

The main objective of this sounding rocket is to understand the particle acceleration processes that cause the ion outflow by making in-situ observation of the wave-particle interactionin the cusp region. SS-520-3 sounding rocket experiment aims to resolve the wave-particle interaction by making in-situ measurements in the polar cusp with newly developed instruments for the satellite mission. Since these wave-particle interactions are predicted to be effective above 800km altitude, a two-stage sounding rocket SS-520 whose apex can be higher than 750km is necessary. The rocket range where SS-520 can be launched targeting the cusp region is only Ny-Ålesund in Svalbard. Since simultaneous ground based optical observation of the cusp aurora is necessary to decide the launch timing, the best launch period is determined from the conditions of both the sunlight and the moonlight. From the sunlight condition, the best launch period is in the winter polar night that is around the winter solstice. On the other hand, two weeks before/after the new moon is the best launch period from the condition of the moonlight. Launch window for each day is 0700UT-1130UT (0800LT-1230LT: 1000MLT-1430MLT) when the cusp is possibly on the same magnetic field line as the trajectory of SS-520-3. SS-520-3 sounding rocket experiment is a part of the comprehensive observation campaign including ground-based radar and optical observations. SS-520-3 sounding rocket experiment is also one of the projects participating in “A Grand Challenge Initiative (GCI) Cusp program” that is a large-scale international collaboration for targeting advancement in the common understanding of cusp region space physics.

Although SS-520-3 Payload Instrument team desires the earliest possible launch of the sounding rocket, the severe budgetary situation at ISAS in 2018 prevented the launch of SS-520-3 in winter 2018-2019. Approaching the solar minimum in this solar cycle, that will be in 2020, the opportunities that satisfy the launch condition will decrease since the latitude of cusp tends to be higher comparing the apex latitude of SS-520-3. In order to overcome this situation, SS-520-3 Payload Instrument team is considering to add possible ion outflow over morning side polar cap aurora or nightside auroral arc as alternative targets of SS-520-3 sounding rocket experiment.

Keywords: Sounding Rocket, Ion Outflow, Cusp, Aurora

©2019. Japan Geoscience Union. All Right Reserved.

Development of the chip implemented as high-speed current detection circuits for particle sensors

*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1]

1. JAXA, 2. Kyoto University

Plasma filling the space is very rarefied. Ions and electrons in space plasma do not exchange their kinetic energies through their collisions but through plasma waves. This is so-called “wave-particle interaction,” and it is indispensable for understanding space electromagnetic environments. The WPIA (Wave-Particle Interaction Analyzer) is a new sophisticated method that allows us to understand wave-particle interactions quantitatively. The WPIA was initially installed in the Arase satellite. The WPIA processes instantaneous wave vectors observed by a plasma wave receiver and velocity vectors of each particle observed by a plasma instrument. The high relative time precision for detecting vectors of plasma waves and particles is essential in the WPIA. This requires a synchronous performance of plasma wave receivers and particle instruments. We introduce a system that feeds particle detection pulses of particle detectors into plasma wave receivers to achieve the synchronization. This system can use the sampling clocks for waveforms to keep the high relative time precision between instant values of plasma waves and particle detections. The present study focuses on the part of the circuits dedicated to particle detections and feeds of corresponding pulses into plasma wave receivers. We use the ASIC (Application Specific Integrated Circuit) for integrating the above circuits as one small chip. The chip we developed consists of two stages. The first stage is the current-voltage conversion circuit. Outputs of particle detectors are a series of weak electron current pulses with their pulse widths less than a few tens of nanoseconds. The first stage picks up each current pulse and converts into voltage signals with enough amplitudes to drive the second stage. We designed high-speed circuits dedicated to the first stage. The second stage contains comparator and peak-hold circuits. The comparator ensures picking up real signals by setting a threshold level and the peak-hold circuit has a role to keep the level to connect to the next stage. In this study, we set the count rate of 106/s as the target value and we designed the circuits so that it is within 1 μs from the arrival of a particle to the convergence of the detection signal. Conventional circuits are made of discrete electronic parts. That requires large resources in their sizes and weights. However, the chip we developed is small and light-weight. In this study, we integrate detection circuits using ASIC technology and we aim to accommodate at least 16 channels of circuits within 5 mm square chip.

In this presentation, we show the details of the chip designed for the particle detection circuits. We also examine the verification test results in the operation of those circuits. Furthermore, we describe the development plan for future WPIA system integration.

Keywords: ASIC, WPIA

©2019. Japan Geoscience Union. All Right Reserved.

GEO-X (GEOspace X-ray imager) : Imaging the dayside solar wind-terrestrial magnetosphere interaction

*Yuichiro Ezoe[1], Yoshizumi Miyoshi[2], Satoshi Kasahara[3], Ryu Funase[3], Harunori Nagata[4], Hiroshi Nakajima[5], Kumi Ishikawa[6], Atsushi Yamazaki[6], Hiroshi Hasegawa[6], Junko Hiraga[7], Masaki Fujimoto[6], Kazuhisa Mitsuda[6], Munetaka Ueno[8], Hiroyuki Koizumi[3], Yasuhiro Kawakatsu[6], Takahiro Iwata[6], Hironori Sahara[1]

1. Tokyo Metropolitan University, 2. Nagoya University, 3. University of Tokyo, 4. Hokkaido University, 5. Kanto Gakuin University, 6. ISAS/JAXA, 7. Kansei Gakuin University, 8. Kobe University

Understanding complex nature of the solar wind interaction with solar system objects such as the Earth’ s magnetosphere, the Martian exosphere, and the Jovian magnetosphere is crucial in planetary physics, heliophysics and astrophysics including exoplanet physics. Remote sensing imaging observations provide global variation of these environments as a function of solar winds as demonstrated about aurora ovals, the terrestrial plasmasphere, and the terrestrial ring current. Such observations are complimentary to in-situ electromagnetic and particle observations. Recently soft X-ray emission (0.1-2.0 keV) generated via charge exchange process of high charge state solar wind ions (O6+, N5+, …) with geocorona is discovered. Numerical simulations predict that this emission must allow us to image dayside solar wind-terrestrial magnetospheric interaction such as the magnetosheaths, the cusps and the shock. GEO-X is a Japanese small satellite mission carrying a novel wide-field of view X-ray telescope and a high speed X-ray detector to demonstrate the X-ray imaging of the Earth’ s magnetosphere. GEO-X aims observations of the dayside boundaries of the Earth’ s magnetosphere in the vicinity of the Moon around the next solar maximum.

Keywords: X-ray, Earth's magnetosphere

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Shingo Kameda, Mitsunori Ozaki(Kanazawa University)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PCG21-11] Debye: a multi-spacecraft mission to solve the electron energization problem in the solar wind

★Invited Papers

*Fouad Sahraoui[2], Robert T Wicks[1], Daniel Verscharen[1], The Debye The Debye Team (1.Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, UK, 2.LPP CNRS Ecole Polytechnique)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PCG21-12] Comet Interceptor mission to a dynamically new comet

★Invited Papers

*Shinnaka Yoshiharu[1], Shingo Kameda[2], Satoshi Kasahara[3], Hideyo Kawakita[1], Masanori Kobayashi[4], Ryu Funase[3], Ichiro Yoshikawa[3], Jones H Geraint[5], Colin Snodgrass[6] (1.Kyoto Sangyo University, 2.Rikkyo University, 3.The University of Tokyo, 4.Chiba Institute of Technology, 5.UCL, 6.The Open University)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[PCG21-13] The concept of AI3 and impactors

★Invited Papers

*Koji Wada[1], Jakob Deller[2], Jessica Agarwal[2], Hans Martin Braun[3], Kieran Carroll[4], Hannah Goldberg[5], Martin Jutzi[6], Özgür Karatekin[7], Tomáš Kohout[8], Sampsa Pursiainen[9], Birgit Ritter[7], Olaf Roders[2], Francisco da Silva Pais Cabral[10], Fredrik Sjoberg[11], Mika Takala[9], Esa Vilenius[2], Patrick Bambach[2], Ryo Ishimaru[1], Yutaka WADA[1], Masahiko Arakawa[12], Takanao Saiki[13] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Max Planck Institute, Göttingen, 3.RST Radar System Technik, 4.Gedex Systems Inc, 5.GOMSpace, 6.University of Bern, 7.Royal Observatory of Belgium, 8.University of Helsinki, 9.Tampere University of Technology, 10.GMV, 11.OHB, 12.Kobe University, 13.JAXA)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PCG21-14] Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

*Masafumi Hirahara[1], Hirotsugu Kojima[2], Naritoshi Kitamura[3], Kazushi Asamura[4], Yoshifumi Saito[4] (1.Institute of Space-Earth Environmental Research, Nagoya University, 2.Research Institute of Sustainable Humanosphere, Kyoto University, 3.Graduate School of Science, The University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PCG21-15] Current status of Life Detection Microscope (LDM) for Mars surface exploration

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

Debye: a multi-spacecraft mission to solve the electron energization problem in the solar wind

*Fouad Sahraoui[2], Robert T Wicks[1], Daniel Verscharen[1], The Debye The Debye Team

1. Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, UK, 2. LPP CNRS Ecole Polytechnique

Sub-ion (kinetic) scale turbulence has been the main focus of research in space plasmas in the last decade because of the crucial role that those scales play in energy dissipation and thus particle energization (heating or acceleration). These research topics are relevant to many (more distant) astrophysical plasmas that are not accessible to in-situ measurements (e.g., solar corona, ISM or accretion flows). In the solar wind, orbiting spacecraft such as Cluster, Themis and more recently MMS have allowed us to make a significant progress in understanding the problem of turbulence and energy dissipation at sub-ion and electron scales in space plasmas. Yet, key questions cannot be addressed by those missions or by the upcoming ones (e.g., Parker Solar Probe and Solar Orbiter) because of their instrumental limitations. We will discuss some of these scientific questions and instrumental limitations, then present a new multi-spacecraft mission concept, Debye, designed to solve the problem of turbulence and energy dissipation at electron scales in the solar wind. This mission is currently being considered for selection within the ESA/F1-class call released in 2018 with a strong participation from the Japanese space physics community.

©2019. Japan Geoscience Union. All Right Reserved.

Comet Interceptor mission to a dynamically new comet

*Shinnaka Yoshiharu[1], Shingo Kameda[2], Satoshi Kasahara[3], Hideyo Kawakita[1], Masanori Kobayashi[4], Ryu Funase[3], Ichiro Yoshikawa[3], Jones H Geraint[5], Colin Snodgrass[6]

1. Kyoto Sangyo University, 2. Rikkyo University, 3. The University of Tokyo, 4. Chiba Institute of Technology, 5. UCL, 6. The Open University

'Comet Interceptor' is a proposed mission to the recent European Space Agency (ESA) call for F-class ('fast') missions. This is one of six mission concepts invited to submit detailed proposals. A decision is expected until late July 2019. The purpus of our misson is to characterise a dynamically-new comet or interstellar object like 'Oumuamua, which are visiting the inner Solar System for the first time, including its surface composition, shape, and structure, the composition of its gas coma for the first time. Our mission will launch to the Sun-Earth L2 point, where it will be stayed in a stable L2 halo orbit for a period of up to 2-3 years, until a suitable opportunity for a flyby mission to a dynamically new comet presents itself. Suitable targets will be comets that will have a perihelion distance closer than ~1.2 au and an ecliptic plane crossing time and location reachable with ~1.5 km/s delta-v from L2. Once a target is found, which expected to be within a few years based on predictions for comet discovery rates with the Large Synoptic Survey Telescope (LSST), the spacecraft will depart on an intercept trajectory. Before the flyby, the main spacecraft will resease at least two sub-spacecraft, parallel paths through the coma and past the nucleus to be sampled. This mission will give us a 3D snapshot of the cometary nucleus at the time of the flyby, testing spatial coma inhomogeneity, interaction with the solar wind on many scales, and monitoring of Lyα coma. This mission will be a unique measurement that was not possible with previous missions, in addition to the fact that we will target a dynamicall new comet, which will allow interesting comparisons to be made with the results from Rosetta target comet 67P/Churyumov-Gerasimenko. It is expected that the proposed mission includes contributions from Japan as well as ESA member countries.

Keywords: Comet Interceptor Mission, dynamically new comet

©2019. Japan Geoscience Union. All Right Reserved.

The concept of AI3 and impactors

*Koji Wada[1], Jakob Deller[2], Jessica Agarwal[2], Hans Martin Braun[3], Kieran Carroll[4], Hannah Goldberg[5], Martin Jutzi[6], Özgür Karatekin[7], Tomáš Kohout[8], Sampsa Pursiainen[9], Birgit Ritter[7], Olaf Roders[2], Francisco da Silva Pais Cabral[10], Fredrik Sjoberg[11], Mika Takala[9], Esa Vilenius[2], Patrick Bambach[2], Ryo Ishimaru[1], Yutaka WADA[1], Masahiko Arakawa[12], Takanao Saiki[13]

1. Planetary Exploration Research Center, Chiba Institute of Technology, 2. Max Planck Institute, Göttingen, 3. RST Radar System Technik, 4. Gedex Systems Inc, 5. GOMSpace, 6. University of Bern, 7. Royal Observatory of Belgium, 8. University of Helsinki, 9. Tampere University of Technology, 10. GMV, 11. OHB, 12. Kobe University, 13. JAXA

"Asteroid In-situ Interior Investigation - 3way" (AI3) defines a mission to investigate the interior of a rubble pile asteroid with three different complementary measurements: radar tomography, determination of the gravity field, and seismic sounding. AI3 has been proposed to ESA F-Class call and passed the first selection.

A mothership serving as communication relay will carry 4 CubeSats in the orbit of asteroid Apophis, observing the PHA during its extremely close approach to earth in 2029, getting as close as 0.1 Lunar distances, which is within the geostationary orbit.

Depending on the elongated shape of Apophis the earth fly by will trigger dynamic events on the asteroid and allow for extremely high data rates during the observation.

Two identical DISCUS satellites will be deployed to leverage the multi-point approach enabled by CubeSat technology, taking radar measurements to reconstruct the interior using computed tomography as well as determining the gravity field and analyzing surface composition using a hyperspectral imager. After completing the characterization phase, one of the DISCUS satellites will descent to the surface and measure the local surface gravity at several points on the asteroid. In the final phase, two impacting CubeSats will generate seismic waves, to be detected by the DISCUS satellite on the surface. The impact will be observed in high spatial and temporal resolution to add important data for impact studies in a before unexplored energy regime.

The concept has recently been invited to submit a detailed proposal to the Phase-2 of the ESA F-Class call.

Keywords: Apophis, ESA F-Class, Rubble Pile Asteroids, CubeSats, PHAs, Impactor

©2019. Japan Geoscience Union. All Right Reserved.

Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

*Masafumi Hirahara[1], Hirotsugu Kojima[2], Naritoshi Kitamura[3], Kazushi Asamura[4], Yoshifumi Saito[4]

1. Institute of Space-Earth Environmental Research, Nagoya University, 2. Research Institute of Sustainable Humanosphere, Kyoto University, 3. Graduate School of Science, The University of Tokyo, 4. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

The Japanese space physics community is now conducting the FACTORS mission, which is the first space exploration mission using a formation flight configuration based on multiple satellites orbiting in the terrestrial polar magnetosphere-ionosphere-thermosphere coupling regions. It is well understood that the in-situ observations integrating the particle, field, wave measurements could bring us with unique opportunities for elucidating the dynamics of the space plasmas and the terrestrial/planetary upper atmospheres. Also in the FACTORS mission as the next community-leading mission after the ERG(Arase) satellite mission, we are planning to realize more advanced integrated measurement system than the ERG(Arase) as well as the unified research framework based on the satellite/ground-based observations and the data analysis/modeling/simulation approaches. One of the science objectives in FACTORS is the demonstrative and quantitative verification on the energy transport mechanisms emerging in the ionospheric ion accelerations in the perpendicular direction to local magnetic fields, which have been frequently observed as transversely accelerated ions(TAIs) by previous/ongoing satellites and sounding rockets at altitudes of several hundreds to a few tens of thousands of km in the terrestrial auroral regions. This type of ion accelerations is quite important not only in our understanding the elemental physical mechanisms in the space plasmas but also in the estimate of the amount of the outflowing/escaping terrestrial plasmas. Although it is definitely evident that the plasma waves excited/propagating in the ionosphere are the exclusive energy source for TAIs according to the statistical analyses of the observational results, it should be noted with a surprise that we have not reached any consensus which mode of plasma waves is dominantly or more effective in the ion accelerations. It should also be noticed that the plasma wave modes responsible for TAIs could change, dependent on the event regions, the ambient ionospheric conditions, and the energy ranges of the accelerated ions, which means the there are some observational difficulties especially in the case of single satellite mission because the observational information obtained by in-situ measurements with a single satellite are too much limited to separate time variations from spatial distributions. In the FACTORS mission, it is required to overcome these observational problems by applying the controllable flight formation and attitude configurations of multiple satellites with an adequate accuracy and additionally developing the innovative observational techniques in the ion and wave measurements. In order to identify the plasma wave modes responsible for TAIs, we utilize several types of advanced formation flight configurations of the multiple satellites for longer plasma waves. As the observational technique for shorter waves, an interferometry method using single electric field probes on each satellite would be applicable. In the ion measurements, it would be essential to develop and install two types of ion energy-mass spectrometers covering from the supra thermal to the low-energy ranges independently with wide and controllable field-of-views and adequate energy/angular resolutions to capture the core ion components by compensating the convective plasma drift motion in the auroral regions or trace the conical pitch-angle distributions of the accelerated and upwelling ions. It could also be a breakthrough to carry a gyrophase-resolving ion energy-mass spectrometer with the similar specification to the low-energy ion spectrometer. This presentation introduces the observational methodology and techniques with which we could demonstratively and

©2019. Japan Geoscience Union. All Right Reserved.

quantitatively address the ionospheric ions accelerations from the viewpoint of wave-particle interaction mechanisms occurring universally in space.

Keywords: wave-particle interaction, upper atmospheric plasma, space plasma wave, integrated satellite observation, formation flight, advanced compact satellite

©2019. Japan Geoscience Union. All Right Reserved.

Current status of Life Detection Microscope (LDM) for Mars surface exploration

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3]

1. College of Agriculture, Tamagawa University, 2. Tokyo University of Pharmacy and Life Science, 3. Japan Aerospace Exploration Agency, 4. Nagaoka University of Technology, 5. Tokyo University of Technology, 6. Yokohama National University, 7. Hiroshima University, 8. Fukuoka Institute of Technology

Today’s Mars is a cold and dry planet, but ancient Mars would have had a large amount of liquid water on the surface. Several billion years ago, Mars could have been similar to the early Earth from which life arose, and life may have also originated on Mars during this period. Although the Viking mission in 1976, which explored life on Mars, did not find evidence for life [1], many findings associated with the possibility of life have been discovered since the Viking mission: past and present aqueous environments, organic compounds, methane, reduced compounds for microorganism energy sources, and so on [2] [3]. These findings suggest that microorganisms might exist on Mars surface.

For searching extant microorganisms, a microscopic instrument would be a powerful tool, which directly images life forms and identify their shapes, sizes, and other morphological structures, but it has not been used in space missions yet. For *in situ* detection of microbial cells, we have proposed the Life Detection Microscope (LDM) which visualizes organic compounds by staining the samples with fluorescent pigments [4]. The LDM scans a volume of 1 mm^3 and detects organic compounds including cells and other biological materials in high sensitivity ($<10^4$ cells per gram clay). The fluorescent pigments have been selected to identify the fundamental features of cells by differentiating among organic compounds surrounded by membranes or enzyme activity. The LDM is also equipped with a high resolution imaging system (1 μm/pixel) which visualizes detailed life forms as well as regolith and dust particles [5]. Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. Here we will report the current status of the development of LDM.

References

[1] Margulis, L. et al. *J. Mol. Evol.* 14 (1979)

[2] Eigenbrode, J.L. et al. *Science*, 360 (2018)

[3] Webster, C.R. et al. *Science*. 360 (2018)

[4] Yamagishi, A. et al. *Biol. Sci. Space*, 24 (2010)

[5] Yamagishi, A. et al. *Trans. JSASS Aerospace Tech. Japan*, 16 (2018)

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Mars, fluorescent microscope

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

9:00 AM - 9:10 AM JST | 12:00 AM - 12:10 AM UTC

Introduction

9:10 AM - 9:30 AM JST | 12:10 AM - 12:30 AM UTC

[AOS09-01] **Model Spectra for Turbulence Below and Above the Ozmidov Wavenumber**

★Invited Papers

*Eric L Kunze[1] (1.NorthWest Research Associates Redmond)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS09-02] **A new parameterization of turbulent mixing caused by tidal flow over abyssal rough bathymetry**

*Toshiyuki Hibiya[1] (1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS09-03] Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Meterolorogical Agency, 3.Japan Agency of Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS09-04] The deep Pacific meridional overturning circulation simulated by a low-resolution ocean model

★Invited Papers

*Takao Kawasaki[1], Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Insitutute, the University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS09-05] The Role of Mixing and Geothermal Heating in Altering AABW and NADW Pathways

★Invited Papers

*Qianjiang Xing[1], Stephanie Downes[1], Kate Snow[2] (1.IMAS, Univ of Tasmania, AU, 2.School of GeoSciences, Univ of Edinburgh, UK)

Model Spectra for Turbulence Below and Above the Ozmidov Wavenumber

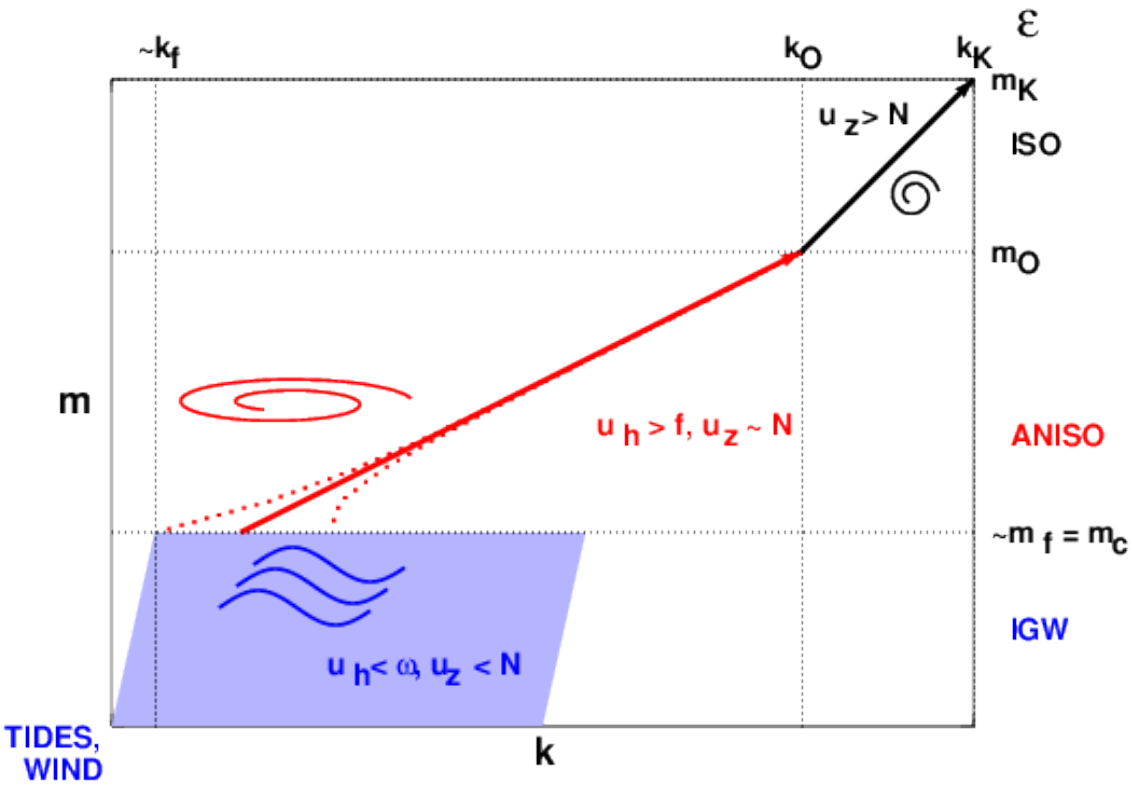
*Eric L Kunze[1]

1. NorthWest Research Associates Redmond

A model spectrum is constructed to describe both anisotropic stratified turbulence below and isotropic turbulence above the Ozmidov wavenumber using dimensional and dynamical scaling in terms of a cascade (or dissipation) rate ε, Coriolis frequency f, buoyancy frequency N and horizontal wavenumber k. The Ozmidov wavenumber $(N^3/\varepsilon)^{1/2}$ is the lowest wavenumber for which turbulence can overcome stratification to produce density overturns. The model reproduces observed spectral shapes and behavior in ocean and atmosphere measurements, specifically the −1 vertical wavenumber spectral slope in the invariant saturated spectrum band and +1/3 horizontal wavenumber spectral slope in the several decades immediately below the Ozmidov wavenumber. Aspect ratios become increasingly anisotropic below the Ozmidov wavenumber until reaching ~O(f/N). It is argued that geophysical turbulence can arise from anisotropic instability of the internal-wave field at wavenumbers well below the Ozmidov then cascade energy forward into isotropic turbulence, in contrast to the conventional wisdom that isotropic turbulence arises directly from vertical instability injecting energy at or above the Ozmidov wavenumber. Thus, anisotropic and isotropic turbulence are manifestations of the same forward energy cascade to dissipation.

Keywords: turbulence, dissipation , cascade

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

A new parameterization of turbulent mixing caused by tidal flow over abyssal rough bathymetry

*Toshiyuki Hibiya[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

It is believed that tidal interaction with abyssal rough bathymetry can create mixing hotspots extending upward from the ocean bottom. Although there exist parameterizations of bottom-enhanced tidal mixing, they do not take into account that the internal waves generated by tide-topography interactions transform from *internal tidal waves* to *quasi-steady internal lee waves* as $k_H U_0 / \omega$ increases and exceeds unity (k_H is the horizontal wavenumber of the bottom topography; U_0 is the amplitude of the tidal flow; ω is the tidal frequency) (Mohri et al., 2010).

In this study, we formulate a new parameterization of tidal mixing over abyssal rough bathymetry in which the vertical decay scale of the energy dissipation rate (ε) is estimated by multiplying the theoretically obtained vertical group velocity of the *internal tidal wave* or the *quasi-steady internal lee wave* by the time scale of its nonlinear interaction (induced diffusion) with the background Garrett-Munk (GM) internal wave field (McComas and Müller, 1981). The resulting parameterization explicitly shows that the vertical decay scale of ε becomes independent of U_0 but inversely proportional to k_H squared when $k_H U_0 / \omega < 1$ and independent of k_H but proportional to U_0 squared when $k_H U_0 / \omega > 1$.

It is confirmed that the formulated parameterization predicts the vertical distribution of ε in agreement with that obtained from the eikonal calculation for the *internal tidal wave* or the *quasi-steady internal lee wave* propagating from the ocean bottom up into the background GM internal wave field (Iwamae et al., 2009; Hibiya et al., 2017).

Keywords: Tidal mixing, Abyssal rough bathymetry, Parameterization, Internal tidal waves, Internal lee waves, Resonant triad interactions

©2019. Japan Geoscience Union. All Right Reserved.

Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Japan Meterolorogical Agency, 3. Japan Agency of Marine-Earth Science and Technology

A new efficient microstructure measurement with fast-response thermistors attached to CTD as common ship-based observational platforms were elaborated. This revealed cross-Pacific top-bottom turbulence distributions. Vertical distribution of turbulent energy dissipation is found to be proportional with local squared buoyancy frequency N^2(representing density vertical gradient) and local internal tide energy generation and dissipation, indicating that main part of energy dissipation of tide-induced turbulence occurs in the main thermocline. These contribute to revising models of tide-induced three-dimensional distribution used in ocean/climate models, which will contribute to reproducing ocean meridional overturning circulation and oceanic heat/material circulation.

Keywords: Turbulence, microstructure observation method, Meridional Overturning Circulation , Tide-induced mixing, North Pacific

©2019. Japan Geoscience Union. All Right Reserved.

The deep Pacific meridional overturning circulation simulated by a low-resolution ocean model

*Takao Kawasaki[1], Hiroyasu Hasumi[1]

1. Atmosphere and Ocean Research Insitutute, the University of Tokyo

The deep Pacific meridional overturning circulation (PMOC) is composed by the northward transport of deep water originated from the Southern Ocean and upwelling of deep water. Tidal mixing is an important process for maintenance of the upwelling of deep water. Several previous modeling studies suggested that geothermal heating at the sea floor also has a significant impact on the strength of deep PMOC. Many previous modeling studies employed distributions of the tidal mixing enhanced near the ocean bottom (local mixing). A previous modeling study suggested that tidally-induced mixing far from the ocean bottom (remote mixing) significantly influences the strength and structure of PMOC. It is pointed out that the mixing energy depends on the ocean stratification by microscale vertical temperature profiles. In this study, we try to reproduce the PMOC by using the distribution of remote mixing based on the recent observation and geothermal heating.

The model employed in this study is an ocean general circulation model (COCO). Its horizontal grid size is 1 degree (non-eddy-resolving model). The horizontal distributions of local and remote tidal mixing energies are estimated by a tide model. The local mixing energy is enhanced near the bottom and decayed with height. The vertical profile of remote mixing depends on the ocean stratification, which is suggested by many observational and theoretical studies. The heating of bottom water is added based on the horizontal map of geothermal heating.
The strength of deep PMOC is increased by using the stratification-dependent tidal energy of the remote mixing. The geothermal heating also significantly enhances the deep PMOC. The northward volume transport of deep water originated from the Southern Ocean is smaller than an observational estimate by the one-time 17-month moorings. We additionally calculated the isotope ratio of radiocarbon (seawater age) for validation of the strength of the modeled PMOC. When both remote mixing and geothermal heating are applied, the age of seawater in the deep Pacific Ocean is consistent with observation.

Keywords: Pacific meridional overturning circulation, ocean general circulation model, tidal mixing

©2019. Japan Geoscience Union. All Right Reserved.

The Role of Mixing and Geothermal Heating in Altering AABW and NADW Pathways

*Qianjiang Xing[1], Stephanie Downes[1], Kate Snow[2]

1. IMAS, Univ of Tasmania, AU, 2. School of GeoSciences, Univ of Edinburgh, UK

Antarctic Bottom Water (AABW) and North Atlantic Deep Water (NADW) constitute the deep Meridional Overturning Circulation (MOC). Surface mechanisms such as wind forcing, heat and freshwater fluxes have been identified as drivers of the deep-water mass formation. However, the interior drivers help transport NADW and AABW across ocean basins. Using sensitivity experiments in an Atlantic sector model, we diagnosed the influence of two poorly understood interior drivers on AABW and NADW, namely geothermal heating and vertical mixing, both as individual drivers and combined. We found that both enhanced mixing and geothermal heating increased the temperature and decreased the density of AABW and NADW. The meridional overturning circulation of NADW changed minimally (less than 3%) in all perturbations, while enhanced mixing and geothermal heating individually strengthened the AABW cell by 31.6% and 26.3%, respectively. The combined effect of the two mechanisms prompted a decrease in the MOC of the AABW cell by 21.1%. A diagnostic of Water Mass Transformation was applied to quantify the all transformations between water masses over time. The total transformation between AABW and NADW in the perturbations were estimated to be strengthened in the Atlantic sector model due to enhanced mixing and geothermal heating except a weakening water mass transformation from NADW into AABW posed by mixing and geothermal heating combined effect in the basin of south of 30S. The largest water mass transformation changes occurred in the Southern Ocean, where deep ocean property changes were remarkable throughout the water column.

Keywords: Mixing, Geothermal Heating, MOC, Water Mass Transformation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Jun Nishioka(Institute of low temperature science, Hokkaido University)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS09-06] Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves

★Invited Papers

*Seth L Danielson[1] (1.University of Alaska Fairbanks)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS09-07] Important roles of marginal seas and intermediate water for micro- and macro-nutrients circulation in the North Pacific

*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2] (1.Hokkaido University, Institute of low temperature sciences, 2.The University of Tokyo, Atmosphere and Ocean research institute)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS09-08] An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS09-09] Change in lower trophic level ecosystem and its complex mechanism in the North Pacific

★Invited Papers

Naomi Harada[1], Fujiki Tetsuichi[1], *Maki Noguchi Aita[1], Makio Honda[1], Minoru Kitamura[1], Takuhei Shiozaki[1], Yoshihisa Mino[3], Akira Kuwata[2], Kazuaki Tadokoro[2], Osamu Seki[4], Megumi Chikamoto[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Institute of Low Temperature Science, Hokkaido University, 5.International Pacific Research Center, University of Hawaii at Manoa)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS09-10] Numerical simulation of iron cycle in the North Pacific

*Kazuhiro Misumi[1], Jun Nishioka[2], Hajime Obata[3], Daisuke Tsumune[1], Tsubono Takaki[1], Matthew C Long[4], Keith Lindsay[4], J. Keith Moore[5] (1.Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, 5.Department of Earth System Science, University of California at Irvine)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS09-11] Influence of tide on the growth and migration of walleye pollock (*Gadus chalcogrammus*) in the Oyashio region

*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Fisheries Research and Education Agency Japan, 3. Hokkaido University)

Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves

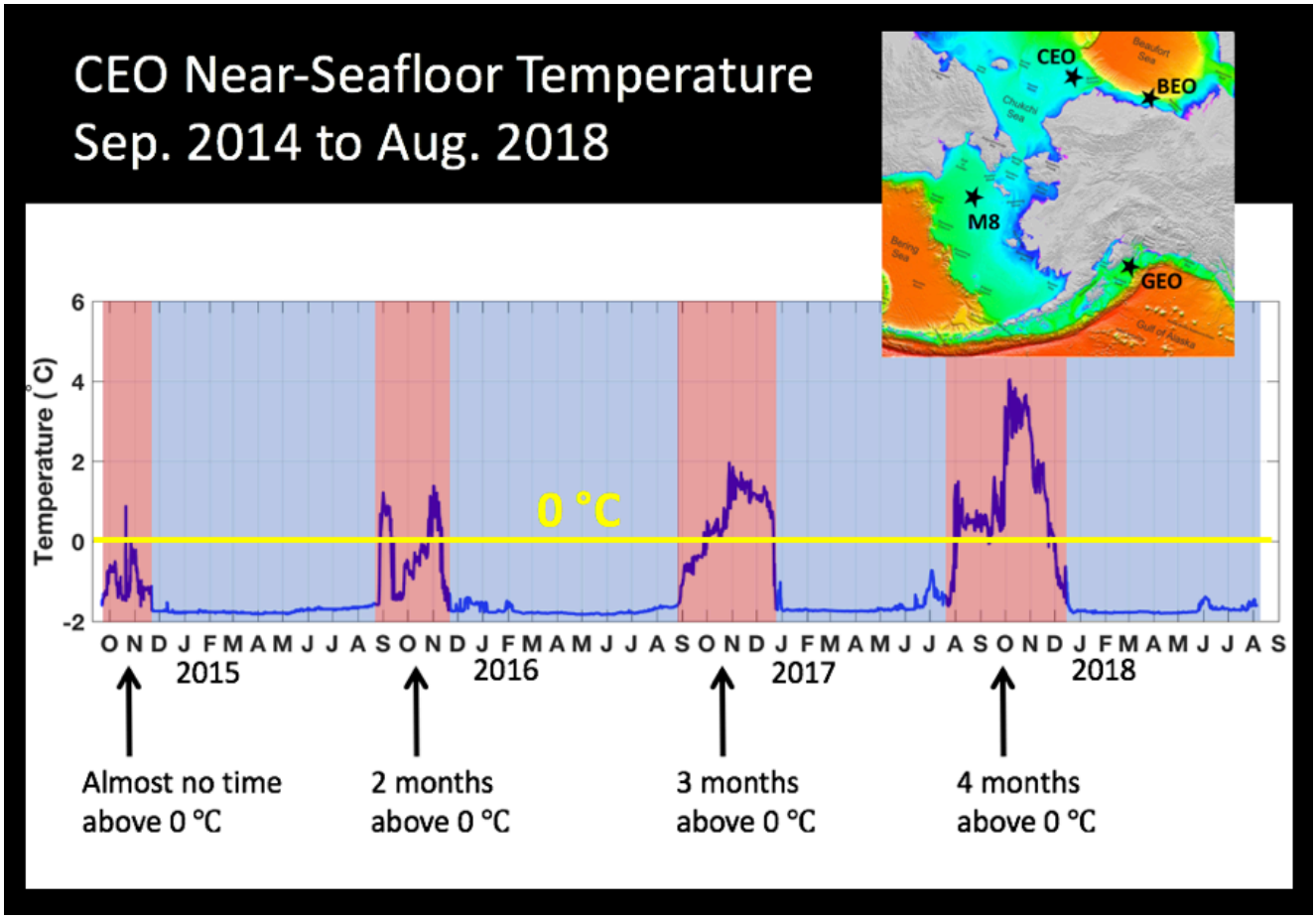
*Seth L Danielson[1]

1. University of Alaska Fairbanks

The recent century of increasing North Pacific marine temperatures culminated with a still ongoing multi-year marine heat wave over the Bering and Chukchi continental shelves. Relative to the modern observational record, 2014-2018 is characterized by anomalously elevated heat contents and temperatures, advanced spring sea ice retreat, delayed winter sea ice onset, and shifts in the timing and location of sea ice melt. To provide oceanic context to the satellite-derived sea ice concentration record, we construct a simple heat budget for the Chukchi shelf using atmospheric reanalysis model estimates of ocean-air heat fluxes (ECMWF ERA-Interim), lateral advection northward into the Arctic through Bering Strait, and in situ hydrographic profiles. We construct a new CTD climatology for the region, using a compilation of over 10^5 hydrographic profiles collected between 1950 and the present. Sea surface temperature analysis shows that 2014 was a transition year into a series of consecutive years for which the mean surface temperature exceeds 2 standard deviations from the longterm mean. Subsurface temperatures also exhibit steadily increasing temperatures over 2014 to 2018. Relative to 1979 to 2013, the most recent five years exhibits an acceleration of the Chukchi shelf heat engine: absorbing more incoming solar radiation in the spring and losing more latent and sensible heat to the atmosphere in the fall. On an annual basis the Chukchi shelf’ s rate of heat loss has modestly increased, but the Bering shelf is losing less heat to the atmosphere on an annual basis. However, the modeled heat flux changes are not temporally uniform over the course of the year and the anomalies exhibit spatial structure that is closely linked to the location of the sea ice cover. Our estimates suggest that the delivery of Pacific origin heat to the Arctic basin has appreciably increased in recent years. The analyses highlight the importance of the oceanic heat capacity, the heat loss rates of the cooling fall and winter, ice thickness, and tightly coupled positive feedbacks in heat exchanges between the ocean, ice and atmosphere. Understanding the new hydrograhic status quo is important for anticipating future physical and biological conditions on the Bering-Chukchi shelves. To the extent that ecosystem structure may be disrupted by altered seasonality, specie distributions, metabolic rates, and trophic exchange transfer efficiencies, we can use this work to better understand how the changing thermal environment may trigger a cascade of nonlinear reactions by the region’ s sympagic, pelagic and benthic communities.

Keywords: Ocean-atmosphere-ice heat fluxes, Bering-Chukchi shelf

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Important roles of marginal seas and intermediate water for micro- and macro-nutrients circulation in the North Pacific

*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2]

1. Hokkaido University, Institute of low temperature sciences, 2. The University of Tokyo, Atmosphere and Ocean research institute

The North Pacific is recognized as an end of the deep ocean conveyor belt circulation, and has been vaguely perceived as a place where deep high nutrient water rises to the surface. Details of the mechanism by which macro-nutrients are supplied from the deep layer to the surface layer, however, have not been properly described. Additionally, basin-scale micro-nutrient (iron) supply process for controlling biological production in this high nutrient region is still not completely understood. Here we report basin scale micro- and macro-nutrients circulation in the North Pacific. We compiled observed dissolved iron and nutrients dataset with other water properties in the North Pacific, as well as in the marginal seas and around the island chains. Judging from the isopycnal analysis of the dataset, a zonal gradient of dissolved iron concentration in the subarctic Pacific is constructed by iron rich water propagating from the Okhotsk Sea intermediate waters to the wide area of the upper-intermediate waters on the western North Pacific. While, high macro-nutrient water is discharged from the Bering Sea and spread in wide density range of the intermediate layer of the whole subarctic area. Two to three orders higher upward turbulent fluxes of the macro-nutrients were observed around the marginal sea islands chains, indicating that a part of macro-nutrients are supplied to surface and are returned and pooled to the intermediate layer through the biological production and microbial degradation of organic substances. These results highlighted an important roles of the marginal seas and the intermediate water for circulating micro- and macro-nutrients at the end of ocean conveyor belt.

Keywords: micro- and macro-nutrients circulation, marginal seas, North Pacific intermediate water

©2019. Japan Geoscience Union. All Right Reserved.

An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Institute of Low Temperature Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute, The University of Tokyo

Iron has known to be one of the important factors controlling phytoplankton growth and nitrogen fixation by diazotrophs in large areas of the open ocean. Iron is less soluble in oxic seawater, therefore, external inputs of iron, which are spatially and/or temporally sporadic, regulate ocean primary productivity. The stability of iron in seawater, which is mainly controlled by organic ligands, is a contributing factor to its long-distance transport from external point sources to remote areas. Siderophores, saccharides, and humic substances have been considered to be probable iron-binding organic ligands in marine environments. Among these, bio-refractory humic substances can be the more important iron carriers in the intermediate waters, because siderophores and saccharides have known to be easily degradable by microbes.

Although sedimentary iron from continental margins has been considered to have a strong impact on iron distribution in the open ocean. In the North Pacific, it has been pointed out that sedimentary iron from the shelf region of the Sea of Okhotsk is widely distributed via circulation of the dense shelf water, the Okhotsk Sea Intermediate Water, the North Pacific Intermediate Water. However, the chemical species of iron contributing long-distance transport by the circulation of intermediate waters have not been clarified.

We determined a transect of concentration of dissolved iron together with levels of humic-like fluorescent dissolved organic matter, as a tracer of iron species, from the Sea of Okhotsk to the subtropical gyre of the western North Pacific. In this presentation, we will discuss possible chemical species of dissolved iron contributing to long-distance transport through the circulation of intermediate waters in the North Pacific.

Keywords: North Pacific, Iron, humid-like fluorescent dissolved organic matter

©2019. Japan Geoscience Union. All Right Reserved.

Change in lower trophic level ecosystem and its complex mechanism in the North Pacific

Naomi Harada[1], Fujiki Tetsuichi[1], *Maki Noguchi Aita[1], Makio Honda[1], Minoru Kitamura[1], Takuhei Shiozaki[1], Yoshihisa Mino[3], Akira Kuwata[2], Kazuaki Tadokoro[2], Osamu Seki[4], Megumi Chikamoto[5]

1. Japan Agency for Marine-Earth Science and Technology, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Institute for Space-Earth Environmental Research, Nagoya University, 4. Institute of Low Temperature Science, Hokkaido University, 5. International Pacific Research Center, University of Hawaii at Manoa

The principal aims of this study is to understand how primary and secondary producers response on the several potential nutrient supply processes associated with physical mechanisms such as atmospheric dynamics, vertical mixing and ocean current in the western North Pacific where is the most active biological drawdown area of sea surface pCO_2 in the world. Here we present the latest three results:

1) Mechanism of spring bloom of major phytoplankton, diatoms in the Oyashio region

The pelagic Oyashio region, western North Pacific is one of the world’s richest fishing ground. Massive diatom blooms occur extensively every spring in this region, suggesting that these blooms could support high biological productivity in this region. For spring blooming of diatoms in this region, two processes; supply of sufficient nutrients (including N, P, Si and Fe) and seeding of active diatom cells have been recognized to be essential. We have elucidated mechanism of the spring diatom blooms in the Oyashio region, focusing on seeding and growth processes of blooming diatoms. We examined conditions of spring diatom blooms and population dynamics of key diatom species in this area by analysis of long-term monitoring data of physico-chemical parmaters and diatom communities along a transect known as the “A-line” in the Oyashio off the southeast coast of Hokkaido, Japan.

2) Seasonal variation in eukaryotic phytoplankton from surface to the abyssopelagic zone

Eukaryotic phytoplankton is also important primary producer. Recent molecular techniques have revealed highly diverse species, but little is known about their dynamics. We examined size-fractionated eukaryotic phytoplankton communities by a 18S rRNA gene sequencing analysis from surface to abyssopelagic zone throughout one year at St. S1 (30°N, 145°E). The spring bloom was triggered not only by autochtonous community but also by phytoplankton delivered from outside regions. The allochthonous phytoplankton included many coastal origin taxa, and would significantly contribute to the biological pump at St.S1. Furthermore, our results show the taxa which efficiently export to deep waters in addition to well-known taxa having the “ballasting effect” such as coccolithophores and diatoms. Of particular interest is Prasinophytes putative *Pseudoscourfieldia marina*, *Ostreococcus*, *Micromonas*, and *Bathycoccus*, which sank to the abyssopelagic zone when they bloomed. Our molecular survey unveiled that the previously-overlooked species would significantly contribute to the subtropical biogeochemical cycles.

3) Sinking velocities of particles in the subarctic and subtropical regions of the western North Pacific Organic compounds produced by phytoplankton bloom settle into deeper layer as sinking particles. We have investigated the sinking velocities of particles to understand how biogeochemical cycle works after the production in the surface. Sinking particles were collected by drifting sediment traps at 100-200 m at

©2019. Japan Geoscience Union. All Right Reserved.

two observation sites K2 (47°N, 160°E) and S1 and were fractionated in 5 ranges of sinking velocities between 5 and 1000 m d^{-1} using an elutriation system. The averaged sinking velocities (w_{POC}) calculated from the velocity distributions of POC were faster at S1. For S1 particles, a positive correlation was found between w_{POC} and $CaCO_3$ content. This indicates that particles containing large amounts of denser $CaCO_3$ sink faster than those containing large amounts of organic matter with low densities. Particles at K2, mainly composed of opal and organic matter, did not exhibit a clear relationship between w_{POC} and the denser opal. Instead, w_{POC} had a positive correlation with $\delta^{15}N$ of the sinking particles and was small (large) when the surface layer was stratified (well-mixed). These results implied that the upper water stability/mixing would influence the growth/fragmentation of aggregates as well as chemical composition of them, thereby affecting w_{POC}.

©2019. Japan Geoscience Union. All Right Reserved.

Numerical simulation of iron cycle in the North Pacific

*Kazuhiro Misumi[1], Jun Nishioka[2], Hajime Obata[3], Daisuke Tsumune[1], Tsubono Takaki[1], Matthew C Long[4], Keith Lindsay[4], J. Keith Moore[5]

1. Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, 2. Institute of Low Temperature Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, 5. Department of Earth System Science, University of California at Irvine

Iron is an essential micronutrient for the marine phytoplankton growth. The deficiency of iron limits the primary productivity in the subarctic North Pacific, and also controls the production of nitrogen fixers in the subtropical region. Therefore, the understanding of iron cycle is key to understand biogeochemical cycling in the whole North Pacific. In this study, we used a regional ocean model (ROMS) coupled with a marine biogeochemical cycle model (BEC) configured to a quarter degree horizontal resolution to investigate iron cycle in the North Pacific. The model showed that iron supplied from shelf sediments are extensively distributed through the intermediate layer, and the transport is supported by adsorption/aggregation to and desorption/disaggregation from slowly sinking particles that prolongs residence time of iron in seawater. It is suggested that the iron supplied from shelf sediments of the Okhotsk and Bering Seas are exported to the Pacific Ocean, implying the biogeochemical linkage between the marginal seas and the ocean basin. Iron distributed in the intermediate layer is supplied to the surface water through diapycnal mixing around the Straits connecting the marginal seas. We will present the importance of the diapycnal mixing on primary productivity in the western subarctic region from the results of iron budget analysis.

Keywords: North Pacific, Iron, Nutrients

©2019. Japan Geoscience Union. All Right Reserved.

Influence of tide on the growth and migration of walleye pollock (*Gadus chalcogrammus*) in the Oyashio region

*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Fisheries Research and Education Agency Japan, 3. Hokkaido University

A bioenergetics model of walleye pollock (*Gadus chalcogrammus*) coupled with a lower trophic level nutrient-phytoplankton-zooplankton model was developed to investigate environmental effects on the pollock growth in the Oyashio region. The bioenegertics model was coupled to was coupled to a migration model of pollock based on the environments calculated by an ocean general circulation model (CCSR (Center for Climate System Research) Ocean Component Model: COCO) coupled to a simple nutrient cycle model. In the growth-migration model, two physical environment conditions (with and without tidal forcing) were applied to investigate the tidal effects on the growth and migration of pollock. With tidal effect, warm water supply through the Tsugaru Strait to the southwestern coast of Hokkaido increased and a strong temperature front was formed along the southwestern coast of Hokkaido. Coastal current associated with the temperature front advected the pollock larvae to the Cape Erimo and pollock successfully settled to the bottom layer. Comparing the result without tidal forcing, tide potentially provide optimal temperature condition for growth and higher possibility to settle near coast. On the contrary, tide potentially provide lower nutrient supply with increasing nutrient poor water through the Tsugaru Strait. Therefore, the pollock growth itself did not change between with and without tidal forcing.

Keywords: marine ecosystem model, fish growth-migration model, walleye pollock

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Shin-Ichi Ito(The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS09-12] What can horizontal stirring tell us about vertical mixing?

★Invited Papers

*Sylvia T Cole[1] (1.Woods Hole Oceanographic Institution)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS09-13] Acoustic remote sensing of ocean mixing

★Invited Papers

*Tetjana Ross[1], Andone Lavery[2], Doris Leong[3], Rolf Lueck[4] (1.Institute Of Ocean Sciences, Fisheries and Oceans Canada, 2.Woods Hole Oceanographic Institution, 3.British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 4.Rockland Scientific International)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS09-14] Assessment of the effectiveness of the global ocean state estimation using tide-induced mixing parameterizations

*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1] (1.JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS09-15] **Energetics of Eddy-Mean Flow Interactions in Western Boundary Currents: The Kuroshio and the Gulf Stream**

★Invited Papers

*Enrique N Curchitser[1], Dujuan Kang[1], Xiaomei Yan[2] (1.Rutgers University New Brunswick, 2.Institute of Oceanology, Chinese Academy of Sciences)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS09-16] Mixing Processes in the Kuroshio region and their influence on the low-trophic ecosystem

★Invited Papers

*Xinyu Guo[1], Takeshi Matsuno[2], Tomoharu Senju [2], Kaoru Ichikawa[2], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ayako Nishina[3], Hirohiko Nakamura[3], JING ZHANG[4], Daisuke Hasegawa[5], Naoki Yoshie[1], Toru Kobari[3] (1.Center for Marine Environmental Studies, Ehime University, 2.Research Institute for Applied Mechanics, Kyushu University,, 3.Faculty of Fisheries, Kagoshima University, 4.Graduate School of Science and Engineering, University of Toyama, 5.Tohoko National Fisheries Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS09-17] Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*Takeyoshi Nagai[1], Silvana Duran[2], Diego Otero[2], Yasutaka Mori[1], Naoki Yoshie[3], Kazuki Ohgi[3], Daisuke Hasegawa[4], Ayako Nishina[5], Toru Kobari[5] (1.Department of Ocean Sciences, Tokyo University of Marine

Science and Technology, 2.Facultad de Pesquería, Universidad Nacional Agraria La Molina, Peru, 3.Center for Marine Environmental Studies, Ehime University, 4.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5.Faculty of Fisheries Kagoshima University)

What can horizontal stirring tell us about vertical mixing?

*Sylvia T Cole[1]

1. Woods Hole Oceanographic Institution

Basin-scale tracer distributions are influenced by horizontal stirring and eddy diffusivity. Eddy diffusivity estimated from Argo temperature and salinity profiles together with ECCO-2 eddy kinetic energy has been updated to include additional years of data, finer horizontal resolution, and a formal error estimate. Assumptions related to vertical mixing inherent in the method for estimating eddy diffusivity are tested. Near the surface, thermohaline structure is influenced by the atmosphere more so than either horizontal stirring or vertical mixing. Locally, vertical mixing is responsible for setting thermohaline structure where large-scale horizontal gradients are weak. The equatorial regions are particularly influenced by these imprints of vertical mixing. Implications for ocean dynamics and numerical modeling are discussed.

Keywords: Global Ocean, Mesoscale dynamics, Tracer distributions

©2019. Japan Geoscience Union. All Right Reserved.

Acoustic remote sensing of ocean mixing

*Tetjana Ross[1], Andone Lavery[2], Doris Leong[3], Rolf Lueck[4]

1. Institute Of Ocean Sciences, Fisheries and Oceans Canada, 2. Woods Hole Oceanographic Institution, 3. British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 4. Rockland Scientific International

Based on data collected in a number of environments, from coastal fjords to the north Atlantic, from the laboratory to Antarctica, we present evidence for sound scattering from turbulent and double diffusive microstructure in the ocean. We discuss the advantages of using acoustics to observe ocean mixing (i.e. inexpensive, fast and remote). We also discuss the limitations (e.g. ambiguity in source of scattering) and some methods for dealing with it. We illustrate how one of these ambiguities can even be turned into a strength for observing zooplankton in turbulence, through the use of broadband acoustics.

Keywords: oceanic turbulence and mixing, underwater acoustics , ocean observation, bio-physical interactions

©2019. Japan Geoscience Union. All Right Reserved.

Assessment of the effectiveness of the global ocean state estimation using tide-induced mixing parameterizations

*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1]

1. JAMSTEC

Recent data synthesis experiments showed that adjusting mixing coefficients through data assimilation approach is a promising way to reduce a global misfit between a model simulation and ocean observations, while mixing coefficients should satisfy constraints from energetics. Aiming for a data synthesis experiment that is energetically consistent with the known constraint on the ocean energy budget and can assimilate turbulence observation data, we have developed a new quasi-global four-dimensional variational dataassimilation system using two parameterizations for tidally induced vertical mixing. As a preliminary preparation of the synthesis experiment, we optimally estimated their parameters along with other physical parameters based on the Green’ s function method. The simulation using the optimal parameters well reproduces temperature and salinity in the deep Pacific Ocean. Using this simulation as the first guess field, we are conducting a long-term data synthesis experiment. We will present some preliminary results of the synthesis experiment to assess the effectiveness of our new system.

Keywords: vertical mixing, tide, data assimilation

©2019. Japan Geoscience Union. All Right Reserved.

Energetics of Eddy-Mean Flow Interactions in Western Boundary Currents: The Kuroshio and the Gulf Stream

*Enrique N Curchitser[1], Dujuan Kang[1], Xiaomei Yan[2]

1. Rutgers University New Brunswick, 2. Institute of Oceanology, Chinese Academy of Sciences

Mesoscale eddies are most energetic along Western Boundary Currents, such as the Gulf Stream in the North Atlantic and the Kuroshio in the North Pacific. A better understanding of the eddy dynamics and variability is essential for prediction of ocean states and evaluating the ocean contributions to the climate system and interactions with the ecosystem. We derive a full set of eddy energetics analysis framework that provides quantitative description of the energy sources, sinks, and exchanges among different energy reservoirs. We perform detailed energetics analysis of the Kuroshio eddies using the OFES quasi-global ocean simulation and compare it to high-resolution simulations of the Gulf Stream region. Through the combination of theoretical and numerical analysis, we investigate eddies' generation, spatio-temporal variability and the underlying dynamics in these two eddy-prominent Western Boundary Current regions.

©2019. Japan Geoscience Union. All Right Reserved.

Mixing Processes in the Kuroshio region and their influence on the low-trophic ecosystem

*Xinyu Guo[1], Takeshi Matsuno[2], Tomoharu Senju [2], Kaoru Ichikawa[2], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ayako Nishina[3], Hirohiko Nakamura[3], JING ZHANG[4], Daisuke Hasegawa[5], Naoki Yoshie[1], Toru Kobari[3]

1. Center for Marine Environmental Studies, Ehime University, 2. Research Institute for Applied Mechanics, Kyushu University,, 3. Faculty of Fisheries, Kagoshima University, 4. Graduate School of Science and Engineering, University of Toyama, 5. Tohoko National Fisheries Research Institute

In order to understand the vertical mixing processes in the Kuroshio, we carried out field observations in the Luzon Strait, east of Taiwan, outer shelf region of the East China Sea, and Tokara Strait in the past several years. The strong vertical mixing mainly due to interaction between the Kuroshio and seamounts were found in the areas east of Taiwan and Tokara Strait, while that mainly due to internal tides was found in the Luzon Strait and outer shelf region of the East China Sea. The nitrate flux associated with the strong vertical mixing in the Kuroshio was estimated using simultaneously measured nitrate concentration and vertical eddy diffusivity coefficient. The influences of vertically supplied nitrate on the phytoplankton and zooplankton were examined by field observations and laboratory experiments. In addition to the vertical mixing, the supply of nutrients from coastal waters was also observed and that due to horizontal and vertical advections were also diagnosed from results of a numerical model for a purpose of fully understanding on the nutrient dynamics along the Kuroshio.

Keywords: Kuroshio, Vertical Mixing, low-trophic ecosystem

©2019. Japan Geoscience Union. All Right Reserved.

Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*Takeyoshi Nagai[1], Silvana Duran[2], Diego Otero[2], Yasutaka Mori[1], Naoki Yoshie[3], Kazuki Ohgi[3], Daisuke Hasegawa[4], Ayako Nishina[5], Toru Kobari[5]

1. Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2. Facultad de Pesquería, Universidad Nacional Agraria La Molina, Peru, 3. Center for Marine Environmental Studies, Ehime University, 4. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5. Faculty of Fisheries Kagoshima University

The Kuroshio carries nutrients in its subsurface layer as a nutrient stream, which flows along the southern coast of Japan. The nutrients in the dark subsurface layers of the Kuroshio, however, are not available for phytoplankton unless they are supplied through diapycnal mixing processes and/or adiabatic upwelling to sunlit surface layers. It has been unclear whether and how these nutrients are supplied to euphotic zone on the continental shelves. In this study, using a state-of-the-art tow-yo microstructure profiler, it is shown that the very strong turbulence occurs over a scale of 30-km and 200-m along lateral and vertical direction, respectively, near the Kuroshio, which flows on the continental slope in Hyuganada Sea, southeast of Kyushu. The observed turbulent kinetic energy dissipation rates are O(10^{-7} Wkg^{-1}) near the Kuroshio over a distance of 30-km, which corresponds to O(10^{-3} m^2s^{-1}) of eddy diffusivity. Turbidity data suggest that this strong turbulence at the shelf edge provides sediment resuspension from the bottom to 50 m depth. Nitrate diffusive flux is estimated as large as 1-10 mmol N m^2day^{-1} at the base of euphotic zone.

Keywords: Kuroshio, Turbulence, Nutrients

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 106 1F

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University), Chairperson:Yuei-An Liou(Center for Space and Remote Sensing Research (CSRSR)), Kim-Anh Nguyen(National Central University)

Natural system, environmental quality, and anthropogenic processes interact with each other closely. Environmental changes and their causes increase the needs to address the consequences taking place in the structural and functional ecosystems. Much progress of anthropogenic activities has been made and significantly improves social economics. However, human system has been altering and raising burden on the natural system by alerting land use and land cover, bringing up water, soil and air pollution, changing regional and global climate, and increasing frequency of natural disasters, e.g., floods, landslides. Planners are increasingly pressured by the challenges in balance between demands and development, while lessening the detrimental impact of social processes on environment. Remote sensing and GIS have been proven with their advantages in providing data and tools to model and visualize spatiotemporally environmental changes and influential factors so that practical policy for environmental protection and management can be proposed.
This session seeks for papers on advancements in the development of techniques and models with remote sensing and GIS to contribute environmental applications, to exhibit and visualize influences of human activities on environmental changes, and to improve understanding of the relationship between anthropogenic activities and natural system and climate patterns. Solutions for environmental management in short- and long-term visions are very welcome.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HGG01-01] Monitoring of Subsidence Area of Jakarta City using PS-InSAR

*Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HGG01-02] **Understanding and classifying spatial patterns of global eco-environmental vulnerability**

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.National Central University, Taiwan)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HGG01-03] Human-water interface in hydrological modeling: Current status and future directions

*Yoshihide Wada[1] (1.International Institute for Applied Systems Analysis)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HGG01-04] **Urban greenspace spatial patterns and eco-function by using Sentinel 2 imagery**

*Yuei-An Liou[1], Kim-Anh Nguyen[1] (1.National Central University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HGG01-05] Assessing performance of L-band SAR backscatter for above ground forest biomass estimation over complex topography

*Waqar Mirza Muhammad[1], Ji Yaqi[1], Josaphat Tetuko Sri Sumantyo[1], Hasil Khan[1] (1.Chiba University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HGG01-06] **Feasibility Analysis of Engineering Monitoring Using the VLP-16 LiDAR Puck: A Case Study in Henglingshan Tunnel**

*Zhen-Yu Wu[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Ren-Jhih Yang[1] (1.National Chung Hsing University)

Monitoring of Subsidence Area of Jakarta City using PS-InSAR

*Josaphat Tetuko Sri Sumantyo[1]

1. Center for Environmental Remote Sensing, Chiba University

Jakarta city proposed the Jakarta Giant Sea Wall as waterfront city for new urban settlement zone, and deep seaport for new economic zone along coastal area at northern Jakarta. This research investigated land deformation at eleven watersheds of West Java Mega Urban Region (WJMUR) using Persistent Scatterer Interferometry (PSI) technique of ALOS PALSAR data. The result shows that land deformation at study area, especially Bandung city area gives significant impact to sedimentation velocity along eastern Jakarta strait, especially deep seaport for 43 years later. This research recommends to evaluate land conservation at upland watersheds, and well management of artificial canals to reduce the impact of sedimentation at Jakarta strait, especially new depth seaport.

Keywords: DInSAR, Peatland, Assesment, ALOS 2 PALSAR 2

©2019. Japan Geoscience Union. All Right Reserved.

Understanding and classifying spatial patterns of global eco-environmental vulnerability

*Kim-Anh Nguyen[1], Yuei-An Liou[1]

1. National Central University, Taiwan

Anthropogenic processes cause profound changes to natural systems and result in a consistent decline in the quality of eco-environment. In this paper, a framework that aims to qualify eco-environmental vulnerability levels over the global scale has been presented for decision making. The global map of eco-environmental vulnerability was generated by using easily accessible datasets. The vulnerability is classified into six levels consisting of *potential*, *light*, *slight*, *medium*, *heavy*, and *very heavy.* Eco-environmental vulnerability tends to be high and very high in Asia and Africa with leading countries China, India and Ethiopia. Spatial patterns of eco-environmental vulnerability are driven by human and natural disturbances including socioeconomic, natural hazards, hydrometeorology, topography and land resources, among which population growth and natural hazards are the key drivers. $PM_{2.5}$ that can be considered as a hazardous substance in the human environment and an anthropogenic disturbance associated with nature and human-made influence was selected to validate the global eco-environmental vulnerability map. It is demonstrated that global eco-environmental vulnerability map has high correlation with $PM_{2.5}$ distribution patterns with correlation coefficient approximately 0.82 based on 100 validating points. Outcomes of this study include the mapping of global eco-environmental vulnerability and eco-protection zones that provide key hotspots of eco-environmental vulnerability at global scale for informing the decision makers and the people to take actions to lessen the disturbances and achieve environmental sustainability

Keywords: global eco-environmental vulnerability, human and nature, environmental sustainability

©2019. Japan Geoscience Union. All Right Reserved.

Human-water interface in hydrological modeling: Current status and future directions

*Yoshihide Wada[1]

1. International Institute for Applied Systems Analysis

The Earth’ s surface has undergone drastic changes due to the human-driven alteration of land use and vegetation patterns and the management of surface water and groundwater systems. Over the last century, the global population has quadrupled and currently exceeds 7 billion, half of which live in urban areas. Human needs for water are ever-increasing, dominated currently by agricultural irrigation for food production worldwide, while rapid urbanization and economic development are likely to be the main drivers for increasing water demands in coming decades. The phenomenal growth of the human footprint has significantly modified hydrological processes in various ways (e.g., irrigation, artificial dams, and water diversion) and at various scales (from a watershed to the globe). During the early 1990s, awareness of the potential for increased water scarcity led to the first detailed global water resource assessments. Shortly thereafter, in order to analyse the human perturbation on terrestrial water resources, the first generation of large-scale hydrological models (LHMs) was produced. However, at this early stage few models considered the interaction between terrestrial water fluxes and human activities, including water use and reservoir regulation, and even fewer models distinguished water use from surface water and groundwater resources. Since the early 2000s, a growing number of LHMs have incorporated human impacts on the hydrological cycle. Notwithstanding such growing sophistication, most current-generation of LHMs still fall short of simulating the direct human influence on the terrestrial freshwater systems, leaving the task of representing human land-water management activities within these models, and consequently in Global Circulation Models and Earth System Models, as one of the grand challenges for the hydrologic research community. In this talk I would like to provide a synthesis of progress in the development and application of human impact modeling in LHMs. Importantly, I would like to highlight possible ways forward for LHMs linking to emerging socio-hydrology that currently focus on understanding the detailed local and regional processes that integrate humans and water in a coupled hydrological-social system. This talk highlights a number of key challenges and discusses possible improvements in order to better represent the human-water interface in hydrological models.

Keywords: Global Hydrological Cycle, Human Impacts, Water Resources Management

©2019. Japan Geoscience Union. All Right Reserved.

Urban greenspace spatial patterns and eco-function by using Sentinel 2 imagery

*Yuei-An Liou[1], Kim-Anh Nguyen[1]

1. National Central University

Urbanization is the process of land transformation and area growth to fulfill the needs of accommodating the increased population, infrastructure and facility in the urban area. Hanoi is the capital city of Vietnam. Its government currently has a great ambition to develop it to become an internationalized city. Under Hanoi Master Plan to 2030 and vision to 2050 by Decision 1259/QD-TTg, Hanoi has been reconstructing and reshaping greatly. Its population in 2020 is expected to reach 15 million inhabitants with green public transport system Metro and a huge increased demand on land transformation from natural spaces to dense concreted infrastructure. This current process poses multi-challenges for the current Hanoi City in terms of greening, urban microclimate and urban environment as well as social and physical impacts on its residents. In the recent few years, Hanoi has dynamically changed in particular by reducing the areas of urban greenspaces that play a vital role in maintaining good ecological and environmental characteristics of the city. Sentinel 2 data are used to investigate the change of urban greenspaces in inner Hanoi City during the timeframe from Oct. 2016 - Oct. 2018. Accuracy assessment is conducted by using Google Earth map and field survey data. Results show that urban greenspaces in inner Hanoi City were significantly declined in recent two years from 24 km^2 to 11.1 km^2, or equivalent to percentages of tree-coverage reduced from 15% to 7%, respectively, and with overall accuracies of 97% and 95% and Kappa coefficients of 0.94 and 0.92, respectively. Spatial patterns of eco-function services of urban greenspace are then investigated. Hotspots of risk heat areas are also highlighted in the map. The reduced accessibility and availability of urban greenspaces in inner Hanoi City reveal that the Hanoi citizens are urgently in needs of more greenspaces. It is advised that the Hanoi City Government and decision makers should take serious measures to enhance the greenness and the effectiveness of urban greenspaces for the benefits of citizen’s health. Also, it is indicated that Sentinel 2 data are well suitable for not only visualizing the urban greenspaces, but also offering the guidance for landscape planning and management at a city scale.

Keywords: urban greenspaces, Hanoi Master Plan, Sentinel 2, urban environment

©2019. Japan Geoscience Union. All Right Reserved.

Assessing performance of L-band SAR backscatter for above ground forest biomass estimation over complex topography

*Waqar Mirza Muhammad[1], Ji Yaqi[1], Josaphat Tetuko Sri Sumantyo[1], Hasil Khan[1]

1. Chiba University

Forest above ground biomass (AGB) estimation is always challenging using SAR backscatter over challenging topography because topographic introduce topographic and radiometric distortion in SAR images. These distortions can be corrected using topographic and radiometric correction methods but these methods are effective over moderate topography. Most of the forest in Pakistan exist over challenging topography. This research is an initial effort to estimate forest AGB of Gilgit-Baltistan, Pakistan. As Gilgit-Baltistan exist in the north of Pakistan, it lies at approximately 5000 m above the sea level. The prime goal of this research is to estimate above ground forest biomass using L-band SAR backscatter. For this, full polarimetric data of ALOS-2 was acquired. Terrain geometric and radiometric correction was performed and backscatter (σ o) was estimated. Resultant σ o was correlated with ground based forest AGB and regression analysis was performed. It was identified that σ HH – σ HV is most sensitive for biomass estimation.

Keywords: SAR, Biomass, Topography, Forest

©2019. Japan Geoscience Union. All Right Reserved.

Feasibility Analysis of Engineering Monitoring Using the VLP-16 LiDAR Puck: A Case Study in Henglingshan Tunnel

*Zhen-Yu Wu[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Ren-Jhih Yang[1]

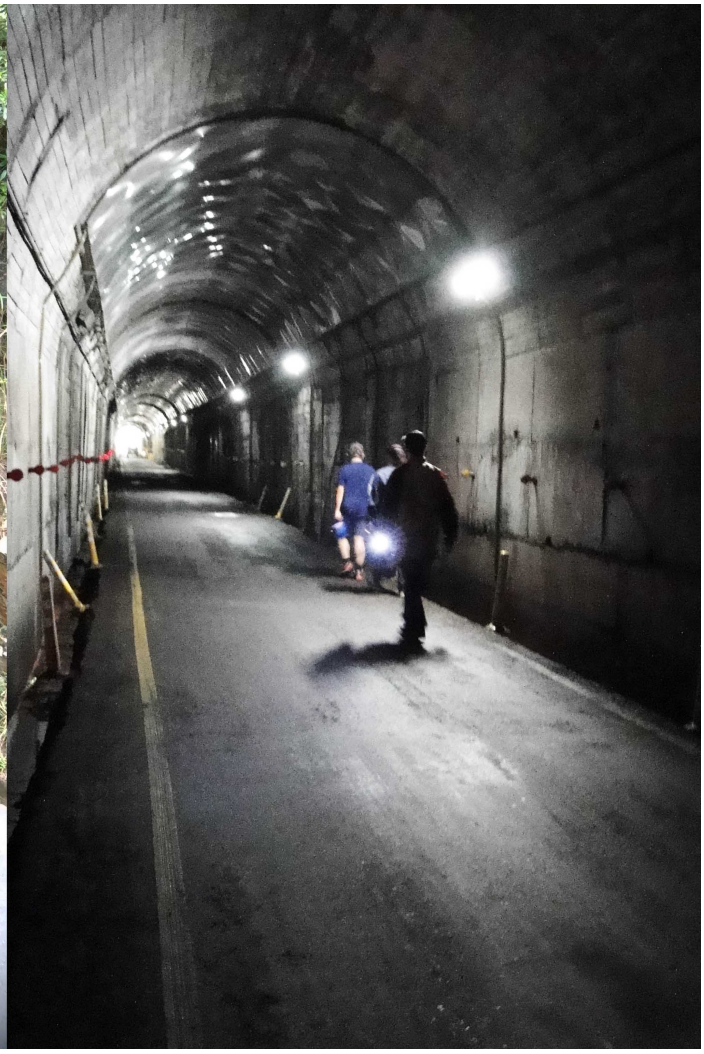
1. National Chung Hsing University

This study is aimed at monitoring structural stability of time series using a low-cost remote sensing instrument, the VLP-16 LiDAR Puck. Natural disasters, such as typhoons and earthquakes, usually cause hidden damaged on engineering structures. In the past, structural stability monitoring can be done by a traditional 3D laser scanner. However, the price is high. In the study, a small-scale and low-cost scanner, the VLP-16 LiDAR Puck, is used for tunnel deformation monitoring. The study location is in the Henglingshan Tunnel, Taichung, Taiwan. This tunnel is almost 400m long and its appearance is shown in the attached figure. The results from the VLP-16 LiDAR Puck is well compared with those from the Reigl VZ-1000 LiDAR scanner. The comparisons between two scanners include their spatial resolution, accuracy, practicality, convenience, and cost–performance ratio. If the VLP-16 LiDAR Puck is proven to be feasible for tunnel deformation monitoring, we will further investigate its practicality on the other engineering structure monitoring, such as retaining walls, buildings, bridges, and sand-blocking dams.

Keywords: Remote sensing, LiDAR, Tunnel deformation monitoring

©2019. Japan Geoscience Union. All Right Reserved.





©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 106 1F

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), Chairperson:Wei Yang(Chiba University)

Our human beings are encountering various environmental issues on the Earth, and it is urgent to find out the solutions. Remote sensing is currently the only feasible means to observe the Earth environment at regional/continental /global scales over long periods, and consequently detects the environmental changes occurred all over the world. This session invites presentations on theory, science, technology, and applications of remote sensing to study the Earth environment from regional to global scales. Both oral and poster presentations are sincerely welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HTT20-01] Evaluation of Climate Change Impacts on Wetland Vegetation in the Dunhuang Yangguan National Nature Reserve in Northwest China Using Landsat Derived NDVI

*Feifei Pan[1] (1.University of North Texas)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HTT20-02] Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*LINLIN WANG[1] (1. Institute of Atmospheric Physics, Chinese Academy of Sciences)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HTT20-03] **THE STUDY OF RIVER CHANGE DETECTION INTEGRATING OBJECT-BASED CLASSIFICATION AND EDGE EXTRACTION**

*Yu-Chan Lee[1], Fang-Shii Ning[1], Hao-Che Ho[2] (1.Department of Land Economics, National Chengchi University, 2.Department of Civil Engineering, National Taiwan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HTT20-04] **Monitoring winter wheat spring phenology in the North China Plain using MODIS**

*Xifang Wu[1], Wei Yang[2], Chunyang Wang[3], Yuki Sofue[4], Yanjun Shen[5], Akihiko Kondoh[2] (1.Graduate School of Science and Engineering , Chiba University, 2.Center for Environmental Remote Sensing, Chiba University, 3.School of Surveying and Land Information Engineering, Henan Polytechnic University, 4.Graduate School of Science, Chiba University, 5.Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HTT20-05] Assessment of numerous Data Assimilation Approaches in Regional Retrieval of Ground NO_2 Spatial Distribution via Remote Sensing products

*Hugo Wai Leung MAK[1,2], Jimmy Chi-Hung FUNG[1,2] (1.Department of Mathematics, Hong Kong University of Science and Technology, 2.Division of Environment and Sustainability, Hong Kong University of Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HTT20-06] Spectro-polarimetric BRF measurement of leaves and model of individual leaf

*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2] (1.Hokkaido University, 2.Shiga University of Medical Science)

Evaluation of Climate Change Impacts on Wetland Vegetation in the Dunhuang Yangguan National Nature Reserve in Northwest China Using Landsat Derived NDVI

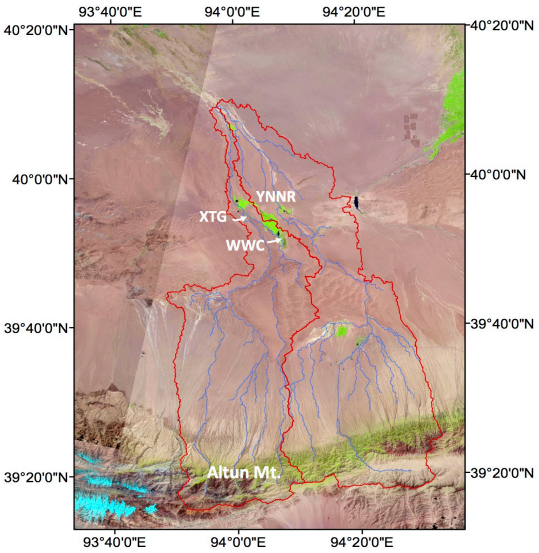
*Feifei Pan[1]

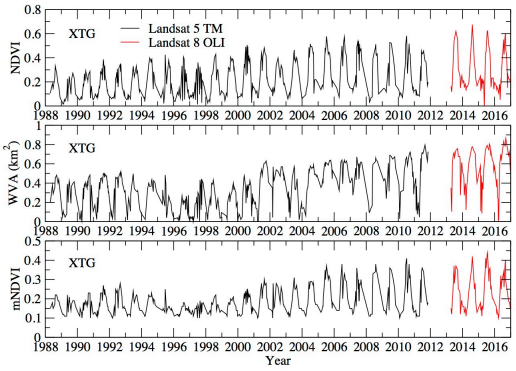
1. University of North Texas

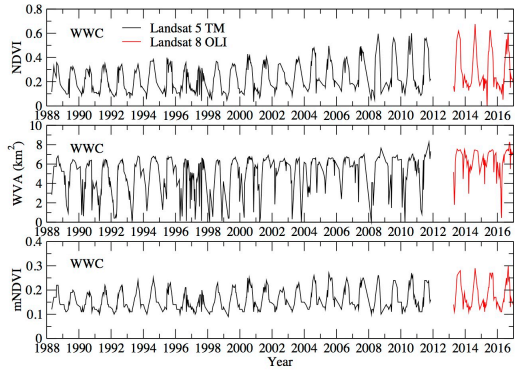
Based on 541 Landsat images between 1988 and 2016, the normalized difference vegetation indices (NDVIs) of the wetland vegetation at Xitugou (XTG) and Wowachi (WWC) inside the Dunhuang Yangguan National Nature Reserve (YNNR) in northwest China were calculated for assessing the impacts of climate change on wetland vegetation in the YNNR. It was found that the wetland vegetation at the XTG and WWC had both shown a significant increasing trend in the past 20–30 years and the increase in both the annual mean temperature and annual peak snow depth over the Altun Mountains led to the increase of the wetland vegetation. The influence of the local precipitation on the XTG wetland vegetation was greater than on the WWC wetland vegetation, which demonstrates that in extremely arid regions, the major constraint to the wetland vegetation is the availability of water in soils, which is greatly related to the surface water detention and discharge of groundwater. At both XTG and WWC, the snowmelt from the Altun Mountains is the main contributor to the groundwater discharge, while the local precipitation plays a lesser role in influencing the wetland vegetation at the WWC than at the XTG, because the wetland vegetation grows on a relatively flat terrain at the WWC, while it grows on a stream channel at the XTG.

Keywords: NDVI, Wetland Vegetation, Climate Change, Precipitation, Air Temperature, Snowmelt

©2019. Japan Geoscience Union. All Right Reserved.







©2019. Japan Geoscience Union. All Right Reserved.

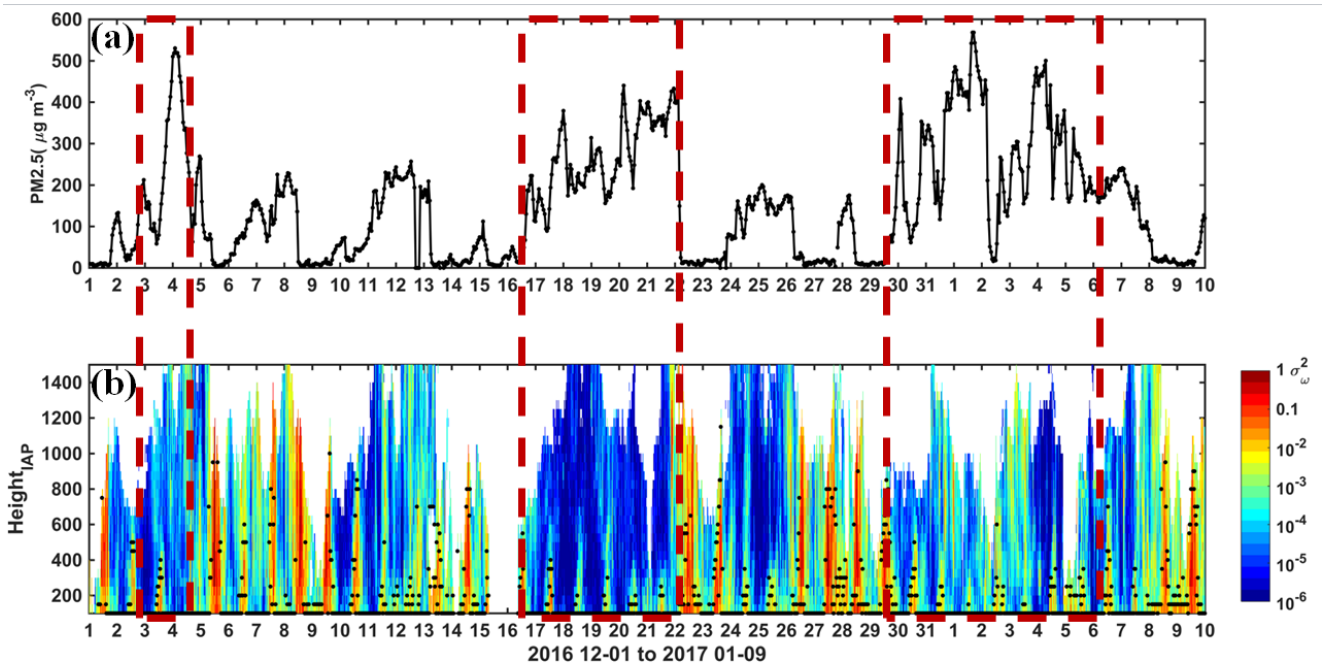
Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*LINLIN WANG[1]

1. Institute of Atmospheric Physics, Chinese Academy of Sciences

The boundary layer (BL) structure not only controls the transportation, accumulation and diffusion of primary pollutants but also affects the generation and transformation of secondary aerosols. A better understanding of the interactions between the occurrence of air pollution and the structure of the BL is very important for the air-pollution-relevant investigations. Although the influence of the vertical structure of the BL on air pollution has been recognized in many previous studies, understanding this influence remains limited due to the lack of sufficient field observations, especially for high-temporal-resolution vertical observations. Recently, Lidar techniques have become the most valuable and popular systems to detect the atmosphere because of their higher spatiotemporal resolution. As a result, many techniques have been developed to determine the BL structure by using the remote sensing instruments, such as radar wind profilers, aerosol lidars, and ground-based microwave radiometers. In this study, the BL structure was studied by using a Doppler lidar, a Depolarization lidar and the 325-m meteorological tower in Beijing during the winter 2016-2017, in particular during heavy polluted episodes. The height of BL was estimated by using lidar data. The characteristics of wind, temperature and relative humidity at 15 levels, turbulence transport and radiation balance at three levels (47, 140 and 280 m) were analyzed by using the observational data collected on the 325-m meteorological tower.

Keywords: remote sensing instruments, heavy polluted episodes, Beijing, boudary layer structure



(a) $PM_{2.5}$ at Aoti surface station (red box: heavy polluted episodes);
(b) Velocity variance, σ_w^2 (m^2 s^{-2}), calculated from the Doppler wind lidar data , from 1 December 2016 to 10 January 2017. Derived boundary layer depths, based on the threshold method, are depicted as black dots.

©2019. Japan Geoscience Union. All Right Reserved.

THE STUDY OF RIVER CHANGE DETECTION INTEGRATING OBJECT-BASED CLASSIFICATION AND EDGE EXTRACTION

*Yu-Chan Lee[1], Fang-Shii Ning[1], Hao-Che Ho[2]

1. Department of Land Economics, National Chengchi University, 2. Department of Civil Engineering, National Taiwan University

Rivers in Taiwan have the characteristics of short mainstream and steep slope. With seasonal changes and different geographic environment, the middle course of drainage basin is prone to lateral erosion and deposition. However, due to the global climate change and the occurrence of natural disasters, the increasing precipitation strength and unstable river channel make the river migration more frequent and complex. Therefore, river governance has become a challenge in recent years.
In the history of change detection, we often needed multi-temporal of remote sensing images. Depending on geographical landscape and types of data, different methods like image classification are applied for change detection. All of these methods have their own advantages and disadvantages, so it is necessary to combine these methods to achieve river change detection. This study used remote sensing data and image processing software for object-based classification and also edge extraction as an aid to achieve river change detection.

Keywords: Change Detection, Image Classification, Edge Extraction, Remote Sensing Images

©2019. Japan Geoscience Union. All Right Reserved.

Monitoring winter wheat spring phenology in the North China Plain using MODIS

*Xifang Wu[1], Wei Yang[2], Chunyang Wang[3], Yuki Sofue[4], Yanjun Shen[5], Akihiko Kondoh[2]

1. Graduate School of Science and Engineering , Chiba University, 2. Center for Environmental Remote Sensing, Chiba University, 3. School of Surveying and Land Information Engineering, Henan Polytechnic University, 4. Graduate School of Science, Chiba University, 5. Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences

North China Plain (NCP) is one of the most important granaries in China. Crop spring phenology is a sensitive indicator of climate change and crop management. Monitoring of crop spring phenology is of great importance to food security. Winter wheat is the main crop cultivated in the study area. There are few studies that evaluate the performance of different vegetation indices in detecting winter wheat spring phenology in the study area. Moreover, the spatiotemporal variation of winter wheat spring phenology since 2000 is also not very clear. In this study, NDVI, EVI and NDPI derived from MODIS were used to investigate the characteristic of winter wheat spring phenology. The results showed that there was good agreement between the winter wheat spring phenology of satellite-based and the ground observation records. At the spatial scale, winter wheat spring phenology derived from NDVI, EVI and NDPI showed the similar spatial pattern. At the regional scale, winter wheat spring phenology monitored by NDVI, EVI and NDPI all showed a delayed trend during 2001-2017. Furthermore, winter wheat spring phenology was most affected by the average temperature from February to mid-March and the cumulative precipitation from November to mid-March. Winter wheat spring phenology was negatively correlated with temperature and precipitation, and the effect of temperature on winter wheat spring phenology was greater than precipitation. The decrease of the average temperature from February to mid-March and cumulative precipitation from November to mid-March were the main reasons for the delayed trend of winter wheat spring phenology during 2001-2017. In addition, the interannual variation of winter wheat spring phenology in the study area was not only affected by climate factors but also influenced by topography and available water resources.

Keywords: Winter wheat, Spring phenology, North China Plain, Temperature, Precipitation, MODIS

©2019. Japan Geoscience Union. All Right Reserved.

Assessment of numerous Data Assimilation Approaches in Regional Retrieval of Ground NO_2 Spatial Distribution via Remote Sensing products

*Hugo Wai Leung MAK[1,2], Jimmy Chi-Hung FUNG[1,2]

1. Department of Mathematics, Hong Kong University of Science and Technology, 2. Division of Environment and Sustainability, Hong Kong University of Science and Technology

Combating with environmental pollution problems and reducing human exposure to unhealthy levels of airborne chemicals are important global missions nowadays, particularly in more developed cities in China. Existing monitoring network for ground pollutant measurements in most places of southern China are currently too sparse, therefore spatial variation and characteristics in rural regions or places with mixed land use may not be well detected and distinguished. Thus, the use of satellite remote sensing techniques play important roles in observing temporal changes of pollutants within troposphere through satellite scans. Based on tropospheric NO_2 column density inferred from Ozone Monitoring Instrument (OMI), together with certain meteorological quantities, ground NO_2 spatial distribution could be retrieved via data assimilation techniques, thus providing a possibility to detect changes of pollutants within a prescribed domain over long period.

In this research, we adopt the use of modified Berkeley High Resolution product (BEHR-HK v3.0C) and meteorological outputs from the Weather Research and Forecasting (WRF) model to describe tropospheric NO_2 column density within southern China, especially Greater Bay Area. The preliminary steps of such approach are mostly in line with NASA Standard Product, however it makes use of higher-resolution a priori NO_2 profiles and terrain patterns to reformulate the Air Mass Factor (AMF), thus doing a better job in capturing changes of NO_2 within lower troposphere, particularly in places with large spatial variabilities and terrain height differences like China.

Furthermore, based on understanding in atmospheric meteorology, we combine the use of updated tropospheric NO_2 column density and 8 meteorological factors from WRF (e.g. Planetary Boundary Layer Height (PBLH), atmospheric pressure and perturbation potential temperature), then retrieve the estimated spatial distribution of ground-level NO_2 concentration in southern China within 4 seasons of 2015, via combination of machine learning approaches and kernel-based probabilistic models. These data assimilation techniques include non-parametric models like Gaussian Process Regression (GPR), imposing of different statistical kernels (like Gaussian or Radial Basis Function (RBF)) or Support Vector Machine (SVM). Retrieval results are then validated by available measurement datasets obtained from ground monitoring stations. Respective accuracy and applicability of these models are assessed by same statistical metrics, which we conclude that GPR model reaches the best performance in predicting ground NO_2 concentration after a series of machine learning and training processes were applied, followed by Tree Ensemble model. This finding opens new window into long-term ground NO_2 retrieval and prediction, and dealing with environmental problems that require continuous monitoring and assessments.

Keywords: Satellite Remote Sensing Techniques, Tropospheric Column Density and Ground Retrieval, Inverse Approaches in Data Assimilation

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Spectro-polarimetric BRF measurement of leaves and model of individual leaf

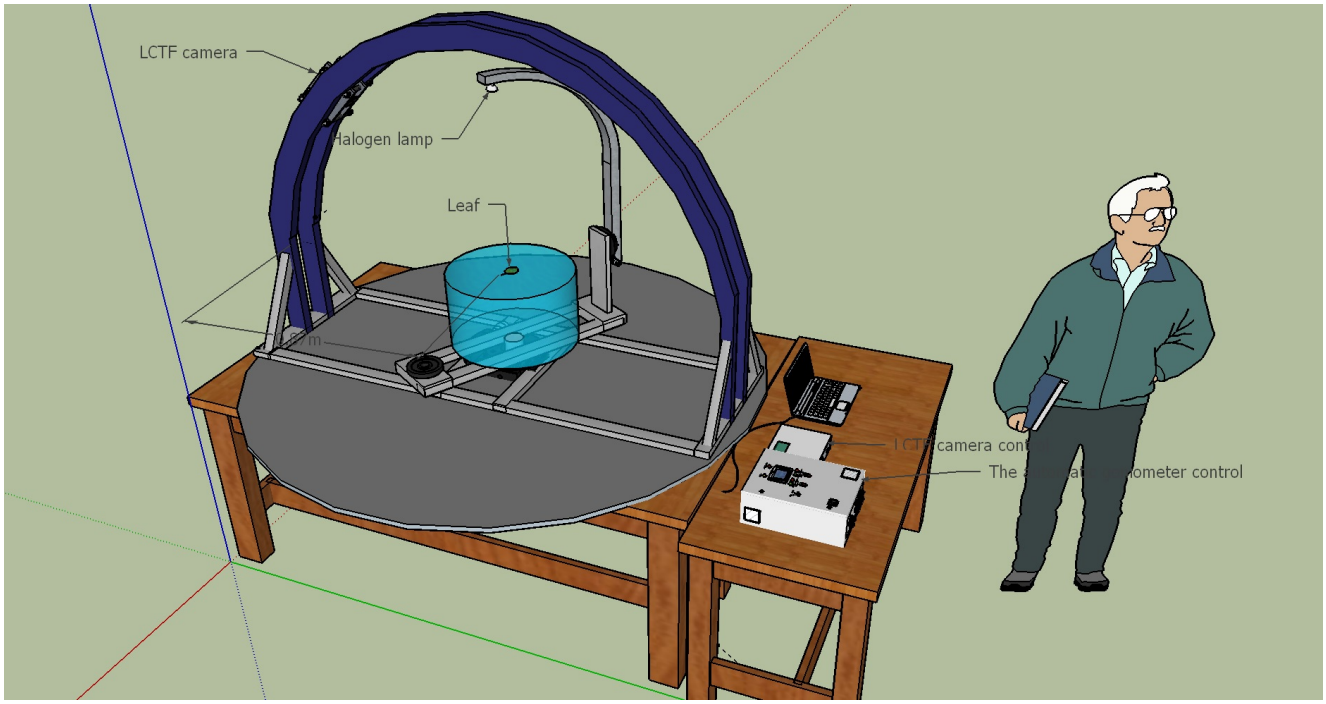
*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2]

1. Hokkaido University, 2. Shiga University of Medical Science

The reflectance of the leaf consists not only of its intensity but also of polarization, and the polarization techniques are generally used for separating specular reflectance from diffuse reflectance. The internal diffuse component of the spectral reflectance contains the details of the biochemical properties of the plant, an activity of photosynthesis, an expected amount of harvest, and water condition. Specular reflectance of the leaf strongly depends on a combination of the angle of incidence of the light source and the angle of observation view. The leaves look shiny at the shallow angle, where most of this reflection is polarized from the surface of leaves. Although the leaf spectral reflectance which is a point of convergence for many types of research, the study of spectral measurement with polarization in a single leaf is largely unexplored. To do this, the estimation of single leaf BRDF of Coffea canephora Pierre (Coffee), Epipremnum aureum (Pothos), and Fragaria ×ananassa (Strawberry) was carried out based on the measurements by Liquid Crystal Tunable Filter (LCTF) camera in the wavelength range of 460-780 nm with a linear polarizer. The imaging with the multispectral LCTF camera has a great advantage in measuring a selected leaf area with an arbitrary size of the field of view. There are hundreds of combinations of incident light and observation direction in single leaf Bidirectional Reflectance Factor (BRF) measurement. In order to conduct the measurements for all those conditions, we built the automatic goniometer with LCTF camera in a laboratory.
In previous studies, the leaf BRF prediction is usually based on the Cook-Torrance (Cook and Torrance, 1981) prevalent model in computer graphics assuming that the surface micro-geometry acts as a set of specular mirrors. Another type of models are widely used in the optics community, computing diffraction effects caused by differences in height in the surface micro-geometry and predicts visual appearance from the frequency content of the height distribution. The Cook-Torrance model may not be suitable for the leaf reflectance in our observation because the actual measurement cannot determine the surface roughness. The Generalized Harvey-Shack (GHS) scattering theory is well studied from rebound models determined by height distribution (Krywonos, 2006) and the GHS theory is not limited to any special wavelength range and RMS roughness value. Spectro-polarimetric measurement results and physical scattering theory have led us to create a new reflectance model. We successfully created a new leaf bidirectional reflectance model which considers that the diffuse component is Lambertian inside of the leaves and an internal scattering coefficient is calculated to an output value of PROSPECT model; the specular component is explained by GHS scattering theory. The polarization property of reflected light on a single leaf is also identified and rebuild bidirectional reflectance factors including polarized, unpolarized, and the total reflectance factors according to our model in this work. Finally, a new spectro-polarimetric bidirectional method is more controllable for the BRF pattern of a single leaf.

Keywords: BRDF measurement , Polarization, leaves , spectral

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 301B 3F

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris), Chairperson:Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)

In the last two decades the number of high quality seismic instruments being installed around the world has grown exponentially and probably will continue to grow in the coming decades. This data explosion has shown the limits of the current standard routine seismic analysis, often performed manually by seismologists. Exploiting the massive amount of data is a challenge that can be overcome by using new generation, fully automated and noise robust seismic processing techniques. In the last years waveform-based detection and location methods have grown in popularity and their application have dramatically improved seismic monitoring capability. More recently, Machine Learning techniques, which are a perfect playground for data-intensive applications, are showing promising results in seismicity characterization applications opening new horizons for the development of innovative, fully automated and noise robust seismic analysis methods. Such techniques are particularly useful when working with datasets characterised by a massive number of weak events with low signal-to-noise ratio, such as those collected in induced seismicity and volcanic monitoring operations. This session aims to bring to light new methods that can be applied to large datasets, either retro-actively or in near-real time, to characterize seismicity (i.e. detection, location, magnitude and source mechanisms estimation) at different scales and in different environments. We thus encourage contributions that demonstrate how the proposed methods helps improve our understanding of earthquake and/or volcanic processes.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS04-01] MyShake: A global smartphone seismic network to characterize urban earthquakes

*Richard M Allen[1], Qingkai Kong[1], Sarina Patel[1], Robert Martin-Short[1] (1.University of California Berkeley)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS04-02] Full waveform-based automatic monitoring of microseismic activity using high sampling rate records: application to Garpenberg mine (Sweden)

★Invited Papers

*Natalia Poiata[1,2], Kadek Hendrawan Palgunadi[3], Jannes Kinscher[4], Pascal Bernard[1], Francesca De Santis[4], Emmanuelle Klein[4] (1.Institut de Physique du Globe de Paris, France, 2.National Institute for Earth Physics, Romania, 3.King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, 4.Institut National de l'Environnement Industriel et des Risques Ineris, Nancy, France)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS04-03] A deep convolutional neural network for localizing and detecting earthquake swarm activity based on full waveforms: Chances, challenges and questions

★Invited Papers

*Marius Kriegerowski[1,2], Gesa Maria Petersen[1,2], Hannes Vasyura Bathke[2], Matthias Ohrnberger[2] (1.German Research Centre for Geosciences Potsdam, Germany, 2.Inst. of Geosciences, University of Potsdam, Germany)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS04-04] **Fast Location Parameters Determination of Seismic Events from Few Seconds of P Wave Recorded at a Single Seismological Station Using Support Vector Machine Regression**

*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1] (1.Universidad Nacional de Colombia)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS04-05] Foreshock activity detection by a threshold-free matched-filter technique

*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2] (1.Department of Physical Science, College of Science and Engineering, Ritsumeikan University, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS04-06] Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

*Andri Hendriyana[1,3], Takeshi Tsuji[1,2] (1.International Institute for Carbon-Neutral Energy Research, 2.Kyushu University, 3.Bandung Institute of Technology)

MyShake: A global smartphone seismic network to characterize urban earthquakes

*Richard M Allen[1], Qingkai Kong[1], Sarina Patel[1], Robert Martin-Short[1]

1. University of California Berkeley

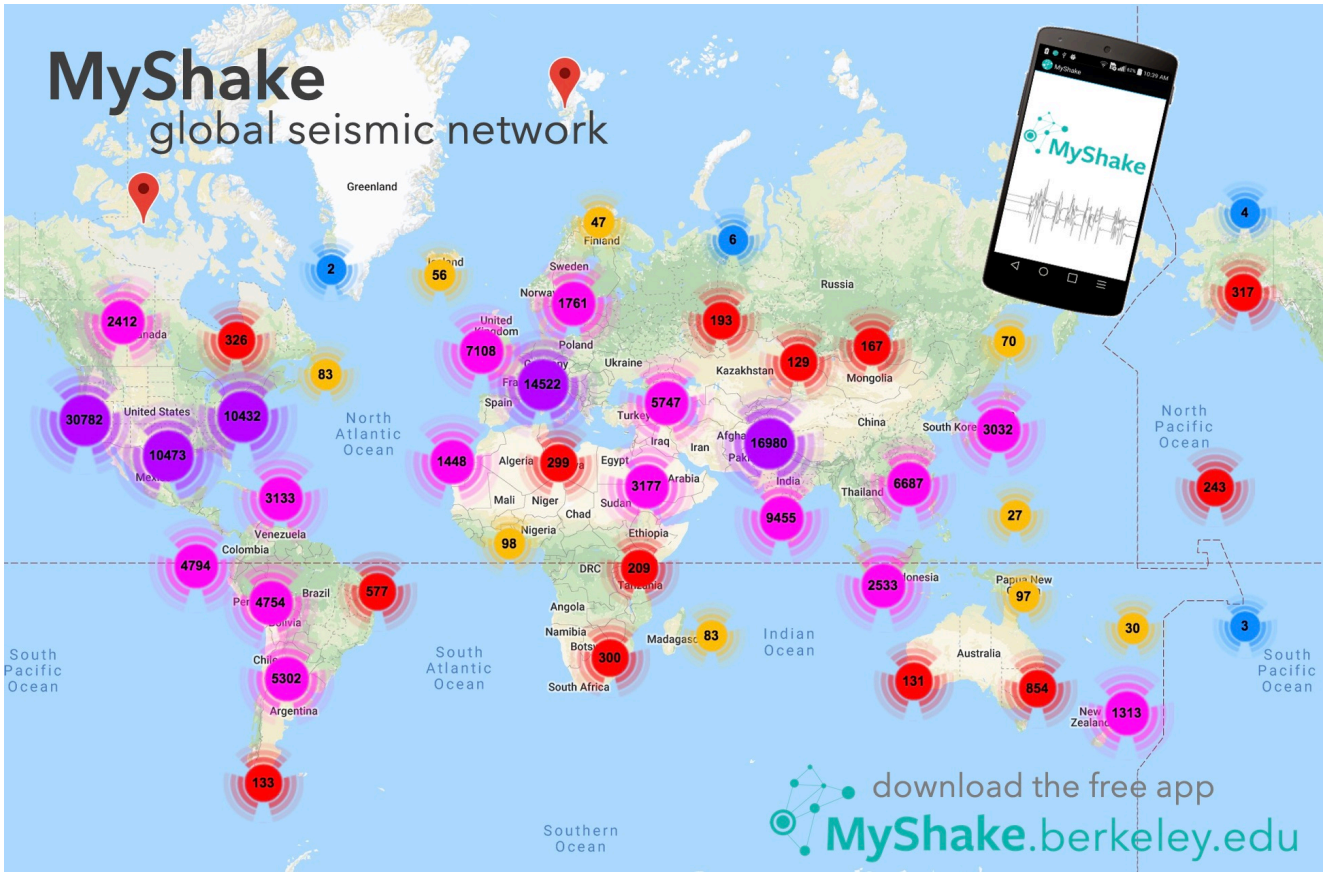
MyShake is a smartphone-based seismic network now collecting seismic data around the globe. Since its launch in 2016, over 300,000 people have downloaded the free public app. Once installed on a private phone, the phone goes into monitoring mode when it is stationary. Any subsequent motion is evaluated by an artificial neural network on the phone to determine if it is earthquake-like. If it is, then a trigger is sent to the MyShake servers immediately, and 5 minutes of 3-component acceleration data is collected and uploaded to the server (including 1 minute of data before the trigger). A real-time clustering algorithm detects earthquakes on the server and the location and magnitude is estimated. So far, MyShake has collected seismic waveforms for more than 900 global earthquakes.

In 2019 version 2.0 of MyShake will be launched. It will be available for Android and iPhones and will provide additional user functionality. The system will have an earthquake early warning capability providing rapid alerts to users when earthquakes are detected. In addition to the phones recording ground motions, users will also be able to report their experience in earthquakes and any damage observed. The resulting information about the distribution of shaking and damage will be immediately available to users as they try to understand the impact of an earthquake that has just occurred.

We will report on the use of the acceleration data to characterize earthquakes. In addition to detecting and locating earthquakes in regions that do not have traditional seismic networks, MyShake can also be used to map the distribution of ground shaking including the response of buildings.

Keywords: Machine learning, Earthquake detection, Earthquake early warning

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Full waveform-based automatic monitoring of microseismic activity using high sampling rate records: application to Garpenberg mine (Sweden)

*Natalia Poiata[1,2], Kadek Hendrawan Palgunadi[3], Jannes Kinscher[4], Pascal Bernard[1], Francesca De Santis[4], Emmanuelle Klein[4]

1. Institut de Physique du Globe de Paris, France, 2. National Institute for Earth Physics, Romania, 3. King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, 4. Institut National de l’ Environnement Industriel et des Risques Ineris, Nancy, France

Recent studies demonstrated success of automatic full waveform detection and location methods in analyzing and monitoring natural and induced seismicity. These approaches provided a significant improvement in events detectability increasing the significance of statistical analysis permitting to identify small changes of seismicity rates in space and time. It is expected that application of full waveform-based method to seismic monitoring of active mines could significantly improve forecasting of potential destructive rock-burst events. However, such implementations are currently non-trivial and by far nonstandard. Main challenges here come from the presence of a wide range of seismic sources related to mining activity and a high sampling rates of recorded data (~ kHz) posing problems for real-time data transfer and processing.

We present an adapted, full waveform-based automatic method for detection and location of microseismic events that makes use of continuous seismic records from an in-mine seismic network. The method can be adjusted to a real-time monitoring scheme and consists of two steps: event extraction and amplitude ratio-base preliminary location; and event relocation using coherency-based backprojection approach. The event extraction based on multi-band 2-D signal characterization allows to overcome the challenge of high sampling rate data (8 kHz), reducing the overall volume of transferred data and providing an energy-based signal classification scheme for removing signals from machinery noise sources. The technique is developed and tested on the case study of Garpenberg mine (Sweden) monitored by a high-resolution permanent local seismic network maintained by Ineris. We demonstrate the improvement in event detection capacity offered by our method in comparison to the standard triggered-based monitoring schemes and discuss how the increased number of detected microseismic events permits to better characterize the response of the mine to production activity.

Keywords: full waveform methods, mining induced seismicity, automatic monitoring, continuous data analysis

©2019. Japan Geoscience Union. All Right Reserved.

A deep convolutional neural network for localizing and detecting earthquake swarm activity based on full waveforms: Chances, challenges and questions

*Marius Kriegerowski[1,2], Gesa Maria Petersen[1,2], Hannes Vasyura Bathke[2], Matthias Ohrnberger[2]

1. German Research Centre for Geosciences Potsdam, Germany, 2. Inst. of Geosciences, University of Potsdam, Germany

Deep learning approaches have outperformed established methods in various disciplines in recent years. Earthquake localization is a crucial first step for seismological studies. We explore in howfar deep learning regression can be used for that task when operating on three component full waveform recordings of regional stations. We implemented a deep convolutional neural network with three output neurons representing the three Cartesian coordinates of the hypocenter under investigation. We apply only basic preprocessing like filtering and use of absolute amplitudes. We trained the neural network on full waveform recordings of the 2008 North Bohemia earthquake swarm recorded by 9 stations. Accurate locations based on double difference arrival times are available and provide us with a favorable testing environment. We select time windows based on hand picked first arrivals at the closest station. We consider this approach as semi-automatic as the current implementation requires the earliest arrival at the closest station to be picked. After training for approximately 1 hour on a dataset of 2000 events we locate a different set of 900 events to validate and evaluate the location performance. The results show location accuracies of 56.4 m in East-West-,123.8 m in North-South- and 136.3 m in vertical directions compared to the double difference relocated reference catalog. It takes about 1 second to locate all 900 target events. Furthermore, we demonstrate, that the filters of the first layer can be exploited as an event detector for earthquakes of the same source region. During training, these filters become sensitive to the signals they are trained on, similar to a pattern matching detector commonly used in seismology.
A drawback of the proposed approach is the fixed station geometry. We discuss an alternative approach which allows to apply this method independent of station configurations.

Keywords: Deep learning, Machine learning, Earthquake Swarm

©2019. Japan Geoscience Union. All Right Reserved.

Fast Location Parameters Determination of Seismic Events from Few Seconds of P Wave Recorded at a Single Seismological Station Using Support Vector Machine Regression

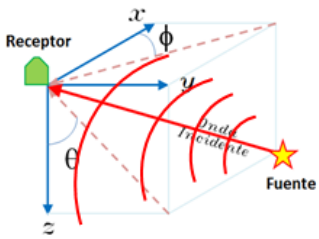
*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1]

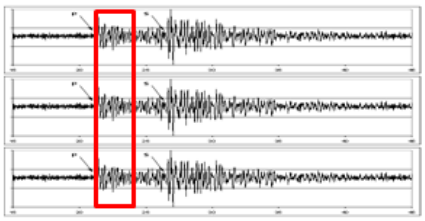
1. Universidad Nacional de Colombia

A Support Vector Machine Regression (SVMR) algorithm was applied to calculate Local Magnitude (ML), epicenter distance, focal depth and back-azimuth of seismic events using only five seconds of signal since P wave onset of one three component of “El Rosal” seismic station located, near to the city of Bogota –Colombia. The algorithm was trained with descriptors of time signals of 863 seismic events acquired between January 1998 and October 2008. During training stages of SVMR several combinations of kernel function exponent and complexity factor were considered for time signals of 5, 10 and 15 seconds along with earthquake local magnitudes of 2.0, 2.5, 3.0 and 3.5. Input parameters were an exponential function of waveform envelope estimated by least squares and maximum value of recorded waveforms for each component of the seismic station as well as a “Polarity Attenuation Factor”, which is proposed as a key for a successful modelling parameter for short time earthquake characterization. We used SVMR algorithm with normalized polynomial kernel and tested with a ten-fold cross validation, obtaining mean absolute error for different exponents and complexity parameters. A grid search method was applied to choose the best model parameters. The mean absolute error obtained in estimation of parameters were: Local Magnitude (ML) with 0.19 units of magnitude, hipocentral distance with 10.3 kilometers, focal depth with 16.5 kilometers and back-azimuth with 45.4 degrees. Proposed algorithm is easy to implement directly in the seismological stations to generate fast decisions at seismic control centers, increasing the possibility of having an effective early warning generation.

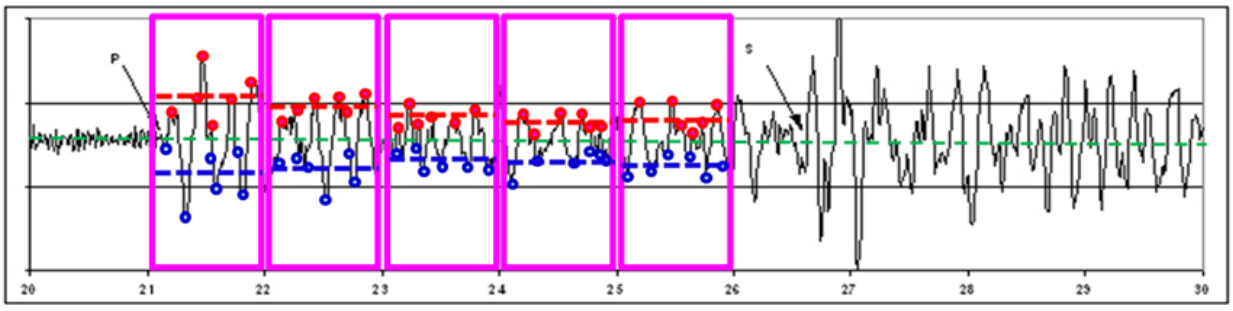
Keywords: Earthquake Early Warning, Support Vector Machine Regression, Polarity Attenuation Factor, Earthquake, Bogotá, Colombia, Location Parameters

©2019. Japan Geoscience Union. All Right Reserved.









©2019. Japan Geoscience Union. All Right Reserved.

Foreshock activity detection by a threshold-free matched-filter technique

*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2]

1. Department of Physical Science, College of Science and Engineering, Ritsumeikan University, 2. Disaster Prevention Research Institute, Kyoto University

Revisiting earthquake catalogs have revealed that 40% or more of major earthquakes are accompanied by foreshock activities, at least in California [Abercrombie & Mori 1996 Nature] and Japan [Tamaribuchi et al. 2018 EPS].
To investigate whether the foreshocks are magnification and activation of background seismicity, we have to compare waveforms due to the foreshocks and background events that might be sometimes uncataloged because of their small sizes.
We can mine even small seismic signals similar to some template waveforms from continuous waveform records by using a matched-filter analysis based on cross-correlation coefficients (CC) between the template waveforms and continuous records.
However, in the conventional analysis, we have to define a threshold of CC to detect similar seismic waveforms, which have been chosen subjectively and empirically.
Then, we propose a threshold-free method to detect outliers from the empirical distribution of CC among seismic waveforms.
In our framework, empirical distributions of the coefficients are modeled by the theory of extreme value statistics, and the detectability is automatically determined from Akaike's Information Criterion (AIC), depending on data.
We applied the method of seismic signal detection to 2-years-continuous records before an M5.4 earthquake in Nagano, Japan (June 30, 2011) that followed 27 foreshocks cataloged by JMA.
First, we found that the empirical frequency distribution of CC between the continuous records and foreshocks did not follow a normal distribution, which means that we cannot estimate the possibility of a false positive by assuming the normal distribution as a model.
Instead, we also found that the maximum value of CC in every few seconds follow the Gumbel distribution after elimination of some outliers.
The elimination can be achieved by comparing AICs of data including and excluding the outlier candidates.
Given this method, we found a similar event ~2 months before the mainshock and 3 similar events 3-4 days before the mainshock.
This result implies that the foreshocks were not similar to background events, and hence, not magnification or activation of them.

Keywords: matched-filter technique, foreshock activity, extreme value statistics, AIC

©2019. Japan Geoscience Union. All Right Reserved.

Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

*Andri Hendriyana[1,3], Takeshi Tsuji[1,2]

1. International Institute for Carbon-Neutral Energy Research, 2. Kyushu University, 3. Bandung Institute of Technology

The interplay between earthquakes and volcanic activity that may lead to eruptions has been well-established. Dynamic stress from a remote large earthquake brought by propagating of body and surface waves triggers gas exsolution at a magma reservoir. The exsolution of gasses could further lead to a bubble nucleation and pressurize the magma chamber. If the pressure continues to increase and exceeds a critical value, then magmatic fluids could breach impermeable layers overlying the magma chamber. Hot magmatic fluids heat up water filling hydrothermal system or continue to rise until surface resulting in an eruption. The interaction between the ascent of magmatic fluids with water at shallow triggers long-period (LP) seismicity. LP events reflect the resonance of fluid-filled cracks due to changes in fracture pressure. Because this process usually occurs near the surface, then LP seismicity could be used as a possible precursor to volcanic eruptions. Many studies have been conducted to analyse LP seismicity at Aso volcano. The origin of this seismic activity was a pressurization at the hydrothermal system at depth of about 1 km from the surface. However, the relationships between LP seismicity and earthquakes have not been studied. Moreover, LP signals show no clear onset of wave arrivals causing difficulties in performing classical seismic event localization that relies on manual travel-time picking. In this study, we present the source location of LP (with period of 15 s) seismicity at Aso volcano recorded by F-net and V-net seismic networks, between January 2015 and December 2016, a period that includes the Mw 7.0 Kumamoto earthquake of April 2016 and volcanic eruptions of October 2016. The initial LP events were identified by applying STA/LTA method using window lengths of 10 s and 100 s. To avoid false positive detection, waveform cross-correlation was applied to all pairs of the initial events resulting in a reliable three-component template waveform. In order to obtain robust LP events from 2-year continuous seismograms, a template matched filter was employed. We developed a differential-time back-projection method to locate LP events. Then, a coherency measure (semblance) was computed from the cross-correlograms of waveforms instead of the seismograms. In order to increase the focusing of the coherency image, we applied weighted-semblance by making use of a phase-stacking function. The seismic event locations with uncertainties were estimated from the probability density function of the coherency image. The performance of the developed method was remarkable since we have successfully revealed two distinct clusters of LP seismicity beneath the Nakadake crater. The spatio-temporal variation of LP events could be related to the large earthquake and volcanic eruption.

Keywords: differential-time, back projection technique, template matched filter, coherency, long-period seismicity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Chairperson:Luca Urpi(ETH-Zurich; Swiss Seismological Service), Bogdan Enescu(Graduate Schoold of Science, Kyoto University), Francesco Grigoli(ETH-Zurich; Swiss Seismological Service), Yosuke Aoki

Induced and triggered seismicity occurs in conjunction with human activities such as reservoir impoundments, mining operations, conventional and non-conventional hydrocarbon production, geothermal energy exploitation, wastewater disposal, CO2 sequestration and gas storage operations as well as volcanic and hydrogeological processes. The stability of faults is affected by external solicitations such as pore-pressure diffusion, relaxation effects as well as stress field perturbations related to mass and/or volume changes, dike intrusions and earthquake-earthquake interactions. A better understanding of the physical processes governing induced and triggered seismicity is important for the assess the risk of current and future industrial activities, including the geological disposal of nuclear waste.

The study of Induced and triggered seismicity is inherently an interdisciplinary problem, which requires the combination of seismological, hydrogeological, geodetic data and a wide range of modeling approaches. This session welcome contributions covering the analysis and modeling of induced and triggered seismicity at different spatial scales and environments.

Relevant topics to be presented include but are not limited to case-studies of induced and triggered seismicity, spatio-temporal variations of physical parameters (including stress, pressure and temperature changes), spatio-temporal patterns of seismicity, modeling and risk mitigation strategies.

The goal of the session is to cover both theoretical and experimental aspects of these topics.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS05-01] Causality between induced seismicity b-value reduction and stress state of existing fractures

★Invited Papers

*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4] (1.Institute of Fluid Science, Tohoku University, 2.ERL, Massachusetts Institute of Technology , 3.FREA, AIST, 4.Häring GeoProject)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS05-02] Micromechanical model connecting earthquake statistics and observed spatiotemporal changes in source parameters of fluid induced seismicity

*Daisuke Sato[1], Keisuke Yoshida[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS05-03] Seismicity induced by Multi-cycle operation of Hutubi underground gas storage, Xinjiang, China

*Baoshan Wang[1,2], Bo Zhang[2], Zhanbo Ji[2], Jinxin Hou[2], Lu Li[2] (1.University of Science and Technology of China, 2.Institute of Geophysics, China Earthquake Administration)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS05-04] Investigating the origin of the Mw 5.4 Pohang, Korea, earthquake of November 15, 2017: the investigations and conclusions of the Overseas Research Advisory Committee (ORAC)

*Toshihiko Shimamoto[1], William Ellsworth[2], Shermin Ge[3], Domenico Giardini[4], John Townend[5] (1. Institute of Geology, China Earthquake Administration, 2.Stanford University, 3.University of Colorado Boulder, 4.ETH, Zurich, 5.Victoria University of Wellington)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS05-05] **Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes**

*Martha K Savage[1], Kenny Graham[1], Yosuke Aoki[2], Richard Arnold[1], Tomomi Okada[3], Yoshihisa Iio[4], Satoshi Matsumoto[5] (1.Victoria University of Wellington, 2.Earthquake Reserach Institute, University of Tokyo, 3.Tohoku University, Sendai 980-8578, Japan, 4.Kyoto University, Uji 611-0011, Japan, 5.Kyushu University, 2-5643-29 Shin'yama, Shimabara, Nagasaki, 855-0843, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS05-06] Long-term behavior of induced seismicity in the Val d'Agri basin (Southern Apennines, Italy).

★Invited Papers

*Luisa Valoroso[1], Luigi Improta[1], Samer Bagh[1], Davide Piccinini[1], Pasquale De Gori[1] (1.Istituto Nazionale di Geofisica e Vulcanologia)

Causality between induced seismicity b-value reduction and stress state of existing fractures

*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4]

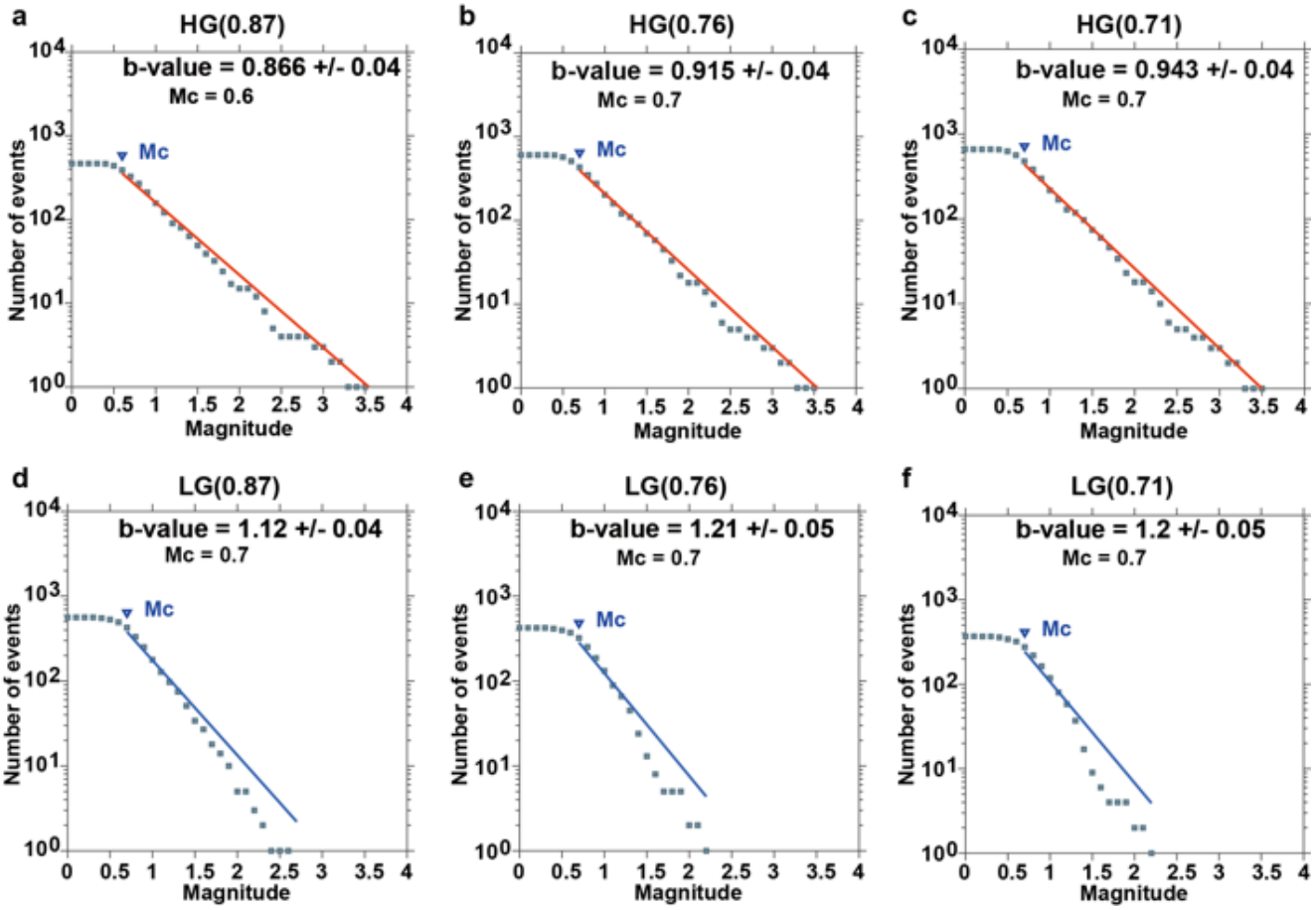
1. Institute of Fluid Science, Tohoku University, 2. ERL, Massachusetts Institute of Technology , 3. FREA, AIST, 4. Häring GeoProject

The Gutenberg–Richter distribution of earthquakes is a power law relationship and it holds for laboratory scale earthquakes (acoustic emission) to subduction zone earthquakes as well as induced seismicity. The gradient of the power law is known as the b-value, which can be considered the ratio of the number of the larger earthquakes to small ones. Larger earthquakes are often observed in low b-value regions, or alternatively a b-value reduction has been observed before some main shocks. Some authors have argued that b–value is negatively correlated with differential stress level. Therefore, a b-value anomaly found in time-space analysis may be used for detection of an area of stress concentration and used for earthquake prediction or hazard risk assessment.

In the field of induced seismicity where b-value reduction has also been observed, the physical mechanism of b-value reduction has not been well understood. Since induced seismicity related with fluid injection usually occurs at depths around 1000 ~ 5000 m, a significant tectonic loading to cause a stress change during the short time period of a hydraulic stimulation might not be expected. We used borehole analysis and focal mechanism information to investigate the stress state on the existing fractures that caused induced seismicity. Then we divide the catalog into the groups with varying normalized shear stress threshold and estimated the b-value. We found that b-value for the events that occurred along higher shear stress fractures were significantly lower (figure 1a) than those from the moderate/lower shear stress fractures (figure 1b). Thus, b-value dependency on the shear stress can be observed for induced seismicity on a reservoir scale. Therefore, we propose that the reason for the observed b-value reductions in induced seismicity on a reservoir scale is the events that occur along higher shear stress fractures. Supposing that the earthquakes occur along well-orientated fractures, the b-value dependence on differential stress can be translated to dependence on shear stress. Thus, our observations about b-value are consistent with the conventional interpretations of b-value.

Keywords: b-value, Shear stress, induced seismicity

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Micromechanical model connecting earthquake statistics and observed spatiotemporal changes in source parameters of fluid induced seismicity

*Daisuke Sato[1], Keisuke Yoshida[2]

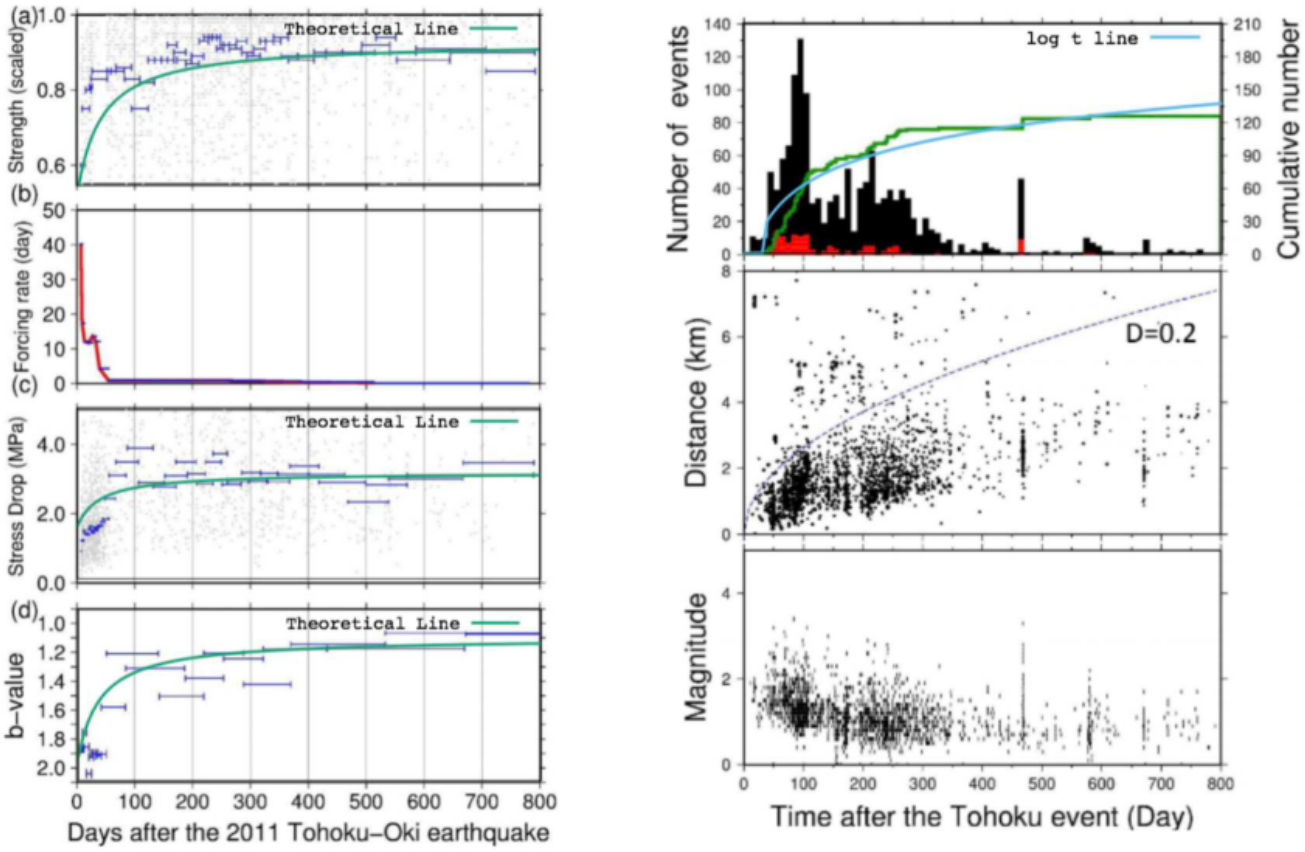
1. Disaster Prevention Research Institute, Kyoto University, 2. Tohoku University

In the context of the hazard assessment of fluid-induced seismicity, the earthquake activities are known to successively continue even after the stop of fluid-injection. The change in earthquake statistics (typified by b-values and seismicity rate) is shown to be the functions of elapsed time from fluid injection similar to the Omori-law of aftershocks, even without any mainshocks (Bachmann et al., 2012). Such statistical features are also seen in the natural earthquake swarms, and simultaneously, it is further shown that the corresponding change of the stress-strength state can be captured by using source parameters (such as stress drops, strength) (Yoshida et al., 2017). The model is now required to describe synchronized observed changes in the source parameters and earthquake activities (Segall and Lu, 2015).

In this research, by considering strength heterogeneity of faults expected from experimentally verified physics, we provide the micromechanical model of such seismicity induced by on-fault fluid diffusion, and explain the results of the above data-driven analysis. Presentation contains following four contents. First, a micromechanical model is proposed. In the model, many patches are distributed randomly on a fault so that the patches are sufficiently small (or distant) to interact with each other; those patches rupture when the effective strength becomes smaller than applied shear stress due to the fluid diffusion, and the rupture cascades in each patches as in Scholz (1965). The assumption of the on-fault diffusion is based on the recent observation that the earthquake activities propagate facially (e.g., Yukutake et al., 2010, Yoshida et al., 2017). Second, the spatiotemporal changes of the source parameters are obtained as the solutions of the model. Consequently, multiple source parameters are parametrized by injected pressure, diffusion radius of fluid, normal stress on the fault, and the fluctuation of the excess strength; after the parametrization, those source parameters are shown to follow the common master curve. Third, the observed data is fitted, and the consistency between the theory and the observation is suggested. Fourth, the theoretical prediction for the temporal transience in the moment release rate is checked by the data of Yoshida et al. (2017), and the result strongly supports the theory.

Keywords: Induced-Seismicity and Earthquake Swarms, Micromechanical Model, Source Paraemters

©2019. Japan Geoscience Union. All Right Reserved.



Yoshida et al. (2017)

Fig. 1. A data example of Yoshida et al. (2017) fitted by our theoretical model (written as theoretical or log t line in the figure), after Yoshida et al (2017). (Left) Temporal evolution of the source paramters. (Right) Number of events and the spatial patterns of the seismicity.

©2019. Japan Geoscience Union. All Right Reserved.

Seismicity induced by Multi-cycle operation of Hutubi underground gas storage, Xinjiang, China

*Baoshan Wang[1,2], Bo Zhang[2], Zhanbo Ji[2], Jinxin Hou[2], Lu Li[2]

1. University of Science and Technology of China, 2. Institute of Geophysics, China Earthquake Administration

In 2013, one of the largest UGSs in China, the Hubuti UGS started to operate in Xinjiang, northwestern China. To monitor the seismicity near the Hutubi UGS and adjacent area, we deployed 36 portable broadband 3-component seismic stations, complementing four permanent seismic stations within 100 km from the Hutubi UGS. We calibrate the 1-D model with the active source record and relocated the events which are used as template to search for the missed events with the Match and Located method. In the period of January 2013 to December 2017, we detected and located more than 3000 earthquakes, 5 times more than the catalog. Our results suggest a possible correlation of seismicity and the gas injection/extraction process, and it is spread to 10-20 km in the last two cycles. Control the rate of gas injection and extraction can reduce the risk from seismic events.

Keywords: Underground Gas Storage, Multi-cycle operation, Induced Seismicity

©2019. Japan Geoscience Union. All Right Reserved.

Investigating the origin of the Mw 5.4 Pohang, Korea, earthquake of November 15, 2017: the investigations and conclusions of the Overseas Research Advisory Committee (ORAC)

*Toshihiko Shimamoto[1], William Ellsworth[2], Shermin Ge[3], Domenico Giardini[4], John Townend[5]

1. Institute of Geology, China Earthquake Administration, 2. Stanford University, 3. University of Colorado Boulder, 4. ETH, Zurich, 5. Victoria University of Wellington

On November 15, 2017 a Mw 5.4 earthquake struck the city of Pohang, Republic of Korea, causing numerous injuries and in excess of $50 million in damage. Initial estimates of the location of the earthquake placed it near an enhanced geothermal systems (EGS) project that was still under development. The proximity of the earthquake to the project raised question about the possible association between industrial activities and the earthquake, and also led to the termination of the project. The Pohang EGS project was developing a geothermal reservoir by high-pressure hydraulic injection into a pair of wells at depths in excess of 4 km in the crystalline basement. The goal was to create a permeable pathway between the boreholes for the extraction of heat for the production of electricity. As part of the official government investigation into the earthquake, the Geological Society of Korea (GSK) formed an Overseas Research Advisory Committee (ORAC) charged with conducting a comprehensive investigation of the earthquake and any potential involvement of the Pohang EGS project in its origin. Investigations included the analysis of both natural seismicity and earthquakes induced during stimulation of the wells, development of mechanical and hydrogeologic models of the stimulations and comprehensive review of relevant drilling and stimulation data. As part of their investigation, the ORAC has been working closely with university researchers and with the full cooperation of government agencies and the EGS project. The summary report by the GSK and the ORAC will be released in March 2017. This presentation will summarize the findings of the ORAC investigation.

Keywords: Pohang earthquake, Korea, induced earthquake, triggered earthquake

©2019. Japan Geoscience Union. All Right Reserved.

Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes

*Martha K Savage[1], Kenny Graham[1], Yosuke Aoki[2], Richard Arnold[1], Tomomi Okada[3], Yoshihisa Iio[4], Satoshi Matsumoto[5]

1. Victoria University of Wellington, 2. Earthquake Reserach Institute, University of Tokyo, 3. Tohoku University, Sendai 980-8578, Japan, 4. Kyoto University, Uji 611-0011, Japan, 5. Kyushu University, 2-5643-29 Shin'yama, Shimabara, Nagasaki, 855-0843, Japan

Seismic anisotropy in the crust may be caused by stress that aligns microcracks, strain that aligns minerals or structural effects. Recently both anisotropic and isotropic velocity changes have been determined after large earthquakes, and are often considered to be related to cracks that heal with time. In 2016, large earthquakes in Japan (April, Kumamoto, Kyushu) and in New Zealand (November, Kaikoura) caused widespread disruption, and also produced data with which to test some of these theories. Here we use shear wave splitting to study the seismic anisotropy before and after the 2016 Kumamoto and the Kaikoura earthquakes to study the phenomena.

In Kyushu, measurements from NIED stations between 2004-2012 yielded fast anisotropic directions that align well on average with the maximum horizontal stress from focal mechanism inversions and the maximum horizontal strain rate as measured by the GNSS system. We measured shear wave splitting on these same stations during 2016 to determine whether shear wave splitting changed over time after the Kumamoto earthquake. A few stations yielded different fast directions or increases in delay times. We are checking whether those changes are due to structural changes or can be explained by changing earthquake locations.

In New Zealand, we have measured shear wave splitting and Vp/Vs ratios on permanent stations near the Kaikoura earthquake rupture region between 2013 and 2018. Some stations exhibit apparent changes in fast direction, but spatial averaging does not yield strong changes in fast directions with time. Delay times and Vp/Vs ratios both increased after the M=6.5 and M=6.6 Cook Strait earthquakes and after the M=7.8 Kaikoura earthquake. After the Cook Strait earthquakes, measurements returned to background levels within several months. But by the end of 2017 the measurements had not yet returned to normal. Laboratory measurements suggest that crack healing should yield more rapid recovery, and we are exploring whether aftershocks help to keep the cracks open.

Keywords: Anisotropy, Vp/Vs, Kumamoto, Kaikoura, temporal variation, Shear wave splitting

©2019. Japan Geoscience Union. All Right Reserved.

Long-term behavior of induced seismicity in the Val d’ Agri basin (Southern Apennines, Italy).

*Luisa Valoroso[1], Luigi Improta[1], Samer Bagh[1], Davide Piccinini[1], Pasquale De Gori[1]

1. Istituto Nazionale di Geofisica e Vulcanologia

The Val d’ Agri (VA) basin in the southern Apennines seismic belt is one of the regions in the central Mediterranean with highest seismogenic potential, testified by a M7+ historical earthquake in 1857. In the past forty years, the Val d’ Agri basin only experienced weak background seismicity (M_{max} 3.2). This background activity coexists with two well-documented cases of anthropogenic seismicity. The first case is related to the operation of the largest onshore oilfield in Europe, hosted in a high productive reservoir formed by naturally fractured, low-porosity carbonates. Hydrocarbons are currently extracted through 22 wells from 1.8 to 3.5 km depth below sea level. Extraction started in the mid-1990 and present-day oil production rates 80,000–90,000 barrel (bbl)/d with 2.6 x 10^5 m^3/d of associated gas. Due to a low primary porosity of the reservoir rocks, production is controlled by fracture systems at various scales. Since 2006, co-produced saltwater is re-injected at 3 km depth in the Costa Molina 2 (CM2) well located at a marginal portion of the carbonate reservoir, with injection rate and well-head pressure reaching maximum values of 2800–3000 m3/d and 13–14 MPa, respectively, inducing well-documented microseismicity (M_{max}2). The wastewater injection, which started on June 1st 2006, has continued since then without major interruptions. The second case of antropogenic induced seismicity includes M3+ swarms that have been associated to the medium-sized Pertusillo water reservoir (PWR) characterized by seasonal water-level oscillation as high as 40 m, corresponding to storage changes of about 110 million m^3. In this work, we show a comprehensive analysis of the spatiotemporal seismicity distribution in the Val d’ Agri area, by using data collected during the 2001-2014 by integrating three different permanent and temporary dense networks. Due to the presence of continuously recording permanent stations run by INGV, we also used cross-correlation (CC) matched filter technique to look for undetected earthquakes with the aim to decrease the completeness magnitude of the available seismicity catalogue. Seismicity data have been used to compute high-precision seismicity locations by integrating cross-correlation and double-difference methods and to reconstruct the detailed three-dimensional Vp and Vp/Vs tomography structure of the area. The properties of the carbonate reservoir (rock fracturing, pore fluid pressure) and inherited faults control the occurrence and spatiotemporal distribution of seismicity. For the CM2 wasterwater injection-linked seismicity, the comprehensive picture obtained by integrating reservoir-scale tomography, high-precision earthquake locations, and geophysical and injection data suggests that the driving mechanism is the channeling of pore pressure perturbations through a high permeable fault damage zone within the reservoir. Analogously, the combined interpretation of the spatiotemporal seismicity distribution with the velocity structure the PWR induced seismicity, suggests that the observed seismicity migration can be caused by poroelastic deformation of the fractured water-bearing carbonates in response to the seasonal loading of the PWR.

Keywords: induced seismicity , fault zone structure, velocity model , high-precision earthquake locations

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence), Chairperson:Tatsuya Sakamaki(Tohoku University), Yoichi Nakajima(Kumamoto University)

Liquids of silicates and metals inside of terrestrial planets play important role in the physical, chemical, and thermal evolutions of planets. This session aims at understanding the physical and chemical properties of liquids from shallower to deep parts of terrestrial planets, which are strongly related to the long history of those planets from the planetary accretion to the present-day dynamics. In addition, we call for presentations by researchers from various backgrounds of geochemical, experimental, theoretical/computational, and seismic/geodynamical ones, who investigate the physical and chemical properties of liquids and the behaviors and roles inside of terrestrial planets. Relevant topics include, but are not limited to, partial melting and melt extraction, liquid-solid partitioning, high pressure experiments on melts, and seismic detections of mantle melts and outer core anomaly.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[SIT20-01] Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

★Invited Papers

*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2] (1.Geodynamics Research Center, Ehime University, 2.Argonne National Laboratory, 3.The University of Chicago)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT20-02] **Scaling pseudotachylytes from the lab to the field**

*Thomas P. Ferrand[1], Alexandre Schubnel[2], Nadège Hilairet[3], Loïc Labrousse[4], Stefan Nielsen[5] (1.Earthquake Research Institute, 2.Ecole Normale Supérieure, Paris, France, 3.Unité Matériaux et Transformations, Université de Lille, France, 4.Sorbonne Université, Institut des Sciences de la Terre Paris, France, 5.Department of Earth Sciences, Durham University, United Kingdom)

11:30 AM - 12:00 PM JST | 2:30 AM - 3:00 AM UTC

[SIT20-03] *Ab initio* molecular dynamics study of atomic diffusion in covalent liquid under high pressure

★Invited Papers

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Institute of Technology, 2.Ehime University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SIT20-04] **Pressure-induced structural change in magnesium silicate melts**

*Toshiaki Iitaka[1], Nguyen Van Hong[2] (1.RIKEN, 2.Hanoi University of Science and Technology)

Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2]

1. Geodynamics Research Center, Ehime University, 2. Argonne National Laboratory, 3. The University of Chicago

Possible existence of ultrahigh pressure structural change in silicate magma with the Si-O coordination number (CN) larger than 6 is one of the most important issues in understanding nature of silicate magmas at the Earth’s core-mantle boundary. However, structure of silicate magmas at the ultrahigh pressure conditions of the core-mantle boundary remain poorly understood, because of experimental challenges. Efforts have been made to investigate structure and/or properties of silicate glasses, as an analogue of silicate magma, at ultrahigh pressure conditions. Pioneering work by Murakami and Bass (2010) discovered a kink in the pressure dependence of shear-wave velocity in SiO_2 glass around 140 GPa, which was interpreted as evidence of ultrahigh pressure structural transition with the CN>6. However, no structural information is available under such ultrahigh pressure conditions. Our recent development of double-stage large volume cell combined with multi-angle energy dispersive X-ray diffraction opened a new way to investigate structure of oxide glasses under ultrahigh pressure conditions of >100 GPa. The new experiment revealed existence of ultrahigh pressure polyamorphism in GeO_2 glass with CN>6 (Kono et al., 2016). Our latest development further enhanced the structure measurement capability and we succeeded to measure structure of SiO_2 glass up to 120 GPa. Here we will show ultrahigh-pressure structural change in SiO_2 glass at the pressure conditions near the Earth’s core-mantle boundary.

Kono Y*, et al.* (2016) Ultrahigh-pressure polyamorphism in GeO_2 glass with coordination number> 6. *Proceedings of the National Academy of Sciences* 113(13):3436-3441.

Murakami, M., & Bass, J. D. (2010). Spectroscopic evidence for ultrahigh-pressure polymorphism in SiO_2 glass. *Physical review letters*, *104*(2), 025504.

Keywords: high pressure, SiO2 glass, magma, core-mantle boundary

©2019. Japan Geoscience Union. All Right Reserved.

Scaling pseudotachylytes from the lab to the field

*Thomas P. Ferrand[1], Alexandre Schubnel[2], Nadège Hilairet[3], Loïc Labrousse[4], Stefan Nielsen[5]

1. Earthquake Research Institute, 2. Ecole Normale Supérieure, Paris, France, 3. Unité Matériaux et Transformations, Université de Lille, France, 4. Sorbonne Université, Institut des Sciences de la Terre Paris, France, 5. Department of Earth Sciences, Durham University, United Kingdom

Recent experimental and field results described high-pressure pseudotachylytes that formed in peridotite at mantle depth in similar pressure-temperature conditions. The pseudotachylyte is the rock originating from the solidification of the rupture-induced magma, often referred to as “frictional” melt, which transiently forms and aids sliding on the fault plane.
The pseudotachylyte thickness *a* scales with the relative displacement. The scaling law seems continuous over eight orders of magnitude from the laboratory to the field scale, for measured sliding varying from microns to meters. For magnitudes between -6 and 9, experimental and natural high-pressure faults show striking similarities.
In most lithologies, a kink is observed in the scaling law when the sliding and thickness reach 1 mm and 100 μm, respectively, i.e. Mw >1. This saturation of the pseudotachylyte thickness is due to the scale-depend efficiency of thermal diffusivity, and may also be affected by variations in magma mobility. Previous studies show a similar kink in seismological estimations of the fracture energy *G* as a function of *D*, for $D > 10$cm. The saturation of both *a* and *G* for large magnitudes would mark the transition from adiabatic to diffusive rupture propagation.
In addition, experimental micro-pseudotachylytes and experimental faults due to transformational faulting follow the same scaling law, which brings into light that transformational faulting could hide a transient melting stage.

Keywords: pseudotachylytes, melt, earthquakes, scaling, lubrication, laboratory analogues

©2019. Japan Geoscience Union. All Right Reserved.

Ab initio molecular dynamics study of atomic diffusion in covalent liquid under high pressure

*Satoshi Ohmura[1], Taku Tsuchiya[2]

1. Hiroshima Institute of Technology, 2. Ehime University

Transport properties of covalent liquids under high pressure are very interesting in the sense that they show unexpected pressure dependence. For a number of covalent liquids, such as SiO_2, B_2O_3 and silicates abnormal behavior of the viscosity has been observed, i.e. the viscosity significantly drops with increasing pressure [1, 2, 3]. This anomalous behavior of the viscosity is considered to be related to the atomic diffusion in the liquids under pressure. It is, however, unclear how the rearrangement process of the covalent bonds is affected by compression. In order to explore the pressure dependence of microscopic diffusion mechanism in covalent liquids, we performed *ab initio* molecular dynamics simulations for liquid B_2O_3 and liquid basaltic aluminosilicate. These liquids has diffusivity maximum (viscosity minimum) under high pressure. We investigate the microscopic diffusion mechanism under high pressure. In the presentation, we discuss the origin of the anomalous pressure response of diffusivity from microscopic point of view.

[1] P. F. McMillan and M. C. Wildind. J. Non-Cryst. Solids, **355**, 722
[2] V. Brazhkin, et al., Phys. Rev. Lett. **105**, 115701 (2010)
[3] T. Sakamaki, *et al., Nature Geoscience* **6**, 1041 (2013)

Keywords: liquid , silicate, atomic diffusion, ab initio molecular dynamics

©2019. Japan Geoscience Union. All Right Reserved.

Pressure-induced structural change in magnesium silicate melts

*Toshiaki Iitaka[1], Nguyen Van Hong[2]

1. RIKEN, 2. Hanoi University of Science and Technology

First principles calculation using periodic boundary conditions and density functional theory on high-performance computers have made great achievements in materials science under extreme conditions. However, many difficulties related to the dynamics and the size effects arise when it is extended to aperiodic systems such as liquids and amorphous solids under high temperature and high pressure [1]. Nonetheless the remarkable improvement of hardware capabilities and invention of new algorithms in the scope of the post-post-K computers will promote discoveries of new physics of such liquids.

Recently, a glass-glass transition of $MgSiO_3$ was observed at 88 GPa and room temperature using X-ray diffraction measurement under static compression in a diamond anvil cell[2]. It was suggested that this transition may be extended to a liquid-liquid transition of $MgSiO_3$ melt at higher temperatures and pressures, which corresponds to the perovskite post-perovskite (Pv-PPv) transition of $MgSiO_3$ crystal [3, 4].

Shock compression experiments for $MgSiO_3$ [5, 6] and Mg_2SiO_4 [7, 8]melts have been also performed making it possible to explore the structure and properties of liquids directly.

In this presentation, we report the results of molecular dynamics simulation of magnesium silicate melts under high temperature and high pressure using various simulation schemes such as Empirical Potential Molecular Dynamics (EPMD) [9]and First Principle Molecular Dynamics (FPMD) simulation[10] as well as Large-scale First Principle Molecular Dynamics (L-FPMD) simulation for a consistent understanding.

References

[1] T. Iitaka: High Pressure Science and Technology, **27**, 174 (2017).

[2] Y. Kono, *et al.*: Proceedings of the National Academy of Sciences, **115**, 1742 (2018).

[3] M. Murakami, *et al.*: Science, **304**, 855 (2004).

[4] T. Iitaka, *et al.*: Nature, **430**, 442 (2004).

[5] D.E. Fratanduono, *et al.*: Phys. Rev. B, **97**, 214105 (2018).

[6] D.K. Spaulding, *et al.*: Phys. Rev. Lett., **108**, 065701 (2012).

[7] T. Sekine, *et al.*: Science Advances, **2**, UNSP e1600157 (2016).

©2019. Japan Geoscience Union. All Right Reserved.

[8] S. Root, *et al.*: Geophys. Res. Lett., **45**, 3865 (2018).

[9] F.J. Spera, *et al.*: Geochim. Cosmochim. Acta, **75**, 1272 (2011).

[10] L. Stixrude, *et al.*: Science, **310**, 297 (2005).

Keywords: magnesium silicate melts, liquid structure, phase diagram

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Takashi Yoshino(Okayama University)

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SIT23-01] In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

*William F McDonough[1], Bedrich Roskovec[2], Ondrej Sramek[3] (1.Tohoku University, Sendai, Japan, 2.Universidad Catolica de Chile, Santiago, Chile, 3.Charles University, Praha 8, Czech Republic)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SIT23-02] Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SIT23-03] Denoising S-Net Data to Image the Japan Trench: Comparisons to Alaska and Cascadia

*Claire Diane Doody[1,2], Qingkai Kong[1,2], William Scott[3], William Bythewood Hawley[1,2], Robert Martin-Short[1,2], Richard M Allen[1,2] (1.UC Berkeley, 2.Berkeley Seismo. Lab, 3.Imperial Coll. London)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SIT23-04] **Experimental confirmation of a spineloid transitional olivine polymorph using ultrafine-grained aggregates of Mg_2GeO_4**

*Thomas P. Ferrand[1], Takehiko Hiraga[1] (1.Earthquake Research Institute)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SIT23-05] Effects of fine-scale laminated heterogeneity on seismic anisotropy from long-period surface waves: Evaluation with two-dimensional waveform modelling

*Xu Yunao[1], Kazunori Yoshizawa[1,2], Takashi Furumura[3] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Japan , 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Japan, 3.Earthquake Research Institute, The University of Tokyo, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SIT23-06] **Redox kinetics of olivine revealed by diffusion profile of oxygen fugacity and its implication to the redox evolution of the uppermost mantle**

*Chengcheng Zhao[1], Takashi Yoshino[1] (1.Institute for Study of the Earth's Interior, Okayama University)

In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

*William F McDonough[1], Bedrich Roskovec[2], Ondrej Sramek[3]

1. Tohoku University, Sendai, Japan, 2. Universidad Catolica de Chile, Santiago, Chile, 3. Charles University, Praha 8, Czech Republic

Plate tectonics provides the framework for understanding the modern evolution of the crust and mantle system, with subduction zones linking these two major domains of the silicate Earth. Sediment recycling into the mantle at subduction zones is well established, although unknowns (e.g., past and present-day rates, amounts, depth of recycling, etc) remain significant. The present day subduction zone settings include ocean-ocean, ocean-continent, and continent-continent collisions and each of these likely have differing degrees of efficiencies of sediment recycling, as evidence by distinct differences in the remnants of meta-sediments exposed in fossil forearc regions of different collision zones. The retrieved metamorphic record of ocean-ocean and ocean-continent collision zones documents meta-sediments experiencing high-grade (granulite to eclogite facies) metamorphism. In contrast, continent-continent collisions return meta-sediments having experienced ultrahigh-grade (up to diamond facies) metamorphism. What is not known is the effectiveness of deep sediment recycling, past the magmatic zone, in each of these three different convergent margins.

Models that envisage successful subduction channel transport of upper crustal materials below 300 km depth, past a critical phase transition in buoyant crustal lithologies, are capable of accumulating and assembling these materials into so-called “second continents" that are gravitationally stabilized at the base of the Transition Zone, at some 600 to 700 km depth [Kawai et al., 2013]. Global scale, Pacific-type subduction (ocean-ocean and ocean-continent convergence), which lead to super continent assembly, were hypothesized to produce second continents that scale to about the size of Australia, with a maximum potential of continental upper crustal concentration levels of radiogenic power. Seismological techniques are incapable of imaging these second continents because of their negligible difference in seismic wave velocities with the surrounding mantle. We can image the geoneutrino flux linked to the radioactive decays in such hypothesized continental lithologies with land and/or ocean-based detectors. We present predictions of the geoneutrino signal for these continental lithologies, assuming different scaled models and show that the combination of the KamLAND-JUNO-Jinping neutrino experiments are strategically positioned to discover or constrain a predicted second continent beneath eastern China. The power emissions from such second continents were proposed to be drivers of super continental cycles. Thus, testing models for the existence of continental lithologies in the Mantle Transition Zone will place constraints on mantle and plate dynamics when using land and ocean-based geoneutrino detectors deployed at strategic locations.

Keywords: mantle transition zone, geoneutrino, second continent, heat producing elements, sediment subduction

©2019. Japan Geoscience Union. All Right Reserved.

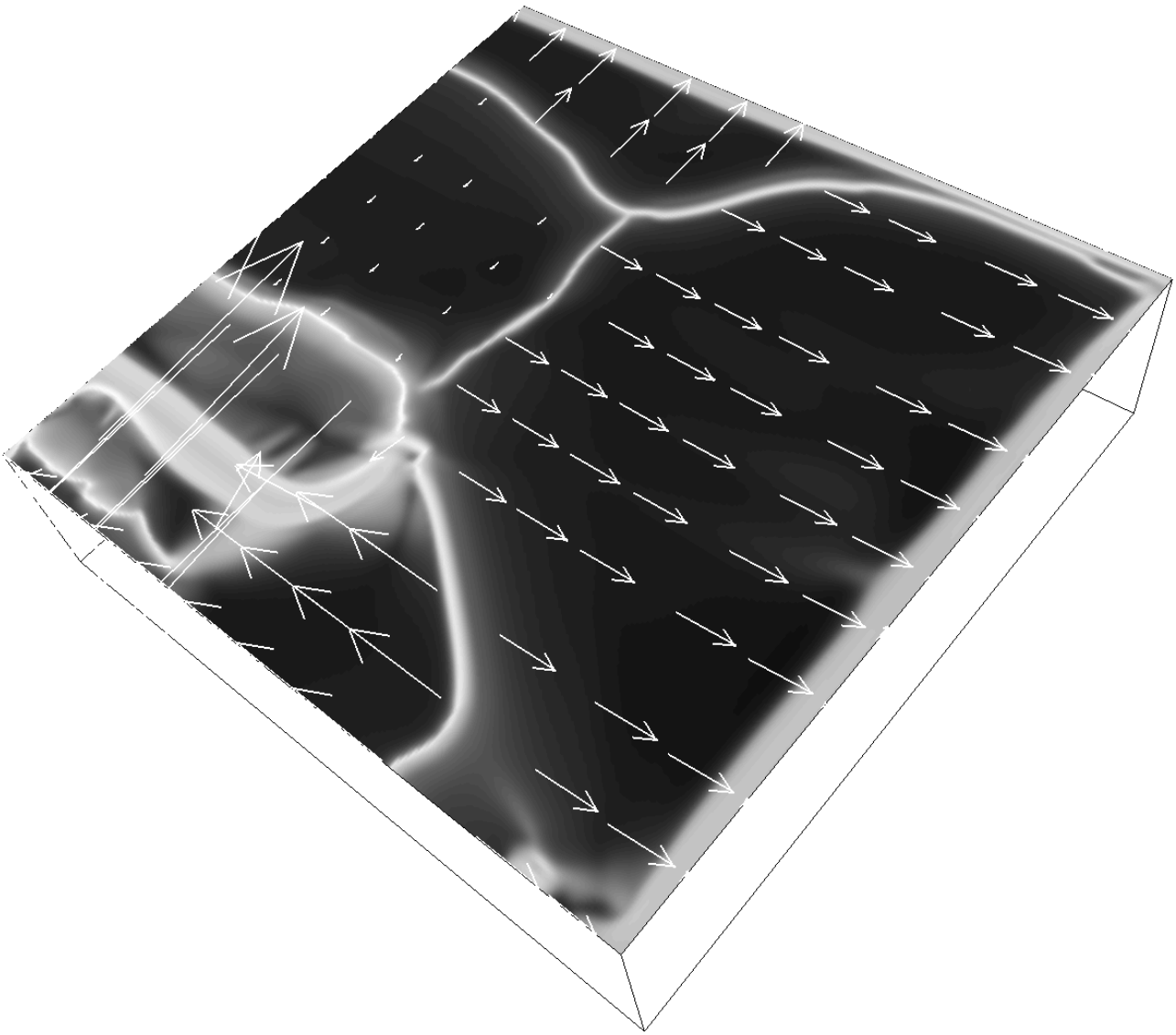
Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Ehime University, 3. University of Tokyo

We present a three-dimensional numerical model of plate tectonics (Figure 1; grayscale shows viscosity and arrow shows velocity). Tectonic plates steadily move on the Earth, because the lithosphere “remembers” the plate boundaries formed by its rupture that took place in the past: Once the stress in the lithosphere exceeds a threshold, the lithosphere is rifted, a sharp plate boundary develops, and the adjacent plates begin to rigidly move with respect to each other. This plate boundary and the resulting relative plate motion persist, even after the stress is reduced below the threshold around the plate boundary. We developed a model of this stress-history dependent nature of the rheology, and implemented the model to our three-dimensional numerical model of mantle convection (ACuTEMAN) in an internally heated rectangular box of 3000 km in depth and 12000 km×12000 km in horizontal dimensions. In our models, the lithosphere is rifted into several pieces, each of which rigidly moves and rotates, as observed for the Earth. The deformation of the lithosphere concentrates to narrow plate margins where the vertical component of rotation of the velocity field takes large values. The plate margins persist and allow the relative plate motion across the margin for billions of years. The heat flow takes a high value at spreading centers, and declines with the distance from the centers in their vicinity. Away from the centers, however, the heat flow tends to a steady value that is determined from the secondary convection that occurs beneath the tectonic plates as rolls with their axis aligned in the direction of plate motions.

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Denoising S-Net Data to Image the Japan Trench: Comparisons to Alaska and Cascadia

*Claire Diane Doody[1,2], Qingkai Kong[1,2], William Scott[3], William Bythewood Hawley[1,2], Robert Martin-Short[1,2], Richard M Allen[1,2]

1. UC Berkeley, 2. Berkeley Seismo. Lab, 3. Imperial Coll. London

The release of the S-Net data by NIED has created access to a wealth of information for seismologists. However, the S-Net data is inherently noisy due to its placement on the ocean floor. To suppress noise within the data, we have modified the deep-learning approach taken by Zhu et al., 2018 to denoise the S-Net data; we assembled data from on-land Hi-Net stations as the “clean” training dataset, and added the S-Net data as its noisy counterpart. This denoised data set is used to extract compressional wave arrival times to create a high-resolution image of the Japan Trench in hopes of better understanding the structure of the uppermost 200km of the mantle. The structure of the Pacific Slab is compared to Alaska and Cascadia to compare subduction zone features using identical methods. By directly comparing Japan, Alaska, and Cascadia, we seek to make a preliminary attempt at exploring comparable features in these subduction zones to work towards a more unified view of subduction zone processes.

Keywords: S-Net, Machine Learning, Japan Trench

©2019. Japan Geoscience Union. All Right Reserved.

Experimental confirmation of a spineloid transitional olivine polymorph using ultrafine-grained aggregates of Mg_2GeO_4

*Thomas P. Ferrand[1], Takehiko Hiraga[1]

1. Earthquake Research Institute

Ultrafine-grained aggreagtes of Mg_2GeO_4 were synthetized using spark plasma sintering and deformed using an 1-atm deformation rig between 950˚C and 1200˚C. Observations with SEM, EBSD, XRD and Raman together confirm that the samples consist of α-olivine with minor enstatite, with a grain size of 1-10 microns. Deformation data indicate an extreme softening of the material around 100 MPa in samples deformed at temperatures of 1000˚C or above. This softening is followed by a sharp hardening, suggesting that the fast deformation process ended.
The olivine-spinel transition in Mg_2GeO_4 occurs around 810˚C, and all experiments were done in the stability field of olivine. The deformation curves, supported by Raman and XRD data, suggest that ω-olivine, expected by Poirier in 1981, and observed in Mg_2GeO_4 within a meteorite in 2017, transiently forms during the deformation. ω-olivine is a spineloid metastable olivine, which does not have any stability field in a P-T diagram, but it might have one in a P-T-σ diagram. It was reproduced in the stability fields of β-olivine (Guyot et al., 1991) of γ-olivine (Reynard et al., 1994). Here I show that it can also form in the stability of α-olivine.
It seems that the transition occurs only between 1000˚C and 1150˚C when the stress approaches 100 MPa, as a result of a competition between diffusional and displacive processes.
The existence of ω-olivine in stressed mantle regardless of stability fields could have major consequences on how we understand the solid-state olivine-spinel transition and related earthquakes triggering. Below 1200˚C, if ω-olivine does not form then α-olivine is metastable.

Keywords: olivine-spinel transition, ω-olivine, mantle, laboratory, metastable, martensitic

©2019. Japan Geoscience Union. All Right Reserved.

Effects of fine-scale laminated heterogeneity on seismic anisotropy from long-period surface waves: Evaluation with two-dimensional waveform modelling

*Xu Yunao[1], Kazunori Yoshizawa[1,2], Takashi Furumura[3]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Japan , 2. Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Japan, 3. Earthquake Research Institute, The University of Tokyo, Japan

Recent seismic studies using long-period surface waves have revealed lateral variations of radial anisotropy in the lithosphere and asthenosphere (e.g., Nettles & Dziewonski, 2008; Yoshizawa, 2014). Such radial anisotropy estimated from long-period surface waves can be linked partly to the existence of fine-scale laminated structure suggested by recent high-frequency body wave studies (e.g., Kennett et al., 2017).

The aim of this study is to investigate quantitative relationship between such fine-scale laminated heterogeneity and observed radial anisotropy through synthetic experiments with numerical simulations of seismic wavefields. Quantifying the effects of fine-scale heterogeneity on total seismic anisotropy will allow us to estimate the proportions of “apparent anisotropy” (caused by heterogeneity) and “intrinsic anisotropy” (the elastic properties of the medium) that are generally mixed up in observed seismic anisotropy from long-period surface waves.

To investigate the effects of fine-scale laminated heterogeneity on long-period surface waves, we performed a series of 2-D finite-difference method simulations using velocity models with a variety of wavenumber spectrum of random heterogeneity based on von Karman distribution function with varying horizontally-elongated correlation scales. Following the earlier works of Kennett and Furumura (2008, GJI), we considered finely laminated heterogeneities with RMS 2% velocity deviations from PREM in the depth between Moho and 100 km. While the vertical correlation scale is fixed to 0.5 km in 2-D vertical structure along propagation paths, we have changed horizontal correlation scales from 10 km (as suggested by Kennett & Furumura, 2008) to 2000 km (almost equivalent to a 1-D velocity profile).

Using about 100 synthetic seismograms located at the epicentral distances between 2000 and 4000 km for each model, average phase velocities of the fundamental-mode Love and Rayleigh waves are measured using inter-station waveform fitting method (Hamada & Yoshizawa, 2015, GJI). By comparing the average inter-station phase velocities between different models, we investigate the effects of finely-laminated heterogeneity with various horizontal correlation length on the apparent radial anisotropy of surface waves.

Through these numerical experiments, we have found that the horizontal correlation length of laminated random heterogeneity strongly affects the apparent seismic anisotropy; i.e., extending the horizontal correlation length will make the apparent radial anisotropy greater. While the Love wave phase velocities are less affected by such random heterogeneity with any scales, Rayleigh wave phase velocities drop about 0.5-0.6 % slower than the isotropic case in the period range 40-70 s for a relatively long horizontal correlation length (2000 km). Such effects become weaker for a short horizontal scale (10 km), and phase velocity drop of Rayleigh waves is reduced to about 0.1 %. These results indicate that finely laminated heterogeneity with intermediate horizontal scale (several hundred kilometers or greater) may cause

©2019. Japan Geoscience Union. All Right Reserved.

non-negligible influence on phase velocity drop of Rayleigh waves, as suggested by observation of scattering and guiding of high-frequncy seismic waves traveling through lithosphere (e.g., Kennett & Furumura, 2015), generating apparent radial anisotropy of S-waves in the upper mantle.

Keywords: Heterogeneity, Seismic anisotropy, Forward modelling, Surface waves

©2019. Japan Geoscience Union. All Right Reserved.

Redox kinetics of olivine revealed by diffusion profile of oxygen fugacity and its implication to the redox evolution of the uppermost mantle

*Chengcheng Zhao[1], Takashi Yoshino[1]

1. Institute for Study of the Earth's Interior, Okayama University

The evolution of the redox state of the mantle through time has been a focus of hot debate. Recent study implies that the redox budget of the slab may not be significantly changed during subduction [1]. Thus, ferric iron transported by oxidized slab is expected to change the redox state of the upper mantle. However, concentrations of Cr, V, and the V/Sc ratio of the oldest known rocks indicate that the upper most mantle has remained at approximately FMQ over the past 3.5 Gyrs [2, 3]. Therefore, it seems that although oxidized slab is continuously subducted into mantle, the redox state of the upper mantle does not change systematically. It is possible that the mantle represents an almost infinite buffer reservoir and renders the addition of oxidized slab ineffective. On the other hand, the possible extremely slow reaction speed between slab and the uppermost mantle materials might disable the oxidized component to be an effective redox changer. However, the mechanism of the interaction between them remains unclear, which is of great urgent to investigate.

Olivine (MgO, SiO_2 and Fe_2O_3 oxide mixture) with 5 wt% Pt powder used as oxygen sensor was first synthesized using gas mixture furnace at iron-wustite (IW) buffer and Ni-NiO (NNO) buffered condition at 1300 °C. Diffusion couple method is adopted to investigate the redox kinetics of olivine, within which pre-sintered piece of oxidized and reduced olivine was stacked face to face. Diffusion experiments were conducted for different durations at 1 GPa, 1100-1300 °C using piston cylinder apparatus. After recovery, oxygen fugacity profiles were calculated from iron fraction in Pt alloy and iron content in olivine measured by EPMA [4]. Diffusion coefficients were obtained using Boltzmann-Matano method through fitting and calculation of iron content in Pt alloy as a function of distance from Matano interface. Water content after diffusion was measured using FTIR.

Except one couple, the water content of all the other couples shows < 10 wt. ppm. Redox process in olivine could be viewed as a diffusion-controlled process. Diffusion coefficient in oxidized olivine shows obvious oxygen fugacity dependence, while that in reduced one shows small dependence. The activation enthalpy is calculated to be 235 kJ/mol, which is comparable with that for Fe-Mg diffusion in olivine. However, the magnitude is 2-4 orders higher. Since the activation enthalpy and magnitude are comparable with that of diffusion of hydrous defects related to Mg-vacancies [5], it is possible that even extremely small amount of water could dominate redox kinetics in olivine. The diffusion length calculated indicate that the influence exerted by slab on the reduced mantle is very limited (< 4 km at 1600 °C even for 4500 Ma’ s stagnation in the upper mantle). Therefore, it is possible that the extremely slow redox process prevents subducted slab to change the redox state of the upper mantle. Once subducted more, the oxidized slab can bring redox budget to deep mantle as it keeps dry condition.

[1] Lee, C.A., et al., *Nature*, 468, 681 (2010). [2] Canil, D., *Earth Planet. Sci. Lett.*, 195, 75 (2002). [3] Li, Z.A. and Lee, C.A., *Earth Planet. Sci. Lett.*, 228, 483 (2004). [4] Faul, U.H., et al., *Phys. Chem. Mineral.*, (2017). [5] Padron-Navarta, J.A., et al., *Earth Planet. Sci. Lett.*,392, 100 (2014).

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Redox kinetics , Olivine, Diffusion , Subducting slab, Upper mantle

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Dapeng Zhao(Tohoku University)

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SIT23-07] Reactive Melt Channelization in the Earth's Mantle

*Matej Pec[1], Benjamin Holtzman[3], Mark Zimmerman[2], David Kohlstedt[2] (1.Massachusetts Institute of Technology, 2.University of Minnesota, 3.Lamont-Doherty Earth Oservatory, Columbia University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SIT23-08] Deep structure and origin of the intraplate volcanoes in Northeast Asia

*Dapeng Zhao[1] (1.Department of Geophysics, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SIT23-09] 3D passive-source reverse-time migration imaging of mantle discontinuities

*Yang Shen[1], Jiahang Li[1], Hitoshi Kawakatsu[2] (1.Graduate School of Oceanography, University of Rhode Island, USA, 2.Earthquake Research Institute, University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SIT23-10] Configuration of slab beneath Ogasawara Islands and P-wave time differences between high and low frequencies

*Keiko Kuge[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SIT23-11] Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2] (1.Hiroshima Univ., 2.Univ. Bayreuth)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SIT23-12] Crystal chemistry and compressibility of $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ silicate perovskites at pressures up to 95 GPa.

*Iuliia Koemets[1], Zhaodong Liu[2], Egor Gennadievich Koemets[1], Catherine McCammon[1], Artem Chanychev[1], Tomoo Katsura[1], Michael Hanfland[3], Aleksandr Chumakov[3] (1.Bayerisches Geoinstitut, Universitat Bayreuth, Bayreuth, Germany, 2.Jilin University, Changchun, China , 3.European Synchrotron Radiation Facility (ESRF), Grenoble Cedex, France.)

Reactive Melt Channelization in the Earth's Mantle

*Matej Pec[1], Benjamin Holtzman[3], Mark Zimmerman[2], David Kohlstedt[2]

1. Massachusetts Institute of Technology, 2. University of Minnesota, 3. Lamont-Doherty Earth Oservatory, Columbia University

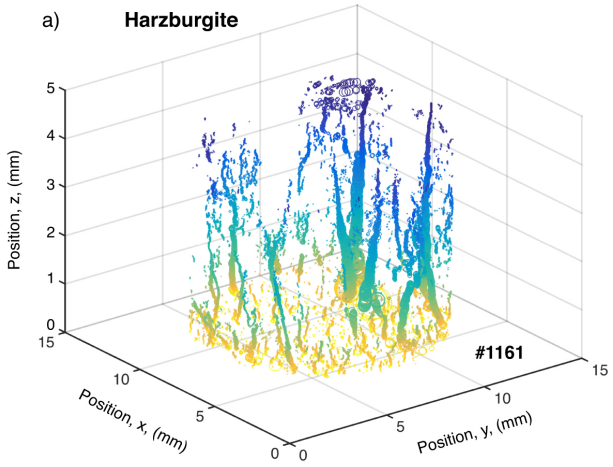
The formation of oceanic plates requires extraction of large volumes of melt from the mantle. Several lines of evidence suggest that melt extraction is rapid and, therefore, necessitates high-permeability pathways. Such pathways may form as a result of melt-rock reactions.

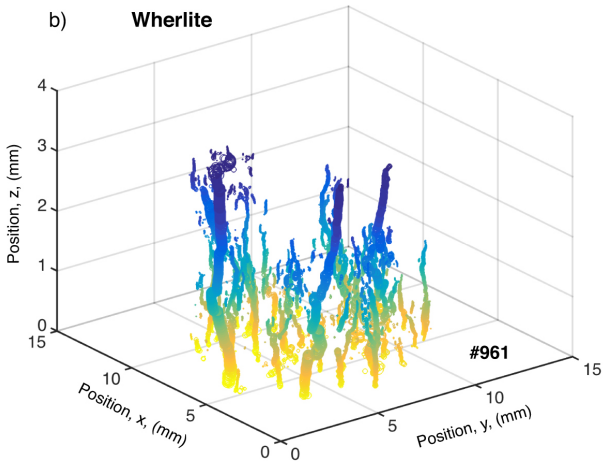
We report the results of a series of Darcy-type experiments designed to study the development of channels due to melt-solid reactions in mantle lithologies. We sandwiched a partially molten rock between a melt source and a porous sink and annealed it at high pressure (P = 300 MPa) and high temperatures (T = 1200˚ or 1250˚C) with a controlled pressure gradient ($\partial P/\partial z$ = 0-100 MPa/mm). To study the influence of lithology on the channel formation, we synthesized partially molten rocks of harzburgitic (40:40:20 Ol –Opx –basalt), wherlitic (40:40:20 Ol –Cpx –basalt) and lherzolitic (65:25:10 Ol –Opx –Cpx) composition. The melt source was a disk of alkali basalt.

In all experiments, irrespective of the exact mineralogy, melt - undersaturated in silica - from the source dissolved pyroxene in the partially molten rock and precipitated olivine (~Fo_{82}), thereby forming a dunite reaction layer at the interface between the source and the partially molten rock. In samples annealed under a small pressure gradient, the reaction layer was roughly planar. However, if the velocity of melt due to porous flow exceeded ~0.1 μm/s, the reaction layer locally protruded into the partially molten rock forming finger-like, melt-rich channels in rocks of wherlitic and harzburgitic composition. The lherzolitic rocks were generally impermeable to the melt except at highest pressure gradients where a narrow fracture developed, forming a dyke which drained the melt reservoir. Three-dimensional reconstructions using micro-CT images revealed clear differences between the dyke (narrow, through-going planar feature) and the channels formed by reactive infiltration (multiple sinuous finger-like features). Apparently, the fraction of soluble minerals together with the melt fraction in the partially molten rock control whether dykes or reactive channels develop. Our experiments demonstrate that melt-rock reactions can lead to channelization in mantle lithologies, and the observed lithological transformations broadly agree with those observed in nature.

Keywords: melt - rock reaction, mantle, melt migration

©2019. Japan Geoscience Union. All Right Reserved.





©2019. Japan Geoscience Union. All Right Reserved.

Deep structure and origin of the intraplate volcanoes in Northeast Asia

*Dapeng Zhao[1]

1. Department of Geophysics, Tohoku University

We have investigated the detailed mantle transition zone (MTZ) structure beneath the active Changbai intraplate volcano in NE Asia by using seismic tomography and receiver-function methods. Teleseismic receiver functions recorded at many broadband stations are obtained by using a common-conversion-point stacking method. For conducting the time-to-depth conversion, we use a 3-D velocity model of the study region so as to take into account the influence of structural heterogeneities. Our results reveal significant depth variations of the 410, 520, and 660 km discontinuities. A broad depression of the 410 km discontinuity and a low-velocity (low-V) anomaly are revealed beneath the Changbai volcano, which may reflect a large-scale hot mantle upwelling around the 410 km discontinuity with a positive Clapeyron slope. The 520 km discontinuity is identified clearly, and its uplift occurs above the stagnant Pacific slab. We also find a prominent depression of the 660 km discontinuity, which is elongated along the trend of deep earthquake clusters in a range of 39˚N–44˚N latitude, and the depression area has a lateral extent of about 400 km. Because the 520 and 660 km discontinuities correspond to positive and negative Clapeyron slopes, respectively, we think that the 520 uplift and the 660 depression are caused by the cold subducting Pacific slab. A part of the Pacific slab may have penetrated into the lower mantle and so caused the large-scale 660 depression in front of the deep earthquake clusters. Our results also reveal a part of the upper boundary of the subducting Pacific slab in the MTZ.

High-resolution P-wave velocity (Vp) tomography of the upper mantle beneath NE China is obtained by inverting teleseismic P-wave travel-time data recorded by two dense linear arrays. The inclusion of the new data set has greatly improved sampling of the upper mantle beneath the study region, providing tight constraints on the seismic structure under the intraplate Wudalianchi and Halaha volcanoes. Local-scale low-Vp anomalies are revealed in the shallow mantle beneath the two volcanoes, whereas a large-scale high-Vp zone is imaged in the MTZ. These new results suggest that the two volcanoes, though located at different sites above the stagnant Pacific slab in the MTZ, are likely related to the deep subduction and dehydration of the Pacific slab, possibly through hot and wet upwelling in the big mantle wedge beneath Wudalianchi and through deeper hydrous upwelling related to slab avalanche beneath Halaha. Our results also reveal other striking features, such as high-Vp anomalies resting atop the 410-km discontinuity beneath the Great Xing'an Range and the Songliao Basin, which are attributed to detached continental lithosphere. The delamination most likely occurred in the Cretaceous, which induced widespread magmatism in NE China.

References

Tian, Y., H. Zhu, D. Zhao et al. (2016) Mantle transition zone structure beneath the Changbai volcano: Insight into deep slab dehydration and hot upwelling near the 410-km discontinuity. *J. Geophys. Res.* 121, 5794-5808.

Wei, W., J. Hammond, D. Zhao et al. (2019) Seismic evidence for a mantle transition zone origin of the Wudalianchi and Halaha volcanoes in Northeast China. *Geochem. Geophys. Geosyst.* 20, 398-416.

Zhao, D., Y. Tian (2013) Changbai intraplate volcanism and deep earthquakes in East Asia: A possible link? *Geophys. J. Int.* 195, 706-724.

Zhao, D., Y. Isozaki, S. Maruyama (2017) Seismic imaging of the Asian orogens and subduction zones. *J.*

©2019. Japan Geoscience Union. All Right Reserved.

Asian Earth Sci. 145, 349-367.

Keywords: Intraplate volcano, mantle structure, seismic tomography

©2019. Japan Geoscience Union. All Right Reserved.

3D passive-source reverse-time migration imaging of mantle discontinuities

*Yang Shen[1], Jiahang Li[1], Hitoshi Kawakatsu[2]

1. Graduate School of Oceanography, University of Rhode Island, USA, 2. Earthquake Research Institute, University of Tokyo

With the advance of computational power and deployment of dense seismic networks, wave-equation-based imaging methods, which account for wave multi-pathing, scattering and focusing/defocusing, have become increasingly practical and advantageous for imaging complex crustal and mantle discontinuity structures. Over the past few years, we have developed a 3D passive-source reverse-time migration (3D PS-RTM) method using scattered and converted earthquake arrivals to image mantle discontinuities. Here we present results of its first applications in two different tectonic regions with different receiver settings and thus different applicable wave frequencies: The western U.S. centered on the Yellowstone and southwest Japan. Data processing involves selection of quality teleseismic events with epicentral distances of 28-98 degrees, calculation of vertical-, radial- and transverse-component receiver functions with an iterative deconvolution method, suppression of random noise using principle component analysis, and interpolation of wavefields recorded at stations onto numerical grids of the model surface. The P arrival and its coda, which contains the converted and scattered waves, are time reversed and back-propagated separately into the model via a finite-difference method. The back-propagated wavefields are decomposed into the P and S modes and their imaging condition reflects the convergence of the two modes at velocity interfaces or scatters. In the western U.S., the ~70 km station spacing of the USArray stations dictates that only intermediate- and long-period (>10 s) wavefields of teleseismic body-wave arrivals can be reliably reconstructed on the surface. Our RTM results show remarkably clear images of the 410-, 520- and 660-km discontinuities. The mantle transition zone is ~20 km thinner than the average of the transition zone beneath the western U.S. and the global average, an anomaly comparable to that beneath Iceland. The anomaly is centered ~100 km northwest of the Yellowstone hotspot in a 200 km by 300 km area, supporting the notion of a tilted mantle plume between the surface hotspot and the high temperature thermal anomaly in the transition zone. In contrast, we observe a ~40-km depression of the 660-km discontinuity, an indication of substantially lower mantle temperatures, beneath Nevada, where tomographic models reveal the presence of a subducted slab. In southwest Japan, the combined seismic stations from the Hi-net and other networks have a station spacing of 10-20 km, making it possible to reconstruct teleseismic body-wave wavefields on the surface at periods down to 2-3 s and thus achieve potentially much higher resolution than in Yellowstone. Teleseismic P waves for earthquakes with magnitude greater than 5.6 between 2004-2018 were collected from the Hi-net, F-net, JMA, and several university networks. Data processing and imaging are ongoing and preliminary results for southwest Japan will be presented at the meeting.

Keywords: passive-source reverse-time migration, mantle transition zone, receiver function, Yellowstone, Japan subduction zone, 3D wave simulation

©2019. Japan Geoscience Union. All Right Reserved.

Configuration of slab beneath Ogasawara Islands and P-wave time differences between high and low frequencies

*Keiko Kuge[1]

1. Department of Geophysics, Graduate School of Science, Kyoto University

Here I examine arrival time differences in P wave between high and low frequencies, and see a link with the configuration of the descending Pacific slab beneath Ogasawara Islands.

Furumura and Kennett (JGR 2005) showed that P and S waves from intraslab earthquakes beneath the Sea of Japan have low-frequency onsets followed by high-frequency long-duration signals, suggesting the result of small-scale quasi-laminar heterogeneity within the subducting Pacific slab. The late arrivals of high-frequency P and S signals are enhanced for earthquakes deeper than 400 km, probably, due to the low-velocity wedge in the slab (Furumura et al., JGR 2016). By exploring broadband seismograms of regional P waves from deep earthquakes (depth>300 km) worldwide, Ohata and Kuge (JpGU 2017) suggested a possibility of similar observations to Furumura’s in other western Pacific regions. Ohata and Kuge (JpGU 2018) showed the observations from deep earthquakes beneath Fiji and Kermadec Islands.

These previous studies indicate the presence of heterogeneity within the subducting Pacific slab that causes arrival time differences in P wave between high and low frequencies. This also suggests that time delay of high-frequency P waves can be used as a measure to find out if the P waves have traveled within a subducting slab. Based on the idea, I examined arrival time differences of P-wave peaks between high and low frequencies for deep earthquakes beneath Ogasawara Islands.

For an aftershock (USGS depth 678 km) of the isolated 2015 deep large earthquake, time differences of P-wave peaks between high and low frequencies were insignificant to the northwest and east. High-frequency P peaks from a deep earthquake in the nearby Wadati-Benioff zone were, however, delayed, compared with low-frequency ones. The Pacific slab is likely to be absent in the northwestern side of the aftershock. If the Pacific slab extends to the aftershock, its bend toward the east above the aftershock can explain the observation.

©2019. Japan Geoscience Union. All Right Reserved.

Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2]

1. Hiroshima Univ., 2. Univ. Bayreuth

Seismic anisotropy is a powerful tool for inferring dynamics in the Earth’ s interior and recently detected in the lower part (520-660 km depth) of the mantle transition zone (MTZ). The most plausible explanation for seismic anisotropy in the lower MTZ is crystallographic preferred orientation (CPO) of ringwoodite because ringwoodite is dominant in the region (~60 vol%) and has single-crystal anisotropy up to ~10% while the second dominant mineral (majoritic garnet, ~40 vol%) is elastically isotropic. Here we show that CPO of ringwoodite cannot account for seismic anisotropy in the lower MTZ by analyzing ringwoodite samples deformed at 17-18 GPa and 1300-1500 K with a deformation-DIA apparatus and by simulating ringwoodite deformation by viscoplastic self-consistent modeling. The deformed ringwoodite samples showed clear CPO patterns primarily attributed to dislocation glide with the 1/2<110>{111} slip system; however, calculated seismic anisotropy of the model mantle rock was less than 0.4%. To explain seismic anisotropy in the lower MTZ, akimotoite is necessary to exist in the lower MTZ, whose CPO can produce seismic anisotropy in this region. In this hypothesis, temperature in the lower MTZ should be lower than its present estimate by more than 200 K because akimotoite is stable at relatively low temperature.

Keywords: mantle transition zone, seismic anisotropy, ringwoodite, crystallographic preferred orientation, high pressure, deformation

©2019. Japan Geoscience Union. All Right Reserved.

Crystal chemistry and compressibility of $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ silicate perovskites at pressures up to 95 GPa.

*Iuliia Koemets[1], Zhaodong Liu[2], Egor Gennadievich Koemets[1], Catherine McCammon[1], Artem Chanychev[1], Tomoo Katsura[1], Michael Hanfland[3], Aleksandr Chumakov[3]

1. Bayerisches Geoinstitut, Universitat Bayreuth, Bayreuth, Germany, 2. Jilin University, Changchun, China , 3. European Synchrotron Radiation Facility (ESRF), Grenoble Cedex, France.

Bridgmanite is widely considered the most abundant mineral in the Earth’ s lower mantle. Its properties control the dynamics of this region and a large number of previous studies have been focused on the behaviour of bridgmanite at mantle conditions. Bridgmanite elasticity may be affected by chemical variations, presence of oxygen vacancies, and pressure-induced high-spin to low-spin transition in iron. In the case of bridgmanite, the effect of pressure-driven spin transitions on bulk modulus is complex, because iron could occupy different crystallographic sites and can occur as both ferrous and ferric iron. In addition, high-pressure experiments with silicate perovskite end-members could provide us with a self-consistent elasticity database and clarify spin transition impact on elasticity.

We investigate crystalline materials with two compositions, $FeMg_{0.5}Si_{0.5}O_3$ and $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$, recovered after experiments in Kawai-type multi-anvil apparatus. After full sample characterization in terms of chemical composition, crystal structure, and iron oxidation state, we performed a series of compressibility experiments in diamond anvil cells up to 95 GPa. During compression, we collected single crystal X-ray diffraction patterns as well as Mössbauer spectra, which allowed us to follow up changes in crystal chemistry and Fe spin state during compression.

Our compressibility study on the Al-rich sample together with previously published data allowed us to reconstruct $FeAlO_3$ end-member compressibility. We found that $FeMg_{0.5}Si_{0.5}O_3$ has a previously unknown structure: the low-pressure phase is corundum-related type (space group *R3*), and above about 15 GPa it transforms to a new silicate double-perovskite. An outstanding feature of the silicate double perovskite structure is two individual octahedral sites; one occupied by Si only, and the other by iron and magnesium. Combining single crystal X-ray diffraction data and results of Mössbauer spectroscopy, we were able to decipher the crystal chemistry behaviour of this phase during iron spin crossover, which is detectable by both compressibility changes of individual polyhedra and variation of Mössbauer hyperfine parameters.

Keywords: silicate perovskite, single crystal X-ray diffraction , Mössbauer spectroscopy

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS), Chairperson:Kensuke Konishi(Institute of Earth Sciences)

Most tomographic studies have been focused upon drawing maps of seismic velocity (SV) structures based on seismic data, with the ultimate goal of learning more about the structure and the composition of the mantle. Another key physical property that is accessible from seismic data is seismic attenuation (SA). Due to complications in isolating its intrinsic causes - e.g. local physical changes - and its extrinsic contributions - mainly scattering and other wave-propagation effects - SA has been underutilized. Yet, advances in waveform inversion have in association with recent enhancements of data permitted for a finer, more comprehensive determination of SA, opening the way to structural interpretations.
Difficulties in classifying and modelling the possible causes of intrinsic SA - e.g. temperature, melt, volatiles, and grain size - have also been raised. Increasingly, theoretical and experimental mineral physics have come to document the relationship between the behavior of SA and an assortment of other phenomena - most particularly, partial melt. These results can subsequently be used interpret seismological observations.
Seismic attenuation is critically implicated in structure, composition, and in fine mantle dynamics at the local, regional, and global scales. It may be used to constrain the existence of water in the transition zone; the presence of melt in various regions - for instance around subduction zones; and in the temperature field of the deep mantle - which would, in turn, help to resolve the chemical contribution to SV observed in this region.
In this session, we would like to discuss aspects of mantle attenuation, with the aim of sharing the current state of all relevant fields of study. We welcome contributions from different fields - in particular, from seismology, mineral physics, and geodynamics, as these may advance our mutual comprehension of SA and its implications; and lay the groundwork for future research and applications thereof.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT24-01] Anomalous Vp/Vs Ratios at Seismic Frequencies Might Evidence Highly Damaged Rocks in Subduction Zones

*Alexandre Schubnel[1], Lucas Pimienta[2], Marie Violay[2], Jérome Fortin[1], Hélène Lyon-Caean[1] (1.Laboratoire de Géologie, ENS PARIS, 2.EPFL, Switzerland)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT24-02] Imaging crustal seismic attenuation, central Taupo Volcanic Zone, New Zealand

*Stephen C Bannister[1], Sandra Bourguignon[1], Ted Bertrand[1], Cameron Asher[1] (1.GNS Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT24-03] New Constraints on Seismological Structures of the Oceanic Asthenosphere

★Invited Papers

*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1] (1.Earthquake Research Institute, University of Tokyo, 2.Kobe University, 3.JAMSTEC)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT24-04] Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

★Invited Papers

*Jerome Fortin[1] (1.Laboratoire de Géologie, Ecole Normale Superieure - Paris)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT24-05] Rock anelasticity due to grain boundary premelting
★Invited Papers

*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1] (1.Earthquake Research Institute, University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SIT24-06] Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

*Hatsuki Yamauchi[1], Yasuko Takei[1] (1.Earthquake Research Institute, The University of Tokyo)

Anomalous Vp/Vs Ratios at Seismic Frequencies Might Evidence Highly Damaged Rocks in Subduction Zones

*Alexandre Schubnel[1], Lucas Pimienta[2], Marie Violay[2], Jérome Fortin[1], Hélène Lyon-Caean[1]

1. Laboratoire de Géologie, ENS PARIS, 2. EPFL, Switzerland

Unusually high compressional (P) to shear (S) wave velocity ratios (Vp/Vs) were measured at different subduction zones and interpreted as fluid-pressurized regions. Because no laboratory data reported such high values in isotropic rocks, mineralogical or anisotropic constrains were assumed. However, fluid-saturated rocks' Vp/Vs is a frequency-dependent property so that standard laboratory measurements cannot be directly upscaled to the field. Using a new methodology, we measured the property in the elastic regime relevant to field measurements for diverse lithologies. We obtained extreme Vp/Vs values, consistent with those reported at seismic frequency in the field. Consistently with a model, it shows that if high fluid pressure is a key factor, anomalous Vp/Vs values could evidence intense degrees of microfracturation in isotropic rocks, whichever its mineralogical content. The permeability of these regions could be larger than 10^{-16} m^2.

Keywords: VP/Vs ratio, undrained / drained deformation, fluids

©2019. Japan Geoscience Union. All Right Reserved.

Imaging crustal seismic attenuation, central Taupo Volcanic Zone, New Zealand

*Stephen C Bannister[1], Sandra Bourguignon[1], Ted Bertrand[1], Cameron Asher[1]

1. GNS Science

Since 2009 we have deployed broadband and short-period seismometers across a 90 km by 55 km area in the central Taupo Volcanic Zone, New Zealand, encompassing part of the Okataina Volcanic Centre and the Kapenga (Ngakuru) graben, as well as more than 8 hydrothermal systems, including Rotokawa, Wairakei, Mokai, Ohaaki, Waikite, Waimangu, Rotomahana, and Rotorua. Seismic acquisition was carried out using rolling arrays occupying more than 60 sites, with an average spacing of 6-7 km.
We have now undertaken event detection and location analysis for c.900 earthquakes using the seismic data, inverting arrival times to derive 3-D volumes for Vp and Vp/Vs, and using spectral data from the best earthquakes to derive a 3-D volume for Qp (1/attenuation). Our path coverage and density is good between 2 kms and 8 kms depth, as visualised using calculated raypath density tensors, and as confirmed by synthetic modelling. We find low Qp (Qp<200) anomalies in the 3D volume have a strong association with low resistivity anomalies highlighted from magnetotelluric data collected in the same region, as well as with seismicity swarms; we link these features to partial melt and the effect of volatiles in the mid- and upper crust

Keywords: Seismic attenuation, Taupo Volcanic Zone

©2019. Japan Geoscience Union. All Right Reserved.

New Constraints on Seismological Structures of the Oceanic Asthenosphere

*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1]

1. Earthquake Research Institute, University of Tokyo, 2. Kobe University, 3. JAMSTEC

The oceanic lithosphere and asthenosphere are one of the most fundamental features in the plate tectonics. Oceanic asthenosphere is characterized by lower S velocity (lower Vs) and stronger S attenuation (lower Qs), which shows sharp contrast with oceanic lithosphere. These features have been primarily constrained by lower frequency surface waves observed in higher quality land data. To reveal higher frequency features (or frequency dependency) and P structures (or relative behavior of P and S anomalies), in-situ observations on the seafloor would be critical.

In this presentation, we present our recent results on new features revealed by our BBOBS observations. We deployed BBOBSs in the northwestern Pacific (NOMan project) during 2010-2014. Long term and in-sits observations enabled us quantitative inference on the frequency dependent attenuation and Vp/Vs structures of the oceanic lithosphere-asthenosphere system (LAS). We previously analyzed higher frequency scattered waves and reported that the attenuation in the oceanic lithosphere is weak and frequency dependent, while that in the oceanic asthenosphere is strong and frequency independent (Takeuchi et al., 2017, Science). We recently analyzed longer period P body waveforms and revealed Vp/Vs of the LAS. The results show that P velocity reduction in the asthenosphere is large (~6.1%) and is comparable with S velocity reduction observed by surface waves (~7%). The results suggest that Vp/Vs is comparable between the lithosphere and the asthenosphere.

The stronger attenuation and lower velocities in the oceanic asthenosphere has been previously attributed to either of partial melt (Anderson et al. 1970), elevated water content (Hirth and Kohlstedt 1996), or reduced grain size (Jackson amd Faul 2010). Grain boundary softening by solid-state-mechanism (Takei et al. 2014) and flaws in the regular atomic packing under oxidising condition (Cline et al. 2018) are also reported by recent laboratory experiments. It is not straightforward to propose the mechanism which reconcile all of our observations, however, at the time of presentation, we plan to discuss consistency and inconsistency of each mechanism with our results.

Keywords: Earth's internal structure, plate tectonics

©2019. Japan Geoscience Union. All Right Reserved.

Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

*Jerome Fortin[1]

1. Laboratoire de Géologie, Ecole Normale Superieure - Paris

Comparing ultrasonic measurements (1 MHz) in the laboratory and seismic (100 Hz) or logging (10 kHz) measurements at the field scale is not straightforward due to the dispersion of body-wave velocities. In rocks fully saturated by a Newtonian fluid, dispersion is related to fluid flow at different scales, separating three regimes: the drained, undrained, and unrelaxed regimes.

In this work, the elastic dispersion and attenuation of different sedimentary rocks have been measured over a large frequency range. To cover the frequency range, forced oscillations (0.004 to 100 Hz) and ultrasonic (1 MHz) measurement techniques were done in a triaxial cell, at various differential pressures, on samples saturated by fluids of very different viscosity. The forced oscillations include both hydrostatic and axial oscillations to deduce the bulk and Young moduli, respectively.

For all the samples, we observe the drained–undrained transition and its consequence on the attenuation and the elastic moduli dispersion. Biot-Gassmann’s theory is found to be valid to explained the increased of the elastic moduli from the drained to the undrained regime. Some samples exhibit a second transition from the undrained to the unrelaxed regime, and is explained a squirt-flow mechanism. For this second transition, the rock microstructure, especially the crack density and the crack aspect ratio seems to be the major contributor of the magnitude of the dispersion and attenuation.

Keywords: porous rock, velocity dispersion, squirt-flow

©2019. Japan Geoscience Union. All Right Reserved.

Rock anelasticity due to grain boundary premelting

*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1]

1. Earthquake Research Institute, University of Tokyo

Recently, rock anelasticity has become a matter of concern because it provides a solid-state mechanism causing seismic low velocity and high attenuation in the upper mantle (e.g., asthenosphere). It overcomes the difficulty to interpret the seismological observations in a consistent manner with the geochemical constraint that melt fraction possible in the partially molten mantle is very small (< 0.1%, e.g., Stracke et al., 2006, EPSL). Experimental data obtained in our laboratory by using a rock analogue (binary eutectic system of organic polycrystals) demonstrate the existence of such solid-state mechanism. Our experimental results show that anelastic relaxation by grain boundary sliding is significantly enhanced from just below the eutectic temperature Te (> 0.9Te), probably due to the occurrence of grain boundary premelting (Yamauchi & Takei, 2016, JGR, Takei, 2017, Ann. Rev.). We will report our recent experimental and theoretical approaches to understanding the mechanical consequences and underlying physics of premelting.

Temperature dependence of viscosity η and attenuation Q^{-1} of a rock usually follows the Arrhenius law: $\eta = \eta_0 \exp(H/RT)$ and $Q^{-1} = Q^{-1}(f/f_M)$ with $f_M = f_0 \exp(-H/RT)$. Then, temperature dependence of shear wave velocity V_S is calculated as $d\ln V_S/d\ln T = [d\ln V_S/d\ln T]_{anh} - 2(H/RT)Q_S^{-1}/\pi$, where the first and second terms represent anharmonic and anelastic effects, respectively. This equation has long been used in seismology [e.g., Anderson, 1989]. The temperature dependence, $d\ln V_S/d\ln T$, estimated from this equation by using the observed seismic attenuation Q_S^{-1} is small, indicating that seismic discontinuity cannot be explained by a solid-state mechanism. However, we found that the Arrhenius law starts to break down at the onset of premelting, causing much steeper reductions in V_S and in η than the expectations from the Arrhenius law. Our results show that not only low velocity and high attenuation, but also seismic discontinuity and weak asthenosphere can be explained by premelting, without invoking melt.

In order to clarify the physical mechanism of premelting, we applied to our data the thermodynamic model of grain boundary developed for a binary eutectic system (Tang et al., 2006, Phys. Rev. Lett.). The model predicts a significant increase in grain boundary disorder from just below the eutectic temperature. Such structural transition in grain boundary explains well the breakdown of the simple Arrhenius law in the mechanical properties controlled by the grain boundary diffusivity. In the Earth sciences, occurrence of grain boundary premelting has been known for ice (pure system), but not for a rock (multi-component system). Because a binary eutectic system is the simplest case of a multi-component system, our result indicates the occurrence of premelting in the mantle.

Keywords: anelasticity, grain boundary premelting, asthenosphere

©2019. Japan Geoscience Union. All Right Reserved.

Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

*Hatsuki Yamauchi[1], Yasuko Takei[1]

1. Earthquake Research Institute, The University of Tokyo

In the mantle wedges near subduction zones, seismic high attenuation $Q^{-1} > 0.01$ (or low $Q < 100$) is observed (e.g., Abers et al., 2014, G^3). Partial melting is generally considered as the main cause, but it is still difficult to interpret quantitatively how much melt exist there or how high temperature is. Although poroelastic effect of melt can be estimated theoretically (e.g., Takei, 2002, *JGR*), anelastic effect of melt is poorly understood. Recently, we experimentally captured that, when melt fraction is larger than 1%, anelastic relaxation of polycrystalline material is significantly enhanced by melt (Yamauchi and Takei, 2016, *JGR*). However, accurate measurement of the effect of melt on anelasticity is difficult, because a rapid grain growth occurs at the onset of melting, obscuring the effect of melt. In this study, we develop a new method to prepare samples suitable for the measurement of melt effect, perform the measurement, and establish a model of rock anelasticity applicable to the mantle both at subsolidus and supersolidus temperatures.

We use polycrystalline aggregates made from borneol + diphenylamine binary eutectic system (eutectic or solidus temperature T_m = 316 K) as a partially molten rock analogue. This system has an equilibrium microstructure similar to that of olivine + basalt system (Takei, 2000, *JGR*). Samples used in this study have a few wt% diphenylamine. Above T_m, all diphenylamine grains disappear into the melt phase. In Yamauchi and Takei (2016), to prevent the rapid growth of borneol grains during the mechanical tests at supersolidus temperatures, testing samples were pre-annealed at the supersolidus temperature ($T/T_m \simeq$ 1.03), cooled, and again partially molten to measure the melt effect without grain growth. In this previous experiment, quenched melt network remained even at $T/T_m < 1$. Therefore, the effect of microstructural change at $T/T_m = 1$ from dispersed diphenylamine grains to a connected melt network could not be examined. We have to improve the sample preparation method to clarify the effect of melt-network formation so that we can detect the existence/nonexistence of melt in the upper mantle by using the seismic data.

In this study, after partially melting a sample at supersolidus temperature ($T/T_m \simeq 1.03$) for grain growth, we kept the sample at just below the solidus ($T/T_m \simeq 0.99$) to promote the growth of diphenylamine grains from the quenched melt network. After 50-80 days, we successfully obtained a sample which is composed of large borneol grains and dispersed diphenylamine grains. We prepared two samples with melt fractions 4.5% and 3.7%. We will prepare an additional sample with different melt fraction. Using these samples, accurate measurements of elasticity at 1 MHz, anelasticity at 10^{2}-10^{-4} Hz, and viscosity will be performed at various temperatures from below to above the solidus temperature (T/T_m = 0.89 to 1.01). Data at $T/T_m < 1$ can be used to reproduce the subsolidus effect (due to grain-boundary premelting) captured in Yamauchi and Takei (2016). Data at $T/T_m \geqq 1$ can be used to clarify the melt effect. In the presentation, we will show these mechanical data and discuss seismological implications inferred from them.

Keywords: anelasticity, seismic high attenuation, partial melting, the effect of melt, melt network

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Yusuke Watanabe(Graduate School of Engineering, Kyoto University), Junichi Takekawa(Graduate School of Engineering, Kyoto University)

Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[STT42-01] Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

*Shimin - Zhou[1], Xinding - Fang[1] (1.Southern University of Science and Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[STT42-02] Fundamental study on hydraulic fracturing simulation with DEM under high pressure and temperature condition

*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.kyoto university)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[STT42-03] A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

★Invited Papers

*Junichi Takekawa[1], Hitoshi Mikada[1] (1.Graduate School of Science, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[STT42-04] Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

*Laszlo Olah[1], Hiroyuki K. M. Tanaka[1], Gergo Hamar[2], Dezso Varga[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Wigner Research Centre for Physics of the Hungarian Academy of Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[STT42-05] New development and operation of the EM-ACROSS: an investigation at Mount Kusatsu-Shirane

★Invited Papers

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Takahiro Kunitomo[3], Masato Fukai[1], Hiroshi Ichihara[2] (1.Earth and Planetary science, Tokyo Institute of Technology, 2.Graduate School of Environmental Studies, Nagoya University, 3.Nagoya University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[STT42-06] A feasibility study to identify supercritical geothermal reservoirs on southern Kyushu Island using DTS and DAS systems

★Invited Papers

*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3] (1.ENAA, 2.Daiwa Exploration and Consulting Co., 3.Kyoto Univ., 4.WELMA Co. Ltd., 5.Shizuoka Univ.)

Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

*Shimin - Zhou[1], Xinding - Fang[1]

1. Southern University of Science and Technology

In oil or gas exploration, sonic logging is a routine approach for formation evaluation. The drilling-induced stress redistribution around the wellbore can cause changes in the elastic properties of the near wellbore formations. This can make the sonic logging measurements deviate from the response of the virgin formations. The influence of borehole stress concentration on sandstones has been investigated by a number of researchers, we extend the study of this problem to anisotropic shale formations. To model the effect of borehole stress concentration on the elastic properties of shales, we need to first calculate the borehole stress distribution and then construct a rock physics modeling workflow to compute the changes in elastic properties under given stress conditions. We assume that shale formation is a transversely isotropic medium and its symmetric axis can be in an arbitrary direction with respect to the borehole axis. In our simulation, we first use the borehole stress solution of Amadei to calculate the stress distribution around the borehole, and then the elastic properties of the formation at each position around the wellbore is modified based on the local stress tensor by using a micro-crack rock physics model. The adopted rock physics model considers the influence of both intrinsic anisotropy and stress-induced anisotropy. This results in an inhomogeneous anisotropic borehole model that can reflect the effect of borehole stress concentration on near wellbore shale formations. Based on the proposed modeling workflow, we create a number of different scenarios that correspond to different shale formations and in-situ stress conditions, and then study the characteristics of the compressional and shear wave velocity variations in these situations.

Keywords: Sonic logging, borehole stress concentration, shale, rock physics modeling, in-situ stress

©2019. Japan Geoscience Union. All Right Reserved.

Fundamental study on hydraulic fracturing simulation with DEM under high pressure and temperature condition

*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. kyoto university

One of the most attractive topics in geothermal development is the realization of enhanced geothermal systems (EGS) in ductile zones. Thermal energy extraction from hot dry rock may require hydraulic fracturing through rocks in ductile zones, where rocks are supposed to deform in a ductile way due to the high pressure and high temperature (HPHT) conditions. One of the key factors in its realization is, therefore, to understand their mechanical behaviors of ductile rocks and of hydraulically created fractures under the HPHT condition, which have not been well investigated in the past.

Numerical simulations are widely accepted as one of the effective approaches to understand the mechanism of hydraulic fracturing, and numerical studies taking cooling effects from injected fluid on hydraulic fracturing into consideration have been conducted. Though distinct element methods (DEM) are frequently used to understand brittle failure or ductile deformation mechanism of rock in biaxial or triaxial compression tests, hydraulic fracturing simulations including both ductile behaviors and cooling effects due to injected fluid in the HPHT environment has not been fully investigated yet. Since the mechanical response to the fluid injection shows drastic changes at the brittle-to-ductile transition condition, incorporation of the transition behavior of granite into DEM is an essential step.

In this study, we demonstrated a series of hydraulic fracturing simulations with degradation approaches for the bond properties in DEM, i.e. bi-linear approximation model and degradation model, to replicate semi-brittle or ductile behavior at the HPHT condition including hydro-thermo-mechanical model. The numerical simulation results showed that results from bi-linear approximation model, which is suitable for replicating ductile behavior of granite, were consistent with laboratory experiment results under the HPHT condition. We can observe the cooling effect of rock mass due to injected fluid, while a considerable interaction between solid and fluid cannot be observed due to the shortness of injection time.

Keywords: Hydraulic fracturing simulation, Distinct Element Method, Ductility, Hydro-Thermo-Mechanical model, High Pressure and High Temperature, Geothermal Energy Development

©2019. Japan Geoscience Union. All Right Reserved.

A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

*Junichi Takekawa[1], Hitoshi Mikada[1]

1. Graduate School of Science, Kyoto University

Hydraulic fracturing technique has been widely used in the development of unconventional oil reservoirs and geothermal reservoirs. To prevent the induced fractures from closing, supporting materials (proppant) are pumped into the induced hydraulic fractures. The ultimate goal of hydraulic fracturing is to keep high conductive flow paths from the formation to the wellbore. Recently, a new technique has been proposed to improve the fracture conductivity by making open channels throughout the proppant pack. In this technique, fluid with and without proppant is alternately pumped into the well. This treatment creates discontinuous proppant pillars in a hydraulic fracture, and then, the fracture conductivity could be improved significantly. However, proppant slurry behavior inside the fracture still remains poorly understood.
In the present study, we applied a smoothed particle hydrodynamics (SPH) method to the fluid-solid interaction analysis in order to investigate proppant behavior inside the fracture. Our final goal is to establish analysis method for slurry behavior in hydraulic fractures. As a preliminary step toward the final goal, we simulate the Couette flow between coaxial cylinders to investigate the accuracy of the coupled simulation with the SPH method. We evaluate the L2-norm error as a function of the number of particles along the diameter of the inner cylinder. As a result, about 15 and 20 particles are required to achieve less than 15 % and 10 % error, respectively. Based on this result, at least 20 particles along the diameter of proppant grains should be used. In the future study, many effects (viscosity of fluid, grain shape, fracture roughness) on the efficiency of creating open channels will be investigated by using the proposed method.

Keywords: proppant, numerical simulation, particle method

©2019. Japan Geoscience Union. All Right Reserved.

Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

*Laszlo Olah[1], Hiroyuki K. M. Tanaka[1], Gergo Hamar[2], Dezso Varga[2]

1. Earthquake Research Institute, The University of Tokyo, 2. Wigner Research Centre for Physics of the Hungarian Academy of Sciences

Muography is an innovative imaging technique for investigation of large-sized natural and human-made objects based on the measurement of absorption rate of cosmic-ray muons [1]. The monitoring of mass density variation occured during volcano eruptions is a possible applicability of muography. The first large-sized, high-resolution muography observatory is under development based on Multi-Wire Proportional Chamber technology (MMOS) for monitoring of mass density variations in the vicinity of Minamidake crater of Mt. Sakurajima [2,3]. An automated analysis framework provides real-time data and allows analysis and visualization of the variations of muon flux and average mass density across the crater regions via a web-server [4]. The MMOS system consists of five tracking systems with the total surface of 4 square meters is operated at a distance of 3 kilometers from Showa crater in South-West direction since October 2018. The track rates are found stable within 3 % from the backward-direction, which demonstrates that the MMOS system is applicable to detect the average density variation well below the practical limit of about 5 %. We observed a decrease in average density across the West side of Minamidake crater during the ongoing data taking period, which suggests that the amount of material has decreased due to the consecutive occurred eruptions between 30th November 2018 and 11th of January 2019. The extension of MMOS system is scheduled up to the sensitive surface of 20 square meters between 2017-2021. The density-length variation of 5 (10) % is expected to be detected within 5-20 (2-8) days with 68 % confidence level with the designed muography observations system.

[1] H. K. M. Tanaka, L. Olah, Overview of Muographers, Phil. Trans. R. Soc. A 377, 20180143 (2019) https://doi.org/10.1098/rsta.2018.0143
[2] L. Olah, H. K. M. Tanaka, T. Ohminato, D. Varga, High-definition and low-noise muography of the Sakurajima volcano with gaseous tracking detectors, Scientific Report, 8:3207 (2018) https://doi.org/10.1038/s41598-018-21423-9
[3] L. Olah, H. K. M. Tanaka, G. Hamar, D. Varga, Investigation of the limits of high-definition muography for observation of Mt Sakurajima, Phil. Trans. R. Soc. A 377, 20180135 (2019) https://doi.org/10.1098/rsta.2018.0135
[4] L. Olah, H. K. M. Tanaka, G. Hamar, D. Varga, Muographic observation of density variations in the vicinity of Minami-dake crater of Sakurajima volcano, Journal of Disaster Research (submitted research article)

Keywords: Muography, Volcanology, cosmic-ray muon, density monitoring, gaseous detector

©2019. Japan Geoscience Union. All Right Reserved.

New development and operation of the EM-ACROSS: an investigation at Mount Kusatsu-Shirane

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Takahiro Kunitomo[3], Masato Fukai[1], Hiroshi Ichihara[2]

1. Earth and Planetary science, Tokyo Institute of Technology, 2. Graduate School of Environmental Studies, Nagoya University, 3. Nagoya University

The Electromagnetic Accurately Controlled, Routinely Operated Signal System (EM-ACROSS) is a specially designed system for controlled source electromagnetic investigation. The EM-ACROSS combines with a stable transmitter system and at least one receiver for obtaining the electric and magnetic field at the observation site. The core purpose of this system is a specifically designed signal which is repeatedly transmitted with high accuracy and precision to against the noise.

An initial experiment was made at Volcano Kusatsu-Shirane in 2017. We designed a superimposed signal with 10 geometric sequences frequencies, same amplitude and randomly chosen phase shift. A function generator, which was synchronized with a GPS clock, stored our designed waveform and sent the signal to an amplifier. There were two sets of grounded dipoles, north-south and east-west. After that signal was enlarged 80 times, the current was injected to the earth by one set of the grounded dipoles for at least 12 hours before switching. The amplifier was monitored and recorded by a digital data logger for obtaining the transmitter data. At the observation area, nine receivers measured the changing of electric and magnetic field. The data was processed by a simply stacking method in frequency domain. This initial experiment presented a good anti-noise ability at higher frequencies (between 1~5 Hz) and indicated a necessity of longer investigation for lower frequency band.

In 2018, we made a new development and operation of this system based on the result of initial experiment. The transmitter system had one more amplifier to inject both the grounded dipole sets at the same time. The chosen frequencies of superimposed signal were selected from the prime number as two sets of quasi-geometric series. The amplitude of lower frequency band was increased to against the noise floor. The system was operated three months for obtaining a better anti-noise ability in low frequency band. A new procedure of data processing was applied to eliminate the non-stationary and non-Gaussian noise. We used weighted stacking method to calculate the final electric and magnetic field.

Compare with the initial experiment, this investigation presents an obvious enhancement in lower frequencies. The large effect of non-Gaussian noise is reduced. A smaller error of the initialized electric field is acceptable for the modeling work.

Keywords: geophysical prospecting, geophysical techniques, controlled-source electromagnetics, signal design

©2019. Japan Geoscience Union. All Right Reserved.

A feasibility study to identify supercritical geothermal reservoirs on southern Kyushu Island using DTS and DAS systems

*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3]

1. ENAA, 2. Daiwa Exploration and Consulting Co., 3. Kyoto Univ., 4. WELMA Co. Ltd., 5. Shizuoka Univ.

Introduction: Supercritical water is drawing the attention of members of the global geothermal community as an important future renewable energy source for the world (*e.g.*, Dobson *et al.*, 2017). NEDO is promoting supercritical geothermal exploration as an important future energy source. There have been several efforts to use the fiber-optic distributed acoustic sensor (DAS). The DAS method is sensing strain or strain rate caused by seismic waves and the spatial resolution is a few meters. Because the temperature at the supercritical point is higher than 374 ˚C, ordinary geophones cannot be used in such supercritical conditions. In contrast, the optical fiber can be used at ~500 ˚C. We evaluated the usefulness of DAS technology on land and concluded that it is comparable to using geophones (Kasahara *et al.*, 2018a). In order to study supercritical water reservoirs, we carried out a simulation using full-waveform inversion (Kasahara *et al.*, 2018b). It was found that physical properties such as Vp, Vs, and density in the reservoir were well retrieved.

Field study: To evaluate the feasibility of our approach in a real geothermal field, we carried out a field study in the Medipolis geothermal field in Kyushu, Japan in fall, 2018. The fiber-optic cable was deployed down to a 977 m depth in the IK-4 borehole. We conducted the distributed temperature sensor (DTS) and DAS seismic measurements in the borehole using the same fiber-optic cable. We also installed 20 sets of three-component geophones along the 2 km long EW line at approximately 100 m spacing.

Results: The maximum temperature was measured as 264 ˚C at 914 m. The DAS data were obtained continuously at every 1 m for 4.5 days. Using the DAS system, we observed seven natural earthquakes between M0.8 and M5.2. The P-wave first arrival of the M5.2 earthquake was observed at the whole depth of 977 m to 0 m. Although the temperature at the 914 m depth was 264 ˚C, any evident seismic attenuation was not observed. In some earthquake records, some surface geophones show large amplitudes on horizontal components at 0.8 seconds after the P first arrivals in the vertical component. To estimate the vertical Vp profile of the surrounding area, we conducted a semblance analysis and obtained the Vp for every 100 m depth interval along the borehole. The Vp is estimated to be approximately 4 km/s and 3.3 km/s between 800–977 m, and between 500–800 m, respectively.

Discussion and conclusions: Although the temperature at a 914 m depth was as high as 264 ˚C, no significant attenuation of P arrivals was observed. The Vp profile in the borehole shows approximately 4 km/s between 800 m and 977 m. It seems no effects by the high-temperature zone. The reason for these measurements might be explained by the wavelengths of natural earthquakes being longer than the thickness of the high-temperature zone.

We observed seven natural earthquakes, but we did not see reflected phases from the deep reflectors. Surface geophones suggest the presence of P-to-S converted waves, and the conversion could be happening just below the study field. Although further studies are needed, the DAS system could supply a very dense vertical seismic array, and with the DAS seismic system and full-waveform inversion method, we could image the deep-seated supercritical geothermal reservoirs if they exist.

©2019. Japan Geoscience Union. All Right Reserved.

Acknowledgements: This study is supported by the New Energy and Industrial Technology Development Organization (NEDO). Medipolis Energy Co. kindly allowed the use of their IK-4 geothermal well for this study. Mr. Kimura provided us with the Schlumberger hDVS measurements. WELMA Co. provided us with the borehole fiber-optic system and measurement of temperatures in the borehole. The staff of West Japan Engineering Consultants, Inc., helped us during the field study.

Keywords: DAS, Geothermal field, Geothermal reservoir, Seismic monotoring, DTS, Passive seismic source

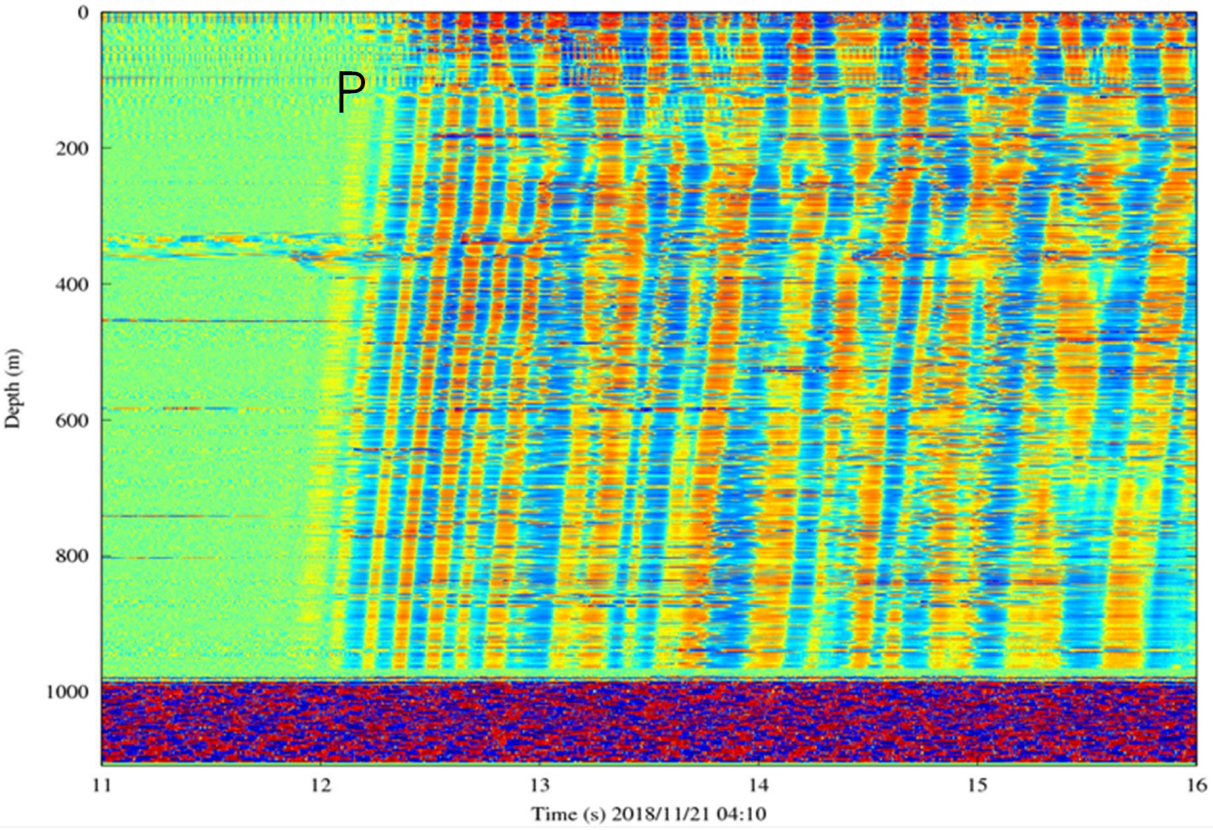


Figure : An M5.2 natural earthquake occurring 100 km focal distance and 123km focal depth recorded by the DAS. The vertical axis is depth from 0 m (top) to 977 m (bottom). The horizonal axis is the arrival time in seconds.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Junichi Takekawa(Graduate School of Engineering, Kyoto University), Yusuke Watanabe(Graduate School of Engineering, Kyoto University)

Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT42-07] The observation of active source and ambient noise signals with telecommunication fiber-optic cable in urban area

*Baoshan Wang[1], Xiangfang Zeng[2], Xiaobin Li[3], Weiwei Xu[4], Shanhui Xu[4], Zhenghong Song[1] (1.School of Earth and Space Sciences, University of Science and Technology of China, 2.State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, 3.Earthquake Agency of Yunnan Province, 4.Institute of Geophysics, China Earthquake Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT42-08] Comparison of RTM results of time-lapse imaging in foam-assisted EOR

*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT42-09] The estimation of physical properties of buried targets using the Cole-Cole equation in fictitious wave domain method

*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT42-10] Numerical investigation of permeability anisotropy in porous media using a particle method

*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT42-11] **Numerical Description of Flow Channel in Pipe Conduits Considering Solid-fluid Phase Shift with Lattice Boltzmann Method**

*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT42-12] Evaluation of anisotropic parameters using virtual cross-dipole data with full waveform approach

*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto Univesity)

The observation of active source and ambient noise signals with telecommunication fiber-optic cable in urban area

*Baoshan Wang[1], Xiangfang Zeng[2], Xiaobin Li[3], Weiwei Xu[4], Shanhui Xu[4], Zhenghong Song[1]

1. School of Earth and Space Sciences, University of Science and Technology of China, 2. State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, 3. Earthquake Agency of Yunnan Province, 4. Institute of Geophysics, China Earthquake Administration

The Distributed Acoustic Sensing (DAS) is a rapidly developing technique, which can provide dense (~ meters) seismic observations. Recently, several experiments were performed using specifically deployed fiber-optic cables, while the seismic observation with telecommunication fiber-optic cable in urban area is still challenging. A 5.2 km long telecommunication fiber-optic cable buried at about 30-cm depth in urban area is used to record active source shots and more than 10-hours continuous ambient noise. We are able to extract seismic signals with the telecommunication fiber-optic cable 9 km from the active source (~Ml0.7). The high-frequency (~ 10 Hz) Rayleigh wave signal emerges from the noise cross-correlation functions. The dispersion information of Rayleigh wave is inverted for Vs at the top 30 m and construct a 2D profile, which helps to assess ground shaking in this area.

Keywords: Urban Area, Telecommunication Fiber-optic Cable, Seismic Monitoring

©2019. Japan Geoscience Union. All Right Reserved.

Comparison of RTM results of time-lapse imaging in foam-assisted EOR

*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

Due to the demand of oil remains high in the world, enhanced oil recovery (EOR) plays an important role to optimize the oil production from existing reservoirs. Among the EOR methods, foam-assisted EOR, one of the chemical methods, has drawn attention for its enhancement in sweep efficiency and incremental oil recovery. Although the mechanisms of the foam-assisted EOR have been revealed both in macroscopic and in microscopic ways, methods for monitoring the movement of pore fluids in the reservoir have not been fully established yet. Since seismic waves bring the state variation of the pore fluids where seismic wave propagated, we hypothesized that seismic methods could capture the movement of pore fluids in the reservoir in the practice of the foam-assisted EOR. For testing this hypothesis, we conducted numerical experiments on the time-lapse monitoring of foam-assisted EOR using seismic methods. In the previous studies, our numerical results indicated that we could capture the position of foam and the advancement of injected fluids, i.e. foam, CO2, and water, using simple AVO (Amplitude Versus Offset) analysis, and we would like to locate the advancement of the injected fluids in the subsurface through the application of the reverse time migration (RTM) to time-lapse seismic exploration data. Although our results showed the effectiveness of the seismic exploration method, the effect of the recorded component (vertical and horizontal) on the imaging results has not been revealed yet. In our previous study, we only utilized the vertical component for RTM imaging, i.e. information comes from P-wave reflections were mainly used. It is known that wavelength of S wave is shorter than that of P wave, and therefore the improvement of resolution is expected by including S wave in seismic analysis. As horizontal component of recorded data is mainly derived from S waves, we compare the RTM results of horizontal component and vertical component of recorded data. Results of our numerical experiments show that RTM results using horizontal component show the position of advancement of the injected fluids more accurately than those of vertical component. The signals which cannot be seen in the results of vertical components are observed slightly. In this study, we confirm the difference of RTM visualization caused by the components of recorded data used in RTM, and indicate that integration of analyses of RTM results obtained from two components would help the interpretation of results.

Keywords: foam-assisted EOR, Reverse Time Migration, time lapse, numerical simulation

©2019. Japan Geoscience Union. All Right Reserved.

The estimation of physical properties of buried targets using the Cole-Cole equation in fictitious wave domain method

*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

Electromagnetic waves have been used for nondestructive measurements to investigate subsurface anomalies using its reflection. For example, we use Ground Penetrating Rader (GPR) survey to visualize shallow subsurface. Since the travel time of reflection signals tells us the position and the depth of objects in the subsurface, GPR survey has been widely used in many engineering fields.

On the other hand, it is still difficult for the conventional GPR survey to estimate physical properties of the subsurface targets, although there is great demand for estimating physical properties of buried targets has been increasing in recent years.

In our previous study, the possibility of estimating the physical properties of subsurface targets using the Cole-Cole equation has been shown when calculating the complex relative permittivity of the target media for the changes both in amplitude and in phase of the reflected EM waves. However, since the behavior of imaginary part of the complex relative permittivity against frequency usually shows its peak at the range of several GHz, the frequency band used for our proposed method would be limited.
Since the high frequency band, i.e. several GHz, is appropriate for the estimation of physical properties in the fictitious wave domain, we would like to see if the method is applicable to geoexploration of subsurface targets using the Cole-Cole equation. We discuss the validity of our previous conclusions based on the numerical results and try to propose survey methodologies to use the Cole-Cole equation.

Keywords: Cole-Cole equation, Fictitious wave domain method, Ground Penetrating Rader

©2019. Japan Geoscience Union. All Right Reserved.

Numerical investigation of permeability anisotropy in porous media using a particle method

*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

It is important to analyze fluid flow in reservoir rocks in the production of oil, gas, and any other fluidal unconventional resources. For reservoir analyses, we require information on hydraulic conductivity of reservoir rocks, which could theoretically be estimated using the Kozeny-Carman equation under the assumption of laminar flow in isotropic media. However, some numerical and laboratory experiments indicated that the subsurface materials show anisotropic feature in permeability. This indicates that it is important to consider anisotropy in reservoir analyses for accurate simulations. In the present study, we simulate fluid flow in three-dimensional models which imitate reservoir rocks by using a smoothed particle hydrodynamics (SPH) method and investigate the effect of porosity, viscosity on anisotropy of permeability.

We assumed four digital specimens which imitate porous media, through which fluid flows depending on pressure gradient in different directions. We measure average fluid velocity component in the direction parallel to the pressure gradient for calculating permeability. The results indicate that our digital specimens show permeability anisotropy in various degrees although the porosity of the specimen is kept constant.

Next, we compare our numerical results with theoretical formulas. Our calculated permeability has good agreement with those derived from theoretical equations when the porosity is high. On the other hand, in the case of low porosity, our results show large difference with the theoretical ones. Since dominant flow path is limited in low porosity specimen, the bulk permeability is directly affected by the anisotropic feature of the dominant flow path. Therefore, permeability of low porosity specimen is sensitive to the direction of fluid flow. Our results indicate that it is important to consider permeability anisotropy in reservoir analyses in view of the porosity of reservoir rocks.

Keywords: permeability, anisotropy, numerical simulation, particle method

©2019. Japan Geoscience Union. All Right Reserved.

Numerical Description of Flow Channel in Pipe Conduits Considering Solid-fluid Phase Shift with Lattice Boltzmann Method

*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

It is an essential task to secure the stable flow in metallic pipes for efficient energy production of fluid resources such as oil, gas and geothermal brine. One of the main obstacles to the efficient extraction of fluid is silica scaling which causes pipe clogging due to the precipitation of inorganic salts dissolved in geothermal fluid. Mineral deposition is observed not only in geothermal power plants but also in heat transfer systems of nuclear power plants. Moreover, the precipitation of asphaltenes and the hydrate formation in petroleum or gas pipelines, which are problems similar to silica scaling, deteriorate fluid motion through . As countermeasures against the scaling, pH adjustment for suppressing high molecular polymerization of dissolved silicates has been conducted, but it’ s still in a stage of trial and error. Although lots of experimental researches on scaling prediction have been done based on kinematical analysis on the chemical reaction in the process of silica deposition, the case where the polymerization rate of silicates is independent of temperature has also been confirmed and the limit of chemical approach has been pointed out.

Besides silica scaling, pipe thinning can be cited as a serious issue threatening the stable operation of energy production. This relates a phenomenon in which the piping loses its original function of fluid transport due to the alternation, wear or rupture as a result of interaction between metallic pipe and surrounding environment. Most of the past experimental works on pipe corrosion have focused on pH as a dominant factor of chemical reaction in the wall vicinity. However, it has been said to be difficult to accurately reproduce the actual reduction of pipe thickness in the case of complicated conduits such as elbow piping or downstream of orifice plates since hydrodynamic influence induced by the complicated flow field becomes dominant over the chemical melting effect.

In this research, we combine microscopic and macroscopic analyses which reflect the physical influence over a wide area on silica scaling and pipe thinning. As the simulation method of flow calculation and reactive boundaries between solid and fluid, we use the lattice Boltzmann method (LBM), which has advantages in parallel computation and arbitrary boundary settings. In the process of sequential calculation in the solid-fluid boundaries with LBM, an analogical algorithm of random selection and volume fractions for crystal growth is utilized. Both results of scale visualization and corrosion simulation showed good agreement with real data with high numerical stability. Our research suggested that applications of LBM is effective with regards to various flow analyses in pipe conduits with complex phase shift.

Keywords: LBM, Hydrodynamics, Scale, Corrosion

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of anisotropic parameters using virtual cross-dipole data with full waveform approach

*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto Univesity

Crack density and orientation in the subsurface dominates velocity anisotropy of S-wave. S-wave anisotropy estimation is also practically useful for the exploration and development of natural resources and understanding tectonics. The estimation of S-wave anisotropy is, therefore, a quite important clue to grasp subsurface stress field information from past to present. In spite of the importance of S-wave anisotropic parameter estimation, S-wave survey in the offshore is quite difficult because S-wave never propagates in the sea water. In our previous study, we proposed a novel analysis scheme in order to estimate S-wave anisotropic parameters with virtual cross-dipole data utilizing seismic interferometry from air-gun sources and a single tricomponent ocean bottom seismometer. However, there are still some limitations to apply our method because of some assumptions for anisotropic medium. In this study, we developed another novel analysis scheme, which combines our virtual cross-dipole method and a full-waveform inversion method. In the proposed method, we set 5 components of the stiffness matrix, anisotropic azimuthal angle and dip angle as estimated parameters. This strategy makes the inversion process stable. For a performance test of this scheme, we conducted simple numerical experiments with a numerical model containing an anisotropic target. The numerical results indicate that the proposed method could provide anisotropic information in the subsurface with sufficient accuracy.

Keywords: Seismic Interferometry, Cross-dipole survey, S-wave survey, S-wave anisotropy, Full waveform inversion

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | B (Biogeosciences) : B-PT Paleontology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Kotaro Hirose(Waseda University School of Creative Science and Engineering), Takashi Toyofuku

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BPT04-01] Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

★Invited Papers

*Takuma Suzuki[1], Hiroki Hayashi[1] (1.Shimane University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[BPT04-02] Mathematical models for the geochemical composition of foraminiferal calcium carbonate

*Jelle Bijma[1], Dieter Wolf-Gladrow[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[BPT04-03] Response of structurally substituted sulfur in foraminifera shells to glacial-interglacial changes: a 1.0-million-year record from the Ontong-Java Plateau

*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Synchrotron Radiation Research Institute, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Tohoku University Museum, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[BPT04-04] Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Center for Computational Sciences, University of Tsukuba, 3.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BPT04-05] Characterization of cogwheel structures in foraminifera

★Invited Papers

*Inge van Dijk[1], Markus Raitzsch[2], Gernot Nehrke[1], Jelle Bijma[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Am Handelshafen 12, Bremerhaven 27570, Germany, 2.MARUM - Zentrum für Marine Umweltwissenschaften, Universität Bremen, Leobener Str., 28359 Bremen, Germany)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BPT04-06] Benthic foraminiferal characterizations from the seascape point of view

*Hiroshi Kitazato[1] (1.Tokyo University of Marine Science and Technology (TUMSAT))

Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

*Takuma Suzuki[1], Hiroki Hayashi[1]

1. Shimane University

Body size is a key morphological attribute which has fundamental and significance information. For paleobiologic study based on fossil records, classification depends mainly on morphology of hard tissue. Previous studies noted that the temporal reduction in dominant size was observed in several fossil records when the taxon faced mass extinction or strong biostress.

This phenomenon was termed as “Lilliput effect” and appears to be ubiquitous to extinction events and occurs not only within unicellular and multicellular but also terrestrial and marine organisms, therefore it has a potential to make clear what the relationship between organism response and environmental fluctuation.

Then, a size analysis to investigate the phenomenon requires a lot of individuals of single taxon, therefore microfossil characterized by rich and successive abundance is more valid material than macrofossil. Particularly, planktonic foraminifera shows accretion growth by a adding new chamber on its penultimate chamber, therefore the size well reflects the ontogenic pattern.

The core samples we used in this study were drilled at the Integrated Ocean Drilling Program (IODP) Sites U1337 and U1338 consisting of the Pacific Equatorial Age Transect (PEAT) project, which was planned in order to obtain the Cenozoic successive geologic record. The stratigraphic interval of approximately 400 million years in Middle Miocene (15–11 Ma) was used for this study. This interval includes the transition from the relatively warm face (MCO: Miocene Climatic Optimum) to the colder mode with the expansion of the Eastern Antarctica Ice Sheet (EAIE: 13.8 Ma).

Keywords: Planktonic Foraminifera, Size, Giantism, Middle Miocene Climatic Optimum, Eastern Antarctic Ice-sheet Expansion

©2019. Japan Geoscience Union. All Right Reserved.

Long term diameter changing

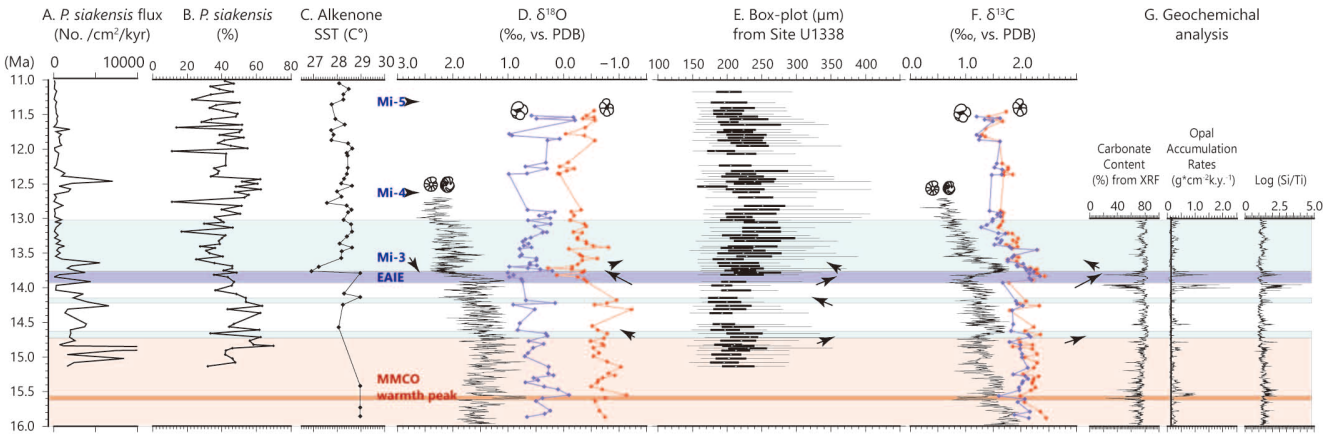


Fig.1 Temporal size changes are plotted with other previous data. A: Flux of *P. siakensis* at Site U1338 (Hayashi et al., 2013). B: Relative abundance of *P. siakensis* at Site U1338 (Hayashi et al., 2013). C: Alkenone SST data at Site U1338 (Rousselle et al., 2013). D: Stable oxygen isotope data. The black line represents benthic foraminiferal data at Site U1338 (Holbourn et al., 2014). The red line represents data for *P. siakensis* and the blue line does data for *Dentoglobigerina venezuelana* at Site U1337 (Matsui et al., 2017). E: Diameter of *P. siakensis* at Site U1338. F: Stable carbon isotope data. The color of each line is same as D. G: Geochemical data (Holbourn et al., 2014; Lyle et al., 2012).

©2019. Japan Geoscience Union. All Right Reserved.

Mathematical models for the geochemical composition of foraminiferal calcium carbonate

*Jelle Bijma[1], Dieter Wolf-Gladrow[1]

1. Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung

The isotopic compositions ($\delta^{11}B$, $\delta^{13}C$, $\delta^{18}O$) of foraminiferal calcium carbonate are used as paleo-proxies for pH, biological production, temperature or ice-volume. However, in order to interpret the observed isotopic values, one needs a process-based (`mechanistic´) understanding of the generation the proxy data. For this purpose, mathematical models have been developed. Because of missing detailed information about various processes involved in biomineralization these models were somewhat speculative despite their formulation based on physical and chemical principles. Application of these models in the framework of paleoceanographic simulations (generation of `simulated sediment cores´) can be used to test these models. I will discuss limitations of the models, open questions, and possible further developments.

Keywords: biomineralisation, foraminifer, geochemistry, numerical models

©2019. Japan Geoscience Union. All Right Reserved.

Response of structurally substituted sulfur in foraminifera shells to glacial-interglacial changes: a 1.0-million-year record from the Ontong-Java Plateau

*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Synchrotron Radiation Research Institute, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Tohoku University Museum, Tohoku University

During the Quaternary, the Earth’s surface has experienced large changes in the extent of glaciation, sea-level, and temperature. The preservation of biogenic carbonates in deep-sea sediments reflects changes in deep-water circulation and in rates of production of carbonate and organic carbon in the surface ocean. The response of carbonate alkalinity to glacial-interglacial cycles provides important constraints on past oceanic carbon cycles. Because the relative activity of sulfate ions to carbonate ions in the calcifying fluids would influence sulfate incorporation into $CaCO_3$, sulfate contents (or sulfur to calcium ratio) have been proposed as a potential archive of carbonate ion concentrations. However, the preservation of some trace elements in biogenic carbonates is highly susceptible to physicochemical conditions of sedimentation, thus the spatiotemporal variability of sulfur proxy in foraminiferal calcite is still under debate. Here we show a 1.0-million-year record of structurally substituted sulfur in foraminifera shells from the Ontong-Java Plateau. For this study, we used a synchrotron source micro-X-ray fluorescence (μ-XRF) as well as *K*-edge XANES to show the sulfur content and local coordination environment in mixed-species foraminifera. All chambers of foraminiferal shells were physically broken in a glass vial and then ultrasonically cleaned in de-ionized water, methanol, H_2O_2 and $HClO_4$. The μ-XRF measurements were taken at a photon energy of 3000.0 eV with an acquisition time of 5 s. The ratios of sulfur to calcium is calibrated using carbonate reference standards. The XANES spectra suggested that the sulfur in foraminifera shells is predominantly in structurally substituted sulfate, and S/Ca ratios fluctuate between 1.0 and 1.5 mmol/mol. The glacial-interglacial cycles were not clearly defined in sulfur contents between 0.9-0.6 Ma, whereas after 0.6 Ma, the emergence of quasi-100 ka cycles was observed. To place the sulfur record into paleoceanographic context, we compare the data with water mass, carbon cycle, and the preservation of foraminiferal calcite in deep-sea sediments.

Keywords: glacial-interglacial cycle, sulfur, foraminifera

©2019. Japan Geoscience Union. All Right Reserved.

Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3]

1. Center for Advanced Marine Core Research, Kochi University, 2. Center for Computational Sciences, University of Tsukuba, 3. Japan Agency for Marine-Earth Science and Technology

Foraminifera, a major group of biomineralizing eukaryotes, have two important roles in paleo and modern Earth environments. Firstly, foraminifers produce a large amount of calcium carbonate in pelagic realm due to their widespread distributions and high-biomass over the world oceans. Their calcification could largely impact on the global biogeochemical cycleof both CO_2 and calcium. The second point is that the foraminiferal shells have been preserved in marine sediments with an excellent fossil record, leading to reconstruction of Earth environmental changes in the past. Because foraminifers uptake the extracellular CO_2 from ambient sea-water during the shell-forming, these shells record the chemical condition of the ocean at that time. Therefore, many scientists have paid attention to the mechanism of foraminiferal biomineralization. The precise cell observations during the shell-forming process mentioned that the calcium ion and inorganic carbon were excreted from vesicles in the cell. Such intracellular storages of indispensable elements for calcification concern non-equilibrium state of calcium ion between sea-water and the shells. Even such studies tackled the biomineralization process, they emphasized the necessity of understanding cellular metabolism for foraminiferal biomineralization.
In order to reveal biomineralizing mechanism of foraminifers, we here present the gene expression profiles during the foraminiferal calcification for the first time. We used cultured specimens of *Ammonia beccarii*, which have hyaline calcite, and applied comparative transcriptomic survey by using high-throughput mRNA sequencing (RNA-seq). We performed *de novo* assembly using ~67 million pair-end reads of mRNAs, and then mapped back the reads to the open read frames (ORFs) for calculating the expression levels. From the results, we identified the candidate genes for the calcification process; Ca^{2+} is transported through multiple ion channels from an extracellular region and pooled in vesicles. These Ca^{2+} seem to play important role for mitochondrial ATP synthesis. We also found the genes coding enzymes, which are related to generate bicarbonate in a cell and to release it to extracellular. In taking account of the studies of cell observations, the present study figured out transportations of ions and molecules for calcification.

Keywords: calcification, single-cell eukaryote, gene expression

©2019. Japan Geoscience Union. All Right Reserved.

Characterization of cogwheel structures in foraminifera

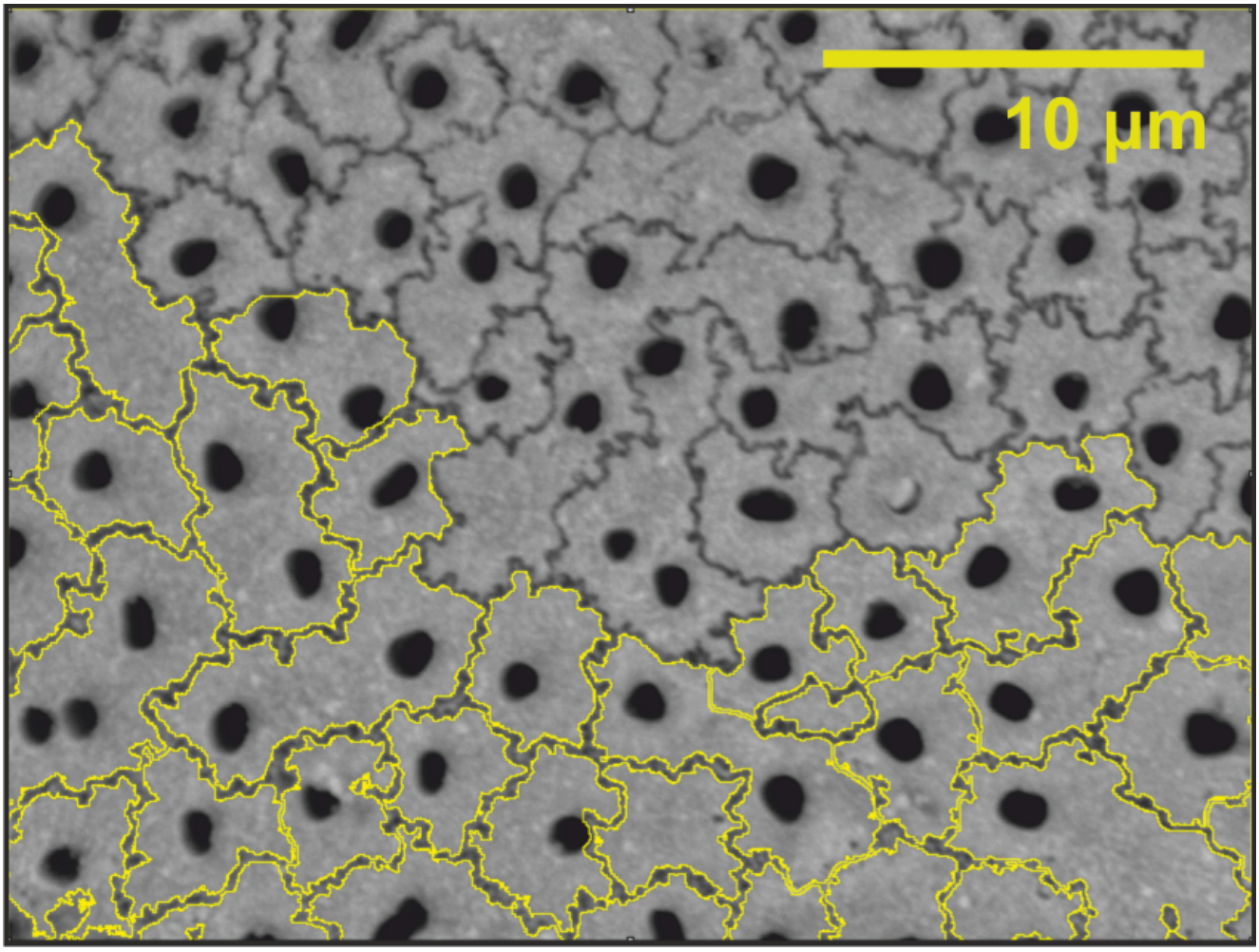
*Inge van Dijk[1], Markus Raitzsch[2], Gernot Nehrke[1], Jelle Bijma[1]

1. Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Am Handelshafen 12, Bremerhaven 27570, Germany, 2. MARUM - Zentrum für Marine Umweltwissenschaften, Universität Bremen, Leobener Str., 28359 Bremen, Germany

Studying biomineralization of foraminifera has become more popular over the last decade and is increasingly directed towards its linkage with element incorporation and isotope fractionation. The next step forward, is to investigate the “systematics” between structure (biomechanical constraints) and chemistry (biochemical constraints). We aim to catalogue species-specific variations in ultra-structures of foraminiferal shells, so-called cogwheels. These features, measuring in general 2-10 μm in diameter, vary greatly between species and become visible after slightly etching the surface of the shell. By using SEM pictures and the software “ImageJ” we can select and automatically measure different parameters of these cogwheels as well as of the pores. These structures will be compared within individuals (e.g. different chambers) as well as between different species. The ultimate goal is to link chemical (e.g. Mg content) to physical (e.g. shape and size) cogwheel properties. By investigating these combinations systematically and by linking them to phylogeny, we hope to find evolutionary patterns and to get insight into calcification mechanisms and geochemical controls. This will improve our mechanistic understanding of proxy incorporation and help to better interpret climate and environmental foraminiferal archives.

Keywords: Biomineralization, Foraminifera

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Benthic foraminiferal characterizations from the seascape point of view

*Hiroshi Kitazato[1]

1. Tokyo University of Marine Science and Technology (TUMSAT)

Benthic foraminifers dwell in bottom environments with habitat segregations. For instance, benthic foraminiferal species live on algal species according to exixting microhabitats such as fronds or thali of algae, or sediments in between fronds. Benthic foraminiferal species that are living with microhabitat segregations show specific characteristics such as feeding behaviors, living positions and test growth patterns according to microhabitat specific environmental characters . These characters are strongly affected by microhabitat specific microenvironments. During my presentation, I will compile group of microhabitats and their microenvironmental characters (Kitazato, 1994). Then, I try to explain how microhabitats segregation relate strongly with habitat specific adaptational tactics of foraminiferal species.
These landscape ecological approaches may have made clear species specific functional ecology of foraminiferal species groups.

Keywords: foraminifers, habitat segregation, seascape in the sea

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | B (Biogeosciences)：B-PT Paleontology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Jelle Bijma(AWI), 北里 洋

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BPT04-07] Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*Satoko Motai[1], Naotaka Tomioka[1], Jun Kawano[2], Saki Harii[3], Takaya Nagai[2], Tsuyoshi Watanabe[2], Yu Kodama[4], Motoo Ito[1] (1.Japan Agency for Marine-Earth and Technology, 2.Hokkaido University, 3.University of the Ryukyus, 4.Marine Works Japan)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[BPT04-08] Skeletal formation of scleractinian corals in response to Mg/Ca fluctuation

*Tomihiko Higuchi[1], Ikuko Yuyama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.University of Tsukuba)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[BPT04-09] **Inter-specific variations in trace element concentrations of modern brachiopod shells collected from Otsuchi Bay, Japan**

*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1] (1.Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, 2.Graduate School of Engineering and Science, University of the Ryukyus, 3.Graduate School of Environmental Studies, Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[BPT04-10] Trace element concentrations of sub-tropical modern brachiopod *Basiliola lucida* collected off Okinawa-jima, Japan

*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1] (1.Tohoku University, 2.University of the Ryukyus, 3.Advanced Industrial Science and Technology (AIST))

11:45 AM - 12:05 PM JST | 2:45 AM - 3:05 AM UTC

[BPT04-11] Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

★Invited Papers

*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4] (1.National Museum of Nature and Science, 2.Ehime University, 3.Tohoku University, 4.JAMSTEC)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC
Discussion

Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*Satoko Motai[1], Naotaka Tomioka[1], Jun Kawano[2], Saki Harii[3], Takaya Nagai[2], Tsuyoshi Watanabe[2], Yu Kodama[4], Motoo Ito[1]

1. Japan Agency for Marine-Earth and Technology, 2. Hokkaido University, 3. University of the Ryukyus, 4. Marine Works Japan

Skeletons of present-day reef-building scleractinian corals consist of aragonite which is one of polymorphs of calcium carbonate. Meanwhile, in the Late Cretaceous, scleractinian corals with two different skeletal mineralogies of aragonite and calcite have been identified (Stolarski et al., 2007; Janiszewska et al., 2017). Although a Cretaceous seawater Mg/Ca molar ratio (*m*Mg/Ca), which affects polymorph selection, of ~1 is a possible reason as to why corals formed calcitic skeletons, previous studies have shown that aragonite was still a major phase in modern symbiotic coral skeletons in a pseudo-Cretaceous sea (Reis et al., 2006; Higuchi et al., 2014). There should be other factors to explanation for the existence of calcite skeletons in such a sea. Our previous work (Motai et al., 2017) has reported that corals form calcite skeleton without a symbiotic relationship between the coral host and zooxanthellae in a pseudo-Cretaceous sea with *m*Mg/Ca ratios of ~1.

Juveniles of modern scleractinian corals (*Acropora* spp.) were cultured without symbionts (Motai et al., 2017). At approximately 26 ˚C, aposymbiotic corals formed entirely aragonite skeleton in the present sea with an *m*Mg/Ca ratio of ~5, whereas aposymbiotic corals formed entirely calcite skeleton in a pseudo-Cretaceous sea with an *m*Mg/Ca ratio of <1. Both aragonite and calcite skeletons have typical structures same as skeleton of symbiotic consisted of basal plates, septa, costae, and walls, in sub-millimeter scale under an optical microscope. To retrieve the effectiveness of different mineral phases on coral skeletal morphology in more fine scale, we have carried out textural observation utilizing a scanning electron microscopy for μm-scale area and a transmission electron microscopy for sub-μm scale area.

The aragonite skeleton consists of granular and needle-like grains less than ~1 μm. The needle-like grains are radially oriented from aggregates of granular grains. The similar microstructures are previously observed in skeletons of symbiotic coral. The components of granular and needle-like grains are called as centers of calcification (COCs) and fibers, respectively. On the other hand, calcite skeleton consists of needle-like grains with larger than ~2 μm in length and shows neither COCs nor fibers components. The difference in grain size and shape between aragonite and calcite skeletons affects their surface morphology: regular shingled thickening deposits with the width ~10 μm appear in aragonite skeletons, whereas no such morphologies are observed in calcite skeletons. Nevertheless, both of aragonite and calcite skeleton of aposymbiotic corals form similar skeletal structure to symbiotic coral skeletons. Therefore, scleractinian corals may control forming their typical skeletal structures despite of different textures and morphologies caused by different mineral phases.

Stolarski J., Meibom A., Przenioslo R., Mazur M., 2007, Science, 318:92–94
Janiszewska K., Mazur M., Escrig S., Meibom A., Stolarski J., 2017, Geology, 45:319–322
Reis J.B., Stanley S.M., Hardie L.A., 2006, Geology, 34:525–528
Higuchi T., Fujimura H., Yuyama I., Harii S., Agostini S., Oomori T., 2014, PLoS One 9014

©2019. Japan Geoscience Union. All Right Reserved.

Motai S., Kawano J., Harii S., Watanabe T., Nagai T., 2017, JpGU-AGU Joint Meeting

Keywords: reef-building coral, biomineralization, symbiotic algae, aragonite, calcite

©2019. Japan Geoscience Union. All Right Reserved.

Skeletal formation of scleractinian corals in response to Mg/Ca fluctuation

*Tomihiko Higuchi[1], Ikuko Yuyama[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. University of Tsukuba

Although coral skeletons generally comprise aragonite crystals, changes in the molar Mg/Ca ratio (*m* Mg/Ca) in seawater result in the incorporation of calcite crystals (Higuchi et al. 2014, Plos one). Also, we found temperature-dependent aragonite and calcite formation by scleractinian corals in low *m*Mg/Ca seawater (Higuchi et al. 2017, Geology). Corals produced more aragonite than formed in inorganic $CaCO_3$ precipitation experiments under the same conditions, except at 19 ˚C. Although the aragonite content reflected the results of the abiotic experiments at 19 ˚C, it is suggested that aragonitic scleractinian corals controlled skeletal formation biologically under low *m*Mg/Ca conditions at higher temperature. The mechanism of formation of aragonite and calcite crystals in coral skeletons was therefore investigated by RNA-seq analysis, using early growth stage calcite (*m*Mg/Ca=0.5) and aragonite (*m*Mg/Ca=5.2)-based corals (Yuyama and Higuchi, submitted). As a result, 1287 genes were up-regulated and 748 down-regulated in calcite-based corals. In particular, 91 skeletogenesis-related genes, such as Collagen alpha and Galaxin, were detected as up-regulated genes and 15, such as Hemicentin, were down-regulated, in low-Mg/Ca conditions. Since the number of down-regulated genes associated with the skeletal organic matrix of aragonite skeletons was much lower than that of up-regulated genes, it is thought that corals actively cause the skeletal organic matrix to construct an aragonite skeleton in low-Mg/Ca conditions. The results also indicated that different types of skeletal organic matrix proteins, extracellular matrix proteins and calcium ion binding proteins changed their expression in both calcite-formed corals and normal corals, suggesting that the composition of these proteins could be a key factor in the selective formation of aragonite or calcite $CaCO_3$.

Keywords: Aragonite-Calcite, scleractinian coral, Mg/Ca fluctuation

©2019. Japan Geoscience Union. All Right Reserved.

Inter-specific variations in trace element concentrations of modern brachiopod shells collected from Otsuchi Bay, Japan

*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1]

1. Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, 2. Graduate School of Engineering and Science, University of the Ryukyus, 3. Graduate School of Environmental Studies, Nagoya University

Carbon- ($\delta^{13}C$) and oxygen-($\delta^{18}O$) isotope composition and trace element to calcium ratios (Me/Ca; e.g., Mg/Ca and Sr/Ca) in biogenic carbonates have been used as a powerful tool for reconstructing paleoceanographic and paleoenvironmental conditions throughout the Phanerozoic. Rhynchonelliformea brachiopods, hereafter called “brachiopod”, are regarded as one of the excellent archives for the conditions because of (1) their extensive fossil records from the early Cambrian onwards, (2) their dense, low-magnesium calcite shells less susceptible to diagenetic alteration than aragonitic precipitates of marine calicifiers, and (3) the occurrence of modern analoguesin the oceans.For these reasons, $\delta^{13}C$ and $\delta^{18}O$ values of fossil brachiopod shells have been served as a major data source in many studies on paleoenvironments, especially those in the Paleozoic and Mesozoic. In contrast, Me/Ca in brachiopod shells has not been used as paleoenvironmental indicators because the relationship between shell chemistry and seawater composition and physical properties (e.g., temperature, salinity) are not well understood. This is at least partly due to difficulties in obtaining time-series of Me/Ca from modern brachiopod shells to compare directly with those in seawater chemistry (pH and carbonate system as well as Me/Ca) and the oceanographic properties at their growth sites.
We investigated inter-specific variations in Mg/Ca, Sr/Ca, Mn/Ca, and Fe/Ca in the shells of four modern brachiopod species collected from two different water depths in Otsuchi Bay, Japan, and established a new technique for converting distance domain Me/Ca profiles of the ontogenetic-series samples to the Me/Ca time-series. Mg/Ca of *Terebratulina crossei*is higher than that of the other species (*Laqueus blanfordi*,*Laqueus rubellus*, and *Terebratalia coreanica*). Significant correlations are found between Mg/Ca and $\delta^{18}O$ values of some samples. If the correlations are statiscally significant, regression equations established for Mg/Ca and seawater temperatures for brachiopod shells have steeper slopes and higher intercepts than those for foraminiferal tests. Sr/Ca profiles are likely different in their patterns among species even though they live at the same water depth. Mn/Ca and Fe/Ca of the all species are verylow or below detection limits.

Keywords: Modern brachiopod, Trace element concentration, Paleoenvironmental proxy, Otsuchi Bay

©2019. Japan Geoscience Union. All Right Reserved.

Trace element concentrations of sub-tropical modern brachiopod *Basiliola lucida* collected off Okinawa-jima, Japan

*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1]

1. Tohoku University, 2. University of the Ryukyus, 3. Advanced Industrial Science and Technology (AIST)

Trace element concentrations in biogenic carbonates have been widely used as an indicator for paleoceanographic conditions, such as seawater temperature, chemical and isotopic composition, and oceanic carbonate system. Since calcium carbonates ($CaCO_3$) are easy to treat and handle for their geochemical analyses, the combined use of trace element and isotopic ratios (e.g., Me/Ca and $\delta^{18}O$) analyzed from the same powder samples from calcareous fossils provides multi-proxy constraints on paleoenvironmental reconstructions. Brachiopods, one of the most crucial marine calcifiers throughout the Phanerozoic, have been regarded as key taxa for expanding our knowledge on the evolution of Earth's oceans and climate. Brachiopod-based paleoenvironments, however, have been mainly reconstructed from carbon and oxygen isotope composition, and the use of their trace element concentrations has been limited. Although some studies were conducted on within-shell variability of trace elements in modern brachiopod shells, it is still uncertain what environmental and/or physiological factors control the incorporation of trace elements into the shells and how precisely the shells record environmental signals of ambient seawater. In order to resolve these questions, it is necessary to compare trace element ratios of modern brachiopod shells with those in seawater along with oceanographic properties at the brachiopod growth site. This study investigates trace element concentrations in shells of a sub-tropical modern brachiopod, *Basiliola lucida*, collected to the west of Okinawa-jima, Ryukyu Islands, southwestern Japan. A previous study indicates no biological controls on carbon and oxygen isotope compositions of *B. lucida* shells. Since a large amount data were obtained on oceanographic conditions and seawater chemistry by scientific cruises of the Geological Survey of Japan of the National Institute of Advanced Industrial Science and Technology (AIST/GSJ) from this region, it is expected that we can specify primary factor(s) controlling the incorporation of trace elements into brachiopod shells.

Keywords: Brachiopoda, Trace element concentrations, Ryukyu Islands, Paleoenvironmental proxy

©2019. Japan Geoscience Union. All Right Reserved.

Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4]

1. National Museum of Nature and Science, 2. Ehime University, 3. Tohoku University, 4. JAMSTEC

Radiolaria, Foraminifera and Phaeodaria are classified to the supergroup Rhizaria. Most of radiolarians and phaeodarians commonly possess skeletons made of amorphous silica ($SiO_2 \cdot nH_2O$), and the overall appearance of some phaeodarians is similar to that of radiolarians. Previous studies, however, revealed the structural difference among the two groups: Phaeodaria generally have spaces inside of the skeleton, and its fine structure is porous. Whereas, Spumellaria (Radiolaria) have solid skeleton, and there are no spaces within the skeleton (Takahashi & Hurd 2008, Nakamura et al. 2018). This study further examines the structural distinction among these two rhizarians groups from the viewpoint of ultrafine and overall structures.
Zooplankton were sampled in from 2011 to 2018 at ca. 20 stations in the North Pacific and the Mediterranean Sea. Phaeodarians and radiolarians were picked up from the samples and identified by observing their morphology. Individual specimens were then analyzed by the following three methods: (1) Thin cross-sections of ca. 70–200 nm were prepared, and the ultrafine structures were observed with a Transmission Electron Microscope (TEM). (2) The framework of the whole skeleton was visualized with a Micro-Xray Computed Tomography (MXCT). (3) Living radiolarians and phaeodarians were cultured with HCK-123, a fluorescent reagent specifically reacting to silica-precipitating parts, and the skeleton formation process was observed.
(1) Detailed observation of thin cross-sections revealed that the skeletons of radiolarians (including the orders Nassellaria and Collodaria) had no space within the skeleton, while the skeletons of all the analyzed phaeodarians were porous. (2) This result was confirmed by the MXCT analysis. Radiolarian skeleton did not contain any spaces, while numerous spaces were observed inside of the phaeodarian skeleton. (3) The culture experiment clarified that radiolarians form their skeleton from the central part of the cell. However, phaeodarians first create new skeletons (daughter cells) with almost the same size as that of the mother cell. The new skeleton then becomes thicker by adding silica from the inside. One mother cell produced four daughter cells within 12 hours at the fastest, suggesting that phaeodarians can create new skeletons faster than radiolarians. Considering also the occasional high biomass of phaeodarians, this group would be able to rapidly increase their number when the environment becomes preferable.

Keywords: Cercozoa, protist, biomineralization, silica, plankton

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Shamil Maksyutov(National Institute for Environmental Studies, Japan), Pavel Groisman(NC State University, USA), Yoshihiro Iijima(Mie University, Japan)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS01-01] Progress and Opportunities in Measurement and Modeling of Arctic Carbon Cycling under a Changing Climate

★Invited Papers

*Qianlai Zhuang[1], Narasinha Shurpali[2], Torsten Sachs[3] (1.Purdue University, 2.University of Eastern Finland, 3.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS01-02] Potential climate change effects on biosystems in Siberia by the 2100s predicted from CMIP5

*Nadezhda Tchebakova[1], Elena Parfenova[1], Amber J Soja[2] (1.Sukachev Institute of Forests, Federal Research Center KSC, Siberian Branch, Russian Academy of Sciences, 2.National Institute of Aerospace, NASA Langley Research Center,)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS01-03] Climate Change and Permafrost Degradation in Northern Eurasia: Geographic Impact Assesment

*Dmitry A Streletskiy[1] (1.George Washington University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS01-04] Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales

*Alexander Olchev[1,2], Vadim Mamkin[2], Inna Rozinkina[3], Yulia Mukhartova[4], Mikhail Nikitin[3], Ekaterina Tatarinovich[3], Julia Kurbatova[2] (1.Lomonosov Moscow State University, Faculty of Geography , 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Hydrometeorological Research Center of Russian Federation, 4.Lomonosov Moscow State University, Faculty of Physics)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS01-05] **Changes in mountain glacier systems and the distribution of main climatic parameters on the territory of Russia (XX -XXI century)**

*Tatiana Khromova[1], Gennady Nosenko[1], Valeria Popova[1], Anton Muraviev[1], Stanislav Nikitin[1] (1.Institute of Geography Russian Academy of Sciences)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS01-06] Projection of changes in water balance components across irrigated lands of Central Asia using a high-resolution modeling system

*Anastasiia Pikaleva[1], Ekaterina Nadyozhina[1], Alexandra Sternzat[1], Boris Egorov[1], Sergey Efimov[1], Igor Shkolnik[1] (1.Voeikov Main Geophysical Observatory)

Progress and Opportunities in Measurement and Modeling of Arctic Carbon Cycling under a Changing Climate

*Qianlai Zhuang[1], Narasinha Shurpali[2], Torsten Sachs[3]

1. Purdue University, 2. University of Eastern Finland, 3. Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

Tremendous progress has been made in the observation and quantification of Arctic carbon cycling with various approaches. A session organized during the 2019 European Geoscience Union meeting showcased this progress with highlights from 17 studies representing different regions of the Arctic. A number of studies investigated the effects of soil freezing on carbon dioxide and methane production, consumption and emissions and the carbon budget in Arctic ecosystems using chamber and eddy flux tower observation techniques. Some of those studies focused on the role of moss, snow and permafrost thawing in carbon fluxes. There were studies that reviewed the methodology of measuring carbon fluxes from Arctic lakes, while several studies examined methane evasions from sea shelves and oceanic environments. Satellite and isotopic data as well as atmospheric transport and inversion modeling have been used in various studies. Several studies used earth system and biogeochemistry models to quantify methane fluxes and wetland area dynamics. The challenges of scaling up carbon balances in fragmented Arctic landscapes were presented, including characterizing and modeling landscape dynamics (e.g., peatland expansion). Based on these EGU session contributions and our own research progress, we present here observations and modeling results on Arctic carbon cycling and identify the challenges and opportunities in this field.

Keywords: Arctic, Carbon dioxide and methane , permafrost, wetlands and lakes, oceanic environment, earth system and biogeochemistry modeling

©2019. Japan Geoscience Union. All Right Reserved.

Potential climate change effects on biosystems in Siberia by the 2100s predicted from CMIP5

*Nadezhda Tchebakova[1], Elena Parfenova[1], Amber J Soja[2]

1. Sukachev Institute of Forests, Federal Research Center KSC, Siberian Branch, Russian Academy of Sciences, 2. National Institute of Aerospace, NASA Langley Research Center,

Regional Siberian studies have already registered climate warming over the last half century from 1960 to 2015 in Siberia. The CMIP5 model simulations show that by the end of the century Siberia would be characterized by a milder climate, with less permafrost coverage: temperature would increase by 3.4˚C (RCP 2.6 scenario) to 9.1˚C (RCP 8.5 scenario) in mid-winter and by 1.9˚C (RCP 2.6) to 5.7˚C (RCP 8.5) in mid-summer; and precipitation would increase by 60 mm (RCP 2.6) to 140 mm (RCP 8.5).

Our goal was to evaluate climate warming consequences for biological systems in Siberia by the 2080s. We developed and used large-scale bioclimatic models and statistical models to evaluate climate effects on vegetation shifts, changes in forest structure and productivity, drylands, agricultural benefits of warming, biotic disturbances, such as infestations of the Siberian moth (*Dendrolimus suprans sibiricus* Tschetv) and a related pathogen needle cast (*Lophodermium pinastri* Chev) in Siberia for the baseline period 1961-1990 and for the 2080s using the RCP 2.6 and RCP 8.5 scenarios of 20 general circulation models from CMIP5.

Principal results are:

Siberian forests are predicted to decrease and shift northwards and forest-steppe and steppe ecosystems are predicted to dominate 50% of Siberia due to the 2080 RCP 8.5 drier climate. Dark taiga would follow the permafrost retreat. Dahurian larch taiga would continue to dominate over continuous permafrost. New temperate broadleaf forest and forest-steppe habitats are predicted in the south;

Agriculture in Siberia would likely benefit from climate warming although potential croplands would be limited by the availability of suitable soils. Traditional crop production may increase by twofold and new crops (maize for grain, gourds) may be introduced in the south, depending on additional irrigation in a drier 2080 climate;

Biotic disturbances. Under the extremely warm RCP 8.5 scenario Siberian moth habitats would considerably shrink and be limited by the main food resources (*Larix spp., Abies sibirica, and Pinus sibirica*) and by future mild winters with frequent thaws that would damage the Siberian moth larvae. Needle-cast of *Pinus sylvestris* was found to be strongly related to precipitation including snow depth rather than summer temperature. In the predicted drier climate, it would shift northwards followed sufficient water and the tree-host *Pinus sylvistris* distribution;

Ecological Landscape Potential for human settlements would improve for 1 (RCP 2.6) to 2 (RCP 8.5) categories over most of Asian Russia, which could lead to a 5- to 7-fold increase in the capacity of the territory to sustain and become attractive to human populations and lead to increased migrations.

Keywords: climate change, CMIP5 , climate warming consequences , biological systems , Siberia

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Climate Change and Permafrost Degradation in Northern Eurasia: Geographic Impact Assesment

*Dmitry A Streletskiy[1]

1. George Washington University

The Arctic regions of Norther Eurasia are progressively warming. One of the major concerned of observed and projected warming is presence of permafrost. Limited permafrost observations show that following climatic trends permafrost is warming across the region. The active layer, the layer just above permafrost that is subject to seasonal thawing and freezing, is also increasing. These changes are important for many natural ecosystem processes and also critical in design of the infrastructure on permafrost. This work is utilizing latest available climate input and permafrost-geotechnical modeling in order to locate the areas where permafrost degradation and associated hazards may negatively impact critical infrastructure. The cost of various types of infrastructure is then used to estimate the monetary value of impacted infrastructure and to evaluate the ability of regions to absorb the cost required to maintain infrastructure on permafrost. The results can be used to inform decision makers and planers in areas occupied by permafrost.

Keywords: permafrost, climate change, economics , Arctic

©2019. Japan Geoscience Union. All Right Reserved.

Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales

*Alexander Olchev[1,2], Vadim Mamkin[2], Inna Rozinkina[3], Yulia Mukhartova[4], Mikhail Nikitin[3], Ekaterina Tatarinovich[3], Julia Kurbatova[2]

1. Lomonosov Moscow State University, Faculty of Geography , 2. A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3. Hydrometeorological Research Center of Russian Federation, 4. Lomonosov Moscow State University, Faculty of Physics

Effects of clear-cutting and forest disturbances on weather conditions and atmospheric fluxes at the local and regional scales were investigated by an aggregated approach that includes continuous field measurements of energy and CO_2 fluxes at the recently clear-cut area and in an undisturbed forest stand, as well as modeling experiments using process-based regional and local scale models. Field measurements of energy and CO_2 fluxes were provided at clear-cut area using the eddy covariance method over the three year period following harvest. Results showed a clear dependence of clear-cut net radiation and energy fluxes on surface albedo and amount of grassy and woody vegetation actively regenerated within the clear-cut area after the harvest. The energy budget of the clear-cut area is characterized by higher latent heat (LE) comparing with sensible heat (H) fluxes over the entire period of flux measurements. The seasonal pattern of the Bowen ratio (β=H/LE) is characterized by its gradual decrease from spring to summer. Whereas in the spring and in the first half of June the β value varied usually around 1.0, in the middle of summer the β value decreased to 0.3-0.5. The mean β values for period from May to October were 0.5 in 2016, 0.3 - in 2017 and 0.4 - in 2018. Analysis of cumulative Net Ecosystem Exchange (*NEE*) rates for the entire growing season from May to October for 2016, 2017 and 2018 years showed that the clear-cur area for the periods was a source of CO_2 for the atmosphere. Comparisons of the sensible and latent heat fluxes measured at the clear-cut area and in an undisturbed spruce forest stand situated not far away from the clear-cut area showed that the largest differences in sensible heat, H_2O and CO_2 fluxes between both sites were observed during the first year (2016) after timber harvesting, and were mainly influenced by differences in surface albedo (Mamkin et al 2019). Comparisons of the sensible and latent heat fluxes measured at the clear-cut area and in the spruce forest stand showed that in the undisturbed forest the latent heat fluxes are steadily exceeded the corresponding clear-cut fluxes even in periods with sufficient soil moisture conditions promoting active regeneration and growth of grassy and woody vegetation at the cleared area. Comparisons of the NEE components for the clear-cut and undisturbed spruce forest are revealed significant differences in NEE rates for the first year after forest clearing, and gradual decrease of their disparities in the following years. Whereas the clear-cut area during the first three years after timber harvesting is functioned as a CO_2 source for the atmosphere, the CO_2 balance of undisturbed mature spruce forest in the period was close to zero (Mamkin et al., 2016, 2019).

All obtained results are well agreed with flux estimations provided by a local 3D turbulent exchange model and the COSMO-Ru-NWR model for regional weather predictions. In particular the numerical experiments provided using the COSMO-Ru-NWR model for several modeling scenarios imitating total deforestation of a large area situated within European southern taiga zone showed that total forest disturbances can result in changes of radiation and energy budgets of the area and consequently in increasing the annual amplitude of the air temperature (decrease of winter temperatures and their growth in summer) and in reducing the precipitation amount in all seasons of the year (projected annual decrease is about 4%) (Olchev et al., 2018).

The results obtained in the present study can be very useful for better understanding the effects of forest

©2019. Japan Geoscience Union. All Right Reserved.

disturbances on atmospheric fluxes at land surface - atmosphere interface and estimating their possible influence on regional weather conditions.

References

Mamkin V., Kurbatova J., Avilov V., Mukhartova Yu, Krupenko A., Ivanov D., Levashova N., Olchev A. 2016. Changes in net ecosystem exchange of CO2, latent and sensible heat fluxes in a recently clear-cut spruce forest in western Russia: results from an experimental and modeling analysis. Environmental Research Letters. 11(12). 125012

Mamkin V., Kurbatova J., Avilov V., Ivanov D., Kuricheva O., Varlagin A., Yaseneva I., Olchev A. 2019. Energy and CO2 exchange in an undisturbed spruce forest and clear-cut in the Southern Taiga. Agricultural and Forest Meteorology, 265, P. 252-268

Olchev A.V., Rozinkina I.A., Kuzmina E.V., Nikitin M.A., Rivin G.S. 2018. Influence of forest cover changes on regional weather conditions: estimations using the mesoscale model COSMO. IOP Conf. Series: Earth and Environmental Science, 107, 012105

Keywords: deforestation, boreal forest, clear-cut, eddy covariance, COSMO model, net ecosystem exchange of CO2

©2019. Japan Geoscience Union. All Right Reserved.

Changes in mountain glacier systems and the distribution of main climatic parameters on the territory of Russia (XX -XXI century)

*Tatiana Khromova[1], Gennady Nosenko[1], Valeria Popova[1], Anton Muraviev[1], Stanislav Nikitin[1]

1. Institute of Geography Russian Academy of Sciences

Mountain glaciers are vital sources of water worldwide to many densely-populated regions including North Eurasia. Most glaciers are now shrinking, resulting in variable water supplies and sustained sea level rise. Rapid glacier change threatens water, energy and food security. Further glacier mass loss is likely in response to recent climate change, driven by global increases in air temperatures and the production of atmospheric pollutants. However, high altitudes and rugged topography generate regional weather systems that complicate the investigation of the relationship between climate and glacier change. Predictive models need to move beyond the state-of-the-art to couple advanced climate models with accurate representations of glacier processes, and more detailed and reliable data describing the state of mountain glaciers are required to constrain these models, both from monitoring individual glaciers and regional remote-sensing observations.

Glaciation exists on the territory of Russia for thousands of years. Glaciers are located now on islands and archipelagoes of Russian Arctic and in mountain regions of continental part of the country and currently cover the area of about 3,480,000 km². Now there are 18 mountain glacier regions on the territory of continental Russia. We present recent data on glaciers state and changes in these regions based on remote sensing and in situ studies and distribution of main climatic parameters that affect the existence of glaciers: summer air temperature and winter precipitation.

Acknowledgements. This presentation includes the results of research project №. 0148-2019-0004 of the Research Plan of the Institute of Geography, RAS and research project supported by the Russian Geographical Society (grant number 05/2017/RGS-RFBR).

Keywords: mountain glaciers , climate change, Russia, glacier changes

©2019. Japan Geoscience Union. All Right Reserved.

Projection of changes in water balance components across irrigated lands of Central Asia using a high-resolution modeling system

*Anastasiia Pikaleva[1], Ekaterina Nadyozhina[1], Alexandra Sternzat[1], Boris Egorov[1], Sergey Efimov[1], Igor Shkolnik[1]

1. Voeikov Main Geophysical Observatory

The economy of arid regions in Central Asia is largely based on irrigated agriculture, which critically depends on the amount of regional water deficit. The insufficiency of water resources requires an accurate estimation of water balance components from irrigated lands in order to develop the optimal strategy of water consumption across Central Asia in a changing climate. This is particularly important for irrigated areas with typical spatial scales several kilometers, not captured by up-to-date regional climate models and thus requiring an explicit description of subgrid processes using a sophisticated high-resolution atmospheric boundary layer model.
A series of climate simulations using MGO regional climate model (RCM) at 25 km resolution and a 150-level atmospheric boundary layer model (ABLM) have been carried out aimed to improve the estimation of evapotranspiration from irrigated lands. It has been shown that the detailed description of boundary layer structure over the irrigated area pushes the RCM simulated temperature towards observations (assuming that CRU observational analysis to some extent accounts for the effect of irrigation on temperature).
A sensitivity study has been conducted in order to assess the impact of the changes in the Aral sea mirror during the second half of the 20th century –early 21st century on regional heat and moisture balance. This helps to build a methodology for optimizing the land use on the coastal areas of internal water bodies in the arid zones.
A series of ensemble (30 members) regional climate change projections by 2050-2059 relative to 1990-1999 has been conducted using the RCM-ABLM chain under IPCC RCP8.5 scenario. The analysis shows that the deficit of moisture over the irrigated areas increases by the mid-21st century during the growing season. This implies that the conditions for cultivating traditional agricultural crops in the region will deteriorate if the sources of irrigation water remain unchanged.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Dmitry Streletskiy(George Washington University), Pavel Groisman(NC State University, USA), Tetsuya Hiyama(Nagoya University, Japan)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS01-07] Rises and Falls of the Socioeconomic-Ecological Systems along the Silk Road

★Invited Papers

*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3] (1.Center for Global Changes and Earth Observation, Department of Geography, Environment, and Spatial Sciences, Michigan State University, 2.Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 3.NC State University Research Scholar, NOAA National Centers for Environment Information)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS01-08] Interdisciplinary study of the mountain geosystems in the Altay-Sayan region

*Margarita Syromyatina[1], Yurii Kurochkin[1], Mariia Andreeva[1], Kirill Chistyakov[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS01-09] Where in High Mountain Pastures does Snow Seasonality Link Most Closely with Subsequent Land Surface Phenology?

*Geoffrey M Henebry[1], Monika A Tomaszewska[2] (1.Michigan State University, 2.South Dakota State University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS01-10] Evaluation of orographic precipitation over Central Asia and its simulated change under a warming environment

*Akiyo Yatagai[1], Ayano Senda[1], Minami Masuda[1], Vinay Kumar[2] (1.Graduate School of Science and Technology/Hirosaki University, 2.Texas A&M University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS01-11] The impact factor of surface spectral albedo in an arid area

*Jiaxi Yang[1], Zhenchao Li[2], Xiaoqing Gao[2], Panmao Zhai[3] (1.University of Chinese Academy of Sciences, 2.Key Laboratory of Land Surface Process and Climate Change in Cold and Arid Regions, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Lanzhou, China, 3.Chinese Academy of Meteorological Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS01-12] **Northern Eurasia Future Initiative (NEFI) Focus on Human-Associated Extreme Events**

*Pavel Groisman[1,2,3], Alexander Shiklomanov[4], Irina Yesserkepova[5], Sergey Gulev[2], Ildan Kaipov[6] (1. NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia , 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. University of New Hampshire, Durham, New Hampshire, USA , 5.Joint Stock Company "Zhasyl Damu", Almaty, Kazakhstan, 6. National Center for Space Research and Technologies, Almaty, Kazakhstan)

Rises and Falls of the Socioeconomic-Ecological Systems along the Silk Road

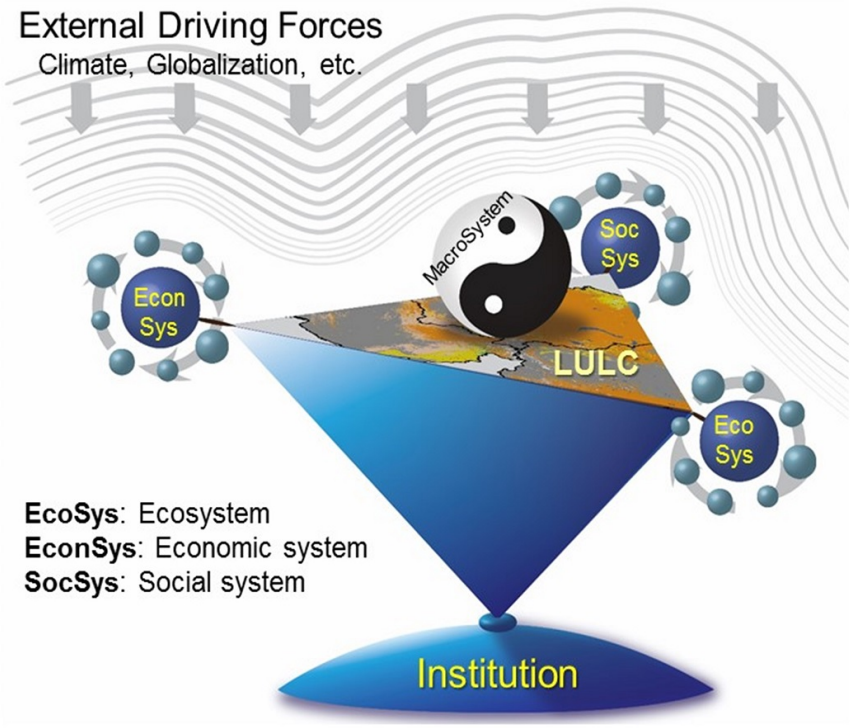
*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3]

1. Center for Global Changes and Earth Observation, Department of Geography, Environment, and Spatial Sciences, Michigan State University, 2. Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 3. NC State University Research Scholar, NOAA National Centers for Environment Information

Our focus is recent fluctuations in the Socioeconomic-Ecological Systems (SES) within the Asian Dryland Belt (ADB) –a region that contains the ancient Silk Road that was, for centuries, the primary route for migration and cultural exchange across Eurasia, as well as trade between east Asia and Europe. Our study advances sustainability science by including institutions as the essential foundation of the three-pillared SES to understand changes in 22 political entities in 17 countries during 1992-2016 (hereafter MacroSES). The ADB includes three broadly-defined subregions: Middle East, Central Asia, and East Asia. Land degradation and land use conversion have occurred at an alarming rate across the region, with shrublands and savannas showing a high degree of turnover across the ADB. Meanwhile, the long term changes in annual precipitation and temperature showed uneven spatial distributions with the numerous hotspots of drying or wetting trends that do not always correspond with the land use. We calculated the relative values of LEI (life expectancy index) , GDPp (gross domestic production per capita), and GPPp (gross primary production per capita) to represent “EconSys”, “EcoSys”, and “SocSys”, respectively. A new sustainable index (SI) was calculated for the 17 MacroSES within the ADB. The balance of the three systems (EconSys, EcoSys SocSys) exhibits distinct temporal trends over the study period. Changes in relationships among LEI, GDPp, and GPPp show that MacroSESs in East Asia were very directional and dynamic, but more stable for the Central Asian MacroSESs, and more variable for the Middle East. One of the major findings is changes in the SI over the study period were attributable to armed conflicts (Iraq, Afghanistan, and Syria) or to reorientation toward a market-driven economy (Mongolia and China). Nevertheless, the three systems in 1992 are in disequilibrium and tilted in favor of ecosystem function, but during 2001-2016, the MacroSESs appear to move in a direction of equilibrium.

Keywords: Sustainability, Asian Drylands Belt, Socioeconomic-ecological systems

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Interdisciplinary study of the mountain geosystems in the Altay-Sayan region

*Margarita Syromyatina[1], Yurii Kurochkin[1], Mariia Andreeva[1], Kirill Chistyakov[1]

1. Institute of Earth Sciences, Saint Petersburg State University, Russia

The results of several projects funded by Russian geographical society and RFBR are presented. The main objective of this regional research is to reveal current state and changes of mountain geosystems mainly under the influence of natural factors as well as socio-economic factors during the last several decades.

Study region is partly located in the Dry Latitudinal Belt of Northern Eurasia and includes several key sites in the Russian, Mongolian and Kazakhstan Altai, in the Tuva Mountains and the Western Sayan Mountains. These mountain systems are the watershed between the Arctic Ocean basin (upper parts of Yenisei and Ob river basins) and Inner Asia closed drainage area (Grate Lake Depression).

Complex geographical field work was conducted during last several years including glaciological, hydrometeorological, hydrochemical, dendrochronological measurements as well as interviewing. Analysis of weather stations' data, remote sensing data acquired from satellites, various map documents and statistical data also was made.

There is positive mean annual air temperature trend in the region during the last several decades (0.2-0.6 degrees Celsius/10ys). But at the same time in recent years the warming trend is weakening in some areas. As for precipitation there is no any statistically significant trend. Such combination of climatic parameters in some areas, for example in the Khovd river basin in Great Lake Depression plays a critical role and we see a tendency to aridization. These facts are well confirmed by dendrochronological streamflow and temperature reconstructions for a longer period.

Dendrochronological analysis results in four regional ring-width chronologies, the longest one is since 1463. Chronologies demonstrate similar year-by-year and long-term variability and contain 10-14 and 29-33-yr cycles. The tree-ring growth is limited mostly by June-July air temperature (R=0.5–0.7). At the same time, chronologies are sensitive to the variability of circulation, hydrological, and glaciological parameters. Strong signal of nature factors permit to use these regional tree-ring chronologies for reconstructions of hydrometeorological parameters.

The water discharge formation in the upper parts of river basins in this region is associated mainly with glaciers. Glacier area and tongue regression was fixed mainly under temperature influence. Large glaciers such as Kozlov and Potanin were retreating at an average rate of 28-34 m/year during last years. At the same time there are some synchronous and non-synchronous changes of glacier retreat rate in different key sites associated basically with location, aspect of a slope, morphological and geomorphological patterns.

Hydrochemical TDS (Total Dissolved Solids) measurements show the dependence on source of nourishment and usually TDS changes from 0-7 ppm in the high-mountain headwaters near glaciers to 65-90 ppm along the river towards the mouth. The water type usually is hydrocarbonate-calcium or hydrocarbonate-magnesian.

©2019. Japan Geoscience Union. All Right Reserved.

Our research also has an applied aspect. We made an independent scientific expertise consisting in assessment of the natural conditions during the realization of large transport projects in the Siberian region, for example construction of the Elegest-Kyzyl-Kuragino railway line along the mountainous territory. Analysis of such parameters as extreme values of air temperature and precipitation, strong winds, snow cover thickness, avalanche danger and others makes it possible to assess the potential natural risks during the construction and further operation of the transportation systems.

Keywords: mountains, changes, Inner Asia, assesment, interdisciplinary study, physical geography

©2019. Japan Geoscience Union. All Right Reserved.

Where in High Mountain Pastures does Snow Seasonality Link Most Closely with Subsequent Land Surface Phenology?

*Geoffrey M Henebry[1], Monika A Tomaszewska[2]

1. Michigan State University, 2. South Dakota State University

Within the context of a NASA LCLUC project, we have been working to detect significant changes in metrics of snow seasonality in high mountain pastures across Kyrgyzstan and to associate them, with metrics of land surface phenology in the subsequent growing season, as modulated by terrain features. There are multiple challenges to address including reconciling spatial and temporal scales of observation, topographic normalization of reflectance, seeking ecological signal amidst a welter of variation across multinomial stratifications, and limitations on statistical tests due to autocorrelation, very large sample sizes, and inappropriate neutral model expectations. Working in mountainous landscapes can pose special challenges because terrain features—elevation, slope, aspect, and landform—as well as geographic context can interact to change the ecological expectations of their interactions. We use two types of MODIS products—land surface temperature (MOD11A2, MYD11A2) and snow cover (MOD10A2)—to track the seasonal progression of thermal time and the seasonality of snow cover. We model land surface phenology using NDVI data from Landsat TM/ETM+/OLI sensors as a quadratic function of accumulated growing degree-day calculated from MODIS LST products. Phenological metrics derived from the fitted parameter coefficients include Peak Height (PH) of NDVI and the Thermal Time to Peak (TTP) NDVI. Snow cover seasonality metrics include First Date of Snow (FDoS), Last Date of Snow (LDoS), and Duration of Snow Season (DoSS). We explore how the phenological metrics (PH, TTP) are linked to the seasonality metrics (FDoS, LDoS, DoSS) and how these relationships change as a function of terrain, particularly in contrasting aspects on moderate to steep slopes. The analyses reveal those parts of the landscape where pasture productivity is more vulnerable to changing snow seasonality.

Keywords: Kyrgyzstan, environmental change, land surface phenology, snow seasonality, MODIS, Landsat

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of orographic precipitation over Central Asia and its simulated change under a warming environment

*Akiyo Yatagai[1], Ayano Senda[1], Minami Masuda[1], Vinay Kumar[2]

1. Graduate School of Science and Technology/Hirosaki University, 2. Texas A&M University

The Central Asia (CA) region located in the central part of the Eurasian Continent receives little precipitation and thus most parts are classified as arid/semiarid. Here, life and ecosystems largely depend on river discharge from the western Tibetan Plateau. As agricultural water stress has caused shrinkage of the Aral Sea, CA is fragile environment where human–nature interaction plays a key role in hydrological sustainability. It is believed that glaciological water is an important water resource for the CA region; however, if glacier accumulation decreases because of reduced precipitation, water stress could become an increasing problem.

According to the IPCC report based on CMIP5 models, CA precipitation by 2080–2100 is expected to increase by about 10%; however, this prediction is unreliable because numerical simulations are inconsistent. Furthermore, because CA largely depends on mountain water resources, we need to predict future precipitation change for mountain areas. For most models, representation of orographic precipitation is difficult because of resolution limitations. Thus, CMIP results must be downscaled with reference to quantitative observational data. To create an ensemble of multiple models, especially when using “teacher” data, the performance of the multimodel superensemble (MMSE) technique provides excellent results for monsoon Asia.

This study applied the MMSE technique to monthly precipitation data of CA (35˚–60˚N, 50˚–85˚E), focusing on spring (March–May), which is the rainy season in CA. First, we applied the MMSE to CMIP5 “historical” monthly precipitation in spring in accordance with APHRODITE data. Although the APHRODITE dataset can represent the orographic pattern well, it has fewer input data recently; hence, we only used data for 1980–1990 (11 years). We used all 20 registered climate models from the CMIP5 archive. We used 10 years’ data for “training” to decide weighting parameters in accordance with APHRODITE. Then, we “simulated” the final year using the derived parameters. We compared the “simulated” values with APHRODITE data of that year. We repeated this process 11 times such that the data for each year were forecasted by the MMSE.

Comparison of the precipitation pattern of each model to APHRODITE revealed higher correlation coefficients (CCs) for the MMSE result (SUP) (0.6–0.8) than for each model (0.2–0.6) for all years.

The MMSE result for the Middle East (Yatagai et al., 2018) showed the SUP produced the best pattern for each year; however, the long-term trend did not match the observations. Hence, we tried used an SUP with the top six models that showed high CCs between the time series of CA mean precipitation and each model. We selected those models that simulated interannual variation of total precipitation in the CA area as a reflection of how each model simulated the dynamic structure based on the observed forcing. Based on this selection, we applied the MMSE using APHRODITE observational data. The CCs of the top six models in terms of temporal correlation were 0.55, 0.53, 0.48, 0.47, 0.34 and 0.33. Among the other models, some showed strong negative correlation with APHRODITE (CC = −0.65, −0.49 and −0.38); thus, we could exclude them from the MMSE.

©2019. Japan Geoscience Union. All Right Reserved.

We determined the weighting using two sets: a) the 6 models superior in representing the horizontal variation and b) the 6 models superior in representing the temporal variation for the 11 years. Then, we applied each weighting to the superensemble for RCP8.5 scenario precipitation over CA, especially the high-mountain area. Set a) showed a trend of increasing precipitation in some months in spring; however, set b) showed a robust decreasing trend in all months.

Considering it reasonable to place greater trust in model outputs that are good at representing interannual precipitation variation in CA, we pessimistically predict that spring precipitation in the 2100s will be reduced in the mountain region of CA.

Keywords: Multimodel Superensemble, CMIP, APHRODITE, Glaciological water resources

©2019. Japan Geoscience Union. All Right Reserved.

The impact factor of surface spectral albedo in an arid area

*Jiaxi Yang[1], Zhenchao Li[2], Xiaoqing Gao[2], Panmao Zhai[3]

1. University of Chinese Academy of Sciences, 2. Key Laboratory of Land Surface Process and Climate Change in Cold and Arid Regions, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Lanzhou, China, 3. Chinese Academy of Meteorological Sciences

Climate is very sensitive to surface albedo. Subtle changes in surface albedo can affect the energy balance of land atmosphere system and cause climate change. Therefore, accurate acquisition of surface albedo parameters and the study of their distribution characteristics are of great significance to regional climate change and to the improvement and validation of land surface process models. As the past studies on the surface albedo are mostly focus on the full-spetrum radiation. And in the third generation of land-surface process models, such as the CLM, LSM, and the later-released CLM4.0 and CLM4.5, the solar radiation is divided into visible and near-infrared radiation, with a wavelength of 0.7 μm as a divide, as well as being divided into direct radiation and scattered radiation in the parameterization process of the surface albedo. However, the absorption and reflection of different wavelengths of sunlight would change by the change of underlying surface. In order to understand the impact factors of surface spectral albedo and provide theory basis for the parameterization of surface albedo, the observational data on the spectral radiation and 2cm soil moisture in Dunhuang, China from July 2017 to December 2018 were analyzed. The reason of choosing Gobi area instead of other areas is it can minimize the impact of cloud cover and other weather conditions on the solar radiation. During the observation period, the surface albedo increased with the wavelength in each season except winter. The surface albedo was affected by the solar altitude and soil moisture, and they exhibited obvious anti-correlations. The annual mean surface albedo of GR, UV, VIS and NIR was 0.25, 0.13, 0.25 and 0.43, while the correlation coefficient with solar altitude was -0.41, -0.08, -0.29 and -0.30, and the correlation coefficient with 2cm soil moisture was -0.60, -0.60, -0.59 and -0.46, respectively. Longer wavelengths correspond to stronger relationship between the surface albedo and solar altitude. In contrast, shorter wavelengths correspond to stronger relationship between the surface albedo and 2cm soil moisture.

Keywords: surface spectral albedo, solar altitude, soil moisture, arid area

©2019. Japan Geoscience Union. All Right Reserved.

Northern Eurasia Future Initiative (NEFI) Focus on Human-Associated Extreme Events

*Pavel Groisman[1,2,3], Alexander Shiklomanov[4], Irina Yesserkepova[5], Sergey Gulev[2], Ildan Kaipov[6]

1. NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia , 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. University of New Hampshire, Durham, New Hampshire, USA , 5. Joint Stock Company "Zhasyl Damu", Almaty, Kazakhstan, 6. National Center for Space Research and Technologies, Almaty, Kazakhstan

NEFI was conceived at the Workshop “*Ten years of Northern Eurasia Earth Science Partnership Initiative (NEESPI): Synthesis and Future Plans*” in April 2015. One year later, a NEFI White Paper was posted at http://nefi-neespi.org/ and, thereafter, the peer-reviewed NEFI Science Plan paper was published (Groisman et al. 2017). NEFI is a continuation of NEESPI and addresses two significant and intertwined changes with focus on Northern Eurasia: 1) continued and exacerbated change in the global Earth system, and 2) societal changes with need for mitigation and adaptation approaches. The changes have already occurred and keep growing. Their impacts on (and feedbacks to) atmospheric, biospheric, cryospheric, hydrologic, oceanic, and macro-socioeconomic processes are ongoing. To develop effective mitigation and adaptation strategies, future NEFI activities will need to consider three unique features of Northern Eurasia: (1) the sensitivity of land surface characteristics to global change that feedback to influence the global energy budget; (2) potential changes in the Dryland Belt of Northern Eurasia that will have a large influence on the availability of water for food, energy, industry, and transportation; and (3) the role of the evolving social institutions and economies.

While natural processes (except the high amplitude of their variations) are mainly the same as in other parts of the World, human factors and changes in land cover and land use in Northern Eurasia during the past decades were dramatic and unique. They have ultimately transformed human-environment interactions. This in turn has transformed regional land cover and water resources towards conditions that endanger the resilience of natural ecosystems. Institutional changes in Northern Eurasia over the past few decades have led to large changes in the socio-economic fabric of the societies in the region, affecting land use and the natural environment. One overarching challenge has been the transition from command-driven to “transitional” and more market-driven economics in the countries of the region. This phenomenon has occurred at different rates, with differing levels of success, and often with societal costs.

The core motivation of NEFI is to best use science to serve the decision-making process to maintain Earth system health and to sustain society. Therefore, we have to reconsider/expand the definition of term “extreme events” from rare events (as it was used in climatology) to events that are “human-related”, i.e., are important for human well-being and are not necessary rare. The Earth climatic system does not know extremes. Unusually rare weather situations can be named disturbances or deviations and these terms do not have emotional connotations. Term “extremes” is used by humans when some events or their anomalous manifestations affect quality of human life, prevent or restrict socioeconomic activities, or endanger human life and/or man-made infrastructure. Using this anthropocentric paradigm, we would rather name “extreme” a gradual thawing of the ground under roads and buildings that causes their destruction than the temperature anomalies above the upper 5% of their daily values. This presentation has a particular focus on several types of human-associated extreme events. They are not necessarily rare,

©2019. Japan Geoscience Union. All Right Reserved.

but such events can be legitimately named as “human-associated extremes” (HAE) and deserve our attention, when their occurrence cause serious disruption in socioeconomic activity and/or endangers human life and/or when we observed significant changes in their occurrence and intensity. In our presentation, we present a few examples of HAE and their changes over Northern Eurasia.

Reference: Groisman, Shugart, Kicklighter *et al* 2017: Northern Eurasia Future Initiative (NEFI): facing the challenges and pathways of global change in the twenty-first century. *Progress in Earth and Planetary Science,* **4**:41; doi:10.1186/s40645-017-0154-5

Keywords: human-associated extreme events, Northern Eurasia, environmental and socioeconomic changes



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Yasuhiro Murayama(NICT)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MGI31-01] WDS: International Coordination for Sustainable FAIR Data, for Science and Society

*Yasuhiro Murayama[1] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MGI31-02] Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3] (1.National Institute of Informatics, 2.ROIS-DS Center for Open Data in the Humanities, 3.EDITORIA, The University of Tokyo, 4.SOKENDAI)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MGI31-03] Data Sharing and Open Science: Practice, Expectation, Transparency, and Credit

*Shelley Stall[1] (1.American Geophysical Union)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MGI31-04] Ethical issues in open science

*Yasuhisa Kondo[1] (1.Research Institute for Humanity and Nature)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MGI31-05] The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*Kazuhiro Hayashi[1] (1.National Institute of Science and Technology Policy)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MGI31-06] Future evolution of open archives for preprints, posters, and presentations as a key component of open science in the Earth and space sciences

*Brooks Hanson[1] (1.American Geophysical Union)

WDS: International Coordination for Sustainable FAIR Data, for Science and Society

*Yasuhiro Murayama[1]

1. Strategic Program Produce Office, National Institute of Information and Communications Technology

The author's personal consideration on the international academic data enterprise World Data System (WDS) is given in the talk, to discuss the value of international coordination work for sustainable FAIR data, based on the community interest and community-based initiative. Digital data is especially of academic and societal concern today.

Keywords: open science, research data sharing , WDS, international coordination

©2019. Japan Geoscience Union. All Right Reserved.

Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3]

1. National Institute of Informatics, 2. ROIS-DS Center for Open Data in the Humanities, 3. EDITORIA, The University of Tokyo, 4. SOKENDAI

1. JDARN: establishment and brief history

Japan Data Repository Network (JDARN) is about community-based activities for sharing recent trends in the world and for improving trustworthiness of Japanese data repositories. Its origin is in “Project for assigning DOI on research data” hosted by Japan Link Center (JaLC) between October 2014 through September 2015. This project became a unique forum in which the experts of research data gathered across disciplines for the first time in Japan. As a follow-up activity, Research Data Utilization Forum (RDUF) was established in June 2016, and a few special interest groups (SIG) were later proposed. One of them is “networking domain repository stakeholders in Japan” SIG on October 2017. Then, on October 2018, it was upgraded to “Japan Data Repository Network” to represent our intention to expand the community to more disciplines and more stakeholders.

The purpose of JDARN is to share recent trends of the data repository, and in particular, it focuses on the issue of trustworthiness of data repositories. Trustworthiness plays an important role on decision making when data producers choose one of external services to deposit their data. One of the criteria to show the trustworthiness is CoreTrustSeal (CTS). CTS is one of international certifications on data repositories, and as of February 2018, over 140 data repositories have received certification, but in Japan the number of certification is still few. To understand the reason of delayed adoption of CTS in Japan, we held a seminar "Trustworthy Data Repositories - Forum for Sharing Practical Information about CoreTrustSeal Certification -" on December 2017, so that major data repositories in Japan could try their self-assessment according to the requirements of CTS. As a result, we realized that self-assessment by CTS is difficult unless we understand the fundamental concepts behind CTS. Hence the SIG started to create documents for understanding CTS, and this grew into the main activity of the SIG. Then, after intensive discussion, the focus of the activitiy has shifted to creating the data repository guideline that takes consideration of not only CTS but also data utilization.

2. Data Repository Guideline

Data repository guideline we are creating now is referring to 16 requirements of CTS, but is not its direct translation and has a unique structure proposed by JDARN. Rethinking of CTS has started by the item-based organization of CTS proposed by Mr. Shigeru Yatsuzuka at National Bioscience Database Center (NBDC). In the review process of CTS, the creation and publication of many types of documents is considered as an evidence of transparency. From the analysis of actual applications accepted by CTS and the type of documents mentioned therein, we can identify next actions to prepare necessary documents for CTS. In other words, we may be able to create an easier-to-understand guideline by converting abstract descriptions of CTS into concrete entities such as people and documents.

However, we also realized that itemizing people involved in data repositories is more difficult than itemizing documents. What kind of jobs do we need in data repositories, and who should be in charge of

©2019. Japan Geoscience Union. All Right Reserved.

them? We also have a problem of naming; namely how those experts should be called. People proposed many new names for data experts, such as data librarian, data curator, data scientist, data engineer, and so on, but the actual meaning of those words are different from person to person. We need to organize the concept of jobs, and demonstrate their long-term career paths; otherwise, open science based on data repositories has uncertain future. We still do not have a solid model for this issue, and we are still in discussion.

3. Future directions

Since the establishment of JDARN, we have had active discussions in meetings held roughly every month. We believe that, as more data repositories join the discussion, we have more data repositories in Japan which are high quality, show more presence in the world, and has greater value as the infrastructure of open science. To realize this goal, data repositories should be considered as indispensable entity in the research. The main focus of CTS is to improve the trustworthiness and sustainability of data repositories as the container of data, but we also need experts for utlizing the content of data such as data integration, data analysis, data visualization and societal impact. A single organization is difficult to take care of all the tasks, so collaboration among data repositories will also be an important issue, and this is where network of data repositories can play an important role.

Keywords: Japan Data Repository Network, Data repository, Trustworthiness , CoreTrustSeal, Guideline, Data expert

©2019. Japan Geoscience Union. All Right Reserved.

Data Sharing and Open Science: Practice, Expectation, Transparency, and Credit

*Shelley Stall[1]

1. American Geophysical Union

The data that underpins our research is a valuable part of the research process. Determining what data is needed in order to analyze the scientific question at hand is a critical part of our work. That data has incredible value to those interested in our research and building upon it.

Research data is best preserved in a trusted digital repository with robust descriptive information. Attribution and credit for data created, used, and reused is an important part of encouraging researchers to share their data and make it available to others. Including persistent, unique, global identifiers for the researchers that created the data as well as the links to associated publications where the data is cited allows us to discover, understand, and increase the possibly of that data being reused for new research in the future.

Within the Earth, space, and environmental sciences a large community of stakeholders has come together to require that data supporting a publication be placed in a trusted repository and properly cited in the publication. Many journals are now transitioning to this requirement and more are joining every day.

The infrastructure is being solidified to give creators of data the attribution and credit that recognizes the importance of the contribution to the scientific record for possible reuse in the future. Making data more findable, accessible, interoperable, and reusable (FAIR) is an important step towards more open science. We will describe what is expected by the Enabling FAIR Data project and the value of attribution and credit in encouraging researchers to share their data.

Keywords: FAIR Data, Trusted Repository, Data Sharing, Data Credit, ORCID, Persistent Identifier

©2019. Japan Geoscience Union. All Right Reserved.

Ethical issues in open science

*Yasuhisa Kondo[1]

1. Research Institute for Humanity and Nature

This paper discusses ethical equity in open science as an emerging issue in promoting civic participatory science for social issues. Open science is understood as a conceptual complex of top-down policies and bottom-up actions. The bottom-up actions are represented by citizen science, wherein non-expert civil actors provide data or participate in fieldwork. Civic participatory science is becoming popular around the world, yet it does have an issue with ethical inequity in it. When holding a civic participatory workshop, such as an *ideathon*to co-create solutions for a given social issue, organizers, such as research experts or governmen agents, invite civic participants so that they can exploit their labor, knowledge, and ideas. Organizers give low, fixed-rate rewards and some entertainment in exchange. In my actual experience, some participants found this to be unbalanced and unfair. A detailed investigation revealed that incentives for researchers, including academic publication and promotion, would not be applicable to civic volunteers because they have different motivations. Even though it is voluntary, this work should be properly acknowledged. I would like to explore and discuss this ethical issue with participants in the Open Science international session.

Keywords: open science, ethical equity

©2019. Japan Geoscience Union. All Right Reserved.

The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*Kazuhiro Hayashi[1]

1. National Institute of Science and Technology Policy

Author introdces the Integrated Innovation Strategy as the latest documment which includes Open Science policy. It aims to develop the source of innovation or knowledge base for innovation with several data platforms including research data platofom of managing, sharing, and distributing data. On the other hand, some new evolutons occur in the scholarly publishing such as preprint servier, open research platform and registered report, which affects researchers directly, but not directly to connect to the research data platform. Author discusses the gap between them to find a way to transform Science as Open Science policy indicates.

Keywords: Open Science, Integrated Innovation Strategy, Research Data Platform, Scholarly publishing

©2019. Japan Geoscience Union. All Right Reserved.

Future evolution of open archives for preprints, posters, and presentations as a key component of open science in the Earth and space sciences

*Brooks Hanson[1]

1. American Geophysical Union

A culture of using preprint servers has been widely established in astronomy, physics, computer sciences, and the social sciences for several decades. Studies of these have shown that sharing of manuscripts on these servers accelerates citations and the pace of science. Further alignment and standardization around this process, and broad cultural adoption would help accelerate these benefits. Servers have been established in other disciplines more recently, and usage has been growing gradually.

Use of preprint servers was slow to catch on in most of the Earth and space sciences, except for disciplines closely aligned with physics and astronomy, although most of the EGU journals are open-review journals and act in many ways like preprint servers. Two open archives were established for the Earth and space sciences in 2017: http://ESSOAr.org and http://EarthArxiv.org. ESSOAr (Earth and Space Science open Archive) was one of the first major archives to include posters presented at meetings. Uptake of both has been growing gradually; about 5% of posters presented at the 2018 Fall AGU meeting were posted on ESSOAr. Several are also including links to data sets or other resources (e.g., e-posters). Deposition was accelerated by automatic transfer of metadata from the meeting abstract system. Similar automated transfer is nearly implemented from major editorial systems for ESSOAr, BioArxiv and several others servers. This process should accelerate uptake and cultural adoption. Further adoption of standards by the broader community would further help adoption, including permission and encouragement from most journals, citation and credit standards, regularly connecting preprints with ORCID and later publications, broader awareness and adoption of standards on sharing code, data, and samples, and expansion to include oral presentations at meetings as technology improves to include audio and capture presentation information regularly. Support open science by adopting these best practices and archive your posters and draft manuscripts.

Keywords: Preprints, Open Science, Sharing Data

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Shelley Stall(American Geophysics Union)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MGI31-07] Cloud Computing Needs for Earth Observation Data Analysis: EGI and the European Open Science Cloud

★Invited Papers

Björn Backeberg[1], Yin Chen[1], *Tiziana Ferrari[1], Pedro Gonçalves[4], Paolo Mazzetti[3], Anabela Oliveira[2], Diego Scardaci[1], Gergely Sipos[1] (1.EGI Foundation, 2.LNEC, 3.CNR, 4.Terradue)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MGI31-08] Open third generation geostationary satellites accelerate environmental studies: Case studies of CEReS, Chiba University, Japan

*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1] (1.Center for Environmental Remote Sensing (CEReS), Chiba University, Japan, 2.EORC, JAXA, 3.NICT)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI31-09] Scientific data chain for better data publication and preservation

*Takeshi Horinouchi[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI31-10] Current status and problems of geodetic observation data distribution

*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5] (1.Hitotsubashi University, 2.Institute of Industrial Science, the University of Tokyo, 3.Hydrographic and Oceanographic Department, Japan Coast Guard, 4.National Institute of Information and Communications Technology, 5.Geospatial Information Authority of Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI31-11] Recent activity of data publication and data citation in the international community of geomagnetism

*Masahito Nose[1], Yasuhiro Murayama[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Strategic Program Produce Office, National Institute for Information Communications

Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI31-12] IGSN: International Collaboration Makes Samples and Sample Data FAIR

*Kerstin Lehnert[1], Jens Klump[2], Lesley Wyborn[3], Sarah Ramdeen[4] (1.Columbia University, 2.CSIRO Kensington, Australia, 3.Australian National University, Canberra, Australia, 4.Ronin Institute, USA)

Cloud Computing Needs for Earth Observation Data Analysis: EGI and the European Open Science Cloud

Björn Backeberg[1], Yin Chen[1], *Tiziana Ferrari[1], Pedro Gonçalves[4], Paolo Mazzetti[3], Anabela Oliveira[2], Diego Scardaci[1], Gergely Sipos[1]

1. EGI Foundation, 2. LNEC, 3. CNR, 4. Terradue

Over recent years, the vision of Open Science has emerged as a new paradigm of transparent, data-driven science capable of accelerating competitiveness and innovation. The embodiment of this vision in Europe is the European Open Science Cloud (EOSC), first proposed by the European Commission in April 2016 as part of the Communication on the ‘European Cloud Initiative’, one of the pillars of the Digital Single Market Strategy. The EOSC puts into practice the European vision for Open Innovation, Open Science and Open to the World by bringing together services and research products such as computing, storage, data, publications, software and workflows from national and international research infrastructures, research performing organisations, collaborations and projects.

Within EOSC and the EOSC-hub H2020 project, the European GEOSS community of the EuroGEOSS initiative, aims at demonstrating the benefit of Earth Observation for the society. Earth Observation data is being used to create the new knowledge needed to support informed decision-making for sustainable development and policy making. In addition, the GEOSS is contributing to EOSC by providing mediation and harmonisation services for accessing information and knowledge from in-situ and Earth Observation data, opening access to models for the generation of indicators.

EOSC will be instrumental in providing the large computation and storage capabilities needed to run scientific models at local, national, regional and potentially global scale. Within EOSC, EGI is the European digital infrastructure respondible for providing a distributed platform for scientific computing. The EGI Federation is the publicly funded e-infrastructure that brings together hundreds of data centres worldwide and also includes the largest community of research clouds in Europe with more than 20 cloud providers across 12 European countries offering IaaS cloud and storage services. The EGI cloud infrastructure is based on open standards allowing a seamless user experience over the cloud sites belonging to the federation through standardised interfaces. Advanced services are available to manage computing services and datasets in a distributed environment hiding the complexity of the geographical distribution to the developers of scientific applications and services.

The EGI Federated Cloud will give scientists the possibility to access and run analytic models in a transparent way, without the need of a local infrastructure hosting data and computing facilities. In this presentaiton, we will introduce the EGI technical solutions which provide the following capabilities: (1) the federation of services, data and resources; (2) the provision of geographically distributed large capacity computing resources and specialized computing facilities; (3) Jupyter notebooks data analysis capabilities integrated with federated Authentication and Authorization and the EGI Cloud; and (4) the support of added-value services, like the the OpenCoastS - for the production on-demand circulation forecast systems, the GEOSS Web Portal - for discovering and accessing GEOSS data from than 170 data systems globally, the Geohazards Thematic Exploitation Platform GEP - providing access to a set of on-demand terrain motion services supporting interferogram generation, co-seismic displacement mapping, landslide rapid mapping and landslide displacement field monitoring with Copernicus Sentinel-1 and Sentinel-2 data.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Open Science, EOSC, EGI, Earth observation data analysis

©2019. Japan Geoscience Union. All Right Reserved.

Open third generation geostationary satellites accelerate environmental studies: Case studies of CEReS, Chiba University, Japan

*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1]

1. Center for Environmental Remote Sensing (CEReS), Chiba University, Japan, 2. EORC, JAXA, 3. NICT

Geostationary satellites, such as well-known Himawari and GOES series, have advantages to capture the surface and the atmospheric status by relatively high-frequent scanning. Himawari-8/9 (Bessho et al., 2016) and GOES-R (Schmit et al., 2017) and GOES-S called as the third- generation geostationary satellites (3rd GEO) of which have capabilities of more-highly temporal scanning intervals (10 min. or 15min. in Full-Disk scan mode, 2.5 min. or 1 min. over target regions) with improved multiple spectral bands (16 bands). We will demonstrate possibility and capabilities by the utilizations of 3rd GEO data through our research and outreach activities, and we will show several research results through the open data policy of 3rd GEO. In addition, we will discuss potential and limitations for the acceleration of open science and contributions for the society.

References: Bessho et al., (2016): JMSJ, 94 (2), 151-183; Schmit et al., (2017): BAMS, 98, 681-698.

Keywords: Geostationary meteorological satellites, Environmental studies

©2019. Japan Geoscience Union. All Right Reserved.

Scientific data chain for better data publication and preservation

*Takeshi Horinouchi[1]

1. Faculty of Environmental Earth Science, Hokkaido University

In this presentation, I will discuss some of the current issues and thoughts on data publication and preservation from the viewpoint of an atmospheric scientist in Japan. Earth observation data are not only experimental data but also are historical data, so their preservation and sharing are no less important than those from laboratory experiments. However, the current status is not satisfactory. I will introduce a way that might improve the situation.

In our field, we have “big” data and “small” data in two aspects. Data from big projects such as satellite observations, coordinated observations for weather forecast, climate prediction for IPCC are big in size and well preserved and shared. On the other hand, data from small projects such as field observations are not necessarily well-shared, and their preservation may be at risk. These longtail data are also important. For them, use of public or institutional data repository (and data journal) may be a solution, but to use it (them) is not yet our common conduct. More incentive and familiarity would be needed.

The other aspect of the big-and-small issue is on the level of process. For example, numerical values visualized in figures (such as line charts) in peer-reviewed papers can be regarded to be on a highest process level. They are normally small and derived from lower-level data, which can be big. This process is usually multi-staged, and to reproduce it is often difficult even when the original data are open.

Considering these issues, one can envision a digital scientific data chain (like food chain) in which research paper is on the top. Here, a plot in a figure is linked to a digital table (like CSV) stored in journal’s site. The table is further linked to a data repository content or a data paper (through which data repository can be linked). A well-organized data chain can realize reproducibility through documentation and digital operations. The latter can be helped by scripting. An example would be to script data screening and processing such as averaging. The data link in this chain can be multifold, starting from big low-level data.

This chain will make scientists familiar with data repository and data paper. It can also give incentive to write data paper to cite, so it can encourage documentation that increases the usability of data. It can also provide a good example of data usage. Therefore, it can promote data publication and preservation.

Keywords: data publication, open data

©2019. Japan Geoscience Union. All Right Reserved.

Current status and problems of geodetic observation data distribution

*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5]

1. Hitotsubashi University, 2. Institute of Industrial Science, the University of Tokyo, 3. Hydrographic and Oceanographic Department, Japan Coast Guard, 4. National Institute of Information and Communications Technology, 5. Geospatial Information Authority of Japan

Geodetic technologies and geodetic data are now regarded as key infrastructure in the modern society. Space geodetic techniques such as GNSS, VLBI, SLR and DORIS totally rely on the global observation network, and therefore the 'service' organizations are formed under International Association of Geodesy to manage the international scientific/technological activities. Each service has its own data centres where the observation data and the analysis products are stored. Users can download them for free of charge.

Considering the fact that the worldwide institutes have spent a lot of expenses and efforts on the geodetic observations, we need to find a way to somehow reward them so that they can continue the operation or upgrade the system. One possibility for the future is the use of data DOI (Digital Object Identifier) which can be assigned to any style of data sets. When users publish their papers etc, they will be requested to cite the data DOI provided by each geodetic service in the reference section of their publication. By clicking the URL link, the readers can directly be guided to the landing page where the detailed description and contributors are given as well as the link to the data set. The data DOI scheme is expected to make the data providers more visible and even promote the usage of the data and the technology.

Early examples in sea-floor crustal deformation (Yokota et al., 2018, doi:10.1594/PANGAEA.885139), and a just-begun activity in GGOS (Global Geodetic Observing System) will be introduced.

Keywords: Geodesy, Space Geodesy, Navigation, GGOS, Data DOI

©2019. Japan Geoscience Union. All Right Reserved.

Recent activity of data publication and data citation in the international community of geomagnetism

*Masahito Nose[1], Yasuhiro Murayama[2]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Strategic Program Produce Office, National Institute for Information Communications Technology

Data-DOI (digital object identifier), data publication, and data citation will promote “Open Science”. Recognizing their importance, solar-terrestrial physics (STP) data centers in Japan have been working to mint DOI to their database. We participated from October 2014 in a 1-year pilot program for DOI-minting to science data launched by Japan Link Center, which is one of the DOI registration agencies. In the pilot program, a procedure of the DOI-minting for STP data was established. As a result of close collaboration with Japan Link Center, the first case of data-DOI in Japan (doi:10.17591/55838dbd6c0ad) was created in June 2015. As of February 2019, there are 18 data-DOIs for the STP data in Japan. Four of them are related to geomagnetic field data: the Dst index (doi:10.17593/14515-74000), the AE index (doi:10.17593/15031-54800), the Wp index (doi:10.17593/13437-46800), and magnetotelluric data at Muroto, Japan (doi:10.17593/13882-05900).

In the International Association of Geomagnetism and Aeronomy (IAGA), scientists who are working for data centers or observatories started discussion about DOI-minting to their data and a task force was formed in August 2013. In the latest IAGA assembly that was held at Cape Town in August 2017, the task force reported about "Present Status of DOI-minting to Geomagnetic Data/Indices" that is available from https://www.ngdc.noaa.gov/IAGA/vdat/. The report found that there are different types of activities of DOI-minting in individual data centers or observatories. In the field of geophysics including geomagnetism, interests to the DOI-minting are rapidly growing. At the next International Union Geodesy and Geophysics General Assemblies that will be held in Montreal, Canada, in July 2019, a joint session entitled “Geoscience data licensing, producing, publication and citation” is planned. This session solicits contributions presenting actual practices and future plans of data licensing, producing, publication, and citation of scientific data, and possible related topics. The international effort will be continued for DOI-minting to scientific data in geophysics.

©2019. Japan Geoscience Union. All Right Reserved.

IGSN: International Collaboration Makes Samples and Sample Data FAIR

*Kerstin Lehnert[1], Jens Klump[2], Lesley Wyborn[3], Sarah Ramdeen[4]

1. Columbia University, 2. CSIRO Kensington, Australia, 3. Australian National University, Canberra, Australia, 4. Ronin Institute, USA

In recent years, the International Geo Sample Number (IGSN) has seen increasing uptake as a Persistent Identifier (PID) for physical samples because there is growing recognition that unambiguous citation and tracking of physical samples allows previously impossible linking of samples to data and publications, linking and integration of sample-based observations across data systems, and paves the road toward advanced data mining of sample-based data. The IGSN leverages the existing Handle system as its technical basis, while following the example of DataCite for its governance structure and technical architecture.

The IGSN was originally developed for the solid Earth Sciences as a centralized system, but has evolved into an international PID system that is now adopted by a growing number and range of stakeholders worldwide, including researchers, collection curators, and data managers, and by other disciplines that need to refer to physical samples. More than 6.7 million samples have been registered so far.

The recent expansion of the IGSN beyond the geosciences confirms the power of its concept and implementation, but imposes substantial pressures on the existing capacity and capabilities of the IGSN architecture and its governing organization. Significant updates to the IGSN organizational and technical architecture are necessary at this point to keep pace with the growing demand and expectations. As stated by Wittenburg et al. [2017], *"in order to be useful and reliable, PID registration and resolution systems need to be trustworthy and sustainable"*. Essential criteria for trustworthiness include an organizational foundation that ensures longevity, sustainability, proper governance, and regular quality assessment of registration services, as well as a reliable and secure technical platform based on open standards that is sufficiently scalable and flexible to accommodate the growing diversity of specimen types, use cases, and stakeholder requirements.

A major planning activity is currently underway funded by a recent award from the Sloan Foundation with participation of an international group of experts to re-design and improve the existing organization and technical architecture of the IGSN for it to be able to respond to, and support in a sustainable manner, the rapidly growing demands of a global and increasingly multi-disciplinary user community in a landscape of maturing research data infrastructures. This will include a revision of the current business model of the IGSN e.V. as it is no longer able to sustain the organization through the necessary professionalization of its operations. The goal is to ensure that the IGSN will be a trustworthy, stable, and adaptable persistent identifier system for material samples, both technically and organizationally, that attracts, facilitates, and satisfies participation within and beyond the Geosciences, that will be a reliable component of the evolving research data ecosystem, and that is recognized as a trusted partner by data infrastructure providers and the science community alike.

Keywords: Research data , Samples, Persistent Identifier, FAIR

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Baptiste Cecconi(LESIA - Observatoire de Paris)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI31-13] Adoption of IGSN in the International Ocean Discovery Program (IODP)

*Sean Toczko[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI31-14] Oceanogrpahic Data and Information Exchange for Open Science

*Toru Suzuki[1] (1.Marine Information Research Center)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI31-15] The International Heliophysics Data Environment Alliance (IHDEA) initiative
★Invited Papers

*Arnaud Masson[1], Aaron Roberts[2], Shing Fung[2], Bob McGuire[2], Jack Ireland[2], Jeremy Faden[12], Jim Lewis[9], Baptiste Cecconi[7], Vincent Genot[8], J.C. Malapert[4], Keiichi Matsuzaki[3], Todd King[5], Daniel Mueller[6], Jon Vandegriff[10], Miyoshi Yoshizumi[11] (1.ESAC Science Data Center, European Space Agency, Madrid, Spain, 2.NASA/GSFC, USA, 3.JAXA, ISAS, Tokyo, 4.CNES, Toulouse, 5.UCLA, USA, 6.ESTEC, European Space Agency, Noordwijk, The Netherlands, 7.LESIA, Observatoire de Paris, France, 8.IRAP, CNRS, Toulouse, 9.Berkeley University, USA, 10.John Hopkins, APL, USA, 11.ISEE, Nagoya University, Nagoya 464-8601, Japan, 12.Cottage Systems, University of Iowa, USA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI31-16] **VESPA: Progress on the Planetary Science Virtual Observatory**

*Stephane Erard[1] (1.Observatoire de Paris / LESIA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI31-17] Publishing planetary science data following FAIR principles

*pierre le sidaner[1], Baptiste Cecconi[2], Stephane Erard[2], Cyril Chauvin[1], Albert Shih[1], Stephane Aicardi[1], Philippe Hamy[1], Alan Loh[2] (1.DIO - Observatoire de Paris, Universite PSL, CNRS UMS2201, 2.LESIA,

Observatoire de Paris, Universite PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cite)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI31-18] Community-developed open tools for supporting the ESA JUICE space mission preparation

*Baptiste Cecconi[1], Alan Loh[1], Stephane Aicardi[2], Corentin Louis[3] (1.LESIA, Observatoire de Paris, CNRS, PSL Research University, Meudon, France, 2.DIO, Observatoire de Paris, CNRS, PSL Research University, Paris, France, 3.IRAP, CNRS-Université Paul Sabatier, Toulouse, France)

Adoption of IGSN in the International Ocean Discovery Program (IODP)

*Sean Toczko[1]

1. Japan Agency for Marine-Earth Science and Technology

The International Ocean Discovery Program (IODP) has moved to adopt the International Geo Sample Number (IGSN). This describes some of the details in adpoting this system to an existing subseafloor core sample respository at the Kochi Core Center (KCC), JAMSTEC.

Keywords: IODP, IGSN, KCC, JAMSTEC

©2019. Japan Geoscience Union. All Right Reserved.

Oceanogrpahic Data and Information Exchange for Open Science

*Toru Suzuki[1]

1. Marine Information Research Center

For more than 50 years, the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO has promoted and facilitated the exchange of oceanographic data and information between Member States for development and enhancement of marine research. The IODE system consists of 80 and more National Oceanographic Data Centres (NODC), Associated Data Units (ADU; former Designated National Agencies (DNAs)), and those data centres have been responsible for the collection, management, quality control and archive oceanographic data observed in each Member States. The World Ocean Database (WOD), gathering oceanographic data through IODE system, is most useable data product by National Centers for Environmental Information (former US-NODC), NOAA, and is also one of achievements by IODE projects for WOD and Global Oceanographic Data Archeology and Rescue (GODAR). Japan Oceanographic Data Center (JODC) is a representative of Japan for IODE and is the second largest contributor to WOD. The Ocean Biogeographic Information System (OBIS) joined as one of IODE projects in June 2009 after the successful decade-long Census of Marine Life project. The IODE system have many other projects for oceanographic data and information collection, quality control and dissemination managed by steering groups or task teams, and has a role of technical support to the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) by World Meteorological Organization (WMO) and IOC. The IODE joined as one of network members of World Data Systems (WDS) in 2013. At the same time IODE has started the Quality Management Framework project to identify a set of quality management criteria for NODCs taking into account those defined for the WDS, and JODC received NODC accreditation in 2019. In 2003 the IOC Assembly adopted Resolution IOC-XXII-6 entitled “IOC Oceanographic Data Exchange Policy” which is mentioned about the timely, free and unrestricted access to all oceanographic data and associated metadata and products. It is nevertheless known that there are many non-disclosure or non-digitized historical data and needs to progress a data publication and citation system for evaluating data management works.

Keywords: Oceanographic data, Data and information exchange, Quality control

©2019. Japan Geoscience Union. All Right Reserved.

The International Heliophysics Data Environment Alliance (IHDEA) initiative

*Arnaud Masson[1], Aaron Roberts[2], Shing Fung[2], Bob McGuire[2], Jack Ireland[2], Jeremy Faden[12], Jim Lewis[9], Baptiste Cecconi[7], Vincent Genot[8], J.C. Malapert[4], Keiichi Matsuzaki[3], Todd King[5], Daniel Mueller[6], Jon Vandegriff[10], Miyoshi Yoshizumi[11]

1. ESAC Science Data Center, European Space Agency, Madrid, Spain, 2. NASA/GSFC, USA, 3. JAXA, ISAS, Tokyo, 4. CNES, Toulouse, 5. UCLA, USA, 6. ESTEC, European Space Agency, Noordwijk, The Netherlands, 7. LESIA, Observatoire de Paris, France, 8. IRAP, CNRS, Toulouse, 9. Berkeley University, USA, 10. John Hopkins, APL, USA, 11. ISEE, Nagoya University, Nagoya 464-8601, Japan, 12. Cottage Systems, University of Iowa, USA

The IHDEA was formed as a result of the first International Heliophysics Data Environment (IHDE) meeting held at the European Space and Astronomy Centre (ESAC), Madrid, Spain, on October 17-18, 2018. Meeting attendees representing NASA, ESA, JAXA, and CNES have all agreed that increasing collaboration and coordination through the use of standard formats (for both data and metadata) and community-based data tools are critical for enabling interoperability of data systems and services and improving sharing of space-based, ground-based, and model-based heliophysics data sets.

The newly created International Heliophysics Data Environment Alliance (IHDEA) is a collaborative organization whose goal is to guide the development of a data environment in which the international heliophysics and space weather research community can seamlessly find, access, and use all electronically accessible, heliophysics relevant data sets.

The specific mission of the IHDEA is to facilitate global access to, and exchange of, high quality scientific data products managed across international boundaries. This will be achieved by adhering to, and promote the use of, a set of governing data standards, data exchange protocols, visualization and data analysis tools.

The role of the IHDEA is to serve as the focal point to engage the heliophysics data centres and the scientific community, foster communication, and identify and identify the standards and services that will best serve the heliophysics and space weather science needs.

Practical examples will be provided, illustrating the mutual interest to foster collaboration between key heliophysics data providers.

©2019. Japan Geoscience Union. All Right Reserved.

VESPA: Progress on the Planetary Science Virtual Observatory

*Stephane Erard[1]

1. Observatoire de Paris / LESIA

The Europlanet-2020 programme, started Sept 1st, 2015 for 4 years, includes an activity called VESPA which focuses on adapting Virtual Observatory (VO) techniques to handle Planetary Science data. The main objectives of VESPA are to facilitate searches both in big archives and in small databases, to enable data analysis by providing simple data access and on-line visualization functions, and to allow research teams to publish derived data in an interoperable environment as easily as possible. VESPA encompasses a wide scope, including surfaces, atmospheres, magnetospheres and planetary plasmas, small bodies, heliophysics, exoplanets, and spectroscopy in solid phase. This system relies in particular on standards and tools developed for the Astronomy VO (IVOA) and extends them where required to handle specificities of Solar System studies. It also aims at making the VO compatible with tools and protocols developed in different contexts, for instance GIS for planetary surfaces, or time series tools for plasma-related measurements. An essential part of the activity is to publish a significant amount of high-quality data in this system, with a focus on derived products resulting from data analysis or simulations

[1] Erard et al 2014, *Astronomy & Computing* **7-8**, 71-80. http://arxiv.org/abs/1407.4886

Keywords: Solar System, Virtual Observatory , GIS

©2019. Japan Geoscience Union. All Right Reserved.

Publishing planetary science data following FAIR principles

*pierre le sidaner[1], Baptiste Cecconi[2], Stephane Erard[2], Cyril Chauvin[1], Albert Shih[1], Stephane Aicardi[1], Philippe Hamy[1], Alan Loh[2]

1. DIO - Observatoire de Paris, Universite PSL, CNRS UMS2201, 2. LESIA, Observatoire de Paris, Universite PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cite

On the frame of Europlanet-2020-RI VESPA program we have developed an infrastructure to publish Solar System data. Our pipeline and tools follow the Open Data and FAIR (Findable Accessible Interoperable Reusable) principles. It uses protocols and infrastructures developed and maintained by the IVOA (International Virtual Observatory Alliance). It takes advantage of 15 years of experience in astronomical data sharing with interoperable data centers distributed all over the world. VESPA follows the IVOA models that define an interoperable system to describe, discover and search data collections and services. It uses standard data access protocols, formats and metadata descriptions. The specificity of the IVOA model is to propose a distributed system. The data are stored at each provider data center with interoperable layers on top of them. This model allows exponential increasing in data volume. One the next largest current project, SKA (Square Kilometer Array) is planning to produce more data than Google, Facebook and Youtube together. IVOA models will have to face this. VESPA proposes an extension to IVOA protocoles for handling Solar System data, namely: a data model for Solar System data product metadata. I will present TAP (Table Access Protocol) as a toolkit to publish a large type of data. This protocol can be associated to a data model to publish planetary data (surface, atmosphere), plasma physics, solar physics, spectroscopic property, time series, exoplanetary dataset, etc. I will also describe how the VESPA project makes use of it to publish any type of planetary science data.

VESPA is part of the Europlanet H2020 Research Infrastructure project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208

Keywords: interoperability, virtual observatory, FAIR, Planetary science data

©2019. Japan Geoscience Union. All Right Reserved.

Community-developed open tools for supporting the ESA JUICE space mission preparation

*Baptiste Cecconi[1], Alan Loh[1], Stephane Aicardi[2], Corentin Louis[3]

1. LESIA, Observatoire de Paris, CNRS, PSL Research University, Meudon, France, 2. DIO, Observatoire de Paris, CNRS, PSL Research University, Paris, France, 3. IRAP, CNRS-Université Paul Sabatier, Toulouse, France

The MASER (Measurements, Analysis and Simulation of Emissions in the Radio range) and VESPA (Virtual European Solar and Planetary Access) teams are proposing a set of tools and dataset used for preparing the ESA-lead JUICE (Jupiter Icy moon Explorer) space mission, with a focus on magnetospheric science topics. The case of the observation planning and science mode assessment in the frame of the JUICE mission is described. This case shows how Jovian radio emissions observations and simulations are used by the JUICE science and operation teams. Developments using the EOSC (European Open Science Cloud) infrastructure are also envisaged in the near future.

Keywords: Radio astronomy, Space mission, Jupiter

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center), Chairperson:Junichi Kurihara(Hokkaido University), Tetsuro Ishida(Hokkaido University)

Microsatellites have great potential as remote sensing platforms, because of the cost-effective implementation of satellite constellations, which increase their overall temporal resolution and ground coverage for Earth observation. However, it is difficult for one single university or institution to maintain a satellite constellation composed of many microsatellites. Recently, the Asian Microsatellite Consortium (AMC) comprising 16 space agencies and universities from nine Asian nations has been created to develop microsatellite technologies and use collected data relating to the environment and natural disasters, etc. This international framework is the first step to share remote sensing data from the microsatellites by the members of the consortium, instead of making a satellite constellation by a single owner. The microsatellites such as the DIWATA-2 (Philippines), MicroDragon (Vietnam), and RISESAT (Japan) developed by the AMC members will be launched in the last quarter of 2018. This session is a unique opportunity to discuss microsatellite development and utilization in terms of international collaboration and data sharing. This session welcomes presentations on microsatellite remote sensing including satellite development and operation, sensor development and calibration, data analysis and utilization. We also seek presentations on ground and information systems, international collaborations, and educational programs using microsatellites.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MSD42-01] Present status of Asian Micro-satellite Consortium

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MSD42-02] **Updates on the Development of the Image Acquisition and Scheduler Portal for the Asian Microsatellite Consortium (AMC) from the Philippines' STAMINA4Space Program**

*Mark Edwin Tupas[1], Alvin Retamar[2], Gay Jane Perez[1], Joel Joseph Jr Marciano[2], Romer Kristi Aranas[1], Benjamin Joseph Jiao[1] (1.University of the Philippines - Diliman, 2.Department of Science and Technology - Advanced Science and Technology Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MSD42-03] **Overview of MicroDragon, a microsatellite for ocean color observation**

*Huy Xuan Le[1], Thao Thi Nguyen[1], Junichi Kurihara[2] (1.Vietnam National Space Center, 2.Graduate School of Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MSD42-04] Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*Tetsuro Ishida[1], Mark Jayson Felix[2], Ellison Caparas Castro[2], Shielo Baes Namuco[2], Francisco Miguel Felicio[2], Harry Casimir Merida[2], Kaye Kristine Vergel[2], Gay Jane Perez[2], Joel Joseph Marciano[3,4], Yukihiro Takahashi[1] (1.Faculty of Science, Hokkaido University, 2.Institute of Environmental Science and Meteorology, University of the Philippines Diliman, 3.Advanced Science and Technology Institute, Department of Science and Technology, 4.Electrical and Electronics Engineering Institute, University of the Philippines Diliman)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MSD42-05] MICROSATELLITE TECHNOLOGY DEVELOPMENT STATUS IN MONGOLIA BASED ON ITS NEEDS

*Erdenebaatar Dashdondog[1], Begzsuren Tumendemberel[2], Turtogtokh Tumenjargal[3], Ulam-Orgikh Duger[4] (1.Senior Lecturer of the National University of Mongolia, 2.Hokkaido University, 3.Researcher National University of Mongolia, 4.Professor National University of Mongolia)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MSD42-06] Potential Agricultural Applications of Microsatellites for Malaysian Agriculture

*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2] (1.Universiti Putra Malaysia , 2.Hokkaido University)

Present status of Asian Micro-satellite Consortium

*Yukihiro Takahashi[1]

1. Department of Cosmosciences, Graduate School of Science, Hokkaido University

Satellite remote-sensing is useful for global monitoring. However, since the revisiting period by the most of the conventional satellite is relatively long compared to the time scale of disasters, etc., its application has been very limited. Here we promote “Asian Micro-satellite Consortium (AMC)” with a concept of “sharing”, namely, the sharing of satellite technology, data and applications. If the target pointing is possible, we can take images for any location once or twice a day only with one very small satellite. Therefore, on-demand image acquisition with several tens of micro-satellite under international agreement provides the continuous monitoring. We are developing the request system for disaster and environmental monitoring among the member countries, as well as 50-kg micro-satellites together with member countries. They can get frequent imaging opportunity at very low cost. Now the member institutions have several micro-satellites in space: RISING-2, DIWATA-1, DIWATA-2, RISESAT and MicroDragon with cutting edge spectral imagers. Moreover, we are negotiating some project with other few members as well. This world first system will provide revolutionary changes in the disaster and environmental management.

Keywords: micro-satellite, Asia, Consortium

©2019. Japan Geoscience Union. All Right Reserved.

Updates on the Development of the Image Acquisition and Scheduler Portal for the Asian Microsatellite Consortium (AMC) from the Philippines' STAMINA4Space Program

*Mark Edwin Tupas[1], Alvin Retamar[2], Gay Jane Perez[1], Joel Joseph Jr Marciano[2], Romer Kristi Aranas[1], Benjamin Joseph Jiao[1]

1. University of the Philippines - Diliman, 2. Department of Science and Technology - Advanced Science and Technology Institute

The Asian Microsatellite Consortium (AMC) is a platform for forging meaningful scientific collaborations among Asian nations in space technology through the development and operation of small satellites for scientific earth observation. The Department of Science and Technology and its attached agencies –the Advanced Science and Technology Institute (DOST-ASTI) and the Philippine Council for Industry, Energy and Emerging Technology Research & Development (PCIEERD), together with the University of the Philippines (UP) participates in and contributes to the AMC through scientific research and development programs such as the PHL-Microsat and its successor, the Space Technology & Applications Mastery, Innovation and Advancement (STAMINA4Space). Through PHL-Microsat and STAMINA4Space, UP and DOST support the interaction and exchange of Filipino researchers with partners and enables access to the country's existing space assets, namely the microsatellites, DIWATA-1 and DIWATA-2, and ground receiving stations.

DIWATA-1 is a 50 kg. microsatellite that was deployed from the Japanese Kibo module in the International Space Station (ISS) on April 2016. In orbit for almost three (3) years and nearing the end of its orbital lifetime, DIWATA-1 has acquired more than 21,000 images of the Philippines and a total of over 36,000 including other parts of the world to support both scientific research and operational objectives. DIWATA-2, another 50 kg. microsatellite, on the other hand, was launched on October 29, 2018 by the JAXA HII-A rocket mission no. 40 to a Sun Synchronous Orbit (SSO) at approximately 600km. The optical cameras onboard DIWATA-2 consists of the HPT and the SMI with LCTF that were carried over end refined from the DIWATA-1 mission and Enhanced Resolution Camera (ERC) at 52.9m resolution to enhance imaging capability. With an expected orbital life of five (5) years, DIWATA-2 is expected to contribute to the AMC through target tasking and the reception, processing and distribution of relevant data.

In this regard, the STAMINA4Space program, through the Ground Receiving, Archiving, Science Product Development and Distribution (GRASPED) component, is currently undertaking the development of the satellite tasking and image acquisition scheduler software, which is expected to be part of a portal that will be accessed by the AMC members. The image acquisition scheduler works like a booking system by allowing AMC members and stakeholders to lodge image acquisition requests. The platform has been designed to follow a service oriented architecture in order to maintain a single source of information and to have flexibility in presentation. The core component of the distribution platform is the WebAPI , which handles geospatial queries through polygons or points. The user facing component of the platform is the web frontend, which consumes data from the WebAPI. It is based on Javascript and LeafletJS, a Javascript framework for interactive maps. Upon lodging of the image acquisition request, the system then identifies available satellites and ground segments for tasking and the member providers are subsequently notified and given the option to accept the tasks. According to the principles of cooperation under the AMC, acceptance and undertaking of the tasks by members is on a best-effort basis with certain requests

©2019. Japan Geoscience Union. All Right Reserved.

gaining priority over others, e.g. in case of emergencies or natural disasters. The cycle ends with the delivery and acceptance of data. More than a resource for facilitating the sharing of both space and ground assets, the AMC portal is expected to contribute towards achieving sustainability of the consortium and of the space technology activities in the region. This presentation provides an update from the GRASPED project component of the Philippines STAMINA4Space program on the development of the scheduler along with related progress of DIWATA-1 and DIWATA-2 microsatellites.

Keywords: Asian Microsatellite Consortium, DIWATA-1, DIWATA-2, Image Acquisition Tasking

©2019. Japan Geoscience Union. All Right Reserved.

Overview of MicroDragon, a microsatellite for ocean color observation

*Huy Xuan Le[1], Thao Thi Nguyen[1], Junichi Kurihara[2]

1. Vietnam National Space Center, 2. Graduate School of Science, Hokkaido University

MicroDragon is an Earth observation satellite with the weight of 50kg and size of 50x50x50 centimeters cube. MicroDragon was developed with participation of 36 Vietnamese engineers from Vietnam National Space Center, Vietnam Academy of Science and Technology, who studied space technology in five Japanese universities (The University of Tokyo, Keio University, Tohoku University, Kyushu Institute of Technology, and Hokkaido University). Starting the manufacturing in 2013, MicroDragon has successfully been completed and tested in 2018 with the strong support of Japanese professors and experts.

The main mission of MicroDragon satellite is ocean color observation to assess coastal water quality and locate living resource. The target of the MicroDragon is to enhance observation of the ocean color and the phenomena in the coastal region as well as the cloud detection and the atmospheric correction. The system will provide data that researchers and scientists in fishery field and oceanography use to analysis and distribute information to fishermen and environmental managers.

For applications in the coastal zone, high spatial resolution, high spectral resolution, and many spectral bands are required. Image data of the old sensors can provide each of them but not all. With advantages of a new technique of Liquid Crystal Tunable Filter (LCTF), all three parameters can be included by a sensor. The LCTFs are optical filters that use electronically controlled liquid crystal elements to transmit a selectable wavelength of light and exclude others. The LCTFs are often used in multispectral imaging or hyperspectral imaging systems because of their high image quality and rapid tuning in small increments (1 nm) over the wide range of wavelengths. Moreover, the LCTF sensor that is small, light and low power consumption is suitable to install in a micro-satellite.

The MicroDragon carries two main scientific instruments including a Space-borne Multispectral Imager (SMI) and a Triple Polarization Imager (TPI). The SMI uses two LCTFs with one in the visible spectrum and another in the near-infrared spectrum for the ocean color observation. The TPI consists of three LCTF cameras, each camera’ s polarizer tilted 60° to the others to observe the polarized solar radiance reflected from the predefined targets for atmospheric correction.

MicroDragon was successfully launched on 18 January 2019 with 6 other technology demonstration satellites by Epsilon rocket from the Uchinoura Space Center in southwestern Japan. After launching, satellite also already communicated and controlled by a ground station and control center in ISAS/JAXA and the University of Tokyo. First images of satellite were sent to ground station after 4 days from launch time.

©2019. Japan Geoscience Union. All Right Reserved.

Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*Tetsuro Ishida[1], Mark Jayson Felix[2], Ellison Caparas Castro[2], Shielo Baes Namuco[2], Francisco Miguel Felicio[2], Harry Casimir Merida[2], Kaye Kristine Vergel[2], Gay Jane Perez[2], Joel Joseph Marciano[3,4], Yukihiro Takahashi[1]

1. Faculty of Science, Hokkaido University, 2. Institute of Environmental Science and Meteorology, University of the Philippines Diliman, 3. Advanced Science and Technology Institute, Department of Science and Technology, 4. Electrical and Electronics Engineering Institute, University of the Philippines Diliman

The PHL-Microsat program, funded by the Department of Science and Technology (DOST) through the Philippine Council for Industry, Energy and Emerging Technology Research and Development (PCIEERD), is a collaboration between the University of the Philippines Diliman, Hokkaido University, Tohoku University, and the Advanced Science and Technology Institute (ASTI) of the DOST. Under this program, two 50-kg class microsatellites, DIWATA-1 and DIWATA-2 were designed and developed and the continuing development of small satellites is now being pursued by the Space Technology & Applications Mastery, Innovation and Advancement (STAMINA4Space) Program as a successor to PHL-Microsat.

DIWATA-1 was released into orbit from the International Space Station on April 27, 2016 and is currently operated at an altitude of ~346 km. More than two years after the release of DIWATA-1, DIWATA-2 was launched via H-IIA rocket from Japan’ s Tanegashima Space Center on October 29, 2018. The second microsatellite has a sun-synchronous orbit with an altitude of ~595 km. Both satellites carry advanced optical systems namely, the High Precision Telescope (HPT) and the Spaceborne Multispectral Imager (SMI) in addition to other cameras. The HPT in both microsatellites can simultaneously capture an image in the blue, green, red, and near-infrared range. It has a ground sampling distance (GSD) of ~2.6 m and ~4.5 m at nadir for DIWATA-1 and DIWATA-2, respectively. On the other hand, the SMI is capable of sensing several spectral bands between 450nm to 1050nm with ~53.1 m and ~121.6 m GSD for DIWATA-1 and DIWATA-2, respectively. The Wide Field Camera (WFC) is a fish eye camera with a field of view of 180 x 134 degrees. This is used in imaging cloud patterns and weather disturbances. Since the start of operation, both DIWATA-1 and DIWATA-2 have been capturing images of various locations in the Philippines. These images are processed to derive geophysical and application products that are useful in monitoring agricultural and aquatic resources. In this presentation, we will highlight land products and coastal and inland water applications. Land applications were produced from the visible and near infrared bands of SMI where vegetation indices namely NDVI and GNDVI. These are used to assess the health and density of vegetation as well as classify areas of agriculture, built-ups, bare soil and river or inland water networks. For water applications, potential capability to assess the health and quality of coastal and inland waters in the Philippines is shown. Retrievals of water quality parameters such as water leaving reflectance and turbidity were done. Furthermore, HPT, SMI and WFC were used to observe cloud patterns and estimate cloud top height. The accuracy assessment and limitations of these satellite-derived products will also be presented.

Acknowledgements: The control, operation, and acquisition of the satellite data are currently being handled by the Philippine Earth Data Resource Observation Center (PEDRO), which is managed by the Department of Science and Technology Advanced Science and Technology Institute (DOST-ASTI). This work was also supported by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) under SATREPS.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Microsatellite, Earth Observation, Remote Sensing

©2019. Japan Geoscience Union. All Right Reserved.

MICROSATELLITE TECHNOLOGY DEVELOPMENT STATUS IN MONGOLIA BASED ON ITS NEEDS

*Erdenebaatar Dashdondog[1], Begzsuren Tumendemberel[2], Turtogtokh Tumenjargal[3], Ulam-Orgikh Duger[4]

1. Senior Lecturer of the National University of Mongolia, 2. Hokkaido University, 3. Researcher National University of Mongolia, 4. Professor National University of Mongolia

The National University of Mongolia is one of the main players on space technology development in Mongolia. The Laboratory of National University of Mongolia successfully launched Mongolian very first satellite (1U cubesat) in 2017 under BIRDS project. The project outcome was to prepare experienced initial engineers in the satellite engineering field. After the project, country had to make next steps toward to space technology. One step is Microsatellite technology development in Mongolia collaborating with the Hokkaido University of Japan. In the framework of this collaboration, some universities, including National University of Mongolia, have enrolled to the Asian Microsatellite Consortium (AMC). In January of 2018, National University of Mongolia organized a Microsatellite mission and needs definition workshop at first time. The low population density, wide land, rich natural resources and nomadic life culture make unique needs of space technology and its application for Mongolia. Also, Hyperspectral imagery of the Microsatellite could be the best suitable solution of the Mongolian Space Technology field. Applications of the hyperspectral imagery of the Microsatellite shall be well-developed. Researches and development of applications are being conducted on imagery of LCTF camera which is the main payload of the Microsatellite with the cutting-edge technology and the Unmanned Airborne Vehicle measurement method. In this presentation, Mongolian current status of the Microsatellite technology development and needs will be presented.

Keywords: Microsatellite, Hyper-spectral imagery, Space Collaboration

©2019. Japan Geoscience Union. All Right Reserved.

Potential Agricultural Applications of Microsatellites for Malaysian Agriculture

*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2]

1. Universiti Putra Malaysia , 2. Hokkaido University

Malaysia is 330,803 km^2 and located in Southeast asia. It comprises two major land masses, that is Peninsular Malaysia and the states of Sabah/Sarawak in the island of Borneo. The South China Sea separates these two land masses. Flying distances between Kuala Lumpur, the capital city located in Peninsular Malaysia to Kota Kinabalu, the capital of Sabah and to Kuching, the capital of Sarawak are 2 hrs 30 minutes and 1 hr 45 minutes respectively. As can be seen this is a fairly wide coverage for which imaging from space is necessary to support viability of agriculture, fisheries, environment, meterology, natural disasters and so on. Malaysia' s early imaging from space satellites used the Tiungsat and Razaksat satellites respectively. Valuable lessons were learnt which clearly demonstrated the need for future image data from space.

With current developments, the idea of using microsatellites as platforms for image acquisitions becomes very attractive as a practical and low cost approach is made available. Though there are a multitude of applications possible with data acquired by microsatellites, this presentation will focus on agriculture applications. Malaysia has 5 millon ha of land under oil palm cultivation. Oil palm is an important food for most of the world, it is the most versatile and efficient vegetable oil in the world, yielding more per hectare than any other edible vegetable oil crop. Currently environmental and nature groups based in Europe have been critical about oil palm cultivation in Malaysia and Indonesia. However, oil palm is cultivated in a systematic and regulatory manner in Malaysia, with 50% of the country still remaining intact as forest. Use of microsatellite data will ensure efficient and effective monitoring of this forest areas from illegal land clearance, illegal logging and other activities detrimental to the environment. Up to date information on landuse for oil palm and forestry can be obtained at very frequent temporal intervals to counter any criticisms on concerns on oil palm cultivation in Malaysia.

Use of such imageries will also help in the precision agriculture applications particularly on using variable rate applications in the oil palm plantations and in paddy farming particularly, with potential applications for example for rubber cultivation, cocoa and pineapples. Apart from fertilizer applications, crop growth monitoring, surveillance against pests and diseases and harvesting are further applications of the imaging technologies. Based on these requirements, the critical bands, its spectral and spatial resolutions identified through local research will be used in the collaborative development of sensors in the satellite building program. Such positive and synergistic efforts will lead to appropriate images being acquired for the needs being addressed.
As crops planted in Malaysia have commonality with crops in Southeast Asia, primarily with Indonesia, Thailand, Philippines, Vietnam and Cambodia, collaborative efforts can be made to share and exchange vital information on the related crops. Thus the microsatellites will not only help to acquire data, but will help bring these neighboring nations closer together.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

convener:Jun Kimura(Osaka University), Yasumasa Kasaba(Planetary Plasma and Atmospheric Research Center, Tohoku University), Kunio M. Sayanagi(Hampton University), Chairperson:笠羽 康正, Kazuo Yoshioka(The University of Tokyo)

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Cassini, Juno, New Horizons, JUICE, and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its trojan asteroids.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS01-01] Circulation of plasma in the Jupiter's inner magnetosphere revealed from time variation in radial profile of plasma temperature and density obtained by Hisaki/EXCEED observation

*Reina Hikida[1], Kazuo Yoshioka[2], Fuminori Tsuchiya[3], Masato Kagitani[3], Go Murakami[4], Tomoki Kimura[5], Atsushi Yamazaki[4], Ichiro Yoshikawa[2] (1.Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 2.Department of Complexity Science and Engineering, Graduate School of Frontier Science, the University of Tokyo, 3.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 4.Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA) , 5.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS01-02] Volcanic change of the distribution of Io’s neutral oxygen cloud observed by Hisaki

*Ryoichi Koga[1], Fuminori Tsuchiya[1], Masato Kagitani[1], Takeshi Sakanoi[1], Tomoki Kimura[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Go Murakami[3], Atsushi Yamazaki[3], Howard Todd Smith[4], Fran Bagenal[5] (1.Tohoku University, 2.The University of Tokyo, 3.ISAS/JAXA, 4.Johns Hopkins University, 5.University of Colorado)

4:00 PM - 4:18 PM JST | 7:00 AM - 7:18 AM UTC

[PPS01-03] New pictures of Jovian magnetosphere obtained from the Hisaki satellite observation

★Invited Papers

*Fuminori Tsuchiya[1], Kazuo Yoshioka[2], Tomoki Kimura[1], Chihiro Tao[3], Ichiro Yoshikawa[2], Go Murakami[4], Hajime Kita[4], Ryoichi Koga[1], Hikida Reina[2], Fumiharu Suzuki[2], Sooman Han[2], Masato Kagitani[1], Takeshi Sakanoi[1], Hiroaki Misawa[1], Yasumasa Kasaba[1], Atsushi Yamazaki[4] (1.Tohoku University, 2.The University of Tokyo, 3.NICT, 4.ISAS/JAXA)

4:18 PM - 4:33 PM JST | 7:18 AM - 7:33 AM UTC

[PPS01-04] Axisymmetric conductivities of Jupiter's middle- and low-latitude ionosphere

*Yuki Nakamura[1], Koichiro Terada, Chihiro Tao[2], Naoki Terada[1], Yasumasa Kasaba[3], Hajime Kita[4], Aoi Nakamizo[2], Akimasa Yoshikawa[5], Shinichi Ohtani[6], Fuminori Tsuchiya[3], Masato Kagitani[3], Takeshi Sakanoi[3], Go Murakami[4], Kazuo Yoshioka[7], Tomoki Kimura[1], Atsushi Yamazaki[4], Ichiro Yoshikawa[8] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.National Institute of Information and Communications Technology, 3.Planetary Plasma and Atmospheric Research Center,

Tohoku University, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 5.Department of Earth and Planetary Sciences, Kyushu University, 6.The Johns Hopkins University Applied Physics Laboratory, 7.Graduate School of frontier Science, The University of Tokyo, 8.The University of Tokyo)

4:33 PM - 4:51 PM JST | 7:33 AM - 7:51 AM UTC

[PPS01-05] The magnetospheres of Saturn and Jupiter as viewed by Cassini and Juno

★Invited Papers

*G Provan[1], Stanley W. H. Cowley[1], Emma Jane Bunce[1] (1.University of Leicester)

4:51 PM - 5:00 PM JST | 7:51 AM - 8:00 AM UTC

Discussion

Circulation of plasma in the Jupiter's inner magnetosphere revealed from time variation in radial profile of plasma temperature and density obtained by Hisaki/EXCEED observation

*Reina Hikida[1], Kazuo Yoshioka[2], Fuminori Tsuchiya[3], Masato Kagitani[3], Go Murakami[4], Tomoki Kimura[5], Atsushi Yamazaki[4], Ichiro Yoshikawa[2]

1. Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 2. Department of Complexity Science and Engineering, Graduate School of Frontier Science, the University of Tokyo, 3. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 4. Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA) , 5. Frontier Research Institute for Interdisciplinary Sciences, Tohoku University

The satellite Io, which has many volcanoes and is located at 5.9 R_J from the center of Jupiter, is a powerful plasma source in the magnetosphere. The resulting specificity of the Jupiter's magnetosphere is the magnitude of energy that circulates internally. Previous researches, using data obtained by Voyager and Cassini spacecraft and chemical models complementarily, showed that the pickup energy of heavy ions originating from volcanoes on Io and the energy of hot electrons are converted into radiation reaching ~3 TW. However, the origins of hot electrons, that is, heating and/or transport mechanisms are still unrevealed. Therefore, in this research, we focus on the response to the change in the amount of plasma supplied to the magnetosphere and explore the above problem. In this study, the radial distributions of plasma density and temperature were derived from the intensities of emission lines in the extreme ultraviolet range obtained by Hisaki satellite. In this presentation, we will show the results using data obtained from December 2014 to May 2015. The activation of volcanoes on Io in early January 2015 was confirmed by ground-based infrared observations.

©2019. Japan Geoscience Union. All Right Reserved.

Volcanic change of the distribution of Io's neutral oxygen cloud observed by Hisaki

*Ryoichi Koga[1], Fuminori Tsuchiya[1], Masato Kagitani[1], Takeshi Sakanoi[1], Tomoki Kimura[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Go Murakami[3], Atsushi Yamazaki[3], Howard Todd Smith[4], Fran Bagenal[5]

1. Tohoku University, 2. The University of Tokyo, 3. ISAS/JAXA, 4. Johns Hopkins University, 5. University of Colorado

Io has a thin atmosphere created by volcanism and sublimation from the surface frost. Io's atmospheric oxygen atoms are heated by atmospheric sputtering, and escape from Io's gravity, forming a neutral oxygen cloud around Io's orbit. The neutral cloud is important as a source of the Io plasma torus. Previous studies derived the distribution and density of the equilibrium neutral oxygen cloud, and showed changes in Io's volcanism can lead to increase densities of both neutral clouds and Io plasma torus. Koga et al (2018) showed the distribution of Io's neutral oxygen cloud from Hisaki observation data during a volcanically quiet period (November and December in 2014). The equilibrium neutral oxygen cloud consists of a dense region distributed around Io (the "banana cloud") and a longitudinally uniform, diffuse region distributed along Io's orbit. However, the evolution of the distribution of neutral clouds was not understood. In this study, we analyzed the Hisaki satellite observations of the spatial distribution of OI 130.4 nm emissions around Io's orbit during a volcanic event in 2015.
The radial distribution shows the oxygen cloud spread outward during the volcanically active period. The outer edge of the OI emission was 7 R_J (Jupiter radii) before the volcanic activity, but it spread to around 8-8.6 R_J during the volcanically active period. We also estimated the oxygen number density outward Io's orbit represented as $n(r)=n_0(r/r_0)^{\gamma}$, where r is radial distnace from Jupiter, r_0 is 5.9 R_J (orbit of Io), n_0 is a number density at 5.9 R_J, γ is a power law slope of the profile. The number density at Io's orbit (where north-south thickness is 1.2 R_J) increased to 88±9 cm^{-3} during the active period that is more than twice as large as the number density during the quiet period (40 cm^{-3}). The power law slope outward Io's orbit during the active period (γ=-5.5±1.3) is similar to that during the quiet period (γ=-5.3). The azimuthal distribution shows the neutral oxygen cloud during the active period also consists of the banana cloud and diffuse region distributed along Io's orbit, but both of the regions enlarge. The observation results show the main escape process of neutrals from Io's graivity remains atmospheric sputtering, but the escape rate of them significantly increased during a volcanically active period. One of the possible mechanisms to increase the escape rate is that the sublimation frost area increases and the density of sublimation driven atmosphere also increases. Another mechanism is that plumes increase the height of the exobase, and the area of atmospheric sputtering increases.

Keywords: Jupiter moon Io, Neutral oxygen, Ultraviolet observation

©2019. Japan Geoscience Union. All Right Reserved.

New pictures of Jovian magnetosphere obtained from the Hisaki satellite observation

*Fuminori Tsuchiya[1], Kazuo Yoshioka[2], Tomoki Kimura[1], Chihiro Tao[3], Ichiro Yoshikawa[2], Go Murakami[4], Hajime Kita[4], Ryoichi Koga[1], Hikida Reina[2], Fumiharu Suzuki[2], Sooman Han[2], Masato Kagitani[1], Takeshi Sakanoi[1], Hiroaki Misawa[1], Yasumasa Kasaba[1], Atsushi Yamazaki[4]

1. Tohoku University, 2. The University of Tokyo, 3. NICT, 4. ISAS/JAXA

In 2013, we got an opportunity to have an extreme ultra-violet (EUV) space telescope orbiting around the Earth, the Hisaki satellite. The strong EUV emissions come from both magnetospheric plasma and aurora through electron impact excitation of ions and molecular hydrogen, respectively. From the spectral observation, we can obtain not only total amount of energy deposited in each region but characteristic energy of electrons. Hisaki is dedicated for observing solar system planets. The monitoring capability of HISAKI provided us discoveries of dynamical behavior of the giant magnetosphere. Here, we show new pictures of Jovian magnetosphere obtained from the Hisaki satellite observation. This paper includes following topics: (1) Origin of hot electron in the inner magnetosphere, (2) Transient brightening of Jovian aurora and subsequent global expansion of the disturbance in the whole magnetosphere, (3) Global response of the magnetosphere to volcanic activity of the satellite Io, (4) Solar wind effects on the inner and middle magnetospheres, (5) Driver of radial diffusion in the Jovian radiation belt, (6) Electromagnetic magnetosphere-satellite interaction, and (7) Identification of new emission lines and new energy states of ion.

©2019. Japan Geoscience Union. All Right Reserved.

Axisymmetric conductivities of Jupiter's middle- and low-latitude ionosphere

*Yuki Nakamura[1], Koichiro Terada, Chihiro Tao[2], Naoki Terada[1], Yasumasa Kasaba[3], Hajime Kita[4], Aoi Nakamizo[2], Akimasa Yoshikawa[5], Shinichi Ohtani[6], Fuminori Tsuchiya[3], Masato Kagitani[3], Takeshi Sakanoi[3], Go Murakami[4], Kazuo Yoshioka[7], Tomoki Kimura[1], Atsushi Yamazaki[4], Ichiro Yoshikawa[8]

1. Department of Geophysics, Graduate School of Science, Tohoku University, 2. National Institute of Information and Communications Technology, 3. Planetary Plasma and Atmospheric Research Center, Tohoku University, 4. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 5. Department of Earth and Planetary Sciences, Kyushu University, 6. The Johns Hopkins University Applied Physics Laboratory, 7. Graduate School of frontier Science, The University of Tokyo, 8. The University of Tokyo

Ionospheric Hall and Pedersen conductivities are important parameters in determining the electric potential distribution and plasma convection in a magnetosphere-ionosphere system. At Jupiter, meteoric ions deposited by meteoroid ablation are expected to play a major role in the ionospheric conductivities [e.g., Cloutier et al., 1978]. Hall and Pedersen conductivities are expected to be axisymmetric at Jupiter due to the long lifetime of meteoric ions. This study evaluates the modification of the potential distribution and plasma convection in the inner magnetosphere caused by the axisymmetric ionospheric conductivities at Jupiter.

We have developed a photochemical model and an ionospheric potential solver to evaluate the contributions of meteoric ions to the Jovian ionospheric conductivities and dawn-to-dusk electric field in the inner magnetosphere. Our photochemical model includes chemical reactions taken from Kim et al. [1994, 2001], mass deposition of meteoric atoms and ions by meteoroid ablation, ionizations by precipitating electrons, and ambipolar diffusion of ions. The input parameters of field-aligned currents are taken from the Region 2-like current in Khurana [2001] and axisymmetric Hill current. Our ionospheric potential solver has been developed using the methods in Nakamizo et al. [2012]. We calculate the global distribution of ionospheric conductivities using ion and electron density profiles acquired from the photochemical model. The ionospheric potential distribution and the resulting dawn-to-dusk electric field in the inner magnetosphere are obtained by the ionospheric potential solver.

Our simulation results reveal that the largest contributions to the Hall and Pedersen conductivities occur in the meteoric ion layer, and the resulting height-integrated conductivities are axisymmetric in the middle- and low- latitudes. Meteoric ions dominate the ion densities in the altitude region of 350 - 450 km with a peak electron number density of ~10^{11} [m^{-3}]. The obtained electron density profile is almost constant at any local time in the middle- and low-latitudes because the lifetimes of H^+ in the high altitude and meteoric ions in the lower altitude ionosphere are sufficiently longer than the half Jovian day (~ 5h). The ionospheric conductivities reach their maxima at the meteoric ion layer, and the height-integrated Hall and Pedersen conductivities become axisymmetric in the middle- and low- latitudes. At high latitudes, the conductance are enhanced at dawn side associated with the Region 2-like upward field-aligned current. The dawn-to-dusk electric field generated in the inner magnetosphere is 4 - 27 [mV/m] around Io’ s orbit. For comparison, we model another case of ionosphere without H^+ and meteoric ions. In this case, the ionospheric conductance are entirely smaller than the former case, and diminished at night side. The resulting dawn-to-dusk electric field is 45 - 270 [mV/m] around Io’ s orbit in this case.

©2019. Japan Geoscience Union. All Right Reserved.

In order to evaluate the validity of our results, we compare our results to observations. Observations by the Hisaki satellite revealed that the variation of dawn-to-dusk brightness intensity ratio of Io plasma torus coincided with a rapid increase in the solar wind dynamic pressure. The correlation between them can be explained by the existence of a dawn-to-dusk electric field of ~4 - 9 [mV/m] around Io's orbit [Murakami et al., 2016]. Our model results are almost consistent with the Hisaki observations in the case of the existence of meteoric ions in the lower ionosphere. It is concluded that the existence of meteoric ions in the lower ionosphere causes the axisymmetric enhanced ionospheric conductance at Jupiter. The large axisymmetric conductance results in the small dawn-to-dusk electric field in the inner magnetosphere, and our model results can be supported by the Hisaki observations.

Keywords: Jupiter, Meteoric ion, M-I coupling

©2019. Japan Geoscience Union. All Right Reserved.

The magnetospheres of Saturn and Jupiter as viewed by Cassini and Juno

*G Provan[1], Stanley W. H. Cowley[1], Emma Jane Bunce[1]

1. University of Leicester

The magnetospheres of the gas giants Saturn and Jupiter are believed to be driven to varying degrees by external drivers, planetary rotation and internal plasma sources. Both planets are rapid rotators with active volcanic moons and complicated ring systems. Their auroras are key indicators to the magnetosphere-ionosphere coupling at the giant planets. At Saturn Planetary Period Oscillations (PPOs) are observed throughout the magnetosphere, including during Cassini’ s Grand Finale on field lines mapping to Saturn’ s rings. In this paper we will report on the latest results from the Cassini and Juno missions, including both the latest observations and theoretical modelling. We will elucidate on a series of studies determining properties of Saturn’ s PPOs throughout the Cassini mission, and compare our results with those derived from analysis of Saturn kilometric radiation emissions from the Voyager, Ulysses, and Cassini mission. We will further model the magnetosphere-ionosphere coupling current at Jupiter and compare these results with observations from the Juno spacecraft and HST observations. We will finish by detailing some of the outstanding questions in the field.

Keywords: Saturn, Jupiter, Juno

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS05] Recent advances of Venus science

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Masaru Yamamoto(Research Institute for Applied Mechanics, Kyushu University), Kevin McGouldrick(University of Colorado Boulder), Chairperson:Takeshi Horinouchi

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS05-01] Super-rotation of Venusian atmosphere in the equatorial region may be caused by the density driven separation

*Adhithiyan Neduncheran[1], Ugur Guven[1,2], Ananyo Bhattacharya[3] (1.University of Petroleum and Energy Studies, India, 2.United Nations Centre for Space Science and Technology Education in Asia and the Pacific, 3.Sardar Vallabhbhai National Institute of Technology,India)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS05-02] Comparison of horizontal distributions of temperature and UV absorbers at the Venus cloud-tops

*Shinichiro Kawase[1], Makoto Taguchi[1], Tetsuya Fukuhara[1], Yeon Joo Lee[2], Atsushi Yamazaki[3,4] (1.Rikkyo University, 2.Max Planck Institute for Solar System Research, 3.Institute of Space and Astronautical Science, 4.Japan Aerospace Exploration Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS05-03] Orographic Gravity Waves in the Venus Atmospheric

*Anna Suzuki[1], Masahiro Takagi[1], Yasumitsu Maejima[2], Hiroki Ando[1], Norihiko Sugimoto[3], Yoshihisa Matsuda[4] (1.Kyoto Sangyo University, 2.RIKEN Advanced Institute for Computational Science, 3.Keio University, 4.Tokyo Gakugei University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS05-04] Atmospheric structures simulated by T21 and T63 Venus GCMs with radiative transfer

*Masaru Yamamoto[1], Kohei Ikeda[2], Masaaki Takahashi[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.National Institute for Environmental Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS05-05] Thermal-tides structure at the cloud level of Venus derived from Akatsuki/LIR observations

★Invited Papers

*Toru Kouyama[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Takeshi Imamura[3], Masahiko Futaguchi[4], Takeru Yamada[2], Masahiro Akiba[2], Yeon Joo lee, Takao M. Sato[7], Shin-ya Murakami[5], George HASHIMOTO[6], Takehiko Satoh[5], Masato Nakamura[5] (1.AIST, 2.Rikkyo Univ., 3.Tokyo Univ., 4.Toho Univ., 5.JAXA, 6.Okayama Univ., 7.Hokkaido Information Univ.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS05-06] From Venus to Mars: viewpoint of comparative meteorology

★Invited Papers

*Takeshi Imamura[1], Kazunori Ogohara[2], Hiromu Nakagawa[3], Shohei Aoki[3] (1.The University of Tokyo, 2.University of Shiga Prefecture, 3.Tohoku University)

Super-rotation of Venusian atmosphere in the equatorial region may be caused by the density driven separation

*Adhithiyan Neduncheran[1], Ugur Guven[1,2], Ananyo Bhattacharya[3]

1. University of Petroleum and Energy Studies, India, 2. United Nations Centre for Space Science and Technology Education in Asia and the Pacific, 3. Sardar Vallabhbhai National Institute of Technology,India

On Venus, the clouds move nearly 60 times faster than the rotation of the planet. Super-rotation of the Venusian atmosphere is an intriguing phenomena and the reasons are still unclear. The super-rotation is possibly due to Venus being tidally locked to Sun as a consequence of which the planet experiences maximum heating in the equatorial zones causing meridional flows in the lower latitudes. The latent heat trapped by the Carbon dioxide gradually rises above due to its increased kinetic energy, which increases the motion of the cloud layers over time. Previous works done shows that the clouds are highly unstable in the altitude ranging from 49-55Km and below 30Km as per *Zasova et al* 2006 (doi:10.1016/j.pss.2007.01.011). This work shall put forth a possibility of density driven separation of cloud layers and its viscosity which helps in the super-rotation of the clouds. Similar hypothesis were presented by *Lebonnois et al* 2017 (DOI: 10.1038/NGEO2971). Using the known densities of atmospheric constituents, and applying the principles of viscosity and fluid dynamics, a simulation in COMSOL Multiphysics is done and analyzed for the flow behavior in the atmospheric layers ranging between 20Km and 80Km with respect to it’ s horizontal distance. The possible reasons regarding the flow will be discussed considering the solar convection in the equatorial region.

Keywords: Venus, atmosphere, super-rotation, clouds, flow simulation

©2019. Japan Geoscience Union. All Right Reserved.

Comparison of horizontal distributions of temperature and UV absorbers at the Venus cloud-tops

*Shinichiro Kawase[1], Makoto Taguchi[1], Tetsuya Fukuhara[1], Yeon Joo Lee[2], Atsushi Yamazaki[3,4]

1. Rikkyo University, 2. Max Planck Institute for Solar System Research, 3. Institute of Space and Astronautical Science, 4. Japan Aerospace Exploration Agency

Venus is the nearest neighbor planet, which has a size similar to that of the earth. However, unlike the earth, Venus is covered with thick - clouds floating at 45-70 km altitudes (Nakamura et al. 2011). It is considered that the clouds are photochemically generated by oxidation of and . In the visible region, light reflected by the clouds are poorly absorbed and few structures are noticeable. On the other hand, in the ultraviolet (UV) region, inhomogeneity of albedo has been identified to be inhomogeneous distribution of UV absorbers above the layer of UV scattering. It has been identified that in the Venusian atmosphere absorbs light in the wavelength region between 200 nm and 320 nm, but chemical species responsible for the absorption in the wavelength region longer than 320 nm is still unidentified. and are candidates (Perez et al. 2018). The UV absorbers play an important role in the atmospheric dynamics, controlling vertical thermal stability by heating at the top of convection layer. The dynamics may feedback the distribution of the UV absorbers by transport of them from the lower atmosphere. Details of the chemical and dynamical coupling are still unknown.

We analyzed images obtained by the Longwave Infrared Camera (LIR) and Ultraviolet Imager (UVI) onboard the Venus orbiter Akatsuki. LIR takes images of thermal radiation in the wavelength range of 8-12 μm emitted from the cloud-tops (Fukuhara et al., 2011). Temperature distributions are derived from the images. Disturbances seen in the temperature distributions are thought to be caused by atmospheric waves and tides, changes in the cloud-top altitude and adiabatic heating and cooling due to convection, direct heating by the UV absorbers, and so on. UVI takes images of the solar radiation reflected by the clouds with narrow bandpass filters centered at the 283 and 365 nm wavelengths, which correspond to the absorption bands of and unknown absorbers (Yamazaki et al., 2018).

Observations at 365 nm often find clouds with a little radiation in the middle latitudes. Such clouds with low radiation (bright) are covering on the clouds with high radiation (dark). The bright clouds are hard to receive the supply of UV absorbers from the lower layer (Titov et al., 2008). We found such bright distributions in the middle latitudes of images taken by LIR and UVI. Examples (on January 26, 2017) are shown in figures. The fact that we can see the similar distributions at different wavelengths means that two cameras observe clouds almost the same altitude. Therefore, we are studying of the dynamics of cloud top distributions at middle latitudes to use data taken by LIR and UVI.

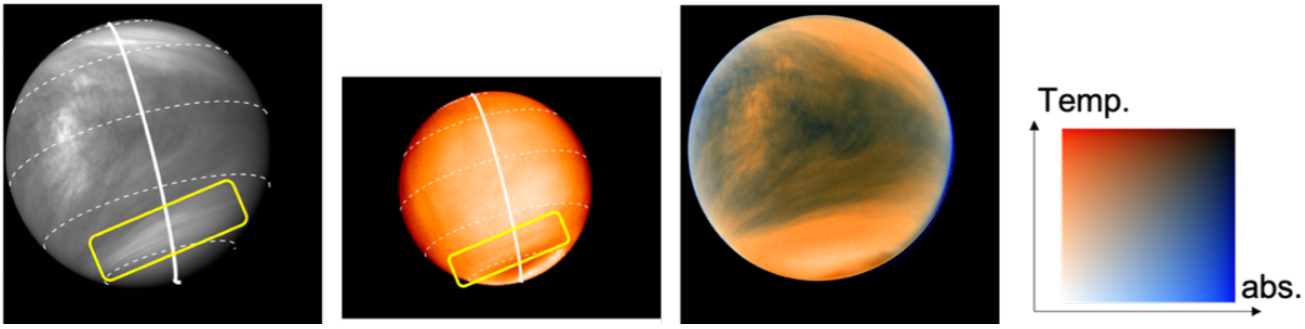
We converted the UV radiation obtained into the absorption rate. Furthermore, we compared by combining the absorption rate and the temperature. The combined image is displayed more reddish when the temperature is higher and it is displayed more blueish when UV absorption rate is higher. Example are shown in figures. The figure is displayed blackish in the equatorial region and whitish in the polar region. In the middle latitudes where we pay attention, the temperature is high and the amount of absorption is small, so it is displayed reddish. In this presentation, we will introduce some examples like this, and will present relationships between temperature and , temperature and unknown absorbers.

As a next step, we will further study the relationship between temperature and UV absorbers for each

©2019. Japan Geoscience Union. All Right Reserved.

latitude and local time, and will clarify what atmospheric dynamics is occurring at the cloud top.

Keywords: Venus, Akatsuki, unknown UV absorber



©2019. Japan Geoscience Union. All Right Reserved.

Orographic Gravity Waves in the Venus Atmospheric

*Anna Suzuki[1], Masahiro Takagi[1], Yasumitsu Maejima[2], Hiroki Ando[1], Norihiko Sugimoto[3], Yoshihisa Matsuda[4]

1. Kyoto Sangyo University, 2. RIKEN Advanced Institute for Computational Science, 3. Keio University, 4. Tokyo Gakugei University

Fast zonal winds called “super-rotation” are predominant globally in the Venus atmosphere, whose wind speed reaches ~100 m/s at ~70 km level (Schubert et al., 1980). Based on the zonal winds inferred from UV cloud images taken by the Venus Monitoring Camera onboard the Venus Express orbiter, Bertaux et al. (2016) pointed out that the zonal wind at ~70 km might be decreased by about 20 m/s over the Aphrodite terra, and suggested that the gravity waves generated by the Venus topography propagate upward, breaking at the cloud levels, giving their momentum to the atmosphere and decreasing of zonal wind. Young et al. (1987, 1994) numerically investigated the excitation and propagation processes of the gravity waves. Their results show that the gravity waves with horizontal wavelengths of 50 –800 km can propagate to the cloud levels if the zonal wind near the surface is of 2.2–3.0 m/s. However, the momentum transfer by the gravity waves is not examined. In the present study, we investigate the gravity waves in the Venus atmosphere with a focus on their momentum transfer using a cloud resolving numerical model named Cloud Resolving Storm Simulator (CReSS). Our preliminary results suggest that the orographic gravity waves can propagate upward and reach the cloud levels, as shown by Young et al. (1987, 1994). We will examine the momentum transfer by the gravity waves and discuss its effect on the super-rotation.

Keywords: Venus atmosphere, orographic gravity wave

©2019. Japan Geoscience Union. All Right Reserved.

Atmospheric structures simulated by T21 and T63 Venus GCMs with radiative transfer

*Masaru Yamamoto[1], Kohei Ikeda[2], Masaaki Takahashi[2]

1. Research Institute for Applied Mechanics, Kyushu University, 2. National Institute for Environmental Studies

Radiative forcing and topography are important in the formations of the thermal and wind structures on Venus. The surface topography forces stationary waves, which induce large-scale stationary bow-shaped wave pattern (Fukuhara et al. 2017) and conspicuous variation of cloud-top zonal flow (Bertaux et al. 2016) over the Aphrodite Terra. The topographical and radiative effects on Venus' atmosphere general circulation have been investigated using a T21L52 Venus AGCM at Atmosphere and Ocean Research Institute, Univ. Tokyo (Ikeda 2011). Our Venus GCM with the topographical data and radiative code simulated solar-locked and geographical atmospheric structures on Venus (Yamamoto et al. 2019). The model reproduced the wind structure near the subsolar point and the slowness of zonal wind over the Aphrodite Terra. Furthermore it showed that (1) the sub-rotation is formed near the surface in and around high land and mountains, (2) weakly stable layer is formed at 10-20 km at low latitudes, and (3) the zonal wind is weakened at the cloud top over the Aphrodite Terra. The third result implies that the negative wind deviation of the topographically forced stationary wave produces the slowness of the cloud-top zonal wind around the Aphrodite Terra. The GCM with the radiative code estimated the heat budget in the lower and middle atmospheres and reproduced the static stability similar to the observation. For the simulated zonal-mean structure, an equatorial fast flow of ~90 m/s and mid-latitude jets of ~120 m/s are formed around the cloud top. A poleward flow of >8 m/s is formed above the cloud layer, where the imbalance between solar and infrared radiative heating is large. Around the cloud top where the solar radiative heating balances the infrared one, a poleward flow is small (~1 m/s) and confined within the equatorward flank of the jet core. In and around the jet core, indirect circulations are formed by the eddy heat fluxes owing to the thermal tide and baroclinic waves. In solar-fixed coordinates, differences are significant between the zonal and dayside averages of the meridional wind and its related fluxes within the cloud layer. This suggests that we must carefully estimate the zonal-mean Hadley circulation, eddy momentum flux, and eddy heat flux from the one-side hemisphere. Most of the abovementioned features obtained from the T21 GCM are also seen in the T63 GCM. In this presentation, under the realistic thermal and topographical condition, the effects of the high resolution are also discussed. If we have room or time in this presentation, we briefly show the momentum budget, together with the heat budget shown in Yamamoto et al. (2019).

©2019. Japan Geoscience Union. All Right Reserved.

Thermal-tides structure at the cloud level of Venus derived from Akatsuki/LIR observations

*Toru Kouyama[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Takeshi Imamura[3], Masahiko Futaguchi[4], Takeru Yamada[2], Masahiro Akiba[2], Yeon Joo lee, Takao M. Sato[7], Shin-ya Murakami[5], George HASHIMOTO[6], Takehiko Satoh[5], Masato Nakamura[5]

1. AIST, 2. Rikkyo Univ., 3. Tokyo Univ., 4. Toho Univ., 5. JAXA, 6. Okayama Univ., 7. Hokkaido Information Univ.

Atmospheric acceleration due to thermal-tides excited in the cloud layer has been considered as one of main contributors for maintaining the atmospheric super-rotation in Venus, where zonal wind speed of the atmosphere at the cloud top (~70 km) rotates more than 60 times faster than the rotation speed of the solid body of Venus. The structures of the thermal-tides have been confirmed firstly in a temperature field and in zonal and meridional wind fields at the cloud top level by tracking cloud motions in several Venus exploration missions. In numerical studies, it has been confirmed that the thermal-tides structure is composed of diurnal, semi-diurnal, and higher frequent components which enhance at different altitudes and latitudes. Since they may contribute atmospheric acceleration according to their enhancement, observational monitoring should be important to understand what components of thermal-tides are dominant in different latitudes. On the other hand, there have been less observational studies about the latitudinal structures of thermal-tides in temperature fields due to time limitation for ground-based observations and limitation of spatial coverage for previous satellite observations.

In this study, we investigated latitudinal profiles of diurnal, semi-diurnal, and higher frequent components of thermal-tides in the temperature field obtained from long-term observation data by Longwave Infrared Camera (LIR) onboard Akatsuski that catches thermal emission from Venusian cloud layer (60-70km). We used the LIR data from October 2016 to December 2018 in which LIR had been remained to be turned on to prevent unexpected temperature increasing in LIR images, and we selected a specified emission angle (60˚) in the analysis to minimize emission angle dependence of a limb darkening effect.

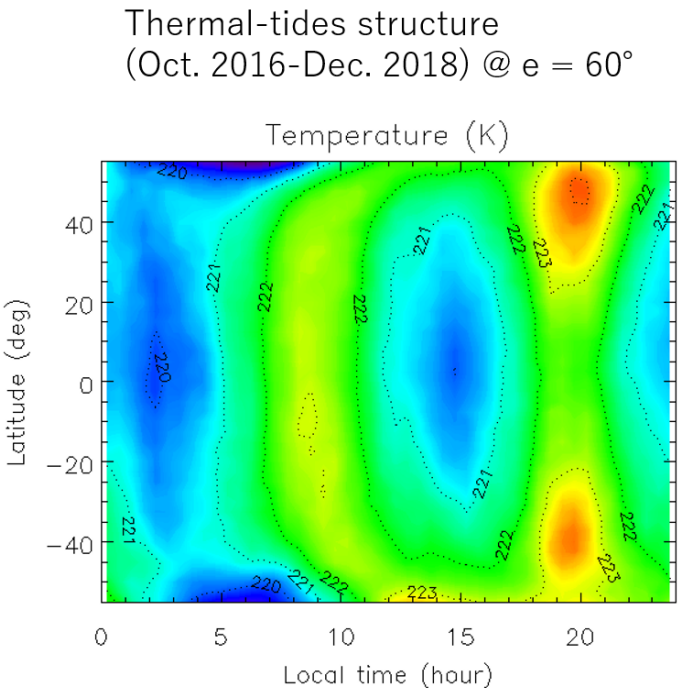
Thanks to the global coverage of LIR observation in both dayside and night side, a global thermal-tides structure (local time-latitude coordinate) was firstly obtained by averaging the long-term LIR observation. By applying Fourier analysis to the thermal-tides structure, we found that the semi-diurnal component was clearly dominant in lower latitudes (< 30˚) whereas the diurnal component became significant in higher latitudes (> 45˚), and both diurnal and semi-diurnal tides showed almost equatorial symmetric profiles. These characteristics were consistent with a numerical expectation in a global circulation model by Takagi et al. (2018). In addition, the diurnal component showed clear phase tilting in mid-latitudes, which may indicate latitudinal energy transportation due to the diurnal component, while the semi-diurnal and other components with higher wavenumbers did not show such clear phase tilting in low-mid latitudes.

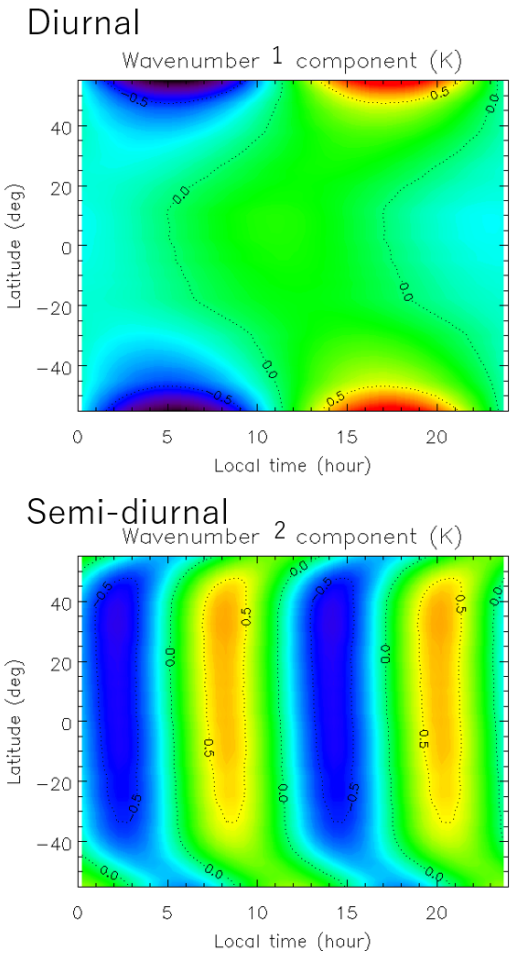
In this presentation, we will provide the structures of each thermal tide components, and latitudinal profiles of their amplitudes and phases, and we will also discuss thermal-tides structures at different

©2019. Japan Geoscience Union. All Right Reserved.

periods for more detail discussion about variability of the tides.

Keywords: Venus, Thermal tides, LIR





©2019. Japan Geoscience Union. All Right Reserved.

From Venus to Mars: viewpoint of comparative meteorology

*Takeshi Imamura[1], Kazunori Ogohara[2], Hiromu Nakagawa[3], Shohei Aoki[3]

1. The University of Tokyo, 2. University of Shiga Prefecture, 3. Tohoku University

The next Japanese planetary mission focusing on atmospheric science will be the Mars observation in the MMX (Martian Moons eXploration) mission. The spacecraft will enter a near-equatorial, high-altitude, circular orbit around Mars in 2025 and stay in orbit for 3 years. During this Mars-orbiting phase, the spacecraft will collect samples from Phobos and remotely observe Phobos, Deimos and Mars. Continuous, high-resolution, multi-wavelength, global observations of the Mars atmosphere enable monitoring of meteorological processes driving dust/water cycle in the atmosphere-surface system. The instruments used will be a near-infrared imaging spectrometer and multi-band cameras.

The Mars observation in MMX is considered a natural extension of the Venus orbiter Akatsuki. The observation sequence of MMX is similar to that of Akatsuki in that global images are acquired at short time intervals from an equatorial orbit similarly to Earth's meteorological satellites. From the viewpoint of comparative meteorology, Martian meteorology is contrasted with Venusian meteorology in many aspects. Examples include: superrotation on Venus vs. strong high-latitude jets on Mars; weak thermal forcing on Venus vs. strong thermal forcing on Mars; internal oscillation on Venus vs. seasonal cycle on Mars; wave-driven circulation on Venus vs. heat-driven circulation on Mars; slow convection on Venus vs. fast convection on Mars; uniform aerosols on Venus vs. variable aerosols on Mars; weak vertical coupling on Venus vs. strong vertical coupling on Mars. In order to maximize scientific achievements, feedbacks from Akatsuki to MMX are required.

Keywords: Venus, Mars, meteorology

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS05] Recent advances of Venus science

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Masaru Yamamoto(Research Institute for Applied Mechanics, Kyushu University), Kevin McGouldrick(University of Colorado Boulder), Chairperson:Takehiko Satoh

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[PPS05-07] A two-stage evolution model of Venus's mantle and its implication for the Earth

★Invited Papers

*Masaki Ogawa[1] (1.Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[PPS05-08] Interaction between the thermosphere and the cloud-level atmosphere of Venus studied with simultaneous observations by Hisaki and Akatsuki

*Yusuke Nara[1], Takeshi Imamura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Kei Masunaga[2], Atsushi Yamazaki[3], Shigeto Watanabe[4], Manabu Yamada[5], Yeon Joo Lee[1], Naoki Terada[6], Kanako Seki[1] (1.The University of Tokyo, 2.Swedish Institute of Space Physics, 3.ISAS/JAXA, 4.Hokkaido Information University, 5.Chiba Institute of Technology, 6.Tohoku University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[PPS05-09] Mesoscale Dyanmics in the Venus Atmosphere

*Kevin McGouldrick[1], Javier Peralta[2], Takehiko Satoh[2] (1.University of Colorado Boulder, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[PPS05-10] Periodicity analysis of Venus' cloud-top temperature measured by Akatsuki LIR

Naoya Kajiwara[1], *Takeshi Imamura[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Toru Kouyama[3] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.College of Science, Rikkyo University, 3.National Institute of Advanced Industrial Science and Technology)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[PPS05-11] Modeling Venus-like Worlds Through Time: The habitable zone, and the evolution of Venus' atmosphere.

★Invited Papers

*Michael Way[1,2,3], Anthony Del Genio[1] (1.NASA Goddard Institute for Space Studies, 2.GSFC Sellers Exoplanet Environments Collaboration, 3.Department of Physics and Astronomy, Uppsala University, Sweden)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

Discussion

A two-stage evolution model of Venus’ s mantle and its implication for the Earth

*Masaki Ogawa[1]

1. Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo

There are two elementary processes that exert control over the evolution of the mantle in Venus and the Earth. The first is the magmatism-mantle upwelling (MMU) feedback: Suppose an upwelling flow in the solid mantle generates magma by decompression melting. The buoyancy of the magma boosts the upwelling flow itself. This positive feedback makes the magmatism and the upwelling flow vigorous. The second is mantle burst. The solid-solid phase transitions at the top of the lower mantle makes the convective flow across the phase boundaries pulsating, provided that the mantle is hot enough to cause an active magmatism. When coupled with the MMU feedback, this pulse of mantle upwelling flow causes an extensive magmatism in the upper mantle. Because of these two elementary processes, the mantle of Venus evolves in two stages. On the earlier stage when the mantle is strongly heated by radioactive elements, mantle bursts repeatedly occurs to episodically resurface Venus. As the radioactive elements decay, however, the mantle evolves into the later stage. Mantle bursts subside, and only a mild magmatism occurs at the top of the mantle to continuously resurface the planet. When a model of tectonic plates is added to this model of Venus, I obtained a two-stage evolution model of the Earth. On the earlier stage, mantle bursts repeatedly occur to make plate motion chaotic and the mantle compositionally rather homogeneous. On the later stage, in contrast, mantle bursts subside, and plate motion becomes more steady; ridge magmatism differentiates the mantle, and basaltic materials accumulate on the core-mantle boundary to form thermo-chemical piles similar to the Large Low Shear wave Velocity Provinces.

Keywords: Venus, Evolution of the interior, numerical simulation

©2019. Japan Geoscience Union. All Right Reserved.

Interaction between the thermosphere and the cloud-level atmosphere of Venus studied with simultaneous observations by Hisaki and Akatsuki

*Yusuke Nara[1], Takeshi Imamura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Kei Masunaga[2], Atsushi Yamazaki[3], Shigeto Watanabe[4], Manabu Yamada[5], Yeon Joo Lee[1], Naoki Terada[6], Kanako Seki[1]

1. The University of Tokyo, 2. Swedish Institute of Space Physics, 3. ISAS/JAXA, 4. Hokkaido Information University, 5. Chiba Institute of Technology, 6. Tohoku University

In the thermosphere of Venus, the flow directing from sub-solar to anti-solar (SS-AS) is dominant driven by large temperature gradient associated with a long Venusian solar day which is ~117 Earth days. According to a numerical study by Mayr et al. (1985), the SS-AS flow without drag would exceed 300 m s^{-1} at the maximum.
It is believed that the drag force generated by gravity waves breaking effectively decelerates the thermospheric wind speed. Zalcucha et al. (2013) developed a Venus Thermosphere General Circulation Model in the presence of the gravity wave-drag, which accelerates the atmosphere when the gravity waves are broken. The model showed the SS-AS flow speed of 100-200 m s^{-1}.
The periodical variation that indicates the atmospheric waves in the thermosphere was observed by Masunaga et al. (2017). They analyzed OI dayglow variation using data obtained by the Extreme Ultraviolet Spectroscope for Exospheric Dynamics (EXCEED) on-board the Hisaki spacecraft and detected the periodicity of ~4 days only on the dawn side. They pointed out planetary-scale waves in the middle atmosphere which are expected to be exist in Venus might responsible for the variations in the thermosphere, while the existence of the planetary-scale waves at that time was not confirmed.
In this study, we investigated the vertical coupling between cloud-level atmosphere and the thermosphere of Venus, focusing on the role of atmospheric waves. To find the evidence for the wave propagation, we used data that are obtained simultaneously by Hisaki and Akatsuki spacecraft on the dawn side of Venus in June 2017.
Analyzing the time series of the atomic O dayglow emissions measured by the EXCEED and the UV images which reflect the spatial distribution of unidentified absorbers at the cloud top (~70 km) obtained by the Ultraviolet Imager (UVI), we identified characteristic periodicities of 3.5 days in both data. The wind velocity deduced with cloud tracking from UV images suggests that the 3.5-day periodicity can be associated with Kelvin waves at the cloud top; however, Kelvin waves should decay with height through radiative damping and will not reach the thermosphere. We propose an indirect process in which the Kelvin waves change the wind field periodically and examine how the vertically propagating small-scale gravity waves influence the thermospheric dayglow with a simplified numerical model.

Keywords: Venus, Thermosphere, Cloud level, Vertical coupling, Gravity waves

©2019. Japan Geoscience Union. All Right Reserved.

Mesoscale Dyanmics in the Venus Atmosphere

*Kevin McGouldrick[1], Javier Peralta[2], Takehiko Satoh[2]

1. University of Colorado Boulder, 2. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

The Akatsuki Spacecraft is capable of observing the full disk of Venus at a number of filter-specified wavelengths, with time cadence on the order of an hour, and for up to nine days at a time (until the orbit brings the spacecraft so close that Venus exceeds the instrumental fields of view). Because of this, it is capable of supporting the elucidiation of both global atmospheric dynamics (i.e., the super-rotation) and mesoscale atmospheric dynamics. Here, we describe the analysis of the driving dynamics associated with mesoscale features observed in the Akatsuki IR2 camera data. This work focuses on just a single orbit of Akatsuki, but the features and behaviors we describe appear to be common in the Venus atmosphere. We make comparisons with similar terrestrial phenomena; and assess the implications for energy and momentum transport that may affect the overall global atmospheric dynamics. Three of the four filters in Akatsuki's IR2 camera image the night side of the planet in emitted radiation. These filters have central wavelegnths of 1.74 micron, 2.26 micron, and 2.32 micron, which are most sensitive to the conditions between about 50 km and 60 km altitude, in the midst of the lower and middle, condensational, cloud deck of Venus.

Keywords: Venus, Akatsuki, Meteorology, Clouds, Atmospheric Dynamics, Infrared Observations

©2019. Japan Geoscience Union. All Right Reserved.

Periodicity analysis of Venus' cloud-top temperature measured by Akatsuki LIR

Naoya Kajiwara[1], *Takeshi Imamura[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Toru Kouyama[3]

1. Graduate School of Frontier Sciences, The University of Tokyo, 2. College of Science, Rikkyo University, 3. National Institute of Advanced Industrial Science and Technology

Planetary-scale waves are thought to play crucial roles in the maintenance of the general circulation of the Venusian atmosphere. However, observational clues are limited, and the nature of such waves is poorly constrained. Here we analyze for the first time the cloud-top temperature field to deduce the periods (frequency) and the spatial structures of planetary-scale waves using LIR image data acquired continuously. Since the systematic (absolute) error in LIR data of around 3 K is larger than the expected amplitudes of the temperature oscillations of around 1 K, the waves are hard to detect by deducing temperature variations with time. In this study, we analyze oscillations of the zonal gradient of the temperature in each image associated with planetary-scale waves. The small random (relative) error in LIR data of 0.3 K enables detection of such small-amplitude waves with this method. Through spectral analyses of the time series of the temperature gradient spanning 142 Earth days from 18 May 2017, distinct oscillations with periods of 3.5 days, 4.9 days and 5.2 days were discovered. All of these modes show almost constant phases along the latitude, indicating that they are planetary-scale waves. Based on the wave period and the latitude dependence of the amplitude, the 3.5-day wave is identified as a Kelvin wave and the 4.9-day and 5.2-day waves seem to be hemispherically-symmetric Rossby waves. The amplitudes of these waves changed with time during the observation period.

Keywords: Venus, Akatsuki, atmosphere

©2019. Japan Geoscience Union. All Right Reserved.

Modeling Venus-like Worlds Through Time: The habitable zone, and the evolution of Venus' atmosphere.

*Michael Way[1,2,3], Anthony Del Genio[1]

1. NASA Goddard Institute for Space Studies, 2. GSFC Sellers Exoplanet Environments Collaboration, 3. Department of Physics and Astronomy, Uppsala University, Sweden

Using a modern three-dimensional general circulation coupled atmosphere/ocean model [1] we recently demonstrated [2] that climatic conditions may have permitted liquid water on Venus' surface for ~2 billion years in its early history. Similar such conditions on Earth are believed amenable to the rise of life. Several assumptions were made based on what little data we have for early Venus such as; the type of solar spectrum extant at that time, orbital parameters, estimates of a shallow ocean from Pioneer Venus D/H ratios, and topography from the Magellan Mission. We also assumed that it would have had an atmosphere similar to modern day Earth: 1 bar N2, 400ppmv CO2, 1ppmv CH4. I will discuss the motivations behind these assumptions and additional parameter space studies with direct relevance to hypothetical exoplanetary Venus-like worlds found at the inner edge of the liquid water habitable zone. Finally, I will show how our studies demonstrate that the reason for Venus' present climatic state is unlikely to be related to the gradual warming of our sun over the past 4Gyr as is commonly believed

[1] Way, M.J. et al. (2017) Astroph Journ Suppl, 231, 1
[2] Way, M. J., et al. (2016) Geophy Res Lett, 43, 8376-838

Keywords: Venus, Habitabilty, Exoplanets

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS05] Recent advances of Venus science

convener:Takehiko Satoh(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Masaru Yamamoto(Research Institute for Applied Mechanics, Kyushu University), Kevin McGouldrick(University of Colorado Boulder), Chairperson:Kevin McGouldrick

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS05-12] Cloud top structure of Venus retrieved from the Akatsuki IR2 dayside observations

★Invited Papers

*Takao M. Sato[1], Takehiko Satoh[2], Hideo Sagawa[3], Naohiro Manago[2], Yeon Joo Lee, Shin-ya Murakami[2], Kazunori Ogohara[4], George HASHIMOTO[5], Yasumasa Kasaba[6], Atsushi Yamazaki[2], Manabu Yamada[7], Shigeto Watanabe[1], Takeshi Imamura[8], Masato Nakamura[2] (1.Hokkaido Information University, 2.ISAS/JAXA, 3.Kyoto Sangyo University, 4.University of Shiga Prefecture, 5.Okayama University, 6.Tohoku University, 7.Chiba Institute of Technology, 8.The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS05-13] Formation of superrotation studied by a TEM model

*Takeshi Horinouchi[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS05-14] Morphological Feature Extraction from Venus' Cloud Images Using Principal Component Analysis

*Minori Narita[1], Takeshi Imamura[1], Yusuke Nara[1], Yeon Joo Lee, Shigeto Watanabe[2], Atsushi Yamazaki[3], Takehiko Satoh[3], Makoto Taguchi[4], Tetsuya Fukuhara[4], Manabu Yamada[5] (1.The University of Tokyo, 2.Hokkaido Information University, 3.ISAS/JAXA, 4.Rikkyo University, 5.PERC/Chiba Institute of Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS05-15] **Principal Components of UV Albedo Variability in Venus' Atmosphere as seen at 283 nm**

*Pushkar Kopparla[1], Yeon Joo Lee[1], Takeshi Imamura[1], Atsushi Yamazaki[2] (1.GSFS, University of Tokyo, 2.ISAS, JAXA)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS05-16] Active and inactive behaviors of the planetary-scale waves on Venus cloud top

★Invited Papers

*Masataka Imai[1], Toru Kouyama[1], Yukihiro Takahashi[2], Takeshi Horinouchi[3], Takeshi Imamura[4], Atsushi Yamazaki[5], Shigeto Watanabe[6], Manabu Yamada[7], Masato Nakamura[5], Takehiko Satoh[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Department of Cosmosciences, Graduate School of Science, Hokkaido University, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Graduate School of Frontier Sciences, University of Tokyo, 5.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 6.Space Information Center, Hokkaido Information University, 7.Planetary Exploration Research Center, Chiba Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS05-17] **Long-term behaviour of the morphology and dynamics of Venus's middle clouds with Akatsuki/IR1.**

★Invited Papers

*Javier Peralta[1], Naomoto Iwagami[2], Sánchez-Lavega Agustín[3], Yeon Joo Lee[4], Ricardo Hueso[3], Minori Narita[4], Takeshi Imamura[4], Phil Miles[5], Anthony Wesley[6], Emmanuel Kardasis[7], Seiko Takagi[8] (1.Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), Sagamihara, Japan, 2.Tokyo 156-0044, Japan, 3.Escuela de Ingeniería de Bilbao, University of the Basque Country (UPV/EHU), Bilbao, Spain, 4.Graduate School of Frontier Sciences, The University of Tokyo, Japan, 5.Rubyvale QLD, Australia, 6.Astronomical Society of Australia, Australia, 7.Hellenic Amateur Astronomy Association, Greece, 8.Research and Information Center, Tokai University, Japan)

Cloud top structure of Venus retrieved from the Akatsuki IR2 dayside observations

*Takao M. Sato[1], Takehiko Satoh[2], Hideo Sagawa[3], Naohiro Manago[2], Yeon Joo Lee, Shin-ya Murakami[2], Kazunori Ogohara[4], George HASHIMOTO[5], Yasumasa Kasaba[6], Atsushi Yamazaki[2], Manabu Yamada[7], Shigeto Watanabe[1], Takeshi Imamura[8], Masato Nakamura[2]

1. Hokkaido Information University, 2. ISAS/JAXA, 3. Kyoto Sangyo University, 4. University of Shiga Prefecture, 5. Okayama University, 6. Tohoku University, 7. Chiba Institute of Technology, 8. The University of Tokyo

We present the cloud top structure of Venus retrieved from a total of 93 dayside images acquired at a wide variety of solar phase angles (0-120 deg) by the 2.02-μm channel of the 2-μm Camera (IR2) onboard Japanese Venus orbiter, Akatsuki, during the period from April 4 to May 25, 2016. Since the 2.02-μm channel locates in a CO_2 absorption band, the sunlight reflected from Venus allows us to determine the cloud top altitude corresponding to unit aerosol optical depth at 2.02 μm with radiative transfer calculation. Firstly, the observed solar phase angle dependence and zonal variation of the reflected sunlight in the equatorial region were used to construct a baseline model characterized by cloud top altitude , Mode 2 radius , and cloud scale height which are 70.287 km, 1.26 μm and 5.1 km, respectively. Secondly, individual cloud top altitudes were retrieved with the assumption that the last two values are valid for the entire planet. The latitudinal structure of cloud top altitude is symmetrical with respect to the equator: the averaged cloud top locates at a constant altitude of 68-70 km equatorward of ±45 deg but rapidly drops in latitudes of 50-60 deg and reaches 61 km poleward of ±70 deg. The averaged cloud top in the equatorial region indicates the tendency to increase from early morning (~7 h) and reach a maximum near early afternoon (~14 h) and decrease toward late afternoon (~17 h). The magnitude of the change is in the order of 1 km. After high-pass filtering of the cloud top altitude maps, small-amplitude features including stationary structures occur within several hundred meters and typically show less contrast than those at two channels (283 and 365 nm) of the Ultraviolet Imager (UVI). Although the long, zonal or tilted streaky features poleward of ~45 deg are clearly identifiable, the features in low and middle latitudes are usually faint and do not necessarily appear as the local variation in cloud top altitude where mottled and patchy patterns are seen in the UV channels, suggesting the existence of convection and turbulence at the cloud top level.

Keywords: Venus, atmosphere, clouds, Akatsuki, near-infrared, radiative transfer

©2019. Japan Geoscience Union. All Right Reserved.

Formation of superrotation studied by a TEM model

*Takeshi Horinouchi[1]

1. Faculty of Environmental Earth Science, Hokkaido University

Recently, a number of studies have reported the formation of atmospheric superrotation in three-dimensional Venus GCMs. However, its mechanism has not been fully understood, which is partly due to the difficulty of model data analysis and possible numerical problems (Lebonnois et al 2012). Earlier studies with two-dimensional models by Matsuda (1980, 1982) and Yamamoto and Yoden (2013) provided useful insights, but to assess their applicability is not straightforward, since these studies are based on the Boussinesq approximation and use fixed uniform eddy diffusivity and Newtonian cooling rate. Here, I present the results of numerical simulations with a two-dimensional axi-symmetric model to overcome these difficulties. The model is based on the transformed Eulerian mean (TEM) equations supporting deep atmosphere over multiple scale heights, and it conserves total zonal angular momentum very well when surface friction is tuned off. The model does not use prescribed eddy diffusivity. Instead, effects of dynamical instabilities (convective, symmetric, barotropic-baroclinic instabilities) are parameterized. The model was initialized with the uniform solid-body rotation at the rate of the planetary rotation and run under radiative forcing similar to that in the recent Venus AFES simulations. A realistic superrotation emerged, and it reached a statistical steady state. It is revealed that the dynamical disturbances associated with dynamical instabilities can work like eddy diffusivity in the Gierasch mechanism to create a local maximum of the angular momentum within the atmosphere. The steady-state meridional circulation is multi-layered. The surface friction works to keep the angular momentum at low levels. Effects of thermal tides will be investigated elsewhere.

Keywords: Venus, superrotation

©2019. Japan Geoscience Union. All Right Reserved.

Morphological Feature Extraction from Venus' Cloud Images Using Principal Component Analysis

*Minori Narita[1], Takeshi Imamura[1], Yusuke Nara[1], Yeon Joo Lee, Shigeto Watanabe[2], Atsushi Yamazaki[3], Takehiko Satoh[3], Makoto Taguchi[4], Tetsuya Fukuhara[4], Manabu Yamada[5]

1. The University of Tokyo, 2. Hokkaido Information University, 3. ISAS/JAXA, 4. Rikkyo University, 5. PERC/Chiba Institute of Technology

We applied principal component analysis (PCA) to Venus' multi-wavelength image data obtained by Venus orbiter Akatsuki, to extract latent morphological patterns for each wavelength and compare them to reveal similarities and dissimilarities between the wavelengths. Statistical approaches that extract latent features using massive amounts of data have hardly been done in Venus researches. The new analysis showed that tilted streaky features are dominant at all wavelengths, especially in mid-latitudes; this feature can be explained by the combination of the latitudinal gradient of the mean zonal velocity and the meridional circulation. Moreover, the result shows a strong morphological similarity between cloud height and ultraviolet absorbers.

We preprocessed images as follows. We used data in which images have been projected onto the latitude-longitude coordinate (Level-3 data). We used the following four wavelengths; near-infrared 2.02 μm (cloud height), thermal infrared 10 μm (cloud top temperature), ultraviolet 283 nm (SO_2 distribution at the cloud top), and ultraviolet 365 nm (an unknown UV absorber). First, we performed photometric correction using Minnaert Law (except for 10 μm images). Then these images are high-pass filtered by subtracting a Gaussian-smoothed image from each original image to extract scales smaller than 6 degrees both in latitude and longitude. Lastly, we extracted image patches from these images to increase the number of samples and extract specific spatial scale. The size of the image patches is 12 degrees in latitude/longitude. The total number of image patches is around 60,000 for each wavelength. Also, we analyzed images in low-latitudes and mid-latitudes separately.

We performed PCA for the image patches. PCA converts a set of observational data into a set of linearly uncorrelated variables called principal components and enables to extract spatial features that appear in data frequently. We focus on 20 most major principal components for each wavelength, and we also calculated the contribution ratios. As a result, it turned out that tilted streaky features are dominant both in low and middle latitudes. Considering that zonal winds have a latitudinal gradient and that a slow, poleward meridional circulation exists, cloud parcels are stretched obliquely while drifting from low latitudes to middle latitudes. Moreover, we found that SO_2 (283 nm) and the unknown UV absorber (365 nm) have spatial patterns similar to that of the cloud height (2.02 μm). It indicates that mechanisms that make the distribution of clouds and these chemical compounds in low latitudes are common. As unique patterns for a specific wavelength, it is worth noting that streaks in the north-south direction prevail in patterns of the cloud top temperature (10 μm). Considering that meridional bow-shaped structures are observed at this wavelength, it seems that these structures are appearing as the main principal component. Besides, the statistical approach could successfully extract streaky features from 10 μm as well, while we cannot recognize such features at this wavelength by our eyes because of apparent dominance of random, patchy features. In conclusion, we successfully extracted statistical spatial patterns in Venus' clouds and enabled further discussions about physical properties corresponding to each wavelength more in detail.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Venus, Principal Component Analysis, Image

©2019. Japan Geoscience Union. All Right Reserved.

Principal Components of UV Albedo Variability in Venus' Atmosphere as seen at 283 nm

*Pushkar Kopparla[1], Yeon Joo Lee[1], Takeshi Imamura[1], Atsushi Yamazaki[2]

1. GSFS, University of Tokyo, 2. ISAS, JAXA

We explore the dominant modes of variability in the observed albedo at the cloud tops of Venus using the Akatsuki UVI 283 nm observations over the period Dec 2016 to May 2018. The observations consist of images of the dayside of Venus, most often observed at intervals of 2 hours, but interspersed with longer gaps. The orbit of the spacecraft does not allow for continuous observation of the full dayside, and the unobserved regions cause significant gaps in the dataset. The missing data are interpolated and the dataset is then subjected to a principal component analysis (PCA) to find six oscillating patterns in the albedo. Some of the spatial patterns and the time scales of these modes correspond to well known physical processes in the atmosphere of Venus such as short period atmospheric waves and the overturning circulation, while others defy a simple explanation. We also a find a hemispheric mode that has not been identified before and discuss its implications.

Keywords: Venus atmosphere, Clouds, UV Observations

©2019. Japan Geoscience Union. All Right Reserved.

Active and inactive behaviors of the planetary-scale waves on Venus cloud top

*Masataka Imai[1], Toru Kouyama[1], Yukihiro Takahashi[2], Takeshi Horinouchi[3], Takeshi Imamura[4], Atsushi Yamazaki[5], Shigeto Watanabe[6], Manabu Yamada[7], Masato Nakamura[5], Takehiko Satoh[5]

1. National Institute of Advanced Industrial Science and Technology, 2. Department of Cosmosciences, Graduate School of Science, Hokkaido University, 3. Faculty of Environmental Earth Science, Hokkaido University, 4. Graduate School of Frontier Sciences, University of Tokyo, 5. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 6. Space Information Center, Hokkaido Information University, 7. Planetary Exploration Research Center, Chiba Institute of Technology

Planetary-scale waves on Venus cloud top cause periodical fluctuations in winds and also UV brightness. The candidates of these waves are 4-day Kelvin wave and 5-day Rossby wave of zonal wavenumber 1, however, their temporal evolutions are poorly understood. In this work, we conducted time-resolved periodical analysis in 365 nm brightness and cloud tracking wind fluctuations obtained by UVI onboard AKATUSKI Japanese Venus Climate Orbiter from January to September 2017, and we have revealed the dramatical evolution of planetary-scale waves and the dynamical connection between wave and planetary-scale UV features.

During the observation season, we could find prominent ~5-day periodicity in both wind and brightness fluctuations, whose phase velocity was slower than dayside mean zonal winds (or the super-rotation) by > 35 ms^{-1}. We succeeded to reconstruct the horizontal wind field related to the observed 5-day mode, and since planetary-scale vortices, whose the center existed ~35° latitudes, having large equatorial symmetric structures in the latitudinal direction were found, it can be a strong manifestation of the retrograde propagating Rossby wave. The observed Rossby wave subjected to temporal changes of enhancing and attenuating in the amplitude of wind fluctuations with ~100-day time scale. According to the temporal evolution of the Rossby wave, white cloud belts in 45° --60° latitudinal regions began rippling synchronously in both hemispheres. Moreover, the Rossby wave deformed the planetary-scale dark UV feature in the equatorial region, and that should be the reason for significant 5.1-day periodicity in brightness variation. Before the Rossby wave enhancement, weak 3.8-day periodical signals can be observed in zonal wind and brightness variations in the equatorial region. This is a suggestive prograde propagating Kelvin wave, and this might be the reason for the origin of dark clusters in the equatorial region.

While wave activities during the observation season from January to September 2017 were clear, significant periodical wind or brightness fluctuations were not always confirmed in the other observation seasons. In orther to investigate the reason for active and inactive behaviors in planetary-scale waves, we will compare seasons when significant planetary-scale waves were observed and they were not focusing on the connection with mean zonal wind speed, global UV albedo, and cloud top temperature.

Keywords: Venus, AKATSUKI, Rossby wave, Kelvin wave

©2019. Japan Geoscience Union. All Right Reserved.

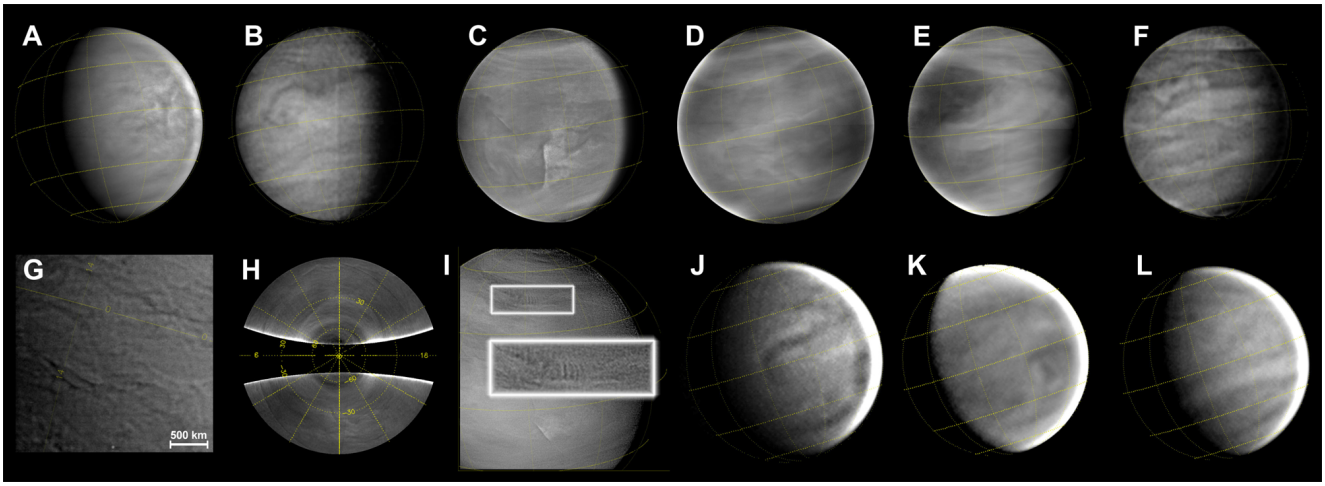
Long-term behaviour of the morphology and dynamics of Venus's middle clouds with Akatsuki/IR1.

*Javier Peralta[1], Naomoto Iwagami[2], Sánchez-Lavega Agustín[3], Yeon Joo Lee[4], Ricardo Hueso[3], Minori Narita[4], Takeshi Imamura[4], Phil Miles[5], Anthony Wesley[6], Emmanuel Kardasis[7], Seiko Takagi[8]

1. Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), Sagamihara, Japan, 2. Tokyo 156-0044, Japan, 3. Escuela de Ingeniería de Bilbao, University of the Basque Country (UPV/EHU), Bilbao, Spain, 4. Graduate School of Frontier Sciences, The University of Tokyo, Japan, 5. Rubyvale QLD, Australia, 6. Astronomical Society of Australia, Australia, 7. Hellenic Amateur Astronomy Association, Greece, 8. Research and Information Center, Tokai University, Japan

The Venusian atmosphere is covered by clouds with super-rotating winds whose accelerating mechanism is still not well understood. Fastest wind speeds occur at the top of the clouds (about 70 km height), and they have been studied for decades thanks to their visual contrast in dayside ultraviolet images caused by the presence of a yet unknown absorber. The middle clouds (at about 50-55 km) can be observed using near-infrared wavelengths (800-950 nm) and they exhibit much weaker contrasts. Here we present the first long-term study of the dayside middle clouds of Venus at middle to low latitudes thanks to the combination of the full dataset of Akatsuki/IR1 images acquired at 900 nm during the year 2016 (A-I), complemented with observations of Venus with small telescopes and band-pass filters 1.0-1.1 μm and 884-900 nm (J-L). Thanks to the analysis of more than 1,000 images, we report the discovery of new cloud morphologies, like fast sharp discontinuities (C), elongated "hook-like" stripes (B,J) and a single case of mesoscale wave packet (I). Surprisingly, the albedo of Venus at 900 nm exhibit periodical hemispherical asymmetry (E-F), and clouds' contrasts varying from 3% to 21%. These contrasts are larger than reported in previous missions, and they are suggestive of important changes in the optical thickness of the clouds or they might imply the presence of a new atmospheric absorber at near-infrared wavelengths. Finally, we also present more than 500 wind measurements from IR1 images and —for the first time— with ground-based observations. The mean zonal winds are observed to peak at the equator, while the combination with data from Venus Express reveals long-term variations in the zonal winds of ˜20 m/s along 10 years.

Keywords: Venus, Atmosphere, Clouds, Atmospheric dynamics, Remote sensing



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-EM10] Multi-scale Coupling in the Magnetosphere-Ionosphere-Thermosphere System

convener:Yue Deng(University of Texas at Arlington), Toshi Nishimura(Boston University), Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Yanshi Huang(Harbin Institute of Technology, Shenzhen), Chairperson:Yue Deng(University of Texas at Arlington), Huixin Liu(Kyushu University, Japan), Yanshi Huang(Harbin Institute of Technology, Shenzhen, China), Yukitoshi Nishimura(Boston University)

Determining the effects of energy deposition and transport, and momentum exchange across different spatial and temporal scales is an important objective in the M-I-T system, due to the clear evidence of multi-scale forcing. Coupling over multiple scales is also a critical challenge since observational and modeling methodologies for bridging different scales do not presently exist. This session solicits presentations on a wide range of coupling processes in the high-latitude M-I-T system from global to small-scale processes and related solar wind forcing. Relevant topics include (but are not limited to) (1) density structures and temperature gradients (polar cap, cusp, plume, trough, irregularities); (2) convection (flow channels, SAPS) and FAC; (3) energy transfer and deposition by precipitation and ULF waves, conductivity, aurora, and heating; and (4) coupling and feedback into the magnetosphere. Discussions of relevant multi-scale observations by means of multiple instruments, including space and ground-based, modeling and data science are encouraged.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM10-01] Auroral fragmentation into patches and pressure balance condition in the source magnetosphere

★Invited Papers

*Kazuo Shiokawa[1], Katsuki Nishi[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM10-02] Formation and Evolution of Polar Cap Ionospheric Patches and Their Associated Upflows and Scintillations: A Review

★Invited Papers

*Qing-He Zhang[1], Zan-Yang Xing[1], Yong Wang[1], Yu-Zhang Ma[1] (1.Institute of Space Sciences, Shandong University, Weihai, China)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM10-03] Global ionospheric disturbances during the 6-10 September 2017 solar storms

★Invited Papers

*Shunrong Zhang[1] (1.MIT Haystack Observatory)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM10-04] Multiscape Coupling of Sub-auroral Polarization Streams

*Nozomu Nishitani[1], Tomoaki Hori[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM10-05] Scale sizes of mass density enhancements inferred from accelerometer measurements

*Yanshi Huang[1], Cheryl Huang[2] (1.Harbin Institute of Technology, Shenzhen, China, 2.Space Physics Directoriate, Air Force Research Laboratory, Kirtland AFB, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM10-06] **Meso-scale forcing in the upper atmosphere: sources and impacts**

*Yue Deng[1], Qingyu Zhu[1], Cissi Lin[1] (1.University of Texas at Arlington)

Auroral fragmentation into patches and pressure balance condition in the source magnetosphere

*Kazuo Shiokawa[1], Katsuki Nishi[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

The auroral fragmentation into patches has been reported by Shiokawa et al. (JGR, 2010; 2014) as finger-like structures developed in the diffuse aurora with horizontal scale sizes of 5-25 km (small scale) and 40-100 km (large scale). The development of these finger-like structures divides the diffuse aurora into patches. Thus we call it as the auroral fragmentation which is a cause of the patchy auroral structures in the diffuse aurora. Hashimoto et al. (JGR, 2015) made a statistical analysis of these auroral finger-like structures and found their occurrence rates of 13% and 4 % for large- and small-scale events, respectively. They also indicated that the finger-like structures tend to occur at the beginning of the substorm recovery phase in the post-midnight and dawn sectors. The auroral finger-like structure suggests the development of pressure-driven instability in the magnetosphere. Recently Nishi et al. (JGR, 2017) made the first conjugate measurement of the auroral finger-like structures with the THEMIS-E satellite at ~8 Re in the magnetosphere. They found clear anti-phase oscillations between the magnetic and plasma pressures in the post-midnight plasma sheet. This anti-phase variation is consistent with the idea of the pressure-driven instability. On the other hand, Nishi et al. (JGR, 2018a) reported that a conjugate event with the RBSP-A satellite at ~5.5 Re does not show systematic phase relationship between the magnetic and plasma pressures. Then Nishi et al. (JGR, 2018b) investigate statistical features of the phase relationship between magnetic and plasma pressures using two-year THEMIS-E observations in the nightside plasma sheet and obtained a high occurrence of the anti-phase oscillations between the magnetic and plasma pressures. In the presentation, we will review these recent results on the auroral fragmentation and pressure balance condition in the source magnetosphere, and discuss possible physical mechanism that contributes these phenomena.

References:
1. Shiokawa, K., A. Nakajima, A. Ieda, K. Sakaguchi, R. Nomura, T. Aslaksen, M. Greffen, and E. Donovan (2010), Rayleigh-Taylor type instability in auroral patches, J. Geophys. Res., 115, A02211, doi:10.1029/2009JA014273.
2. Shiokawa, K., et al. (2014), Auroral fragmentation into patches, J. Geophys. Res. Space Physics, 119, doi:10.1002/2014JA020050.
3. Hashimoto, A., K. Shiokawa, Y. Otsuka, S.-i. Oyama, S. Nozawa, T. Hori, M. Lester, and M. G. Johnsen (2015), Statistical study of auroral fragmentation into patches, J. Geophys. Res. Space Physics, 120, 6207-6217, doi:10.1002/2015JA021000.
4. Nishi, K., K. Shiokawa, and D. Fruehauff (2017), Conjugate observation of auroral finger-like structures by ground-based all-sky cameras and THEMIS satellites, J. Geophys. Res. Space Physics, 122, doi:10.1002/2016JA023774.
5. Nishi, K., K. Shiokawa, and H. Spence (2018a), Magnetospheric source region of auroral finger-like structures observed by the RBSP-A satellite, J. Geophys. Res., 123, doi: 10.0002/2018JA025480.
6. Nishi, K., K. Shiokawa, K.-H. Glassmeier, and J. Z. D. Mieth (2018b), Statistical study of phase relationship between magnetic and plasma pressures in the near-earth nightside magnetosphere using the THEMIS-E satellite, J. Geophys. Res., 123, doi: 10.0002/2018JA025846.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: auroral fragmentation into patches, pressure balance in the magnetosphere, diffuse aurora

©2019. Japan Geoscience Union. All Right Reserved.

Formation and Evolution of Polar Cap Ionospheric Patches and Their Associated Upflows and Scintillations: A Review

*Qing-He Zhang[1], Zan-Yang Xing[1], Yong Wang[1], Yu-Zhang Ma[1]

1. Institute of Space Sciences, Shandong University, Weihai, China

Polar cap patches are common phenomena, especially during southward interplanetary magnetic field (IMF) conditions, in the polar ionosphere. We summarized the recent new progress about the formation and evolution of patches as well as their impact on the magnetosphere-ionosphere-thermosphere (M-I-T) coupling processes and space weather. The dayside reconnection and bursty sunward return flows produced by the modulation of nightside reconnection, are confirmed as the dominated mechanisms to separate the entering ionization into islands (patches). The patches evolve along streamlines of the Dungey convection cycle from the dayside to the nightside and exit the polar cap modulated by pulsed nightside reconnection. However, they slowly move and rapidly fade away behind a lobe “reverse” convection cell when the IMF suddenly changed to northward. Rapidly moving patches are associated with clear ion upflows due to frictional heating and offer more upwelling ion fluxes. Patches often produce significant scintillations due to strong density gradients at their edges, especially during their merging into the auroral oval, which will result in variable disturbances to High Frequency (HF) radio communications, over-the-horizon radar location errors, disruption and errors to satellite navigation and communication.

Keywords: Polar cap patches, Magnetosphere-ionosphere coupling, Ion upflows, Ionospheric scintillations

©2019. Japan Geoscience Union. All Right Reserved.

Global ionospheric disturbances during the 6-10 September 2017 solar storms

*Shunrong Zhang[1]

1. MIT Haystack Observatory

Solar activity during the period of 6-10 September 2017 is characterized with a series of very strong flares and powerful coronal mass ejections (CMEs). Observations indicate more than two dozens of M-class and 4 X-class flares being emmitted from the solar Active Region 12673. In particular, one of these flares led to a halo-type CME which traveled earth-bound at ~1570 km/s apparent speed. With the arrival of this CME, IMF Bz turned to southward and reached a minimum of -30 nT at 23:25 UT on 7 September, triggering a Kp 8 geomagnetic storm with a sudden commencerment at ~2300 UT and a minimum Dst ~ -150 nT near 0100 UT on 8 September. These conditions caused very significant geospace disturbances, in particular, ionospheric disturbances with various spatial and temporal scales. In this presentation, we report flare induced ionospheric perturbations and post-flare traveling ionospheric disturbances (TIDs), storm-enhanced density (SED) plumes at subauroral and high latitudes of the dayside ionosphere, subauroral polarization streams (SAPs), and large scale TIDs over the globe. Our discussion will focus on some unique post-flare ionospheric oscillation and TID features, TIDs at high latitudes, and gigantic cross-hemispheric ionospheric electron density depletion channels. This study is based primarily on ground-based GNSS and Millstone Hill incoherent scatter radar observations.

Keywords: geospace storm, solar flare, traveling ionospheric disturbance

©2019. Japan Geoscience Union. All Right Reserved.

Multiscape Coupling of Sub-auroral Polarization Streams

*Nozomu Nishitani[1], Tomoaki Hori[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

Sub-Auroral Polarization Streams (SAPS) are fast westward flows slightly equatorward of the auroral precipitation boundary, and manifestations of magnetosphere-coupling processes. Recenty it was shown that SAPS sometimes contain perturbation in westward speed, typically with temporal scale of a few minutes (e.g., Hori et al., GRL, 2018). However, it has not yet been clear how small the temporal scales of these perturbations can be and how perturbations with different temporal scales are related to each other. In this paper, multiscape coupling of the sub-auroral polarization streams will be studied, using multiple events observed mainly by the SuperDARN Hokkaido East / West radars.

Keywords: multiscale coupling, SuperDARN Hokkaido East / West radars, sub-auroral polarization stream (SAPS)

©2019. Japan Geoscience Union. All Right Reserved.

Scale sizes of mass density enhancements inferred from accelerometer measurements

*Yanshi Huang[1], Cheryl Huang[2]

1. Harbin Institute of Technology, Shenzhen, China, 2. Space Physics Directoriate, Air Force Research Laboratory, Kirtland AFB, USA

The spatial scale sizes of neutral mass density enhancements inferred from the accelerometer measurements on CHAMP and GRACE satellites are analyzed. Density enhancements are found as the peaks with more than 30% above the average density baseline fitted over a 90 degree magnetic latitude window. The widths of mass density peaks are defined in two different methods, one using the maximum above the average density baseline, the other method using the two minima surrounding each one density peak above a threshold value. We study various cases including one-peak and multi-peak cases using high-resolution density data from year 2002 to 2010. The results give a statistical understanding of the scale sizes of the density enhancements observed at high and polar latitudes. The scale sizes using the baseline are rather independent of solar activity, and the average is over 2500 km, whereas the scale sizes using adjacent density minima vary with solar activity, and the mean value is more than 1000 km. No significant different results are found between northern and southern hemisphere. We also investigate the impact of these mass density peaks on the orbit-averaged densities.

Keywords: neutral mass density , accelerometer measurements , CHAMP and GRACE satellites , spatial scale sizes

©2019. Japan Geoscience Union. All Right Reserved.

Meso-scale forcing in the upper atmosphere: sources and impacts

*Yue Deng[1], Qingyu Zhu[1], Cissi Lin[1]

1. University of Texas at Arlington

We present a systematical study crossing both data analysis and model simulation to improve the specification of the energy and momentum inputs into the ionosphere-thermosphere (IT) system, especially at the meso-scale, and the system response. Our results are organized in two parts. First, two-years of Swarm satellite field-aligned current (FAC) data have been analyzed in order to study the distributions of mean pattern and variability of FACs on different scales (small scale: <150 km; mesoscale: 100~500 km; large scale: >500 km). The FAC distributions are then implemented in the Global Ionosphere-Thermosphere Model (GITM) to assess relative contributions of FACs at different scales to Joule heating. To enhance our capability to directly simulate the meso- and small-scale structures, GITM has been improved with a local patch grid refinement capability. Utilizing GITM with the new grid structure, the meso- and small-scale gravity wave perturbations have been included at the lower boundary of GITM to simulate the influence of meso- and small-scale gravity waves on the upper atmosphere.

Keywords: Meso-scale forcing , upper atmosphere, Joule heating, Gravity waves

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Antti Pulkkinen(NASA/GSFC)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM12-01] NASA Heliophysics Division Space Weather Update

★Invited Papers

*Nicola Justine Fox[1] (1.NASA Headquarters)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM12-02] NOAA's Current and Future Space Weather Architecture

★Invited Papers

*Elsayed R Talaat[1] (1.NOAA National Environmental Satellite, Data, and Information Service)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM12-03] Community Coordinating Modeling Center (CCMC): A hub for collaborative assessment and improvement of space weather capabilities.

★Invited Papers

*Maria M Kuznetsova[1], M. Leila Mays[1], Edward J Semones[2], Peter J Macneice[1], Lutz Rastaetter[1], Ja Soon Shim[1], Yihua Zheng[1], Katherine Garcia-Sage[1], Joycelyn Jones[1], Yaireshka m Collado-Vega[1], Richard E Mullinix[1], Chiu Wiegand[1] (1.NASA Goddard Space Flight Center, 2.NASA Johnson Space Center)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM12-04] Different flux evolutions of relativistic electrons of the outer belt associated with high-speed coronal hole streams; Arase and Van Allen Probes observations

*Yoshizumi Miyoshi[1], Satoshi Kurita[1], Ryuho Kataoka[2], Shinji Saito[1], Vania Jordanova[3], Iku Shinohara[4], Takefumi Mitani[4], Takeshi Takashima[4], Nana Higashio[4], Satoshi Kasahara[5], Shoichiro Yokota[6], Tomoaki Hori[1], Kunihiro Keika[5], Yoshiya Kasahara[7], Shoya Matsuda[4], Atsushi Kumamoto[8], Fuminori Tsuchiya[8], Masafumi Shoji[1], Ayako Matsuoka[1], Mariko Teramoto[1], Harlan Spence[9], Geoff Reeves[3], Daniel Baker[10] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.NIPR, 3.Los Alamos National Laboratory, 4.JAXA, 5.University of Tokyo, 6.Osaka University, 7.Kanazawa University, 8.Tohoku University, 9.University of New Hampshire, 10.University of Colorado)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM12-05] Study on the predictability of imminent giant solar flares based on the theory of double-arc instability

*Kanya Kusano[1], Tomoya Iju[2], Yumi Bamba[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.NAOJ)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM12-06] Update of space weather research and operation activities in NICT

*Mamoru Ishii[1] (1.National Institute of Information and Communications Technology)

NASA Heliophysics Division Space Weather Update

*Nicola Justine Fox[1]

1. NASA Headquarters

NASA is a mission driven agency whose science mission is focused on discovering the secrets of the universe, looking for life elsewhere, and safeguarding and improving life on Earth. Heliophysics plays a key role in every aspect of the NASA science mission, including understanding the drivers of and enabling the prediction of space weather. Heliophysics has an established research program that motivates and funds solar and space physics, which is the essence and foundation of space weather research. Recently, the Heliophysics Division established a Space Weather Science Applications Program, SnAP. The objective of this competed program is to enable the transition of the knowledge and understanding of space weather to operation environments, by partnering with sister agencies, the commercial sector, and academia. SnAP leverages relevant NASA capabilities to reach this objective. This talk provides an overview of space weather research and SnAP in the NASA Heliophysics Division

Keywords: Heliophysics, Space Weather, Sun Earth Connections, Sun, Solar Wind, Magnetosphere

©2019. Japan Geoscience Union. All Right Reserved.

NOAA's Current and Future Space Weather Architecture

*Elsayed R Talaat[1]

1. NOAA National Environmental Satellite, Data, and Information Service

NOAA observational responsibilities in support of space weather forecasting are in the context of significant, numerous, complementary international and domestic efforts. Each measurement plays a unique role at different phases of the forecasting or event characterization process. This paper overviews the current suite of observation that NOAA maintains and utilizes on various platforms, NOAA's forecasting capability, contributions to research efforts, and the status of the NOAA/NESDIS plan forward efforts for the Space Weather Follow-On (SWFO) program to provide needed continuity. This paper will also brief the NOAA space weather goals within the NOAA Satellite Observing System Architecture.

Keywords: space weather, coronagraph, energetic particles

©2019. Japan Geoscience Union. All Right Reserved.

Community Coordinating Modeling Center (CCMC): A hub for collaborative assessment and improvement of space weather capabilities.

*Maria M Kuznetsova[1], M. Leila Mays[1], Edward J Semones[2], Peter J Macneice[1], Lutz Rastaetter[1], Ja Soon Shim[1], Yihua Zheng[1], Katherine Garcia-Sage[1], Joycelyn Jones[1], Yaireshka m Collado-Vega[1], Richard E Mullinix[1], Chiu Wiegand[1]

1. NASA Goddard Space Flight Center, 2. NASA Johnson Space Center

The Community Coordinated Modeling Center (CCMC, http://ccmc.gsfc.nasa.gov) was established at the end of past millennium as a multi-agency strategic investment in the US space weather program. The CCMC has two main goals: 1) to support space weather research and model development aiming to advance understanding of space weather phenomena and to improve forecasting; 2) to facilitate development of space weather applications and deployment of operational capabilities. The CCMC hosts a rapidly growing collection of space weather models and applications, provides simulations services to the international research community through a one-of-a-kind runs-on-request system, and maintains real-time simulations and perpetual archives of space weather information streams. In support of NASA missions, the CCMC provides support for mission planning, develops applications for space weather monitoring and forecasting, and provides space environment analysis services. In partnership with NASA Space Radiation Analysis Group (SRAG) and international modeling community the CCMC is building a flexible system for Solar Proton Event (SPE) risk assessment and forecasting in support of human exploration. Unbiased testing, evaluating and prototyping of new models and forecasting techniques for potential transition to operational organizations (R2O) is one of the primary CCMC functions. To establish internationally recognized metrics and benchmarks the CCMC initiated an international community-wide Forum for Space Weather Capabilities Assessment. Guided by the unfolding activities of Forum working teams as well as by the needs of operational agencies and end users to quantify and track improvements over time, the CCMC has begun to develop an extensive information technology infrastructure to support validation activities through a centralized database and an interactive web-based framework. The presentation will highlight the recent progress and discuss opportunities for international research initiatives aiming to improve space weather forecasting capabilities.

Keywords: space weather, models, assessment, Solar Proton Event

©2019. Japan Geoscience Union. All Right Reserved.

Different flux evolutions of relativistic electrons of the outer belt associated with high-speed coronal hole streams; Arase and Van Allen Probes observations

*Yoshizumi Miyoshi[1], Satoshi Kurita[1], Ryuho Kataoka[2], Shinji Saito[1], Vania Jordanova[3], Iku Shinohara[4], Takefumi Mitani[4], Takeshi Takashima[4], Nana Higashio[4], Satoshi Kasahara[5], Shoichiro Yokota[6], Tomoaki Hori[1], Kunihiro Keika[5], Yoshiya Kasahara[7], Shoya Matsuda[4], Atsushi Kumamoto[8], Fuminori Tsuchiya[8], Masafumi Shoji[1], Ayako Matsuoka[1], Mariko Teramoto[1], Harlan Spence[9], Geoff Reeves[3], Daniel Baker[10]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. NIPR, 3. Los Alamos National Laboratory, 4. JAXA, 5. University of Tokyo, 6. Osaka University, 7. Kanazawa University, 8. Tohoku University, 9. University of New Hampshire, 10. University of Colorado

Relativistic and ultra-relativistic electrons increase largely during the high-speed coronal hole streams, and the enhanced flux levels are controlled by the solar wind speed and the prolonged southward IMF. Such flux enhancements associated with high-speed streams have been observed by Arase/HEP and XEP instruments as well as Van Allen Probes/MagEIS and REPT. Some coronal hole streams produce large flux enhancement of both relativistic and ultra-relativistic electrons, while other coronal holes produce large flux enhancement of relativistic electrons (~2 MeV) but do not produce enhancement of ultra-relativistic electrons. In this presentation, we will show evolutions of the energy spectrum of relativistic electrons during the coronal hole streams and discuss how evolutions of the energy spectrum are related to chorus wave activities that are derived from Arase/PWE measurements and the proxy data from the low-altitude satellite data.

Keywords: radiation belts, Arase, Sun-Earth Connection

©2019. Japan Geoscience Union. All Right Reserved.

Study on the predictability of imminent giant solar flares based on the theory of double-arc instability

*Kanya Kusano[1], Tomoya Iju[2], Yumi Bamba[1]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. NAOJ

Solar flares are catastrophic explosions in the solar corona and sometimes may cause a severe space weather disaster in geo-space and the infrastructure. Although many efforts have been taken for understanding and predicting the onset of solar flares, it is still difficult to accurately predict when, where and how large giant solar flares will occur. Here, we propose a new type of solar flare prediction scheme called the κ-scheme. The κ-scheme is the totally physics-based prediction, and it is capable of providing the information of the location as well as the energy of imminent giant solar flares. The prediction is performed by evaluating how small reconnection can trigger the onset of the double-arc instability, which was recently proposed as the initial driver of solar flares by Ishiguro and Kusano (2017), using the nonlinear force-free field extrapolation. We carried out the analysis of more than 200 active regions in the solar cycle 24 by applying the κ-scheme to the SDO/HMI data. The result shows that most of the imminent giant solar flares larger than the GOES X2 class are predictable with the κ-scheme.

Keywords: solar flares, prediction, space weather

©2019. Japan Geoscience Union. All Right Reserved.

Update of space weather research and operation activities in NICT

*Mamoru Ishii[1]

1. National Institute of Information and Communications Technology

Since September 6 2017, when X9.3 solar flare occured most of Japanese people were scared of it, the situation of Japanese spacw weather operation has been changed so much. The ionosphere observing network has been set more robustly with dual systems. A back up center of space weather information service has been installed at NICT Kobe branch. In addition, we will begin 24/7 operation of space weather forecast services in FY2019.We have been collaborating with academic researchers under the framework of PSTEP which will finish the end of FY2019. Through the activities, we have provided some applications for better service than before. A radio propagatoin simulator, HF-START, and the estimation system of human radiation on flight, WASAVIES will be up on our web soon. In addition, we continue to discuss hazardous map against severe space weather disasters, which will be published within a year.I would like to share our information and have close cooperation with Asia Oceania space weather researchers and operators.

Keywords: Space Weather forecast, AOSWA, social impact

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Ryuho Kataoka(National Institute of Polar Research)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM12-07] Commercial Space Weather Activities From a USA small Business Perspertive

★Invited Papers

*Chigomezyo Mudala Ngwira[1], Geoff Crowley[1], Chad Fish[1] (1.Atmospheric and Space Technology Research Associates, LLC)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM12-08] Development of coronal mass ejection arrival time forecasting system using interplanetary scintillation observations

★Invited Papers

*Kazumasa Iwai[1], Daikou Shiota[2], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Mitsue Den[2], Yûki Kubo[2] (1.Institute for Space–Earth Environmental Research (ISEE), Nagoya University, 2.National Institute of Information and Communications)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM12-09] Development of real-time prediction system of CME arrival and magnetic field with SUSANOO-CME MHD simulation

*Daikou Shiota[1,2], Seiji Yashiro[3], Kazumasa Iwai[2] (1.National Institute of Information and Communications Technology (NICT), 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Catholic University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM12-10] The Role of a Tiny Brightening in a Huge Geo-effective Solar Eruption Leading to the St Patrick's Day Storm

*Yumi Bamba[1,2], Satoshi Inoue[1], Keiji Hayashi[1,3,4] (1.Institute for Space-Earth Environmental Research/Nagoya University, 2.Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency, 3.Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, 4.State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM12-11] Critical Parameters of Photospheric Magnetic Field to Produce Eruptive Solar Flares and CMEs in Active Regions

*Pei Hsuan Lin[1], Kanya Kusano[1], Daikou Shiota[2], Satoshi Inoue[1], KD Leka[1,3], Yuta Mizuno[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Information and Communications Technology, 3.NorthWest Research Associates)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM12-12] Simulation study on internal velocity field variation of eruptive prominence

★Invited Papers

*Takafumi Kaneko[1], Kanya Kusano[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

Commercial Space Weather Activities From a USA small Business Perspertive

*Chigomezyo Mudala Ngwira[1], Geoff Crowley[1], Chad Fish[1]

1. Atmospheric and Space Technology Research Associates, LLC

This talk offers a brief overview of ASTRA (Atmospheric and Space Technology Research Associates), a small business company based in Louisville, Colorado USA. ASTRA was born out of the vision for applying fundamental space physics knowledge to real-world problems. Its motto is Science + Technology + Applications –Bringing it all together. Founded in 2005, ASTRA has become a system design and technology development company. ASTRA is a leader in the “New Space” small satellite revolution specializing in miniaturized sensors, and data modeling and analytics for the government and commercial customers. ASTRA leverages its scientific and engineering expertise to develop unique solutions in HF radar and radio, GPS systems, satellite remote sensing, CubeSats/Smallsats, and LiDAR. ASTRA's technical background spans fundamental space physics disciplines of the upper atmosphere, data analysis and modeling of the complex coupling of the meso-iono- thermosphere, as well as LEO constellation design, spacecraft design, instrument sensor design and manufacture, and space to earth communications.

Keywords: Space Weather, Commercial activities

©2019. Japan Geoscience Union. All Right Reserved.

Development of coronal mass ejection arrival time forecasting system using interplanetary scintillation observations

*Kazumasa Iwai[1], Daikou Shiota[2], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Mitsue Den[2], Yûki Kubo[2]

1. Institute for Space–Earth Environmental Research (ISEE), Nagoya University, 2. National Institute of Information and Communications

Coronal mass ejections (CMEs) sometimes cause disturbances in the environment of the Earth. However, prediction of the arrival of CMEs still remains a challenge. We have developed a data assimilation forecasting system of the CME arrival time by combining radio interplanetary scintillation (IPS) observations and a global magnetohydrodynamic (MHD) simulation of the inner heliosphere. In this system, the initial speed of a CME is roughly derived from the white light coronagraph observations. Then, the propagation of the CME is calculated by global MHD simulation (Shiota et al. submitted in this session). The IPS is estimated by the three-dimensional density distribution of the inner heliosphere derived from the MHD simulation. The estimated IPS is compared with the actual IPS observation made by the Institute for Space-Earth Environmental Research, Nagoya University. The estimated IPS shows good agreement with the observed IPS. We demonstrated the working of the simulation system using a typical halo CME event generated by a X9.3 flare observed on September 5, 2017. We found that the CME simulation that estimates IPS most similar to the observation can most accurately predict the time of arrival of the CME to the Earth. These results suggest that the accuracy of the CME arrival time will be improved if the current MHD simulations include IPS data.

Keywords: coronal mass ejection (CME), space weather forecasting, interplanetary scintillation (IPS), data assimilation

©2019. Japan Geoscience Union. All Right Reserved.

Development of real-time prediction system of CME arrival and magnetic field with SUSANOO-CME MHD simulation

*Daikou Shiota[1,2], Seiji Yashiro[3], Kazumasa Iwai[2]

1. National Institute of Information and Communications Technology (NICT), 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Catholic University

The predictions of CME arrival to the Earth and the southward magnetic field brought by the CMEs are one of crucial tasks for space weather forecast.
We have developed an MHD simulation capable of reproducing the interplanetary propagation of multiple CMEs with internal magnetic flux rope (Shiota & Kataoka 2016) called as SUSANOO-CME. The simulation solves propagation of solar wind and CMEs in the inner heliosphere from 25 solar radii where all the balk flow exceeds fast mode speed. The information of solar wind and CME is specified at the inner boundary with empirical and analytical models using real-time observations of the Sun and the corona.
Recently, we have been constructing a new prediction system of CME impacts (CME arrival and magnetic field) utilizing SUSANOO-CME with the real-time solar observations for the purpose of use in space weather forecast in NICT. The system is capable of preforming ensemble simulation with different sets of multiple CME input parameters, which is controlled from web-browser based interfaces. The results of ensemble simulation can be evaluated with real-time IPS observation in Nagoya University (the detail is reported by Iwai et al. submitted in this session). We will report the current status of the development and discuss the future directions.

Keywords: Space weather forecast, CME, solar wind

©2019. Japan Geoscience Union. All Right Reserved.

The Role of a Tiny Brightening in a Huge Geo-effective Solar Eruption Leading to the St Patrick's Day Storm

*Yumi Bamba[1,2], Satoshi Inoue[1], Keiji Hayashi[1,3,4]

1. Institute for Space-Earth Environmental Research/Nagoya University, 2. Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency, 3. Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, 4. State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences

The largest magnetic storm in solar cycle 24 was caused by a fast coronal mass ejection (CME) that was related to a small C9.1 flare that occurred on 15 March 2015 in solar active region (AR) NOAA 12297. The purpose of this study is to understand the onset mechanism of the geo-effective huge solar eruption. We focused on the C2.4 flare that occurred prior to the C9.1 flare of the filament eruption. The magnetic field structure in the AR was complicated: there were several filaments including the one that erupted and caused the CME. We hence carefully investigated the photospheric magnetic field, brightenings observed in the solar atmosphere, and the three-dimensional coronal magnetic field extrapolated from nonlinear force-free field modeling, using data from *Hinode* and *Solar Dynamics Observatory*. We found three intriguing points : (1) There was a compact but noticeably highly twisted magnetic field structure that is represented by a small filament in the C2.4 flaring region, where a tiny precursor brightening was observed before the C2.4 flare. (2) The C2.4 flaring region is located in the vicinity of a foot point of the closed field that prohibits the filament from erupting. (3) The filament shows a sudden eruption after the C2.4 flare and accompanying small filament eruption. From our analysis, we suggest that a small magnetic disturbance that was represented by the tiny precursor brightening at the time of the C2.4 flare is related to the trigger of the huge filament eruption.

Keywords: St Patrick's Day Storm, Solar Flares, Filament Eruption, Hinode, Solar Dynamics Observatory

©2019. Japan Geoscience Union. All Right Reserved.

Critical Parameters of Photospheric Magnetic Field to Produce Eruptive Solar Flares and CMEs in Active Regions

*Pei Hsuan Lin[1], Kanya Kusano[1], Daikou Shiota[2], Satoshi Inoue[1], KD Leka[1,3], Yuta Mizuno[1]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. National Institute of Information and Communications Technology, 3. NorthWest Research Associates

Solar flares and coronal mass ejections (CMEs) are eruptive phenomena caused by magnetic field in the solar corona. In particular, large eruptive events originate in active regions (AR) on the solar surface. However, it is still unclear what determines the capability of an AR to produce eruptive flares and CMEs, and it hinders our ability to predict CMEs. In this study, we propose a new parameter r_m to measure the possibility that a flare on an AR can be eruptive and produce a CME. The parameter r_m is defined by the ratio of the magnetic flux of twist higher than a threshold T_c to the overlying magnetic flux. The value of rm for each AR can be estimated using the nonlinear force-free field (NLFFF) extrapolation. Based on the data obtained by the Solar Dynamics Observatory (SDO)/Helioseismic and Magnetic Imager (HMI), we calculated the values of r_m for 29 ARs at 51 times before to flares larger than M5.0 class. We find that the foot-point of field lines with twist larger than 0.2 can well represent the flare ribbons, and we thus evaluated r_m for T_c=0.2 as a critical parameter for producing eruptive flares and CMEs using discriminant analysis. The result shows that r_m is moderately able to discriminate ARs which have capability to produce CME-accompanied flares.

Keywords: solar physics, coronal magnetic field, coronal mass ejection, solar flare

©2019. Japan Geoscience Union. All Right Reserved.

Simulation study on internal velocity field variation of eruptive prominence

*Takafumi Kaneko[1], Kanya Kusano[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

Solar prominences, cool dense plasma clouds in the hot tenuous corona, sometimes erupt and evolve into coronal mass ejections. Prominence eruptions have attracted interest in the researches of space weather as well as solar physics. It is known that the interior of prominences is turbulent. Recent observational statistical studies reported that standard deviation of the Doppler velocity in the eruptive prominences started to increase several hours before eruptions even when the mean velocity was nearly zero. This finding is useful to predict prominence eruptions; however, the physical relationship between the magnetically-driven eruptive mechanisms (i.e., magnetohydrodynamic instabilities) and the internal velocity field variation of prominence has not been revealed.
In this study, we performed three-dimensional magnetohydrodynamic simulation including gravity, radiative cooling, and thermal conduction to reproduce eruption of turbulent prominence. In our simulation, a bipolar magnetic field is randomly introduced along the polarity inversion line of the sheared coronal arcade field. A magnetic flux rope is created by reconnection between the bipole and the coronal arcade field. Cool dense prominence is formed in the flux rope by radiative condensation. The prominence erupts after the flux rope exceeds the critical height of torus instability. Before the eruption, the height of flux rope axis monotonically increases; however, the velocity field inside the prominence has complicated distribution containing both upflows and downflows. We confirmed that the increase in standard deviation of the vertical velocity is quantitatively consistent with the observational results. To investigate the relationship with the magnetic field, we compared the histogram of the velocity components perpendicular and parallel to the magnetic field. As a result, we found that the upflows and downflows stem from perpendicular and parallel velocity, respectively. This result indicates that upflows and downflows are driven by Lorentz force and gravity along magnetic field, respectively. We also found that the increase in standard deviation of perpendicular velocity is larger than that of parallel velocity, suggesting that the increase in standard deviation of vertical velocity is caused mainly by increase in Lorentz force.

Keywords: solar prominences, filaments, prominence eruption

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Antti Pulkkinen(NASA/GSFC)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM12-13] Is intensity of auroral electrojet predictable?

★Invited Papers

*Yusuke Ebihara[1], Takashi Tanaka[2], Naoki Kamiyoshikawa[3] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.Kyushu University, 3.Mitsubishi Electric Corporation)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM12-14] Geoelectromagnetics with the Geophysical Instrument Combination of Hydro-Québec, AUTUMNX, and USArray Magnetotellurics

★Invited Papers

*Martin G Connors[1], Sébastien Guillon[2], Adam Schultz[3], Naoto Imamura[3] (1.Athabasca University, 2.Hydro-Québec TransÉnergie, 3.Oregon State University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM12-15] Quantifying the Latitudinal Extent of the Aurorae During Large Geomagnetic Storms

*Sean Blake[1,2], Antti Pulkkinen[1], Pete Schuck[1] (1.NASA Goddard Space Flight Center, Space Weather Laboratory, Greenbelt, Maryland, USA, 2.Catholic University of America, Department of Physics, Washington DC, USA)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM12-16] Simulation of Geomagnetically Induced Current (GIC) Flowing in 500 kV Power Grid in Japan Including a Three-Dimensional Ground Inhomogeneity

*Satoko Nakamura[1], Yusuke Ebihara[1], Shigeru Fujita[2], Tada-nori Goto[3], Shinichi Watari[4] (1.Research Institute for Sustainable Humanosphere, Kyoto University., 2.Meteorological College, Japan Meteorological Agency, 3.Graduate School of Engineering, Kyoto University, 4.National Institute of Information and Communications Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM12-17] Reproducibility of the geomagnetically induced currents in Hokkaido with a two-layer conductivity model

*Takashi Kikuchi[1,2], Yusuke Ebihara[2], Kumiko K. Hashimoto[3], Shinichi Watari[4] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute for Sustainable Humanosphere, Kyoto University, 3.Kibi International University, 4.National Institute of Information and Communications Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM12-18] Fan-shaped aurora as seen from Japan during a great magnetic storm on 11 February 1958

*Ryuho Kataoka[1], Shiori Uchino[1], yasunori Fujiwara[1], Shigeru Fujita[1], Kazuaki Yamamoto[2] (1.National Institute of Polar Research, 2.National Institute of Japanese Literature)

Is intensity of auroral electrojet predictable?

*Yusuke Ebihara[1], Takashi Tanaka[2], Naoki Kamiyoshikawa[3]

1. Research Institute for Sustainable Humanosphere, Kyoto University, 2. Kyushu University, 3. Mitsubishi Electric Corporation

A large amount of energy (of the order of 10^{11} W) is consumed in the auroral ionosphere as Joule dissipation during the substorm expansion phase. The origin of the energy consumed in the auroral ionosphere is in the solar wind, but the energy flow and conversion in between are problematic. Previously, the energy consumed in the ionosphere is thought to consist of the directly driven (DD) component and the loading and unloading (UL) component. The DD component is thought to respond to the magnetic energy entering the magnetosphere, and hence, the DD component is probably predictable. The UL component, on the other hand, is thought to be unpredictable because it might depend on the amount of released energy in the lobe. On the basis of the global magnetohydrodynamics (MHD) simulation, we show that the maximum intensity of the auroral electrojet (and the Joule dissipation rate) during the substorm expansion is well correlated with the magnetic energy entering the magnetosphere. The correlation coefficient between them is 0.90 (and 0.97). There are a few key reasons. First, the amount of the released energy from the lobe increases with the southward component of interplanetary magnetic field (SBZ) and the solar wind velocity, meaning that the amount of the released energy is regulated by the solar wind parameters. Secondly, the magnetic energy released from the lobe goes into the near-Earth reconnection region, and seems not to contribute significantly to the generation of the field-aligned current associated with the substorm expansion. Thirdly, the release of the energy lasts for ~10 minutes, whereas the auroral electrojet keeps developing for 15 minutes and more. Fourthly, 40-90% of the magnetic energy entering the magnetosphere comes from the solar wind kinetic energy for the southward IMF. About 2% of the entering energy goes into the ionosphere during the expansion phase. The ratio is almost independent of the solar wind condition. These simulation results may suggest that the maximum intensity of the auroral electrojet (and the Joule dissipation rate) is predictable when the magnetic energy entering the magnetosphere is adequately predicted.

Keywords: Substorm, Auroral electrojet, MHD simulation

©2019. Japan Geoscience Union. All Right Reserved.

Geoelectromagnetics with the Geophysical Instrument Combination of Hydro-Québec, AUTUMNX, and USArray Magnetotellurics

*Martin G Connors[1], Sébastien Guillon[2], Adam Schultz[3], Naoto Imamura[3]

1. Athabasca University, 2. Hydro-Québec TransÉnergie, 3. Oregon State University

Geoelectromagnetics is a term used by Bolduc et al. (2000) regarding a pioneering study in which electric fields near a part of the Hydro-Québec transmission network were measured during an intense auroral event. To fully characterize space weather effects on an electric power transmission network, we must proceed from the source currents and their variations, through the changing magnetic fields near Earth's surface, to the electric fields induced in the Earth and to some extent in the conducting structures directly, to electric currents flowing in the grid, and finally to the effects of such currents, ranging from voltage distortion to possible equipment damage. The more data can be measured at each link in this complex chain, the better will be our ability to monitor current events in a precautionary manner and assess the robustness of the grid to varying levels of stress.

The Hydro-Québec network has had enhanced monitoring capabilities (as well as improved ability to deal with geomagnetic stresses) since 1989 (Guillon et al., 2016). The last link of the chain, effects, is able to be well quantified, especially through measures of voltage distortion. Direct measurements of transformer grounding currents, essentially the geomagnetically induced currents (GIC) themselves, are available at a few points. The AUTUMNX magnetic network (Connors et al., 2015) complemented grid instrumentation in Québec starting in 2014, and has produced a new view of the association of magnetic variations with signals in the grid. Magnetotellurics (MT) tends to operate in campaign mode, but also measures the electric field, including at relevant low frequencies, giving a more complete indication of the geoelectromagnetic environment while also providing measurements of the frequency dependent electromagnetic impedance of the ground, which can be used to reconstruct the electrical conductivity structure of the Earth's crust and mantle.

We illustrate these comprehensive geoelectromagnetic measurements with the case of the magnetic storm of September 7-9 2017, during which the NSF EarthScope MT array installed by Oregon State University was operating in the northeastern US, near the Hydro-Québec grid, at a time when the electrojet had expanded southward. We find a close correlation of times of large magnetic field variation, measured electric fields, and harmonic distortion in the grid.

While we note the complications stressed by Love et al. (2018), we feel that the enhanced MT monitoring advocated by Love et al. (2016), would give more knowledge of geological structure and geoelectric response in northeastern North America. In this way, our understanding of GIC would be greatly improved, in the areas of understanding basic processes and hazard assessment.

Bolduc et al., A Study of Geoelectromagnetic Disturbances in Québec, 2. Detailed Analysis of a Large Event, IEEE Trans. Power Delivery, 15, 272-278 (2000)
Connors et al., The AUTUMNX Magnetometer Meridian Chain in Québec, Canada, Earth, Planets and Space, 68:2(21pp.) , doi:10.1186/s40623-015-0354-4 (2015)
Guillon et al., A Colorful Blackout: The Havoc Caused by Auroral Electrojet Generated Magnetic Field Variations in 1989, IEEE Power and Energy, doi: 10.1109/MPE.2016.2591760 (2016)
Love et al. Geoelectric hazard maps for the continental United States, Geophys. Res. Lett., 43, 9415–9424

©2019. Japan Geoscience Union. All Right Reserved.

(2016)
Love et al. Geoelectric hazard maps for the Pacific Northwest. Sp. Weather, 16, 1114–1127 (2018)

Keywords: space weather, geomagnetically induced currents, magnetometry, magnetotellurics, geomagnetic storms, instrument networks

©2019. Japan Geoscience Union. All Right Reserved.

Quantifying the Latitudinal Extent of the Aurorae During Large Geomagnetic Storms

*Sean Blake[1,2], Antti Pulkkinen[1], Pete Schuck[1]

1. NASA Goddard Space Flight Center, Space Weather Laboratory, Greenbelt, Maryland, USA, 2. Catholic University of America, Department of Physics, Washington DC, USA

As geomagnetic storms grow larger, the extent of the auroral ovals can be seen to travel further towards the equator. During the famous Carrington event for example, the aurora was reportedly seen as far South as Cuba. Accompanying the auroras are large electric currents in the ionosphere. The magnetic signature of these ionospheric currents can be detected on the ground in magnetic observatories around the world in the form of increased magnetic variations. These variations can lead to large local geoelectric fields, posing a risk to the operation of power networks around the world.

It is therefore necessary to estimate the extent of the aurora and accompanying geoelectric fields during infrequent and large-scale (1-in-100 year) events. Using three decades of historical geomagnetic data from around the world, we have developed a method to detect and quantify the extent of the auroral oval (or latitude threshold) using ground-based data. We use this to statistically estimate the southernmost extent for storms with Dst values < -600 nT, as well as the geoelectric field strengths at these latitude thresholds.

In addition, building on the work by Ngwira et al. (2014) by using magnetospheric and ionospheric magnetohydrodynamic simulations, we simulate 'worst-case' scenario superstorms of different magnitudes. Applying our threshold detecion to the magnetic field outputs of these simulations enable us to estimate the latitude thresholds for storms of magnitudes not seen in the modern era.

Keywords: Aurora, Geomagnetism, Geostorms

©2019. Japan Geoscience Union. All Right Reserved.

Simulation of Geomagnetically Induced Current (GIC) Flowing in 500 kV Power Grid in Japan Including a Three-Dimensional Ground Inhomogeneity

*Satoko Nakamura[1], Yusuke Ebihara[1], Shigeru Fujita[2], Tada-nori Goto[3], Shinichi Watari[4]

1. Research Institute for Sustainable Humanosphere, Kyoto University., 2. Meteorological College, Japan Meteorological Agency, 3. Graduate School of Engineering, Kyoto University, 4. National Institute of Information and Communications Technology

We evaluate geomagnetically induced currents (GICs) flowing in the Japanese power grid during severe space weather by using several methods. First, the three-dimensional distribution of the geomagnetically induced electric field (GIE) was calculated by using the 3D finite-difference time-domain (FDTD) method with a three-dimensional electrical conductivity model constructed from a global relief model and a global map of sediment thickness. To simulate a time evolution of magnetic storms, the sheet current with its intensity inferred from the ground magnetic disturbance for famous magnetic storms is imposed. We compared the calculated GICs with the observed ones at substations around Tokyo, and found a certain agreement when the uneven distribution of GIE is incorporated with the simulation. The simulation result shows that GIE exhibits localized, uneven distribution that can be attributed to charge accumulation due to the inhomogeneous conductivity below the Earth's surface. The charge accumulation becomes large when the conductivity gradient vector is parallel, or anti-parallel to the incident electric field. For given GIE, we calculated the GICs flowing in a simplified 500 kV power grid network in Japan. The influence of the inhomogeneous ground conductivity on GIC appears to depend on a combination of the location of substations and the direction of the source current. Second, we assume conductivity anomaly simulating a plate boundary to test the effect of large-scale underground structure on GICs. We find that these structures may strongly enhance GIC just above them. Finally, we derive transfer functions between the GIC observation at 4 substations in Japan and geomagnetic field recorded at the Kakioka station. The transfer functions are not always applicable for Japanese GIC. We will discuss the validity of the assumption of uniform ground and influence of the time variation of earthing resistance of substations.

©2019. Japan Geoscience Union. All Right Reserved.

Reproducibility of the geomagnetically induced currents in Hokkaido with a two-layer conductivity model

*Takashi Kikuchi[1,2], Yusuke Ebihara[2], Kumiko K. Hashimoto[3], Shinichi Watari[4]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Institute for Sustainable Humanosphere, Kyoto University, 3. Kibi International University, 4. National Institute of Information and Communications Technology

Watari et al. [SW 2009], based on the GIC measurements in Hokkaido, Japan (35.7 GM Lat), found that the GIC is well correlated with the y-component magnetic field (By) (correlation coefficients > 0.8) and poor correlations with Bx,z and dBx,y,z/dt. The good correlation between the GIC and By would help predict the GIC if we have capabilities of reproducing the magnetosphere-ionosphere currents responsible for ground magnetic disturbances. To use the GIC- By relationship for the GIC prediction, we need to clarify if the good correlation is valid for any period/time scale (T) of disturbances. To address this issue, we made correlation analyses for the geomagnetic sudden commencements and pulsations (T=1-10m), substorm positive bays (30m), quasi-periodic DP2 fluctuations (20-60m), and geomagnetic storms (1-20h) as well as quiet-time diurnal variations (3-12h). We found that the correlation is good for short period (cc > 0.8 for T < 1 h), but poor for long periods (cc < 0.3 for T > 6 hours). Using the conventional induction theory based on the Faraday’s, Ampere’s and Ohm’s laws, we calculated the electric field (GIE) induced by By as a convolution of dBy/dt and step response of a uniform conductor. The GIE is found to be better correlated with the GIC for the long-period disturbances (cc > 0.9), whereas the correlation with By remains better for short period disturbances. This result requires us to use two models depending on the period of disturbances. To obtain a model applicable to any period, we made constructed a two-layer model with higher conductivity on the top. We show that the two-layer model is capable of reproducing the GIC with high correlations (cc > 0.9) for any period of disturbances ranging from 1 min to 10 hours. It should be noted; however, the capability of the model may depend on the direction of the power transmission line relative to the coast line and also depend on the structure of the Earth’s conductivity.

Keywords: geomagnetically induced current, Hokkaido, two-layer conductivity model

©2019. Japan Geoscience Union. All Right Reserved.

Fan-shaped aurora as seen from Japan during a great magnetic storm on 11 February 1958

*Ryuho Kataoka[1], Shiori Uchino[1], yasunori Fujiwara[1], Shigeru Fujita[1], Kazuaki Yamamoto[2]

1. National Institute of Polar Research, 2. National Institute of Japanese Literature

A fan-shaped aurora was photographed at Memambetsu, Hokkaido Japan during a great magnetic storm on Feb 11, 1958. This is the first and oldest photograph record of auroras as observed in Japan, and many hand-written drawings were also recorded at the same time during the February 1958 event, giving a rare opportunity of the coexistence of photograph images and hand-written drawings. In fact, the combination of photographs and drawings of the 1958 event reminds us of the great red aurora with fan-shaped white pillars as illustrated during other great magnetic storms in 1872 and in 1770. From the analysis of newly digitized microfilm data, it is also found that the fan-shaped aurora appeared during the peak activity of magnetic storm, and moved westward at 0.4 km/s at 400 km altitude at 38-40 deg magnetic latitudes, which is consistent with the enhanced convection pattern in middle latitude during storm time. Such a fan-shaped aurora can be a fundamental characteristic of middle-latitude evening-to-midnight auroras during great magnetic storms, which show the most destabilized transient appearance of the inner magnetosphere.

Keywords: aurora, magnetic storm, historical records

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Kanya Kusano(Nagoya University)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM12-19] Application Usability Levels: Their evolution and eco-system

★Invited Papers

*Alexa Jean Halford[1], Adam Kellerman[2], Jeff Klenzing[3], Katherine Garcia-Sage[3], Brett A Carter[4], Daniel T Welling[5], Barbara Thompson[3], Antti A Pulkkinen[3] (1.The Aerospace Corporation, 2.UCLA, 3.NASA/GSFC, 4.RMIT, 5.UT Arlington)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM12-20] The Operational Space Weather Forecast at NICT, Japan

★Invited Papers

*Kosuke Sakai[1], Kentaro Ukawa[1], Kentaro Kawahara[1], Mamoru Ishii[2], Yuki Kubo[2] (1.Systems Engineering Consultants Co., LTD., 2.National Institute of Information and Communications Technology)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM12-21] PROGRESS: An overview of data products

*Michael A Balikhin[1], Simon N Walker[1] (1.University of Sheffield)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM12-22] The Probability of Satellite Anomalies by a Disastrous Solar Flare

*Daikichi SEKI[1,2,3] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2.Centre for the Study of Existential Risk, University of Cambridge, 3.Astronomical Observatory, Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM12-23] **Operational Forecasting of Solar Flares using Deep Neural Network**

*Naoto Nishizuka[1], Yuki Kubo[1], Komei Sugiura[1], Mitsue Den[1], Mamoru Ishii[1] (1.National Institute of Information and Communications Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM12-24] **Spring-Autumnal asymmetry in geomagnetic activity and its origin over last 140 years**

*Hao Luo[1], Xiaoming Sha[1] (1.IGGCAS)

Application Usability Levels: Their evolution and eco-system

*Alexa Jean Halford[1], Adam Kellerman[2], Jeff Klenzing[3], Katherine Garcia-Sage[3], Brett A Carter[4], Daniel T Welling[5], Barbara Thompson[3], Antti A Pulkkinen[3]

1. The Aerospace Corporation, 2. UCLA, 3. NASA/GSFC, 4. RMIT, 5. UT Arlington

As space physics becomes both more interdisciplinary and more intertwined with commercial and government operations, there is a need for a framework to easily identify what projects can be used for specific applications and how close each project is to routine autonomous or on-demand implementation and operation. We have developed the Application Usability Level (AUL) framework and encourage publication of instrument-like papers for delivering and publicizing AULs to help the community quantify the progress of successful applications, metrics, and validation efforts.

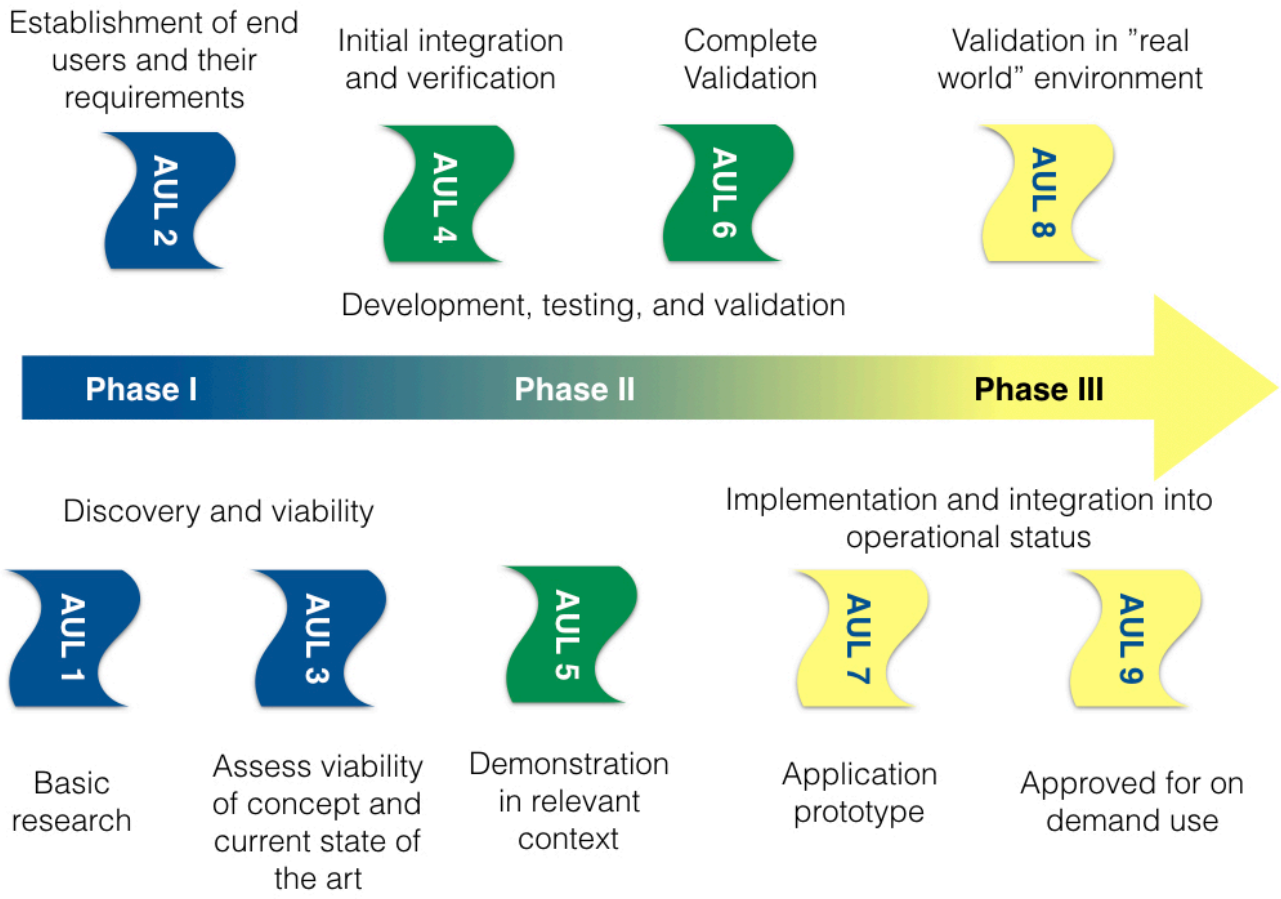
In a given project within the AUL framework, there is typically a diverse eco-system of individuals necessary to ultimately produce a useful space weather product or productive research collaboration. For example, in the case of non-academic fields, users and researchers alike may benefit from a translator, i.e. a *broker*, who may help with the effective transition from research to operations. *Independent validators* are another essential player for validation efforts and comparing like products for a specified application. In many cases, the different players throughout the process will act in multiple roles as well as act in different roles for different projects and AUL pathways.

This paper we discuss the collaborative roles that lead from basic research to successful application within or outside the scientific community and provide examples of how this collaborative application ecosystem is maintained. We will also provide examples of space weather projects using the AUL framework, and show how it can contribute to the project's success. As always, a healthy eco-system can result in benefits for the end user and new exciting research opportunities.

This work has been completed as part of the activities of the Assessment of Understanding and Quantifying Progress working group which is part of the International Forum for Space Weather Capabilities Assessment.

Keywords: Tracking progress, Research to operations, Space Weather

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

The Operational Space Weather Forecast at NICT, Japan

*Kosuke Sakai[1], Kentaro Ukawa[1], Kentaro Kawahara[1], Mamoru Ishii[2], Yuki Kubo[2]

1. Systems Engineering Consultants Co., LTD., 2. National Institute of Information and Communications Technology

At the Space Weather Forecast Center of the National Institute of Information and Communications Technology, the latest 24-hour outlines and forecasts of space weather are provided to space weather users every day.
Delivers of space weather information have been continuously performed for over 50 years as ISES Regional Warning Center, Japan, and operators in the space weather forecast center are in charge of this task.
The operational work is conducted 7 days a week. Operators collect and analyze various observation data and simulation results provided from domestic and overseas collaborators, and summarize current space weather conditions before daily briefing at 14:30 JST.
In order to determine the next 24-hour forecast, operators organize a discussion meeting with specialists, and deliver forecasts before the due at 16 JST.
In addition, operators hold regular monthly meetings, consider the results of the forecasts, and feed back to improve next forecast accuracy.
When a remarkable space weather phenomenon occurs, operators has a responsibility to deliver alerts information immediately.
In this presentation, we introduce the daily work content of the space weather forecaster and the procedure up to deciding the content of the forecast with actual case examples.
In addition, we will also introduce contrivances and other measures to operate 365 days a year without breaks.

Keywords: Space Weather

©2019. Japan Geoscience Union. All Right Reserved.

PROGRESS: An overview of data products

*Michael A Balikhin[1], Simon N Walker[1]

1. University of Sheffield

PROGRESS, an EC Horizon 2020 funded project, used state of the art modelling techiniques inorder to derive forecasts for the evolution of geomagnetoc indices, and the fluxes of electrons at geostationary orbit and within the inner magnetosphere. This presentation provides a review of the aims of PROGRESS and an overview of the tools developed to meet these aims.

Keywords: radiation belt forecasts, geomagnetic index forecasts

©2019. Japan Geoscience Union. All Right Reserved.

The Probability of Satellite Anomalies by a Disastrous Solar Flare

*Daikichi SEKI[1,2,3]

1. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2. Centre for the Study of Existential Risk, University of Cambridge, 3. Astronomical Observatory, Kyoto University

The Sun has a potential risk of various socioeconomic impacts on our human society. It often produces various eruptive phenomena such as a solar flare and a coronal mass ejection, which sometimes bring adverse effect to us like satellite anomalies, radiation exposure, and huge blackouts. Recently, it was revealed that a “super-flare”, a flare whose energy is 100 times larger than X10-class flare, can occur once in 1000 years from statistical and theoretical points of view [Maehara et al. 2012, Shibayama et al. 2013, Shibata et al. 2013].

However, though there are many assessment studies of “moderate” solar eruptive phenomena, the assessment of “disastrous” solar eruptive phenomena like a super-flare has been little conducted. For this reason, this research aims to evaluate the frequency (or probability) and the possible socioeconomic damage of a super-flare, especially focusing on satellite anomalies.

Using various data sets about satellites, their anomalies, flares, and plasma environment around the Earth*, 154 X-class flare events with 9 relating parameters (peak flux of X-ray (0.1–0.8 nm), integral fluxes of electron (> 2 MeV) and of proton (> 1, 5, 10, 30, 50, 60, 100 MeV)) were selected. To avoid multi-collinearity, Ridge regression model was used to compute the regression to the satellite anomaly rate (1/satellite/event). Also 10-fold cross validation was performed. After obtaining the model, the possible plasma parameters in case of X1000-class flare assumed by Takahashi et al. 2016 were input into the model.

As a result, we obtained the model with its coefficient of determination of 0.607 and its Pearson correlation coefficients of 0.691 ±0.212 (for 100 times randomly chosen dataset). Assuming that electron and proton with any energy follow the same scaling law, with applying scaling law by Takahashi et al. 2016, 0.573 satellite anomaly rate (57.3% per satellite per event) was obtained. It should be noted that the scaling law provided by Takahashi et al. 2016 is upper limit, so in the actual case, rate should be lower. The validity of assumption, the comparison between this research and others (Pilipenko et al. 2006; Iucci et al. 2005; Odenwald et al, 2006, 2007), and the possible socioeconomic loss will be also discussed.

* NOAA NGDC Spacecraft Anomaly Data, Satellite Catalogue (https://www.celestrak.com/satcat/search.php), NOAA GOES flare report (https://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-features/solar-flares/x-rays/goes/xrs/) , and OMNI 2 database

Keywords: space weather, satellite anomaly, super-flare

©2019. Japan Geoscience Union. All Right Reserved.

Operational Forecasting of Solar Flares using Deep Neural Network

*Naoto Nishizuka[1], Yuki Kubo[1], Komei Sugiura[1], Mitsue Den[1], Mamoru Ishii[1]

1. National Institute of Information and Communications Technology

Solar flares are the largest explosive phenomena in the Heliosphere. They affect the earth by X-ray and UV emissions, high energy particles, and magnetic storms, causing troubles of satellites and blackout in a large area. To reduce the risk of social impact caused by solar flares and space weather, it is very important to predict solar flares with high accuracy. In our institute NICT, we have predicted solar flares in the daily forecasting meeting by an empirical method. However, the amount of solar observation data is so huge that we cannot deal with all the data by hands.

Here we developed an operational system of solar flare prediction using a deep neural network (DNN), named Deep Flare Net (DeFN; Nishizuka et al. 2018 ApJ), and we started to run it in the operation. The model can predict probabilities of the maximum class of flares occurring in the following 24 hr. The training dataset is maded by 3x10^5 images during 2010-2015 taken by SDO, from which we detected active regions and calculated 79 features for each region attached with the flare occurrence labels (X, M, C). We used features in our previous work (Nishizuka et al. 2017) and added novel features for operational prediction: coronal hot brightening at 131 A (T=10^7 K) and the histories of X-ray and 131 A emissions 1 and 2 hr before an image. The prediction data in the near real-time is downloaded from JSOC server operated by Stanford University and NASA, and all the active regions and features are automatically detected and calculated. The prediction results will be shown in the web site of NICT. In this talk, we will introduce our DeFN model and operational forecasting system and would like to discuss how it works in the daily operations.

Keywords: Solar Flare , Space Weather, Machine Learning, prediction, Operation

©2019. Japan Geoscience Union. All Right Reserved.

Spring-Autumnal asymmetry in geomagnetic activity and its origin over last 140 years

*Hao Luo[1], Xiaoming Sha[1]

1. IGGCAS

Spring-Autumnal asymmetry (SA asymmetry) from years 1873-2010 in the geomagnetic activity is investigated based on the geomagnetic indices (aa, Ap and Kp). Results have shown that in general the SA asymmetry of the geomagnetic activity appears to be alternation, except for the interval during which the change of dominant solar dipole magnetic field polarity occurs. Our study implies that both the polarity of the main solar dipole field and the north-south asymmetry of the sunspot area in the two solar hemispheres control the strength of the south component (*Bs*) of the interplanetary magnetic field (IMF) near the Earth and the resulting SA asymmetry of the geomagnetic activity in the corresponding seasons. A simple sector structure model is devised to establish the relationship between the polarity of solar main dipole magnetic field, the IMF *Bs* component and the corresponding SA asymmetry in the geomagnetic activity. This is confirmed by examining the solar wind parameters from the spacecraft observations during the recent decades.

Keywords: Spring-Autumnal asymmetry, Solar magnetic polarity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 301B 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS09-18] Searching 18.6 year tidal modulation impact in a global gridded ocean oxygen dataset with its improvements

*Shoshiro Minobe[1] (1.Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS09-19] Contribution of tidal energy dissipation to variations of transient climate response and steric sea level rise through ocean heat uptake

*Michio Watanabe[1], Hiroaki Tatebe[1], Tatsuo Suzuki[1], Kaoru Tachiiri[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS09-20] A Wave Resolving Simulation for Upper Ocean Turbulence Driven by Wave-Current Interaction

*Yutaka Yoshikawa[1], Yasushi Fujiwara[1], Yoshimasa Matsumura[2] (1.Graduate School of Science, Kyoto University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS09-21] Revisiting the Characteristics of Mixing Efficiency in the Brazil Basin

*Takashi Ijichi[1], Louis St. Laurent[1], Kurt Polzin[1] (1.Woods Hole Oceanographic Institution)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS09-22] Instabilities of finite-amplitude internal wave beams

*Yohei Onuki[1], Yuki Tanaka[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS09-23] Evaluation of nutrient flux enhanced by double diffusion in the Kuroshio using glider measurements

*Keunjong Lee[1], Ryo Yamamoto[1], Ichiro Yasuda[1], Takahiro Tanaka[2] (1.Atmosphere and Ocean Research Institute, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency)

Searching 18.6 year tidal modulation impact in a global gridded ocean oxygen dataset with its improvements

*Shoshiro Minobe[1]

1. Earth and Planetary Sciences, Faculty of Science, Hokkaido University

The 18.6 year modulation of tidal mixing plays important roles in the ocean as reported by regional analyses by Osafune and Yasuda (2006, 2010) and others. In those studies, they found that ocean water properties including dissolved oxygen concentration vary at the 18.6 year period in a manner consistent with the vertical mixing changes due to the tidal mixing modulation. Dissolved oxygen concentration is interesting not only as a tracer but also because it is important in marine ecosystems. In particular, superposition of 18.6 year variability in addition to the oxygen decline trend known as the ocean deoxygenation due to the global warming can cause more serious damages for marine animals in the specific phase of tidal modulation.

The present study aims to understand the impacts of 18.6 year tidal mixing modulation in the ocean oxygen field more systematically than the previous studies did by analyzing a global gridded dataset of dissolved oxygen concentration. A preliminary analysis using the dataset used by Ito et al. (2017 GRL) for upper 1,000 m indicates that the 18.6 year variation of oxygen concentration also occurs in regions where previous studies did not reported tidal modulation influence, including a region near the Izu-Ogasawa Ridge. In order to obtain the better spatial and temporal coverage, the dataset is and will be improved with two steps. One is to expand its vertical coverage to the top 1,000 m to 6,000 m, and the other is to use the latest version of the World Ocean Database released in September 2018. The first step has been completed, and the second step is planned to be completed in this summer. At the presentation, the analysis results based on the latest gridded dataset will be shown.

Keywords: decadal variability, biogeochemistry, climate variability and change

©2019. Japan Geoscience Union. All Right Reserved.

Contribution of tidal energy dissipation to variations of transient climate response and steric sea level rise through ocean heat uptake

*Michio Watanabe[1], Hiroaki Tatebe[1], Tatsuo Suzuki[1], Kaoru Tachiiri[1]

1. Japan Agency for Marine-Earth Science and Technology

Micro-scale turbulent mixing due to tide-induced internal wave breaking is a key process to determine the strength and pattern of the global ocean overturning circulation, that redistributes the heat all over the world ocean. Heat redistribution in the ocean have a strong impact on ocean heat uptake (OHU), thus transient climate response (TCR) and steric sea level rise (SLR) under the global warming. To study the impact of the vertical diffusivity distribution on the TCR and steric SLR, we ran a climate model of which value of CO_2 concentration is increased by 1% yr^{-1} for 150 years, employing each of two vertical diffusivity distributions in the ocean, an empirical one-dimensional one (CTRL) and a three-dimensional one considering tidal energy dissipation (TED). In TED under the pre-industrial forcing, the larger sea ice in the Southern Ocean prevents the air-sea heat flux, leading to weaker bottom water formation and lower air temperature than in CTRL. The less effective heat transport to the deep layers in TED causes less OHU and larger TCR than in CTRL by about 0.16˚C. In addition, smaller ocean heat content change in TED than in CTRL leads to significant future sea-level depression of ~0.4 m in the Southern Ocean. Since OHU under the global warming is controlled by the distribution of vertical diffusivity, it is necessary to clarify its global distribution in the real ocean for reliable TCR estimation and future SLR projection.

Keywords: diapycnal diffusivity, transient climate response, sea level rise, global warming, climate model, ocean heat uptake

©2019. Japan Geoscience Union. All Right Reserved.

A Wave Resolving Simulation for Upper Ocean Turbulence Driven by Wave-Current Interaction

*Yutaka Yoshikawa[1], Yasushi Fujiwara[1], Yoshimasa Matsumura[2]

1. Graduate School of Science, Kyoto University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

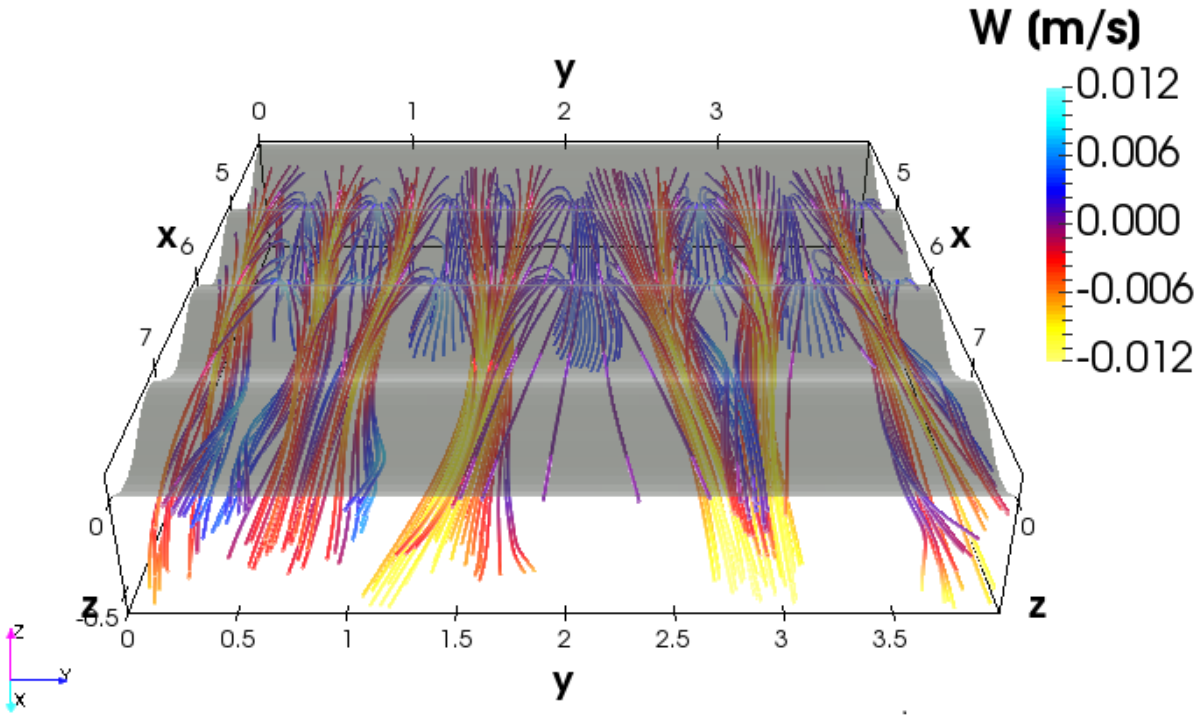
Turbulence in the upper ocean sets bulk properties of the upper ocean. For example, turbulence deepens the surface mixed layer (ML) and entrains low-temperature water below the layer to determine the ML depth and sea surface temperature (SST), which are key parameters for large-scale ocean and climate processes. Quantitative evaluation and parameterization of the upper ocean turbulence thus have crucial importance on the large-scale studies.

Recent studies revealed that turbulence induced by the surface wave has larger impact on the ML deepening than ever considered. Good example is drastic deepening of the ML and significant decrease in SST simulated in the summer Southern Ocean if parameterized wave-induced mixing is included in the simulation (e.g., Li et al. 2016). Among three types of wave-induced turbulence, surface wave breaking, Langmuir turbulence (LT) and nonbreaking-wave induced turbulence (NBWT), the latter two are considered to have significant impacts on the ML deepening. LT is associated with Langmuir circulations (LCs), the secondary circulations driven by the surface waves interacted with the wind-driven currents (e.g., Leibovich 1980). Previous theoretical studies (Craik and Leibovich 1976) showed that the interaction can be represented solely by the vortex force, vortex tilting by the Stokes drift (the Lagrangian velocity due to the surface wave) in the wave-filtered momentum equation. Many simulations with this vortex force representation have been performed so far (e.g., Skyllingstad and Denbo 1995). However, this theoretically-derived representation has not been validated by field or numerical experiments. As a consequence, there are controversial discussions about the validity of the representation and hence the simulation results with the representaion (e.g., Mellor 2016 and Ardhuin et al. 2017). NBWT on the other hand is suggested to be caused without winds (e.g., Qiao et al. 2004; Babanin 2006), but no detailed mechanism was proposed for the turbulence generation. As a result, some people consider that NBWT is the same as LT, even though LT is dependent on winds while NBWT is not. Thus, mechanism of the wave-induced turbulence is not clearly understood.

The present study is intended to clarify dynamics involved in the wave-induced turbulence. To this aim, we developed a new numerical model in which surface waves are explicity and accurately simulated. This wave-resolving simulation provides an unique opportunity to investigate how the surface waves drive / induce turbulence. We used this model to simulate LC at first (Fujiwara et al. 2018). A wave-tank simulation was performed in which a monochromatic surface wave propagated in the surface wind direction. We found that LCs were successfully reproduced through the wave-current interaction (see attached figure). Vorticity analysis showed that the interaction is well represented by the vortex force. We also performed the simulation without the surface wind, and found that NBWT was certainly generated. The virtual wave stress was found to be a key for NBWT generation in our simulation, which induced velocity shear near the surface that interacted with the surface wave as was found in the LC simulation. The wave-resolving simulation also provided an alternative Eulerian view of the vortex force that was originally viewed from the Lagrangian frame (Stokes drift), that is, rectified vortex tilting/shrinking/streatching by orbital motions of the surface waves.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Upper Ocean Turbulence, Surface Wave - Current Interaction, Langmuir Circulation, Non-Breaking Wave Turbulence



©2019. Japan Geoscience Union. All Right Reserved.

Revisiting the Characteristics of Mixing Efficiency in the Brazil Basin

*Takashi Ijichi[1], Louis St. Laurent[1], Kurt Polzin[1]

1. Woods Hole Oceanographic Institution

It is still controversial whether or not the dissipation flux coefficient Γ, often referred to as the “mixing efficiency”, is a global constant of 0.2. A primary justification for continuing to use this conventional value comes from a number of dedicated tracer-release/microstructure surveys done over the past three decades. Most notably, studies in the Brazil Basin have been the basis for examining the characteristics of mixing in the abyssal interior of the global ocean. Here, using recent microstructure data also collected in the Brazil Basin, we revisit the characteristics of Γ in the abyssal interior. It is shown that Γ, estimated from averaged profiles of the TKE dissipation rate and the thermal variance dissipation rate, actually lies around 0.2 in the pycnocline, but on the other hand, it tends to increase up to 0.4-0.8 toward the bottom. Such near-bottom high efficiency appears to be associated with weak stratification in the bottom water. Furthermore, one microstructure profile appears to reach down to within the thin bottom boundary layer: Γ abruptly decreases to $O(10^{-2})$ within 50 m above the bottom, which is reasonable given the no buoyancy flux condition at the bottom. We will also examine these results using the earlier generation microstructure datasets collected in the Brazil Basin.

©2019. Japan Geoscience Union. All Right Reserved.

Instabilities of finite-amplitude internal wave beams

*Yohei Onuki[1], Yuki Tanaka[2]

1. Research Institute for Applied Mechanics, Kyushu University, 2. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Previous studies have shown that instability of small-amplitude internal wave beams, generated by a surface tide flowing over topography, is most significant at a particular latitude where parametric subharmonic instability (PSI) excites inertial oscillations. Here we extend the discussion to the case of finite-amplitude beams using a new kind of Floquet approach. The disturbance growth rate obtained is quantified in terms of two non-dimensional parameters A and F: velocity shear divided by the buoyancy frequency and the Coriolis parameter divided by the beam frequency. If A is small, PSI is indeed the principle mode under the condition $F < 0.5$ with the maximum growth rate achieved when the equality holds. As A is increased, however, instability comes to occur even for $F > 0.5$ but the location of the maximum instability shifts towards lower F, thus totally changing its latitudinal dependence. The resulting energy spectrum is significantly Doppler shifted, and therefore distinguished from that made by PSI. These findings are useful to quantify the energy loss of internal wave beams that causes water mixing prevailing in the major generation sites of internal tides.

Keywords: internal wave, instability, ocean mixing

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of nutrient flux enhanced by double diffusion in the Kuroshio using glider measurements

*Keunjong Lee[1], Ryo Yamamoto[1], Ichiro Yasuda[1], Takahiro Tanaka[2]

1. Atmosphere and Ocean Research Institute, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency

Kuroshio is a very strong current, western boundary current of North Pacific subtropical current system. Strong vertical mixing intensifies through various physical processes were reported in the vicinity of the Kuroshio system. Consequently, this enhanced mixing is considered to supply the nutrients from the lower layer to the euphotic layer and improve the biological productivity.

Extensive measurements were carried out to investigate the detailed structures of turbulence, hydrography, chlorophyll-a using a glider, SeaExplorer manufactured by Alseamar whose 1st science mission, equipped with two shear probes, fast response thermistor, CTD, dissolved oxygen sensor, fluorometer. The fine measurement of 66 casts lasted for 7 days during 20-27, June 2017. Although only 30 % of data acquired by shear probe were survived under the criterion following Peterson et al., (2014), a newly developed method estimating turbulent intensity using a FP07 sensor was introduced.

While, calculated vertical nutrient flux is not quite high supporting biological productivity as we expected. Contribution of double diffusion which intensify the vertical diffusivity could be considered as development of chlorophyll-a patch at subsurface. Previous research already introduced the possibility of enhanced mixing from double diffusion (Nagai et al., 2015, Inoue et al., 2007) and Hamilton et al., (1989) showed underestimation of vertical nutrient flux without using vertical eddy diffusivity for salt in case of salt finger. Interacted with low salinity water which was occurred during our mission show another evidence for supporting this hypothesis.

Following the parameterization of McDougall and Ruddick (1992), mixing efficiency for salt finger and enhancement of salt(nutrient) flux were estimated to be somewhat effective. Parameterized nutrient flux in salt finger favorable layer is 37% larger than the turbulent nutrient flux accepting mixing efficiency 0.2 proposed by Osborn et al., (1980). This value needs to be examined through statistical approach or more careful insight and will be discussed later.
The full path of glider shows Kuroshio interact with various waters with different salinity and temperature. For example, low salinity and low temperature water intruded at subsurface during 23-24, June. Around 600 m during 26-27, June we also found salinity minimum which was assumed with North Pacific Intermediate Water. This feature reminds us considerable nutrient flux with vertical mixing by double diffusive processes in addition to mechanical turbulence. Double diffusive process might be attributed to the intrusion, development, modification of relatively low salinity waters. We found double diffusive regime occurs especially at upper boundary of relatively low salinity layer.

Keywords: Vertical mixing, Double diffusion, nutrient flux, Kuroshio

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

convener:Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Takafumi Hirata(Faculty of Environmental Earth Science, Hokkaido University), Enrique N Curchitser(Rutgers University New Brunswick), Eileen E Hofmann(Old Dominion University), Chairperson:Shin-Ichi Ito(The University of Tokyo)

The ocean accounts for about 50% of global net primary production. This production is significant for carbon cycling and ecosystem functioning, and is related directly or indirectly to a variety of climatic and ecological phenomena. The responses to natural and anthropogenic environmental stressors that influence marine production and diversity can cause perturbations to marine ecosystems that alter trophic dependencies and interactions among organisms at a range of space and time scales. Quantification of the principal mechanisms driving spatio-temporal variability of marine ecosystem remains to be done, especially in terms of evaluation of uncertainty in responses. As a result, evaluating vulnerability of marine ecosystems to environmental change requires systematic and holistic approaches that integrate physics to ecology and are based in observations and modelling. In addition, expectations to deliver these science to public society is raising. This session aims to provide a venue for not only discussing recent advances in understanding marine biogeochemical cycles, ecosystems and their interactions, but also networking with a variety of people to seed new ideas in marine ecological research. Observational, modeling and conceptual studies, including technological development and operational applications, that consider linkages among biogeochemical and ecosystem processes, biodiversity, and the effects of multiple stressors from molecular to planetary scales are encouraged.

9:00 AM - 9:10 AM JST | 12:00 AM - 12:10 AM UTC

Introduction

9:10 AM - 9:30 AM JST | 12:10 AM - 12:30 AM UTC

[AOS12-01] Projected coastal hypoxia in a coupled bio-physical model of the California Current System.

★Invited Papers

*Enrique N Curchitser[1], Raphael Dussin[1,2], Charles Stock[3], Nicoals van Oostende[4] (1.Rutgers University New Brunswick, 2.Lamont-Doherty Earth Observatory of Columbia University, 3.NOAA Geophysical Fluid Dynamics Laboratory, 4.Princeton University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS12-02] **Decadal salinity variation in the western North Pacific correlated with the strength of the Oyashio and the Kuroshio Extension**

*Hitoshi Kaneko[1], Takeshi Okunishi[2], Shinya Kouketsu[3], Sachihiko Itoh[1], Takashi Seto[4], Hiroshi Kuroda[5], Yugo Shimizu[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Japan Agency for Marine-Earth Science and Technology, 4.National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 5.Hokkaido National Fisheries Research Institute, Japan Fisheries Research and Education Agency)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS12-03] **Multiscale routes to supply nutrients through the Kuroshio nutrient stream**

*Takeyoshi Nagai[1], Sophie Clayton[2], Yusuke Uchiyama[3] (1.Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2.Ocean, Earth & Atmospheric Sciences, Old Dominion University, 3.Kobe University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS12-04] **Seasonal variability of upper-ocean primary production around the Kuroshio analyzed using a ROMS-NPZD model**

*Xu Zhang[1], Yusuke Uchiyama[1,2], Yota Suzue[3], Hidekatsu Yamazaki[4] (1.Kobe University, 2.Port and Airport Research Institute, 3.Construction Technique Institute Engineering Co., Ltd., 4.Tokyo University of Marine Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS12-05] Nutrient and light conditions at subsurface chlorophyll maximum: physical-biogeochemical observations along a mid-Pacific meridional transect

*Sachihiko Itoh[1], Hitoshi Kaneko[1], Shinya Kouketsu[2], Takeshi Okunishi[3], Hiroshi Ogawa[1], Mitsuhide Sato[4], Hiroaki Saito[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marin-Earth Science and Technology, 3.Tohoku National Fisheries Research Institute, Fisheries Research Agency, 4.The Hong Kong University of Science and Technology)

Projected coastal hypoxia in a coupled bio-physical model of the California Current System.

*Enrique N Curchitser[1], Raphael Dussin[1,2], Charles Stock[3], Nicoals van Oostende[4]

1. Rutgers University New Brunswick, 2. Lamont-Doherty Earth Observatory of Columbia University, 3. NOAA Geophysical Fluid Dynamics Laboratory, 4. Princeton University

Recent observations have shown an increase of the hypoxic area on the shelf in the California upwelling system. Climate projections suggest this increase would continue over the 21st century. However, the low-resolution ocean component of today' s climate models in this region are hampered by the flawed representation of upwelling and coastal processes.To achieve a more realistic solution, we ported the NOAA-GFDL biogeochemical model COBALT into the regional ocean model ROMS permitting a seamless representation of the biogeochemistry across scales. With the 7km California Current implementation, we carry out sensitivity experiments for the projected changes in biogeochemical and physical drivers of coastal hypoxia : oxygen and nutrients in source waters, solubility and upwelling-favorable wind. We describe here the results obtained and assess the relative impact of drivers of coastal hypoxia in this system.

©2019. Japan Geoscience Union. All Right Reserved.

Decadal salinity variation in the western North Pacific correlated with the strength of the Oyashio and the Kuroshio Extension

*Hitoshi Kaneko[1], Takeshi Okunishi[2], Shinya Kouketsu[3], Sachihiko Itoh[1], Takashi Seto[4], Hiroshi Kuroda[5], Yugo Shimizu[4]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Japan Agency for Marine-Earth Science and Technology, 4. National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 5. Hokkaido National Fisheries Research Institute, Japan Fisheries Research and Education Agency

Decadal changes in salinity around the density (~1026.8 kg m^{-3}) of North Pacific Intermediate Water (NPIW) were investigated in the regions from the Oyashio to the Kuroshio Extension (KE), called as the Mixed Water Region (MWR), based on the long-term-data-sets provided from numerical reanalysis. Based on the reanalysis data provided by an ocean forecast system of the Japan Fisheries Research and Education Agency (FRA-ROMS; 1992–2012, horizontal resolutions of 0.1˚), we found that during increase of the Oyashio velocity in the upstream region, negative salinity anomaly accompanied with the southward velocity at the density was enhanced between 144–145˚E just south of 40˚N. In addition, to examine influences from the downstream region of the Oyashio, we made a lag-correlation analysis focusing on the decadal variation of KE stability calculated from the zonal average (142–165˚E) of the meridional gradient of the sea surface height (34.5–37.0˚E) as the KE strength (KES). The result showed that signals of significant negative correlation appeared around the density from Hokkaido to the north region of KE. Through the composite analysis based on the KE stability, we found that the stable KE could also lead similar anomaly distribution around the north region of KE. We examined relationships between decadal tendency and each component of salinity fluxes at the density along the north-south boundary of the region of 38–40˚N, and 142–145˚E. Concerning estimation of the salinity fluxes, we employed time-mean components (S, V) and eddy components (s', v'), and then, we calculated products of them (Sv', $s'V$, $s'v'$). Decadal tendency of salinity (ds'/dt) was negatively correlated with the meridional difference of Sv' ($-0.5 < r < -0.47$, 95% confidence interval). Whereas Sv' at northern boundary was also negatively correlated with ds'/dt ($-0.45 < r < -0.42$), the correlation between ds'/dt and Sv' at southern boundary was small ($0.03 < r < 0.07$). The result suggested that the southward Oyashio would play an important role for decadal salinity variation in the MWR.

Keywords: North Pacific Intermediate Water , Decadal variation, Oyashio, Kuroshio Extension

©2019. Japan Geoscience Union. All Right Reserved.

Multiscale routes to supply nutrients through the Kuroshio nutrient stream

*Takeyoshi Nagai[1], Sophie Clayton[2], Yusuke Uchiyama[3]

1. Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2. Ocean, Earth & Atmospheric Sciences, Old Dominion University, 3. Kobe University

In this study, the role of the Kuroshio as a nutrient conduit is discussed using results from eddy-resolving, and nested high-resolution numerical simulations using Regional Oceanic Modeling System (ROMS) coupled with a N^2PZD^2 ecosystem model, and results from recent in-situ observations. The eddy-resolving simulation can reproduce the elevated nutrient concentrations along the Kuroshio compared to those in ambient waters of the same density, similar to the Gulf Stream. The nested simulations show that nutrients in the upstream Kuroshio can be supplied to euphotic zone by strong diapycnal mixing associated with the Kuroshio over topography. This large nutrient input is consistent with the very strong turbulent mixing observed directory in the upstream Kuroshio regions, where the Kuroshio flows over the seamounts and on the continental slope. The autonomous microstructure float observations also suggest that the large turbulent nitrate diffusive flux occurs in the Izu Ridge, along the Kuroshio. These diapycnal processes may explain why the basin scale nutrient elevation on the density surface along the Kuroshio path is maintained. During winter-spring, in the model downstream Kuroshio Extension, a large nitrate induction of O(10 mmol N m^2day^{-1}), comparable to or greater than wintertime diffusive nitrate flux, occurs through the inclined mixed layer base, which is strongly influenced by the mesoscale structures.

Keywords: Kuroshio, Nutrient stream, Nutrient flux

©2019. Japan Geoscience Union. All Right Reserved.

Seasonal variability of upper-ocean primary production around the Kuroshio analyzed using a ROMS-NPZD model

*Xu Zhang[1], Yusuke Uchiyama[1,2], Yota Suzue[3], Hidekatsu Yamazaki[4]

1. Kobe University, 2. Port and Airport Research Institute, 3. Construction Technique Institute Engineering Co., Ltd., 4. Tokyo University of Marine Science and Technology

Biological processes have significant influences on the global carbon cycle on all time scales. In the coastal regions, nutrient supply to the surface by river discharge and coastal upwelling leads to active primary production. The Kuroshio, one of the strongest western boundary currents, flows off the Japan, accompanied by intense eddy activities influencing on biogeochemical processes around its path. In general, localized upwelling due to mesoscale cyclonic eddies brings nutrient-rich subsurface water to the nutrient-depleted upper ocean to enhance near-surface primary productivity. In the present study, a climatological ocean modeling is developed for the marginal seas along the Kuroshio off Japan based on ROMS (Shchepetkin and McWilliams, 2005; 2008) coupled with an NPZD biogeochemical model (Fasham *et al.*, 1990; Gruber *et al.*, 2006). The model domain encompasses both the Kuroshio and its Extension regions in a submesoscale eddy-permitting configuration with a horizontal grid spacing of 3 km. The simulation is conducted for 10 years and the results for the 10th year are used for our analysis. A nitrogen budget analysis indicates that nitrogen exists mostly in the phyto- and zooplankton compartments in both the Kuroshio and Kuroshio Extension regions during the spring bloom. The increased zooplankton further enriches detritus that settles down by about 100 m, leading to an increase of ammonium below the mixed layer. In winter, eddy-induced nitrate transport is enhanced in the region about 1˚ away from the Kuroshio axis. The baroclinic instability due to the surface cooling in winter generates meso- and submesoscale eddies and substantially promotes eddy-induced vertical nitrate transport.

Keywords: Kuroshio, eddy-induced nitrate flux, submesoscale eddies, baroclinic instability

©2019. Japan Geoscience Union. All Right Reserved.

Nutrient and light conditions at subsurface chlorophyll maximum: physical-biogeochemical observations along a mid-Pacific meridional transect

*Sachihiko Itoh[1], Hitoshi Kaneko[1], Shinya Kouketsu[2], Takeshi Okunishi[3], Hiroshi Ogawa[1], Mitsuhide Sato[4], Hiroaki Saito[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Japan Agency for Marin-Earth Science and Technology, 3. Tohoku National Fisheries Research Institute, Fisheries Research Agency, 4. The Hong Kong University of Science and Technology

Subsurface chlorophyll maximum (SCM) occurs in a stratified water column that nutrient is depleted in the surface layer. When fully developed, such as those in calm subtropical regions, SCMs were often observed at depth where both nutrient and light availabilities are at a marginal level. Following resource competition theory, the low resource condition is likely generated by a group of phytoplankton with a low resource requirement, which expels other groups through decreasing nutrients and/or deepening the nutricline. Numerical models formulating the phytoplankton dependency on nutrients and light can reproduce some of characteristics of SCM including seasonal and geographical variability. However, comprehensive observations of the SCM and environmental conditions are still limited especially in the open ocean. In the present study, shipboard physical and biogeochemical observations were conducted along 170˚W from the South Pacific Subtropical Front up to Bering Sea during Boreal and Austral summers.

Characteristics of SCMs were estimated from multiple vertical profiles of chlorophyll fluorescence attached to a Conductivity Temperature Depth profiler (CTD), and nutrient concentrations were determined from water samples. Depths of profiles by sensors and water sample data were determined through projections onto potential density coordinate to eliminate effects of internal wave heaving, which are critical in analyzing processes around SCMs. To evaluate diffusive nutrient flux, vertical diffusivity was calculated using a microstructure profiler and multiplied by vertical gradient of nutrient concentrations. Vertical profiles of photosynthetically available radiation (PAR) were estimated using surface PAR from Moderate Resolution Imaging Spectroradiometer (MODIS), averaged over two weeks until shipboard observation, and diffuse attenuation coefficients of downwelling irradiance calculated from *in situ* PAR measurements.

In subtropical regions from 40˚S to 30˚N, except for that at the equator, SCMs were found in 80–150 m, around or slightly deeper than 1% light level relative to the surface. Depth of SCM was deepest in the middle of subtropical gyres, no shallower than 100 m in 15–25˚. Although considerably shallower than subtropical regions, SCMs were also observed at the equator and temperate and subpolar regions in the range of 15–40 m. There are significant positive correlations between the depths of SCM and 1% light level, where SCM depth was generally deeper than the 1% light level in the subtropical regions. However, PAR at SCMs was not uniform but ranged from 0.1–0.7 mol photon m^{-2} day^{-1} within the subtropical regions, and shows a negative correlation with the SCM depth. The SCM depth also shows a strong positive correlation with the depth of maximum subsurface nitrate flux. Considering effects of pure external factors that are not affected by phytoplankton to the SCM depth, we found a positive relationship with absolute dynamic topography indicating the depth of pycnocline.

©2019. Japan Geoscience Union. All Right Reserved.

Although 1% light levels can indicate the SCM depth through the linear correlation for the wide geographical range in the mid-Pacific, it is not concluded that SCM was formed under the limitation of light alone. This is followed by a fact that PAR at the 1% levels is not uniform but depends on the surface PAR, by which the relationship between PAR values at SCMs and depths of SCMs become insignificant. As deep penetration of light is caused by the low productivity in the surface water, we cannot simply consider cause and effect for the above relationship. On the other hand, as the dynamic topography is not affected by phytoplankton, its relationship between the SCM depth suggests that the large-scale hydrographic structure has some influences on the formation of SCMs. In the presentation, we will further discuss the details of the physical processes and their possible impacts on subsurface phytoplankton production.

Keywords: Subsurface chlorophyll maximum, Diffusive nutrient flux, colimitation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

convener:Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Takafumi Hirata(Faculty of Environmental Earth Science, Hokkaido University), Enrique N Curchitser(Rutgers University New Brunswick), Eileen E Hofmann(Old Dominion University), Chairperson:Yoshimasa Matsumura(Atmosphere and Ocean Research Institute, The University of Tokyo)

The ocean accounts for about 50% of global net primary production. This production is significant for carbon cycling and ecosystem functioning, and is related directly or indirectly to a variety of climatic and ecological phenomena. The responses to natural and anthropogenic environmental stressors that influence marine production and diversity can cause perturbations to marine ecosystems that alter trophic dependencies and interactions among organisms at a range of space and time scales. Quantification of the principal mechanisms driving spatio-temporal variability of marine ecosystem remains to be done, especially in terms of evaluation of uncertainty in responses. As a result, evaluating vulnerability of marine ecosystems to environmental change requires systematic and holistic approaches that integrate physics to ecology and are based in observations and modelling. In addition, expectations to deliver these science to public society is raising. This session aims to provide a venue for not only discussing recent advances in understanding marine biogeochemical cycles, ecosystems and their interactions, but also networking with a variety of people to seed new ideas in marine ecological research. Observational, modeling and conceptual studies, including technological development and operational applications, that consider linkages among biogeochemical and ecosystem processes, biodiversity, and the effects of multiple stressors from molecular to planetary scales are encouraged.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[AOS12-06] A Lagrangian view of spring phytoplankton blooms

★Invited Papers

*Shinichiro Kida[1], Taka Ito[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Georgia Institute of Technology)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AOS12-07] Significance of acclimation process in simulating chlorophyll distribution in the Arctic Ocean

*Yoshio Masuda[1], Yasuhiro Yamanaka[1], Takafumi Hirata[1], Hideyuki Nakano[2] (1.Graduate School of Environmental Earth Science, Hokkaido University, 2.Meteorological Research Institute)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[AOS12-08] Responses of lower-trophic level ecosystem to nutrient variation in the central part of the Seto Inland Sea

*Naoki Yoshie[1], Hayato Mizuguchi[1], Xinyu Guo[1], Michio Yoneda[2], Katsuyuki Abo[2], Tomoaki Kono[2], Tatsunori Fujita[3] (1.Center for Marine Environmental Studies, Ehime University, 2.Japan Fisheries Research and Education Agency, 3.Kagawa Prefectural Fisheries Research Center)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[AOS12-09] Effects of the temperature and fish size on metabolism and swimming performance of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

*Chenying Guo[1], Shin-ichi Ito[1], Michio Yoneda[2], Hajime Kitano[2] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Fisheries Research and Education Agency Japan)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[AOS12-10] Sensitivity analyses of growth and migration of Japanese anchovy (*Engraulis japonicus*) in the East China Sea using a fish growth-migration model.

*Shin-ichi Ito[1], Takashi Setou[2], Michio Yoneda[2], Motomitsu Takahashi[2], Michiya Matsuyama[3], Chenying Guo[1], Takashi Kitagawa[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Fisheries Research and Education Agency Japan, 3.Kyushu University)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

Discussion

A Lagrangian view of spring phytoplankton blooms

*Shinichiro Kida[1], Taka Ito[2]

1. Research Institute for Applied Mechanics, Kyushu University, 2. Georgia Institute of Technology

The basic mechanism behind spring phytoplankton blooms is investigated using a 1-dimensional Lagrangian NPZD model, where the movement and transfers of nutrient parcels are solved by tracking a nitrogen parcel. The Lagrangian framework is useful for understanding how the nitrogen cycle works in the ocean since it naturally follows the movement of materials through the turbulent ocean environment. The model reveals that the onset of spring blooms depends on the cumulative euphotic age, which is the total time that inorganic nutrient is exposed to light before the photosynthetic conversion to phytoplankton biomass. This is regardless of the underlying mechanism, such as critical depth hypothesis or critical turbulence hypothesis. The difference between the two modes lies in how cumulative euphotic age is accumulated and this can be distinguished by examining the cumulative euphotic age spectrum. We further examined the impact of mortality by comparing the model experiments with and without mortality. The cumulative euphotic age necessary for a spring bloom is found to increase, as expected, but the spectral shapes remained similar.

Keywords: Spring Bloom, Lagrangian model

©2019. Japan Geoscience Union. All Right Reserved.

Significance of acclimation process in simulating chlorophyll distribution in the Arctic Ocean

*Yoshio Masuda[1], Yasuhiro Yamanaka[1], Takafumi Hirata[1], Hideyuki Nakano[2]

1. Graduate School of Environmental Earth Science, Hokkaido University, 2. Meteorological Research Institute

Recently, our team has developed a new oceanic ecosystem model (FlexPFT-3D) based on a novel theory for phytoplankton physiology (Smith et al. 2015). Different from our previous models (NEMURO, MEM), the model represents phytoplankton acclimation processes in which phytoplankton change their stoichiometry (nitrogen:carbon:chlorophyll:iron) according to the change of a surrounding environment. A clear improvement was found in chlorophyll distributions in oceanic interior and the Arctic Ocean. Arctic chlorophyll concentration in the new model is comparable to the observation, while it is underestimated in the previous models. In the Arctic Ocean, significant seasonal environmental change exists especially in a light condition. The new model can represent increase in the rate of chlorophyll to carbon biomass in the summer and resulting increase in the phytoplankton specific growth rate; those contribute to the improvement in simulating Arctic chlorophyll concentration.

Keywords: Phytoplankton, Ecosystem model, FlexPFT

©2019. Japan Geoscience Union. All Right Reserved.

Responses of lower-trophic level ecosystem to nutrient variation in the central part of the Seto Inland Sea

*Naoki Yoshie[1], Hayato Mizuguchi[1], Xinyu Guo[1], Michio Yoneda[2], Katsuyuki Abo[2], Tomoaki Kono[2], Tatsunori Fujita[3]

1. Center for Marine Environmental Studies, Ehime University, 2. Japan Fisheries Research and Education Agency, 3. Kagawa Prefectural Fisheries Research Center

The Seto Inland Sea is a representative coastal sea in Japan, and various environmental problems such as harmful algae bloom and hypoxia associated with the eutrophication have occurred during 50 years. The nutrient supplies from the terrestrial region related to the human activity have been reduced through the efforts for environmental cleanup over the last several decades. As a result of such excessive environmental cleanup, oligotrophic condition frequently occurred in this region in recent years. The relationships among oligotrophication, primary productivity, and fishery resources such as anchovy in this region are not clear. In this study, we investigated the responses of the lower-trophic level ecosystem in the central Seto Inland Sea to the nutrient variations using a plankton functional types model eNEMURO (4N-4P-4Z-3D). We used two different nutrient conditions for the model based on the time series observations, one was in 2005 with the good catch of anchovy larvae, and another was in 2011 with the poor catch of them. The model results showed that the spring diatom bloom in 2011 was much lower than those in 2005 due to the low nutrient concentrations in the spring of 2011. The meso-zooplankton biomass in the spring of 2011 was also lower than those in 2005 associated with the reduced spring diatom bloom in 2011. We summarized that the interannual variation of nutrient concentrations in the spring may control the interannual variation of anchovy stocks by regulating the scale of the spring diatom bloom in this region.

Keywords: ecosystem model, nutrient, diatom, meso-zooplankton, anchovy

©2019. Japan Geoscience Union. All Right Reserved.

Effects of the temperature and fish size on metabolism and swimming performance of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

*Chenying Guo[1], Shin-ichi Ito[1], Michio Yoneda[2], Hajime Kitano[2]

1. Atmosphere and Ocean Research Institute, the University of Tokyo, 2. Fisheries Research and Education Agency Japan

Pacific chub mackerel (*Scomber japonicus*) is a small pelagic and important commercial fish species widely distributed throughout the coastal areas of the Northwestern, Northeastern, and Southeastern Pacific. Swimming energetic and metabolic data of Northwestern stock at two growth stage (young juvenile of 6.1±0.3 cm and immature of 16.5±1.4 cm fork length) were measured under various temperature (18˚C and 24˚C for young juvenile, 14˚C and 18˚C for immature) using a variable-speed swim-tunnel respirometer, and the new data were compared with the previous data from Northeastern Pacific stocks. For young juveniles, the maximum sustainable swimming speeds (U_{max}) was 50.0±6.5 cm s^{-1} at 24˚C, significantly higher than at 18˚C of 30.7±2.5 cm s^{-1}. For the immature individuals, U_{max} showed no significant increase while temperature changed from 14 to 18˚C, and did not vary significantly from Northeastern Pacific individuals within the same size range. At a given temperature of 18˚C, U_{max} of immatures was significantly higher than those of young juveniles. For all individuals, the mass-specific oxygen consumption rate (V_{O2}) increased exponentially with swimming speed (U, in cm s^{-1}). At a given speed, V_{O2} increased with temperature; at a given temperature of 18˚C, V_{O2} of immature individuals were lower than those of young juveniles. These effects of the temperature and fish size on V_{O2} were consistent with previous studies of chub mackerel of Northeastern stocks, however, compared with Northeastern stocks within the same size range, V_{O2} of Northwestern individuals acclimated to 14˚C did not vary at a given speed, while those acclimated to 18˚C showed higher V_{O2} , indicating the Northwestern stock was more sensitive for temperature on metabolism.

Keywords: Pacific chub mackerel, Scomber japonicus, swimming speed, metabolism, respirometer

©2019. Japan Geoscience Union. All Right Reserved.

Sensitivity analyses of growth and migration of Japanese anchovy (*Engraulis japonicus*) in the East China Sea using a fish growth-migration model.

*Shin-ichi Ito[1], Takashi Setou[2], Michio Yoneda[2], Motomitsu Takahashi[2], Michiya Matsuyama[3], Chenying Guo[1], Takashi Kitagawa[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Fisheries Research and Education Agency Japan, 3. Kyushu University

Japanese anchovy (Engraulis japonicus) is an important species not only as an exploited species but also as prey for variety of predators including marine mammals, tunas, mackerels, flounders, etc. However, the biomass of Japanese anchovy have shown large fluctuation and is one of the main actors of the fish species alternation responding to basin scale climate variabilities. From the stock management views, three sub-populations are defined in Japan: Pacific stock, Tsushima stock (also called the East China Sea stock), and Seto-inland Sea stock. There is evidence (different weights-at-age and longevity) of three sub-populations of anchovy within the Japan system. While he three sub-populations of anchovy share their spawning grounds, the migration route and nursery grounds are divided. In addition, while Seto-inland Sea sub-populations do not show a large migration, Pacific and Tsushima sub-populations make long distance ontogenetic migrations, On the contrary, there is no evidence of a similar migration of juvenile anchovies in the California Current system. Therefore, we are focusing on the movement (advection and migration) routes of eggs, larvae, and juveniles from the spawning grounds to the adult grounds. We developed a fish-migration and growth model using environmental conditions derived from simulations of a coupled ocean circulation and ecosystem model. For the ocean circulation model, a high resolution (1/10 deg.) FRA-ROMS (Fisheries Research Agency - Regional Ocean Modeling System) was used. For the marine ecosystem model, eNEMURO, an extended version of NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography) was used. The larvae transported to southern part of Kyushu Island in Japan (current main fisheries ground for anchovy larvae) were reasonably reproduced in the model. The sensitivity analyses of swimming efficiency will be conducted respect to the migration route of anchovy.

Keywords: marine ecosystem model, fish growth-migration model, Japanese anchovy

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

convener:Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Takafumi Hirata(Faculty of Environmental Earth Science, Hokkaido University), Enrique N Curchitser(Rutgers University New Brunswick), Eileen E Hofmann(Old Dominion University), Chairperson:Enrique Curchitser(Rutgers University)

The ocean accounts for about 50% of global net primary production. This production is significant for carbon cycling and ecosystem functioning, and is related directly or indirectly to a variety of climatic and ecological phenomena. The responses to natural and anthropogenic environmental stressors that influence marine production and diversity can cause perturbations to marine ecosystems that alter trophic dependencies and interactions among organisms at a range of space and time scales. Quantification of the principal mechanisms driving spatio-temporal variability of marine ecosystem remains to be done, especially in terms of evaluation of uncertainty in responses. As a result, evaluating vulnerability of marine ecosystems to environmental change requires systematic and holistic approaches that integrate physics to ecology and are based in observations and modelling. In addition, expectations to deliver these science to public society is raising. This session aims to provide a venue for not only discussing recent advances in understanding marine biogeochemical cycles, ecosystems and their interactions, but also networking with a variety of people to seed new ideas in marine ecological research. Observational, modeling and conceptual studies, including technological development and operational applications, that consider linkages among biogeochemical and ecosystem processes, biodiversity, and the effects of multiple stressors from molecular to planetary scales are encouraged.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[AOS12-11] Micro-scale patchiness enhances trophic transfer efficiency and potential plankton biodiversity

★Invited Papers

*Hidekatsu Yamazaki[1], Anupam Priyadarshi[2], Lan Smith[3], Sandip Mandal[4], Mamoru Tanaka[1] (1.Tokyo University of Marine Science and Technology, 2.Banaras Hindu University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Public Health Foundation of India)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[AOS12-12] Long term observations of marine snow, using cabled observatory system

*Marika Takeuchi[1,2], Mark Doubell[3], Jim Mitchell[2], Hidekatsu Yamazaki[1] (1.Tokyo University of Marine Science and Technology, 2.Flinders University, 3.South Australia Research and Development Institute)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[AOS12-13] An insight into the area characteristic of seasonal change in nitrogen isotope ratio based on a marine nitrogen isotope model

*Chisato Yoshikawa[1], Masahito Shigemitsu[1], Akitomo Yamamoto[1], Akira Oka[2], Naohiko Ohkouchi[1] (1.JAMSTEC, 2.AORI)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[AOS12-14] Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain

*S. Lan Smith[1], Yoshikazu Sasai[1], Chisato Yoshikawa[2] (1.Marine Ecosystem Dynamics Research Group, RCGC, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan, 2.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[AOS12-15] Discussions

Shin-ichi Ito[2], *Takafumi Hirata[1] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

Discussion

Micro-scale patchiness enhances trophic transfer efficiency and potential plankton biodiversity

*Hidekatsu Yamazaki[1], Anupam Priyadarshi[2], Lan Smith[3], Sandip Mandal[4], Mamoru Tanaka[1]

1. Tokyo University of Marine Science and Technology, 2. Banaras Hindu University, 3. Japan Agency for Marine-Earth Science and Technology, 4. Public Health Foundation of India

Recent observations have revealed ubiquitous intermittency in phytoplankton distributions at the micro (mm) scale, and a few recent modelling studies have suggested that this micro-scale variability impacts plankton ecosystem dynamics and biodiversity. Modelling is an essential tool for studying complex food webs, by linking the observed ecological patterns with experimental findings to understand mechanisms and make future predictions. However, so far almost all ecosystem models have been developed based on the mean-field approach, i.e. assuming well mixed environmental conditions within each discretely resolved grid cell. Although this is reasonable for examining patterns at the meso- (km) to global scales, it is not realistic for plankton, which experience micro-scale variability in aquatic environments where predator-prey overlap can substantially enhance trophic transfer. Similar to a recent study that addressed variability at the scale of ocean fronts, we have recently used Reynolds decomposition and truncated Taylor series to develop ‘moment closure’ models accounting for micro-scale variability in the distributions of Nutrients and Phytoplankton (NP closure model), and also Zooplankton (NPZ closure model). Compared to conventional ecosystem models based on the mean-field approach, these closure models yield qualitatively different dynamics.

Using a generalized plankton ecosystem modelling framework, including models of differing trophic complexity and with different grazing functional responses, we investigate how micro-scale variability affects plankton biodiversity and ecosystem function. Specifically, we apply the closure modelling approach to test the functional forms often assumed in ecosystem models against observed micro-scale intermittency as quantified by the coefficient of variation (CV) (ratio of standard deviation to mean) of micro-scale fluorescence field, which is a proxy for phytoplankton biomass. With both saturating and non-saturating grazing functions and in all model configurations considered, we find that micro-scale variability consistently supports the highest trophic level present, i.e. enhances Tansfer Efficiency, and expands the model stability domain, potentially sustaining biodiversity by allowing species with a wider range of trait values to coexist. Based on our observations and model results we hypothesise a novel answer to the “paradox of the plankton” (Hutchinson, 1961) for such calm, low-nutrient oceanic environments: Heretofore under-appreciated high levels of micro-scale variability may explain the great diversity of plankton present in these vast low-nutrient regions of the ocean.

Keywords: plankton, turbulence, microstructures, ecosystem models

©2019. Japan Geoscience Union. All Right Reserved.

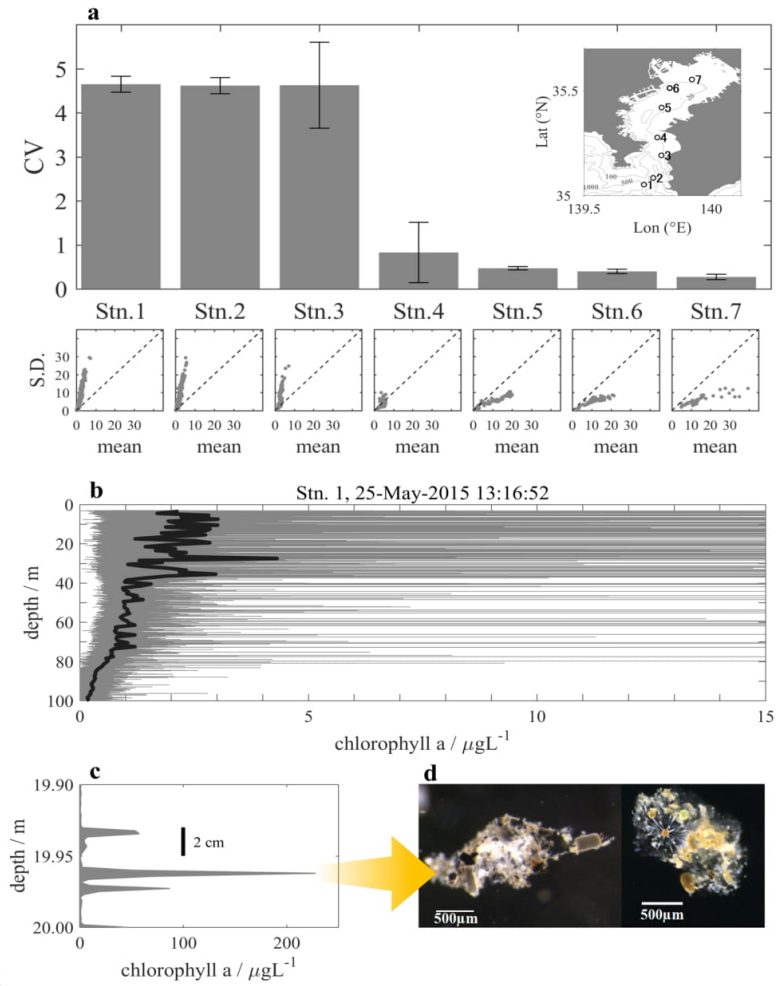


Figure: (a) Observation stations (open, numbered circles) in Tokyo bay, *CV* estimates (bar heights, with error bars indicating 99% confidence intervals) and corresponding scatter plots of observed standard deviation vs. mean of fluorescence data from each station (dotted lines showing one-to-one relationships). (b) Raw data (thin grey lines) and 1 m average values (thick black lines) from a vertical fluorescence profile acquired at stn. 1 by the laser sensor, which was calibrated with *in situ* water samples to obtain values in g chl L^{-1}. (c) A subset of peaks from the same profile around 20 m depth. Vertical thick black bar indicates a scale bar of 2 cm height. (d) Images of typical aggregates.

©2019. Japan Geoscience Union. All Right Reserved.

Long term observations of marine snow, using cabled observatory system

*Marika Takeuchi[1,2], Mark Doubell[3], Jim Mitchell[2], Hidekatsu Yamazaki[1]

1. Tokyo University of Marine Science and Technology, 2. Flinders University, 3. South Australia Research and Development Institute

Marine aggregates are formed through coagulation of small biogenic and non-biogenic components. Visible ones, known as marine snow, are typically larger than 0.5mm. Aggregates are well recognised as hotspots of microbial and planktonic activities. Aggregates formation is an important pathway for transferring organic matter from surface to deep ocean, hence the impatcs of aggregates in carbon flux is significant. However, field observations of aggregates have been challenging and not many long-term observational results have been reported.
In this study, we analysed in-situ observations of aggregates using a high-resolution plankton camera mounted on cabled observatory OCEANS. OCEANS has been continuously collecting hydrographic data and images of aggregates simultaneously since 2014. Here we will present a few months of in-situ observations results to show aggregates size and population change over time. Turbulence and other plankton distributions are compared to aggregates.

Keywords: Marine snow, Turbulence, Size distribution

©2019. Japan Geoscience Union. All Right Reserved.

An insight into the area characteristic of seasonal change in nitrogen isotope ratio based on a marine nitrogen isotope model

*Chisato Yoshikawa[1], Masahito Shigemitsu[1], Akitomo Yamamoto[1], Akira Oka[2], Naohiko Ohkouchi[1]

1. JAMSTEC, 2. AORI

The condition of nitrogenous nutrient in the surface water is an important factor that determines the primary production and the carbon cycle in the ocean. Nitrogen isotope ratios ($\delta^{15}N$) of nitrate, sinking particles, sediments have been widely used as a proxy for the condition of nitrogenous nutrient in the surface water. However, the interpretation of $\delta^{15}N$ values are not simple. The $\delta^{15}N$ value of surface primary producer records $\delta^{15}N$ value of nitrate supplied to the euphotic layer, nitrate utilization efficiency and rate of N_2 fixation. As there are multiple possibilities for the interpretation, $\delta^{15}N$ values should be interpreted with ample consideration of the characteristics of surface nitrogen cycle by region. In this study we show the area characteristic of seasonal change in $\delta^{15}N$ value by using a global ocean nitrogen isotope model in order to improve the interpretation of observed $\delta^{15}N$ values. We installed a marine nitrogen isotope model (Yoshikawa et al., 2005) with denitrification (Shigemitsu et al., 2016) and N_2 fixation (Coles et al., 2007) schemes into an off-line biogeochemical model that is driven by climatological monthly mean physical fields obtained from the outputs of a preindustrial control simulation performed with MIROC 3.2 (K-1 Model Developers, 2004). The simulated $\delta^{15}N$ of sinking particles had a global distribution similar to the observed $\delta^{15}N$ of surface sediments (Tesdal et al., 2013). The simulated sinking particles were enriched in ^{15}N in the eastern and western tropical North Pacific and the Indian Ocean where water column denitrification occurs and were depleted in ^{15}N in the Sargasso Sea, the Kuroshio extension region, and the Indian Ocean where N_2 fixation occurs. The seasonal variations in $\delta^{15}N$ of sinking particles vary considerably from one region to another. In this talk, we will report the seasonal $\delta^{15}N$ patterns categorized by region and the factors in the determination of those seasonal patterns.

Keywords: Marine nitrogen cycle, Nitrogen isotope ratio, Marine ecosystem model

©2019. Japan Geoscience Union. All Right Reserved.

Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain

*S. Lan Smith[1], Yoshikazu Sasai[1], Chisato Yoshikawa[2]

1. Marine Ecosystem Dynamics Research Group, RCGC, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan, 2. Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan

The stable isotope ^{15}N is widely used an indicator of trophic level, and has been incorporated into ecosystem models in order to understand nitrogen cycling and trophic transfer. However, such studies typically consider only the average enrichment per trophic level. We present a recently developed model of the dynamic fractionation of the stable isotope ^{15}N in lower-trophic ecosystems of the North Pacific. The model accounts for the dynamics of trophic transfer from nutrients (nitrate and ammonium) to phytoplankton, and to two idealized zooplankton compartments representing herbivores and carnivores, respectively. The $d^{15}N$ signal of herbivores tracks that of phytoplankton, with a nearly constant offset, i.e., enrichment by a nearly constant factor. However, the modeled $d^{15}N$ difference between carnivores and herbivores varies seasonally, and depends on the mortality rate (turnover time or effective lifespan) of the carnivores. Seasonal variations of modeled $d^{15}N$ signals differ with trophic level because carnivores integrate the signal from their ^{15}N uptake over longer timescales compared to herbivores. Thus, the model reproduces the lower observed variability of $d^{15}N$ for carnivorous zooplankton (chaetognaths) and the more variable $d^{15}N$ for largely herbivorous zooplankton (copepods). Our results imply that for interpreting observed $d^{15}N$ values, it is important to consider not only the average enrichment per trophic level, but also the dynamics of ^{15}N fractionation and the timing of observations, e.g. to avoid unrealistic estimates of trophic linkages based on seasonally biased observations.

Keywords: nutrients, predation, zooplankton, production, transfer efficiency

©2019. Japan Geoscience Union. All Right Reserved.

Discussions

Shin-ichi Ito[2], *Takafumi Hirata[1]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

Discussions

Keywords: Marine Ecosystems, Biogeochemistry

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 104 1F

[A-CG33] Extratropical oceans and atmosphere

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Yoshi N Sasaki(Hokkaido University), Hatsumi Nishikawa(Institute of Low Temperature Science, Hokkaido University), Shun Ohishi(Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Kazuaki Nishii(三重大学)

The extratopical ocean had been considered passive to atmospheric variability. Recent studies, however, revealed some active role of the extratopical ocean in modulating the atmosphere. The goal of this session is to deepen our understanding of the air-sea interaction in the extratropics. A wide variety of researches whose topics range from mesoscale to basin-scale, and from daily to global warming are welcomed. Researches on cloud, aerosol, and ecosystem related to the extratopical air-sea interaction are also welcomed.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[ACG33-01] Gulf Stream and Kuroshio are synchronized

★Invited Papers

*Tsubasa Kohyama[1], Hiroaki Miura[1], Shoichiro Kido[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[ACG33-02] A study on mixed layer depth variability in the Kuroshio Extension region based on a frontal Ekman model

*Tomoki Tozuka[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[ACG33-03] Mechanisms of Reemergence in the North Pacific revealed by Mixed Layer Heat Budget Analysis

*Kazumichi Murata[1], Shoichiro Kido[1], Tomoki Tozuka[1] (1.Department of Earth and Planetary Science, School of Science, The University of Tokyo)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[ACG33-04] Formation mechanism for the North Pacific Transition domain SST and SSS fronts

*Hatsumi Nishikawa[1], Humio Mitsudera[1], Takeshi Okunishi[2], Shin-ichi Ito[3], Taku Wagawa[4], Daisuke Hasegawa[2], Toru Miyama[5], Hitoshi Kaneko[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5.Japan Agency for Marine-Earth Science and Technology)

2:50 PM - 3:10 PM JST | 5:50 AM - 6:10 AM UTC

[ACG33-05] Impact of the Kuroshio front on frontal structure of an extratropical cyclone associated with heavy precipitation

★Invited Papers

*Hidetaka Hirata[1], Ryuichi Kawamura[2], Mayumi K Yoshioka[1], Masami Nonaka[3], Kazuhisa Tsuboki[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Department of Earth and Planetary Sciences, Kyushu University, 3.Application Laboratory, Japan Agency for Marine-Earth Science and Technology)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

[ACG33-06] Discussion on future studies on the role of midlatitude oceans

*Kazuaki Nishii[1] (1.Graduate School of Bioresources, Mie University)

Gulf Stream and Kuroshio are synchronized

*Tsubasa Kohyama[1], Hiroaki Miura[1], Shoichiro Kido[1]

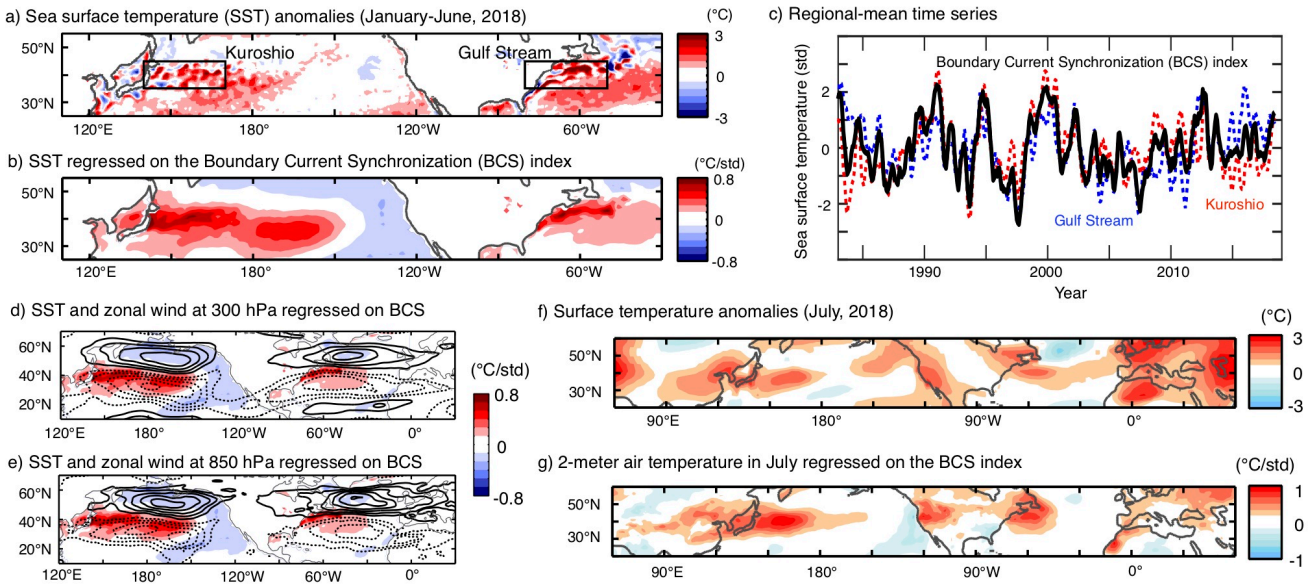
1. Department of Earth and Planetary Science, The University of Tokyo

The Gulf Stream and the Kuroshio transport heat from the tropics to the extratropics, and their temperature variations affect densely-populated areas in the northern hemisphere through extreme weather and fisheries production. The two warm ocean currents are separated by the North American continent, and thus, they cannot exchange heat by the oceanic circulation within a few years.

In this presentation, however, we show that sea surface temperatures (SST) of the two warm currents are synchronized for interannual to decadal time scales. This synchronization, which we refer to as the Boundary Current Synchronization (BCS), is associated with the meridional migrations of the atmospheric jet stream. The singular value decomposition (SVD) analysis between SST and zonal wind shows that, from the conventional viewpoint, BCS is explained as the covariability shared by the Pacific Decadal Oscillation and the Northern Annular Mode. Nevertheless, the SVD time series exhibit high correlations with the zonal-mean meridional SST difference between subtropics and midlatitudes, which supports the notion that BCS may be understood better as the annular mode of the upper ocean.

We also discuss some implications for extreme weather and climate change. The regression map of 2-meter temperature on the BCS index exhibits a similar pattern to the temperature pattern in July 2018, which implies an essential relationship between BCS and the abnormally hot summer. BCS also connects two apparently unrelated global warming responses: the western boundary currents warm faster than the global mean, and that the atmospheric jet stream shifts poleward.

Keywords: Atmosphere-Ocean interactions, Kuroshio, Gulf Stream, Atmospheric jet stream



©2019. Japan Geoscience Union. All Right Reserved.

A study on mixed layer depth variability in the Kuroshio Extension region based on a frontal Ekman model

*Tomoki Tozuka[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

In oceanic frontal regions, surface geostrophic currents have a vertical shear aligned with the density front that can balance a portion of the surface wind stress, and only the portion of the wind stress that is not in balance with the surface geostrophic shear (i.e. "effective wind stress") forces an ageostrophic Ekman spiral. Thus, if the front were uniform with depth, it is expected that the vertical velocity at tthe mixed layer base is better represented by the curl of the effective wind stress, rather than the full wind stress. In this study, we have examined the above in the Kuroshio Extension region, where a prominent sea surface temperature front exists, and some preliminary results based on an analysis of a high-resolution ocean assimilation product are presented.

Keywords: Mixed layer depth, Frontal Ekman model, Ekman pumping, Kuroshio Extension

©2019. Japan Geoscience Union. All Right Reserved.

Mechanisms of Reemergence in the North Pacific revealed by Mixed Layer Heat Budget Analysis

*Kazumichi Murata[1], Shoichiro Kido[1], Tomoki Tozuka[1]

1. Department of Earth and Planetary Science, School of Science, The University of Tokyo

Wintertime sea surface temperature (SST) anomalies that disappear in summer and recur in the following winter is called “reemergence”. Previous studies suggested that temperature anomalies that subduct into the subsurface during the shoaling phase of the mixed layer are preserved under the mixed layer due to isolation from atmospheric forcing and reentrained into the surface mixed layer. Since reemergence is considered to play an important role in the Pacific Decadal Oscillation, it is important to understand its mechanisms, but past studies are mostly based on statistical analyses. Therefore, in this thesis, the mechanisms of reemergence in the North Pacific is clarified quantitatively by an online mixed layer heat budget analysis with an ocean model simulation.

Following a method proposed by a previous study, areas with reemergence are detected and the focus of this study is the Reemergence Area (RA, 35˚-40˚N, 155˚-145˚W) in the central North Pacific. In the RA, the Reemergence Years (RYs) are determined and the mixed layer heat budget analysis is conducted with the integration of the Regional Ocean Model System (ROMS) covering the RA. In contrast to past studies that suggested importance of anomalous entrainment term, it is shown that several mechanisms are operating in reemergence. In particular, the anomalous Ekman meridional advection of the mean meridional temperature gradient induced by zonal wind stress anomalies plays an important role in many RYs. Also, coincidence in the sign of SST anomalies in winter and surface heat flux anomalies in the following autumn leads to recurrence of SST anomalies in some RYs. On the other hand, the conventional

©2019. Japan Geoscience Union. All Right Reserved.

mechanism related to the mean entrainment of anomalous temperature contributes to reemergence in two RYs.

Keywords: Reemergence, North Pacific, mixed layer heat budget analysis

©2019. Japan Geoscience Union. All Right Reserved.

Formation mechanism for the North Pacific Transition domain SST and SSS fronts

*Hatsumi Nishikawa[1], Humio Mitsudera[1], Takeshi Okunishi[2], Shin-ichi Ito[3], Taku Wagawa[4], Daisuke Hasegawa[2], Toru Miyama[5], Hitoshi Kaneko[2]

1. Institute of Low Temperature Science, Hokkaido University, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5. Japan Agency for Marine-Earth Science and Technology

The North Pacific Transition Domain is the area where water exchange between subtropical and subarctic is carried out and there are SST and SSS fronts. The Transition domain is very important area for air-sea interaction, ocean mixed layer formation, biological production, and so on. In this study, to clarify SST and SSS fronts structure and its formation mechanism in the transition domain, we analyzed the data of drifting buoys observation in 2015 and 2017 and modelled particles trajectory.

The buoy trajectories and the modelled trajectories captured the flow structure (i.e. front structure) in detail. They suggest that the flow structure in the transition domain is dominated by low rise bottom topography. We also showed mixing ratio of the subarctic and the subtropical seawater in the Transition domain using the particle tracking. In addition, it was also found that the place where the sea water tends to stagnate well corresponds to the place where the SST deviation appears due to the variation of the Isojet jet J1 indicated by Mitsudera et al. (2018).

Keywords: bottom topography, SST front, SSS front , Subtropical-Subarctic Seawater exchange

©2019. Japan Geoscience Union. All Right Reserved.

Impact of the Kuroshio front on frontal structure of an extratropical cyclone associated with heavy precipitation

*Hidetaka Hirata[1], Ryuichi Kawamura[2], Mayumi K Yoshioka[1], Masami Nonaka[3], Kazuhisa Tsuboki[1]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Department of Earth and Planetary Sciences, Kyushu University, 3. Application Laboratory, Japan Agency for Marine-Earth Science and Technology

It is well known that sea surface temperature (SST) fronts associated with warm ocean currents create horizontal thermal gradients in the near-surface atmosphere in the mid-latitudes. These thermal gradients may affect frontal structure of extratropical cyclones passing near warm currents. Moreover, fronts influenced by the mid-latitude ocean may be related to the occurrence of heavy precipitation. To answer these questions, we examined the impact of the SST front along the Kuroshio Current (Kuroshio front) on the frontal structure of an extratropical cyclone associated with heavy precipitation by utilizing observational data, objective analysis data, and regional cloud-resolving numerical experiments. This study paid special attention to an extratropical cyclone and related heavy precipitation on Miyake Island in early January 2017. When the cyclone intensified around the Kuroshio front, two surface fronts developed around the cyclone center. One was a warm front. The other was a non-classic front, which was called the outer front in this study, forming on the northern side of the warm front. A line-shaped precipitation band and a comma head-shaped precipitation band appeared along the outer front and along the bent-back warm front, respectively. During the passage of these bands, heavy precipitation was observed on Miyake Island. Looking at the evolution of the outer front, we found that it was located just along the Kuroshio front in its early life. During the formation stage of the incipient outer front, sensible heat supply was evident from the Kuroshio Current, whereas it was small on the northern side of the oceanic front. This meridional difference in sensible heating caused frontogenesis along the Kuroshio front, which led to the initial formation of the front. Thus, the Kuroshio front played an important role in the formation of the incipient outer front, contributing to the occurrence of the heavy precipitation.

Keywords: extratropical cyclone, Kuroshio, heavy precipitation

©2019. Japan Geoscience Union. All Right Reserved.

Discussion on future studies on the role of midlatitude oceans

*Kazuaki Nishii[1]

1. Graduate School of Bioresources, Mie University

Here, we will discuss future plans of studies on the role of midlatitude oceans in driving the atmospheric variability, and its feedback onto the midlatitude oceans.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 104 1F

[A-CG33] Extratropical oceans and atmosphere

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Yoshi N Sasaki(Hokkaido University), Hatsumi Nishikawa(Institute of Low Temperature Science, Hokkaido University), Shun Ohishi(Division for Land-Ocean Ecosystem Research, Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Shun Ohishi

The extratopical ocean had been considered passive to atmospheric variability. Recent studies, however, revealed some active role of the extratopical ocean in modulating the atmosphere. The goal of this session is to deepen our understanding of the air-sea interaction in the extratropics. A wide variety of researches whose topics range from mesoscale to basin-scale, and from daily to global warming are welcomed. Researches on cloud, aerosol, and ecosystem related to the extratopical air-sea interaction are also welcomed.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG33-07] Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

★Invited Papers

*Naoya Takahashi[1], Tadahiro Hayasaka[1] (1.Center for Atmospheric and Oceanic Studies, Graduate School of Science, Tohoku University,)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG33-08] **Sea surface temperature trend in the East China Sea during the 20th century simulated by a regional ocean model**

*Yoshi N Sasaki[1], Chisato Umeda[1] (1.Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG33-09] Kuroshio Extension and Gulf Stream’s influences on the variability of near-surface baroclinicity and the associated atmospheric fields

★Invited Papers

*Bunmei Taguchi[1], Kazuaki Nishii[2], Hisashi Nakamura[1,3] (1.Research Center for Advanced Science and Technology, The University of Tokyo, 2.Graduate School of Bioresources, Mie University, 3. Application Laboratory, Japan Agency of Marine-Earth Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG33-10] Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

*Morio Nakayama[1], Masatoshi Mizukoshi[1], Hisashi Nakamura[1], Yu Kosaka[1], Bunmei Taguchi[1], Masato Mori[1], Fumiaki Ogawa[2] (1.RCAST, the University of Tokyo , 2.The University of Bergen)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG33-11] **Hydro-climatic variation in northwestern China and its multi-decadal to multi-centennial teleconnection with the Pacific Ocean**

*Harry F Lee[1] (1.The Chinese University of Hong Kong)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG33-12] Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2] (1.Graduate School of Bioresources, Mie University, 2.Research Center for Advanced Science and Technology, The University of Tokyo)

Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

*Naoya Takahashi[1], Tadahiro Hayasaka[1]

1. Center for Atmospheric and Oceanic Studies, Graduate School of Science, Tohoku University,

Oceanic low-level cloud (i.e. fog, stratus, and stratocumulus) properties are important to determine radiative cooling at the sea surface via reflecting incident solar radiation, and they strongly interact with sea surface temperature (SST) with positive feedback process (Norris et al. 1998). Despite the importance of the role of low-level cloud in climate change or air-sea interaction, the mechanism of cloud evolution on short time-scale is not well investigated. Thus, the objective of this study is to reveal the evolution of low-level cloud cover (LCC) associated with cloud controlling parameters (e.g. SST, horizontal temperature advection, relative humidity in atmospheric boundary layer, and so on) on short time scale which cannot be revealed by monthly-mean dataset.

For cloud data, we used the level-3 daily gridded data product from MODIS imager (MYD08_D3) with 1 degree of horizontal resolution. OISST and ERA-Interim are used for SST and meteorological parameters, respectively. Spatial and temporal resolutions of these dataset are interpolated into that of MODIS. Target region is western North Pacific (150E-180E, 30N-40N) where standard deviation of LCC in summertime (JJASO) is large. Target period is each summertime from 2003 to 2016. To extract the shorter time-scale variability, we applied Lanczos band-pass filter for each variable. The extracted time scale by the band-pass filter is discussed in the next paragraph.

To investigate dominant time scales of LCC and SST, Fast Fourie Transform (FFT) analysis is applied. The results of FFT analysis for each variable show that 3-7-day and 20-100-day are dominant time-scale for LCC. The dominant time scale of temperature advection (Tadv) is similar to shorter one of LCC, which implies that Tadv is a key factor to control LCC on synoptic time scale rather than SST. On the other hand, for more longer time scale (20-100-day; intra-seasonal time scale), the correlation between SST and LCC is consistent with the previous studies (Norris 2000). To investigate the evolution process of LCC and SST on both time-scale, we applied the band-pass filter to them with two time-scale; (1) 3-7 day and (2) 20-100 day.

We further conducted phase composite analysis for each time scale. The result shows that (1) variation of SST (Tadv) lags (leads) to that of LCC on both time scales but (2) propagating direction of LCC anomaly and associated specific and relative humidity is eastward (westward) on synoptic (intra-seasonal) time scale. The difference in amplitude and propagation direction of LCC on each time-scale depend on different atmospheric dynamics and variation of associated moisture field. The above results also suggest that anomalous dry-cold Tadv is a trigger to increasing in LCC and SST decreasing is followed by them. This lead-lag relationship among each variable is clear on the intra-seasonal time scale. Temperature budget analysis for ocean mixed-layer shows that the SST decreasing is caused by shortwave cooling due to low-level cloud radiative effect and enhanced latent heat release. It emphasizes an importance of anomalous Tadv for the intra-seasonal variations of not only LCC but also SST.

Keywords: Summertime North Pacific, Oceanic low-level cloud, Synoptic and intra-seasonal variabilities, Air-sea interaction, Satellite observations

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Sea surface temperature trend in the East China Sea during the 20th century simulated by a regional ocean model

*Yoshi N Sasaki[1], Chisato Umeda[1]

1. Hokkaido University

It has been reported that the East China Sea is one of the region where the sea surface temperature (SST) trend during the 20th century is a couple of times larger than the global mean SST trend. However, the detailed spatial structure of the SST trend in the East China Sea, especially in the early 20th century, and its quantitative mechanism have not been understood. The present study examines the SST trend in the East China Sea from 1901 to 2010 by using a regional ocean modeling system (ROMS) with an eddy-resolving horizontal resolution (0.1˚) from 1871 to 2010. The spatial pattern of our simulation resembles that of the observations. That is, our simulation can reproduce the SST rise along the Kuroshio axis and over the continental shelf along the coast of China. The amplitude of the SST trend in the simulation is within the range between the two observations. The heat budget analysis revealed that the oceanic advection induced the SST rise in both regions. More specifically, the acceleration of the ocean currents plays an important role in the warming of the SST in both regions. In contrast, surface net heat flux acted as the damping of the SST rise.

Keywords: Kuroshio, global warming, ocean model

©2019. Japan Geoscience Union. All Right Reserved.

Kuroshio Extension and Gulf Stream's influences on the variability of near-surface baroclinicity and the associated atmospheric fields

*Bunmei Taguchi[1], Kazuaki Nishii[2], Hisashi Nakamura[1,3]

1. Research Center for Advanced Science and Technology, The University of Tokyo, 2. Graduate School of Bioresources, Mie University, 3. Application Laboratory, Japan Agency of Marine-Earth Science and Technology

Evidence is mounting that mid-latitude western boundary currents (WBCs) can influence large-scale atmospheric circulation variability on interannual-to-decadal time scales. It is, however, still unclear how significantly such extra-tropical oceanic influences stand out of the intense variability intrinsic to the mid-latitude atmosphere. Here we examine the influences of extra-tropical oceanic frontal zone and its variability in the Gulf Stream (GS) and Kuroshio Extension (KE) regions on winter-season atmospheric variability in 20-member ensemble historical AGCM simulations with a horizontal resolution about 100km prescribed with satellite-observed, high-resolution sea surface temperature (SST) and sea-ice variability for the period 1982-2013. We focus on the near-surface baroclinicity $\boldsymbol{B}$ at 925 hPa as the quantity that is crucial for baroclinic eddy growth in the troposphere and is likely to be highly constrained by underlying oceanic frontal zones via air-sea heat exchange. We characterize the $\boldsymbol{B}$ variability separately in the GS and KE regions by applying EOF analysis to DJF-mean $\boldsymbol{B}$ across all the ensemble members and to that based on JRA55 reanalysis and then examine atmospheric and sea surface fields associated with their leading modes.

The simulations capture well the spatial structure of the observed $\boldsymbol{B}$ variability in both the WBC regions. Their leading modes (EOF1), explaining 42% (35%) of the total variance, represents intensifications of $\boldsymbol{B}$ over the GS (KE). While the EOF1 in the GS region is associated with enhanced storm track activity and westerly jet aloft, and geopotential height anomalies that resemble the negative phase of North Atlantic Oscillation (NAO), the EOF1 in the KE region is associated with a meridional dipole in height anomalies that resembles Western Pacific pattern. Further analysis of surface heat flux and SST anomalies contrasts the role of the two WBCs in the variability of $\boldsymbol{B}$ and the associated atmospheric features. Specifically, the enhanced $\boldsymbol{B}$ in the GS region is associated with enhanced heat release from the ocean, but with no SST anomalies, when cold air outbreaks spread across the sharp SST front over the GS. Over the KE, on the other hand, ocean-induced warm SST anomalies enhance heat release from the ocean, strengthening the overlying $\boldsymbol{B}$. Consistently, the evolution of observed PC1 time series is captured by the ensemble mean of the simulated PC1 in the KE region (r=0.46) but not in GS region (r=0.05). The former indicates the KE-induced SST anomalies adds a predictable component to $\boldsymbol{B}$ and the associated atmospheric variability in the North Pacific, while the latter reflects the variability mainly initiated by intrinsic NAO.

Keywords: Atmospheric storm track , Western boundary currents , interannual-to-decadal variability, westerly jet

©2019. Japan Geoscience Union. All Right Reserved.

Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

*Morio Nakayama[1], Masatoshi Mizukoshi[1], Hisashi Nakamura[1], Yu Kosaka[1], Bunmei Taguchi[1], Masato Mori[1], Fumiaki Ogawa[2]

1. RCAST, the University of Tokyo , 2. The University of Bergen

Large-scale tropospheric variability in the extratropical Southern Hemisphere is characterized by two major and independent modes. One is the barotropic annular mode or the Southern Annular Mode (SAM), which represents meridional shifts of the eddy-driven polar front jet (PFJ; Thompson and Wallace, 2000). The other is the Baroclinic Annular Mode (BAM), which represents pulsing of stormtrack activity (Thompson and Woodworth, 2014).

In this study, the sensitivity of BAM to the midlatitude oceanic frontal zone is assessed through aqua-planet experiments in which, after the removal of landmasses, zonally symmetric distributions of sea-surface temperature (SST) are prescribed as the lower boundary condition of an atmospheric general circulation model AFES. In our control experiment, climatological SST profiles observed over the South Indian Ocean in austral summer and winter are prescribed in the model northern and southern hemispheres, respectively. The profiles are characterized by frontal SST gradient at 45˚ latitude. In our NF experiment, the frontal SST gradients are removed by raising SST artificially poleward of the front. The two experiments are both conducted over 3600 days under a perpetual condition with insolation fixed to the boreal summer solstice.
As in the observations, BAM signatures in the control experiment represent pulsing of the climatological stormtrack anchored in the vicinity of the oceanic front. By contrast, in the NF experiment without the oceanic frontal zone, BAM cannot be reproduced: BAM-associated anomalies of eddy kinetic energy and poleward eddy heat flux are reduced by ~30% and ~50%, respectively, and their peaks are displaced equatorward by ~5˚ from the oceanic frontal zone. Our experiments therefore suggest that the oceanic frontal zone enhances and anchors the BAM variability by strengthening stormtrack activity through maintaining near-surface baroclinicity. Specifically, anomalous sensible heat flux from the ocean acts to restore the meridional gradients in surface air temperature modified by anomalous meridional eddy heat flux associated with BAM, and this effect is greatly enhanced under the frontal SST gradient.

Keywords: Annular mode, Oceanic frontal zone, Aqua-planet experiment

©2019. Japan Geoscience Union. All Right Reserved.

Hydro-climatic variation in northwestern China and its multi-decadal to multi-centennial teleconnection with the Pacific Ocean

*Harry F Lee[1]

1. The Chinese University of Hong Kong

Northwestern (NW) China region locates in the boundary region between the Westerlies and the Asian Monsoon. Due to its unique geographical setting, scientific studies that examine the long-term dynamics of the hydro-climate there have received particular attention in recent years. However, these studies are often constrained by the availability of instrumental precipitation records. The present study seeks to address this issue. I based on historical drought/flood records to trace the geographic extent of drought anomalies as well as the intra-regional precipitation variability in NW China in AD580–2008, covering the periods with and without instrumental precipitation records. Moving correlation and wavelet analyses were applied to find their significant determinants. Results show that El Niño Southern Oscillation (Indo-Pacific warm pool sea surface temperature) is the major multi-decadal to centennial (centennial to multi-centennial) determinant of the hydro-climatic variability in NW China. The associated mechanism is anchored with the change of Asian Summer Monsoonal precipitation, while it is driven by different factors at different time-scales. The above findings may help predict the occurrence of drought in the boundary region between the Westerlies and the Asian Monsoon in the extratropics.

Keywords: Hydro-climate, northwestern China, Pacific Ocean

©2019. Japan Geoscience Union. All Right Reserved.

Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2]

1. Graduate School of Bioresources, Mie University, 2. Research Center for Advanced Science and Technology, The University of Tokyo

It is known that, in the zonal-mean tropospheric circulation, diabatic heating drives a thermally direct meridional overturning circulation (MOC) called the Hadley cell. While in the midlatitudes, zonal-mean vertical motion is driven mainly by atmospheric eddies, forming a thermally indirect MOC called the Ferrel cell where warmer (cooler) air apparently sinks (rises) in lower (higher) latitudes. Here we found a thermally-direct, shallow MOC embedded in the downward branch of the zonal mean Ferrel cell in the wintertime northern hemisphere in most of the latest generation reanalysis datasets. AGCM simulations reveal that this local MOC, made of upward (downward) motion around latitudes to the equatorward (poleward) side of midlatitude oceanic fronts, is driven by differential diabatic heating across the ocean fronts due to surface turbulent heat flux from the ocean and precipitation brought by synoptic-scale eddies. The compensating meridional flow in the lowermost atmosphere is northerlies, which decelerates surface westerlies just over the oceanic fronts through the Coriolis force. The decelerated surface westerlies by oceanic fronts in turn exert wind-stress curl forcing that tends to weaken oceanic subpolar and subtropical gyres, indicative of an air-sea coupled feedback that would destruct, rather than maintain, the oceanic fronts.

Keywords: Midlatitude oceanic front, vertical motion, baroclinicity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 201B 2F

[H-DS11] Subaqueous Landslides and Their Anthropogenic Impact for Coastal Regions

convener:Yujin Kitamura(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University), Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Chairperson:Yujin Kitamura(Kagoshima University), Masayuki Utsunomiya(Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Yasuhiro Yamada(JAMSTEC)

A large number of people inhabit coastal areas around the world that are susceptible to natural catastrophes and subaqueous landslides are one of such hazards as demostrated recently. The risk associated with the occurrence of subaqueous landslides is not only constrained to passive margins or subduction zones but any of water areas is also susceptible to their occurrence since subaqueous failures can be triggered at very low slope angles. This realization poses a significant challenge that requires the collection of vast amounts of information and data to unravel the true nature of these events and their potential risk to coastal communities. Despite these challenges, recent technical and engineering advances in the acquisition and processing of sea floor and shallow subsurface data are encouraging. There has also been a concerted effort by scientists from different earth-science disciplines to increase interdisciplinary cooperation at an international level to advance our collective understanding of subaqueous landslides and their consequences.
This session calls for technical contributions covering all aspects of subaqueous landslide research including but not limited to: physical properties of deformed sediments (pre- and post- deformation), role of interstitial fluids in subaqueous landslide development, slope stability and risk assessments, geomorphological and sedimentological/stratigraphic descriptions, tsunamigenic risk and modeling, description of ancient subaqueous landslides, sand-box models and numerical simulations of subaqueous landslides. Case studies from lacustrine landslides and subaerial coastal landslides transitioning into the marine realm are also welcome. Case studies associated with the broader topic of subaqueous gravity-driven flows (e.g.: turbidites and transitional flows) and their relationship with seafloor faulting are also of interest to this session. Participants of IUGS project S4SLIDE IGCP-640 sponsor this session.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HDS11-01] Distribution and sedimentological characteristics of the submarine landslides filling Hidaka Trough, offshore southern Hokkaido, northern Japan with special attention to the uppermost Quaternary submarine landslide bodies

*Hiroyuki Arato[1] (1.Graduate School of International Resource Sciences, Akita University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HDS11-02] Origin and distribution of mass-transport deposits in the Pleistocene forearc basin, central Japan, deduced from tephro- and biostratigraphy

*Masayuki Utsunomiya[1], Yuzuru Yamamoto[2], Kiyohide Mizuno[1] (1.Geological Survey of Japan, AIST, 2.JAMSTEC)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HDS11-03] Physico-chemical properties of sediment cores from Yatsushiro Sea, western Kyushu

*Yujin Kitamura[1], Ryoya Goto[2], Koki Hori[2], Yuta Ikebata[2], Haruka Kageyama[2], Kuniyo Kawabata[1], Daiki Oyama[1], Kaede Yamasaki[2], Hakuho-maru KH-18-3 Scientists (1.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

4:15 PM - 5:00 PM JST | 7:15 AM - 8:00 AM UTC

Discussion

Distribution and sedimentological characteristics of the submarine landslides filling Hidaka Trough, offshore southern Hokkaido, northern Japan with special attention to the uppermost Quaternary submarine landslide bodies

*Hiroyuki Arato[1]

1. Graduate School of International Resource Sciences, Akita University

In the last few years, many examples of submarine landslides have been reported worldwide, and their systematic and genetic researches have been initiated. The studies in distribution, sedimentary pattern and mechanism of submarine landslides are remarkably important mainly from the following two reasons: (1) Submarine landslides affect significantly the state of surrounding water mass due to long distance migration of huge volume sediment mass within relatively short time period. One of the critical phenomena is megatsunami induced by submarine landslides, (2) Secondly nature of submarine landslides is deeply related to transportation mechanisms of siliciclastic sediments into tectonically formed sedimentary basins and their burial processes. In this study, two dataset of 3D seismic survey are utilized to describe some submarine landslide examples, under the owner’ s permission. They are Geophysical Survey and Basin Evaluation Projects “2013FY Hidaka Shujo Kaibon 3D”(hereinafter, called HSK-3D) and “2014FY Hidaka Shujo Kaibon Seibu 3D” (HSKW-3D), acquired at the offshore southern Hokkaido by Ministry of Economy, Trade and Industry (METI).
The surveys cover the northeastern marginal slope and a part of central basin floor of Hidaka Trough elongated NW-SE direction. Water depth of covering area ranges from 577 to 1,156 mBMSL. The seismic reflector indicating seabed have been traced by using “seeded autotracking” function of PETREL, then a time structural contour map for the surface, which is equivalent to bathymetric map, have been drawn. Based on the topographic features, the survey area can be subdivided broadly into two types; one is characterized generally by smooth sea bottom surface, and another by irregular or rough surface in seismic scale. The area of smooth sea bottom cover approximately southwestern two thirds portion of HSKW-3D and a part of the western HSK-3D areas. On the other hand, northeastern one thirds of HSKW-3D, northwestern corner of HSK-3D, and northeastern portion and some extending areas are characterized by irregularly swollen, or roughly heaped unsmooth sea bottom surface. Such irregular topographic features of the seabed can be interpreted formed by Holocene or the youngest Quaternary submarine landslides from the point of view of their distribution within the basin. Within cross sectional views of the seismic data, those landslide bodies are observed as externally discontinuous and internally chaotic layers within orderly stacking parallel layered succession in seismic facies. These youngest submarine landslides seen in recent topography can largely be classified into 4 groups; called i) Shizunai, ii) Urakawa, iii) Samani and iv) Erimo Submarine Landslide, and they are laterally arrayed from northwest to southeast and running down generally from northeast to southwest on the continental slope of Hidaka Trough (Figure).
In addition, many buried submarine landslide bodies in the sediments filling the Hidaka Trough (e.g., Monbetsu SLS) can be recognized by seismic facies interpretation in the cross sections and time slice images. In the Hidaka Trough, Cretaceous to Quaternary sediments ranging up to 10km in thickness are present. Four horizons, A, B, C and D had been selected and traced within the sedimentary succession in this study. On the basis of chronostratigraphic correlation to the preceding studies, B, C, and D are correlative to intra-middle Pleistocene equivalent to the base of NPD12, base of middle Pleistocene Calabrian, and base of Pliocene, respectively. Horizon A is inferred as a horizon in the upper Pleistocene

©2019. Japan Geoscience Union. All Right Reserved.

or Holocene. At least more than 3 landslide events can be detected in the stratigraphic unit between seabed and horizon A. In the unit between horizons A and B, 3 to 5 events are recognized, and there are equivalent numbers of landslide events in the unit between horizons B and C. Almost sediments are interpreted as chaotic seismic facies below horizon D.

Keywords: submarine landslide, Hidaka Trough, submarine landslide-induced tsunami, 3D seismic survey

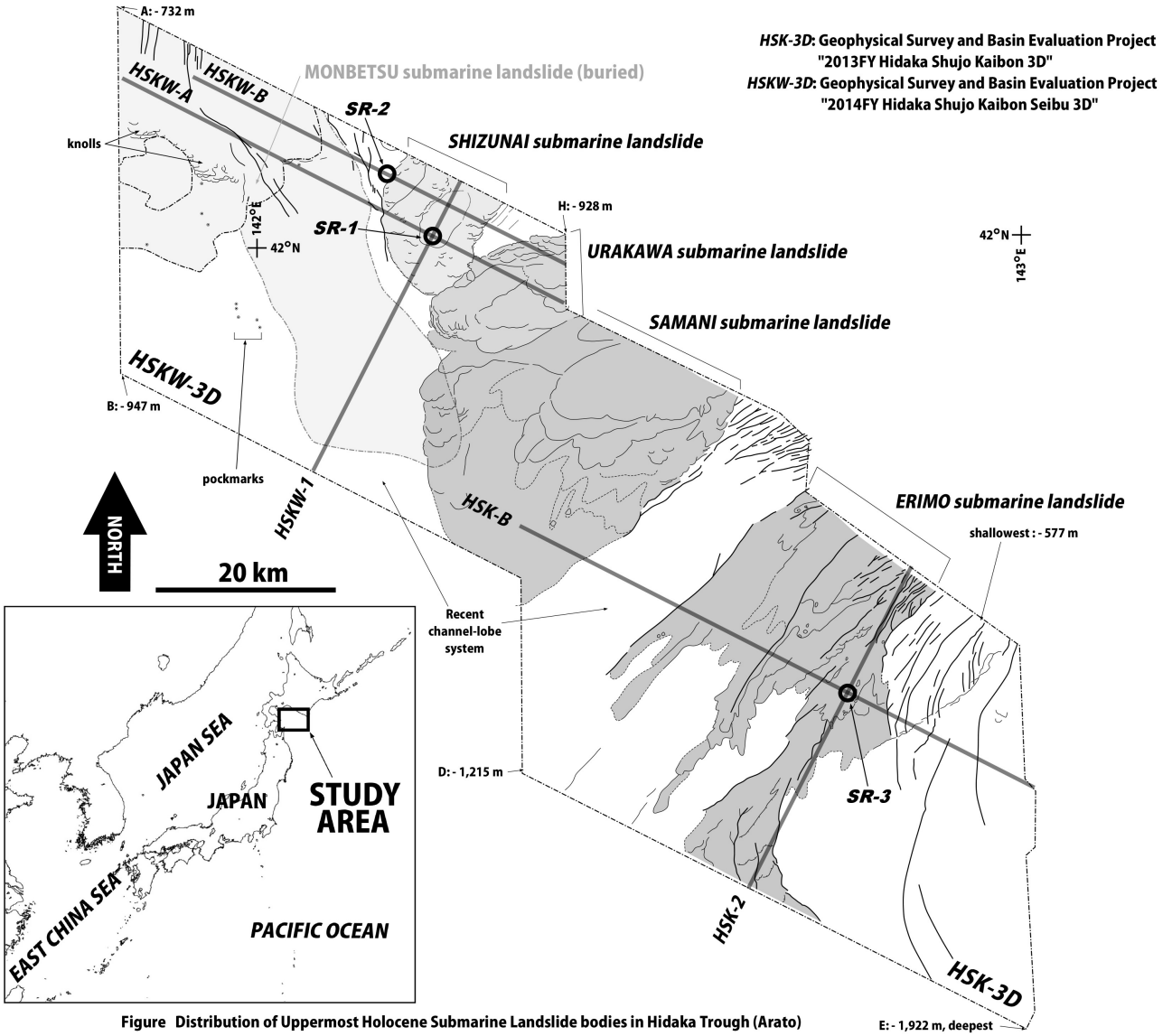


Figure Distribution of Uppermost Holocene Submarine Landslide bodies in Hidaka Trough (Arato)

©2019. Japan Geoscience Union. All Right Reserved.

Origin and distribution of mass-transport deposits in the Pleistocene forearc basin, central Japan, deduced from tephro- and biostratigraphy

*Masayuki Utsunomiya[1], Yuzuru Yamamoto[2], Kiyohide Mizuno[1]

1. Geological Survey of Japan, AIST, 2. JAMSTEC

We introduce a field-based study on the basin-wide mass-transport deposits (MTDs) by means of biostratigraphy and the marker tephra beds. The Kazusa Group, the Pleistocene forearc-basin fill exposed in central Japan, is characterized by high sedimentation rate and its stratigraphy is well-established. We focused on three MTDs referred to as MTDs-8–10. They consist of folded blocks that range from tens of centimeters to more than tens of meters in width and thickness, in a sandy mud matrix commonly containing volcaniclastics (e.g., pumice grains and euhedral crystals). The overall thickness of these MTDs ranges from ~20 to 100 m. Based on the lateral correlation of the tephra marker beds, these MTDs can be traced laterally for more than several tens of kilometers. MTD-8 (1.3 Ma) and MTD-9 (1.2 Ma) contain blocks characterized by folding, internal minor faulting, different attitude of bedding planes from the general trend, and occasionally overturned. The blocks in MTD-8 contain tephra beds and calcareous nannofossils that are typically found in the older strata down to 250 m below it, which suggest that the blocks are considered to have originated from the upstream excavated area and spread out laterally to cover the open seabed. On the other hand, MTD-10 (1.2 Ma) is characterized by a laterally-stacking pattern showing lamp-flat geometry, and the original stratigraphic positions of the blocks are consistent with the host strata, indicative of translational movement. The sedimentary dykes were observed in the basal slide plane, suggesting excess pore pressure within the slip zone. The different modes of occurrence are likely to be a result of local variation in slope gradient and distance of downslope migration. That is, initial phase of mass transportation on low-gradient slope represented a slide (MTD-10), whereas moving over a sufficiency long distance exhibited more mixtured and deformed slump (MTDs-8 and 9). Combination of studies on MTD textures, tephro- and biostratigraphy has great advantage to know their spatial distribution, original stratigraphic position where the MTDs were initiated, and mechanism to generate variable occurrence of MTDs.

Keywords: submarine landslide, mass-transport deposit, Kazusa Group, calcareous nannofossils, tephra

©2019. Japan Geoscience Union. All Right Reserved.

Physico-chemical properties of sediment cores from Yatsushiro Sea, western Kyushu

*Yujin Kitamura[1], Ryoya Goto[2], Koki Hori[2], Yuta Ikebata[2], Haruka Kageyama[2], Kuniyo Kawabata[1], Daiki Oyama[1], Kaede Yamasaki[2], Hakuho-maru KH-18-3 Scientists

1. Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

Submarine active faults in Yatsushiro sea, western Kyushu, constitute the Yatsushiro section of Hinagu fault zone in its southwest end. The 2016 Kumamoto Earthquake was sourced from a part of active faults of the Futagawa-Hinagu fault zones. Earthquake shaking occasionally triggers submarine landslide. As submarine landslide can take place in very gentle slope (< 1˚), Yatsushiro sea is yet to be a scene for it although the area is a shallow and relatively small sedimentary basin. However, any record of submarine landslide in this area has not been reported.

Minamata bay, southern Yatsushiro sea, is known to be mercury pollution from a chemical plant drainage. A complex space-time distribution of mercury content in the sediments has been revealed (Tomuyasu et al., 2014). As the transportation of the mercury-containing clastics depends on sedimentation rate and/or water current, submarine landslide is a candidate for the factor of drastic change in benthic environment.

Here we conducted four-days research cruise Hakuho-maru KH-18-3 in July, 2018 to reveal submarine landslide records and benthic environment in Yatsushiro sea. We conducted subbottom profiling, piston coring at 11 sites, and multiple coring at 13 sites). Recovered cores are analyzed by X-ray CT scanner, multi-sensor core logger, core imaging apparatus, visual core description, color spectroscope, X-ray fluorescence core scanner (Itrax), and so do discrete samples by vane shear tester, picnometer with sediments and by Radon monitor with sea water and pore water.

Our results revealed clear difference in the lower part of each core compared to the upper part. By referring piston cores and their age data by Inoue et al. (2011), these distinctive units is caused by hiatus between about 3 to 8 ka. The lower sediments below the hiatus are characterized by rather high vane shear strength, low porosity and abundant terrigenous sediments. The depth of hiatus varies in site by site, which suggests difference in local depositional environment. Sedimentation rate of recent 50 years which Rifardi et al. (1998) inferred from superficial sediments cannot be applied for whole core, but the rate in longer time scale must be further smaller.

Keywords: turbidites, shallow marine deposit, 2016 Kumamoto earthquake, mercury, Yatsushiro sea, Minamata bay

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-CG Complex & General

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 301B 3F

[H-CG26] Deltas and estuaries: multidisciplinary analyses of complex river-mouth systems

convener:Yoshiki Saito(Estuary Research Center, Shimane University), Guan-Hong Lee(Inha University), David L Dettman(University of Arizona), Kazuaki Hori(Department of Geography, Graduate School of Environmental Studies, Nagoya University), Chairperson:Yoshiki Saito(Shimane Univ/ GSJ, AIST), David Dettman(University of Arizona)

This session has foci on morphodynamics, material cycling, and sustainability in deltas and estuaries. We invite contributions that advance research on deltas and estuaries as complex river-mouth systems from modern and ancient examples, and that develop integrated frameworks for delta & estuary dynamics modeling on a broad range of temporal and spatial scales: from studies of coastal evolution over the Quaternary to small-scale sediment/material transport processes. We also invite physical processes studies based on field observations, numerical simulation and flume experiments. Finally, the conveners encourage contributions that promote data collection and sharing for both advancing science and local problem solving, that consider policy and governance issues linked to the sustainable development of deltas and estuaries, and that use in-situ and satellite data for modeling and risk assessment.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[HCG26-01] Recent Changes of the Asian Major Deltas

★Invited Papers

*Paul Liu[1] (1.North Carolina State University Raleigh)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HCG26-02] **Matching trends in channel width, sinuosity, and depth along the fluvial to marine transition zone of tide-dominated river deltas: the need for a revision of depositional and hydraulic models**

★Invited Papers

*Marcello Gugliotta[1], Yoshiki Saito[1] (1.Shimane University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HCG26-03] **Effects of an Estuarine Dam on Sediment Flux Mechanisms in a Macrotidal Estuary**

Steven Miguel Figueroa[1], *Guan-Hong Lee[1] (1.Inha University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HCG26-04] **Late Pleistocene sedimentary evolution of the north Jiangsu coastal plain revealed by OSL dating based chronostratigraphy**

*Lei Gao[1], Hao Long[1], Ping Zhang[2], Toru Tamura[3,4], Ji Shen[1] (1.Nanjing Institute of Geography and Limnology, CAS,China, 2.Geological Survey of Jiangsu Province (GSJP), Key Lab of EFGD, Ministry of LR, China, 3.Geological Survey of Japan (GSJ), AIST, 4.Graduate School of Frontier Sciences, The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HCG26-05] The sedimentary environments and provenance of the late Quaternary sediments, in South Yellow Sea shelf, eastern China

*Yong Yin[1] (1.School of Geography and Ocean Science, Nanjing University)

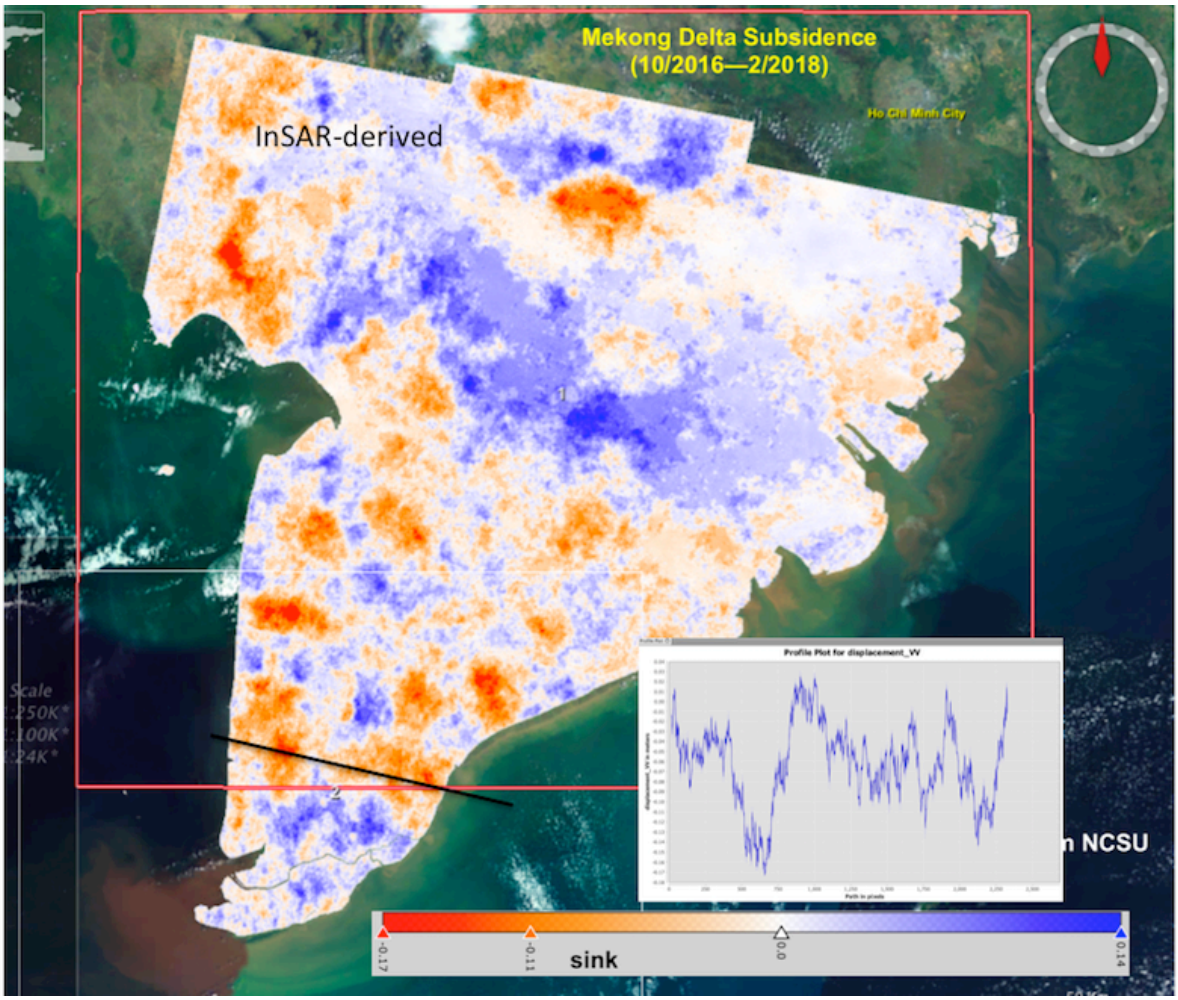
Recent Changes of the Asian Major Deltas

*Paul Liu[1]

1. North Carolina State University Raleigh

In the past 50 years, sediments from major Asian rivers have sharply decreased 80-90% due to the increased human activities (like building dams, overusing water, or sand mining) and climatic changes. Many of those river deltas have been experiencing severe coastal erosions, like the Yellow, Red, Mekong, Chao Phraya, and Indus, etc. Most of these deltas have turned from constructive growing mode to destructive declining mode, for example, the Mekong Delta has shown overall negative net land gain starting ~ 2005. Our studies also show not only the deltaic shorelines are retreating, but also some delta’s subaqueous portions are under strong erosion, such as the Yangtze, Mekong, Chao Phraya and Indus, etc.

Keywords: river delta , sediment decrease , shoreline erosion , subsidence



©2019. Japan Geoscience Union. All Right Reserved.

Matching trends in channel width, sinuosity, and depth along the fluvial to marine transition zone of tide-dominated river deltas: the need for a revision of depositional and hydraulic models

*Marcello Gugliotta[1], Yoshiki Saito[1]

1. Shimane University

Along their fluvial to marine transition zone, tide-dominated river deltas show upstream to downstream trends in channel width, sinuosity, and depth, which at present have been only partially reported. This review article aims to describe these morphological trends from five modern tide-dominated river deltas using original data collected from satellite images and bathymetric maps and published data from field surveys. All the studied channels show similar trends with two distinct tracts separated by areas of morphological changes. The upstream tracts are characterized by constant width, relatively high sinuosity, and seaward-increasing depth, and are mainly controlled by the fluvial dynamics. The downstream tracts are characterized by seaward-increasing width, relatively low sinuosity, and seaward-decreasing depth, and are mainly controlled by the tidal dynamics. The delineation of this morphological configuration of the channels is crucial to understand the responses of deltas to the interacting riverine and marine processes. Additionally, this has important implications for depositional and hydraulic models, and for the long-term evolution and the assessment of human-induced versus natural modifications of these systems.

©2019. Japan Geoscience Union. All Right Reserved.

Effects of an Estuarine Dam on Sediment Flux Mechanisms in a Macrotidal Estuary

Steven Miguel Figueroa[1], *Guan-Hong Lee[1]

1. Inha University

Sediment flux convergence traps sediment in many estuaries of the world coast. This sediment flux can be decomposed into a mean-flow flux and correlation flux to better understand the mechanisms driving the sediment trapping in estuaries. Humans have modified and are modifying many natural estuarine systems, however it isn’ t well understood what affects humans can have on sediment flux mechanisms and flux convergence in altered estuaries. Geum Estuary is a shallow, macrotidal estuary on the eastern Yellow Sea which has experienced tidal amplification and enhanced depositional rates following the operation of an estuarine dam since 1994. Geum Estuary thus serves as a good case for studying decomposed sediment fluxes for a shallow, macrotidal estuary affected by an estuarine dam. To quantify the sediment fluxes, we measured current and acoustic backscatter profiles at 1.5 km and 6.5 km seaward of the estuarine dam in Geum Estuary, over a period of two neap-spring cycles during which six episodic dam discharges occurred. Suspended sediment concentration (SSC) was estimated from acoustic backscatter and sediment flux was computed as the product of current velocity and SSC. The flux was decomposed into a mean-flow flux and correlation flux using 36-hr Lanczos filters. Additionally, ship-borne surveys were conducted at the two stations seaward of the estuarine dam to investigate more closely the role of dam-induced horizontal salinity gradient and vertical stratification on sediment resuspension and flocculation tidal asymmetries. Results indicated landward flux at both moorings with a negative flux gradient indicating deposition. Landward directed correlation flux was the dominant term. Its magnitude was proportional to the tidal range and tidal asymmetry and was found to occur in the bottom boundary layer. Seaward directed mean-flow fluxes were caused by the episodic dam discharges. Their magnitude was proportional to the discharge volume and was greatest in the surface layer of the water column. At the seaward station, periodic stratification occurred following the dam discharge and resulted in tidal asymmetries in resuspension and flocculation providing evidence for landward flux due to tidal straining. Overall the data confirms that the estuarine dam controls the seaward mean-flow fluxes, and these fluxes are smaller when the dam is closed. Furthermore, the proportionality of the correlation flux with tidal range provides supports that the dam enhanced the landward correlation fluxes because of the tidal amplification effect. Finally, the tidal straining effect was confirmed to occur in a macrotidal estuary with an estuarine dam.

Keywords: estuary, sediment flux, tidal straining, dam discharge, anthropocene

©2019. Japan Geoscience Union. All Right Reserved.

Late Pleistocene sedimentary evolution of the north Jiangsu coastal plain revealed by OSL dating based chronostratigraphy

*Lei Gao[1], Hao Long[1], Ping Zhang[2], Toru Tamura[3,4], Ji Shen[1]

1. Nanjing Institute of Geography and Limnology, CAS,China, 2. Geological Survey of Jiangsu Province (GSJP), Key Lab of EFGD, Ministry of LR, China, 3. Geological Survey of Japan (GSJ), AIST, 4. Graduate School of Frontier Sciences, The University of Tokyo

In the past decades, many Chinese geoscientists carried out numerous research works to investigate the sedimentary history of the Jiangsu coastal plain. However, we still have limited understanding of history prior to the Holocene because of the lack of reliable chronology. In this study, we applied quartz optically stimulated luminescence dating (OSL) techniques to determine the ages of 11 sediment samples from a 30-m-long core (EGWY02) drilled from the north Jiangsu coastal plain. The sedimentary facies of the core were identified based on observation, grain-size analysis, colors and textures of sediments. The stratigraphy of the core was then correlated to three cores collected in the adjacent area (Zhang et al., 2010; Xia and Zhang, 2018). In our core, we identified two marine transgressive events T1 and T2 at intervals of 3-5 and 21-27 m deep, respectively. The timing of T1 and T2 were dated as 7.1±0.9 ka and > 77±6 ka, respectively. The interval of T1 is overlain by a littoral sedimentary facies deposited over the last 2 ka. Three layers of “stiff clay” (SC) were identified at depths of 1-2, 8-12 and 27-30 m and are interpreted terrestrial deposits. The first SC layer was dated about 1.8±0.1 ka while the second layer was between 44±3 ka and 72±6 ka. In addition, we recognized fluvial deposits at interval of 12-21 m deep, which was dated from 72 to 77 ka. A lacustrine layer was also identified at 5-8 m deep and dated as 41-44 ka. Our OSL dating application to the core EGWY02 thus clarified that the sedimentary succession represents two transgressive episodes in relation to the last interglacial (MIS 5) and post glacial periods (MIS 1), intervened by the terrestrial environments related to the MIS 4-2. Further application of the OSL dating to the subsurface sediment cores will unveil the pre-Holocene environmental changes in the Jiangsu coastal plain, which was possibly affected by the paleo-Yangtze River.

Keywords: OSL dating, Chronostratigraphy, The north Jiangsu coastal plain , Sedimentary evolution, Late Pleistocene

©2019. Japan Geoscience Union. All Right Reserved.

The sedimentary environments and provenance of the late Quaternary sediments, in South Yellow Sea shelf, eastern China

*Yong Yin[1]

1. School of Geography and Ocean Science, Nanjing University

The late Quaternary sedimentary systems are mainly controlled by sea-level changes, sediment supply and regional subsidence. The late Quaternary source materials of South Yellow Sea shelf were controlled by Yellow and Yangtze rivers. So sediment provenance is very important not only for “source to sink (S2S)” processes but also for land-sea interaction.

The South Yellow Sea is a semi-enclosed epicontinental sea between China to the west and Korea Peninsula to the east. Since the late Quaternary, the South Yellow Sea has experienced several eustatic sea-level changes and sediment supplies alternatively from old Yellow and Yangtze Rivers. Previous work did not documented the late Quaternary environments and sediment provenance in this region. Several boreholes are used: 1) to synthesize the long term sedimentary environments since the late Quaternary; 2) to discriminate the source materials and appraise the contribution of Yellow and Yangtze rivers; 3) to evaluate the driving forces controlling the formation of South Yellow Sea shelf.

The sedimentary facies analysis indicates the South Yellow Sea shelf experienced fluvial and tidal influenced fluvial environments during MIS6. Then the fluvial environment was replaced by tidal flat, estuary and delta front environments during the transgression taking place in MIS5. Delta front environments dominated the South Yellow Sea shelf during the transgression occurred in MIS3. During MIS2, the shelf was cut by network of valleys and filled with coarse materials within the fluvial channels and fine materials beyond the channels. During the Holocene, transgression environment developed in early period followed by tidal dominated coast to shelf environments in late period in South Yellow Sea shelf and estuary to delta environments in Yangtze River mouth area.

Detrital zircon U-Pb ages were employed to analyze the provenance of source materials. By comparison of Yangtze and Yellow rivers U-Pb age spectrum, the Yangtze River is characterized by 100~300Ma and 700~900Ma zircons and Yellow River is dominated by 300~500Ma and 1800~2000Ma zircons. The zircons younger than 150Ma merely found in Yangtze affiliated sediments and the zircons between 1300 and 1600 Ma only found in Yellow River affiliated sediments. For zircons between 1800 and 2000Ma and between 2200 and 2500Ma, the particles from Yellow River are more than those from Yangtze River. The results indicate the late Quaternary sediments are mostly from the old Yangtze River and occasionally influenced by Yellow River, e.g. during some periods in MIS6 and MIS2 and Holocene.

The core-recorded strata have revealed the study area experienced the similar estuary to delta processes in MIS 5 as the Yangtze delta in the Holocene. The deltaic successions dominate the South Yellow Sea shelf during the MIS 5 and MIS 3. The source province indicates the old Yangtze attributed a lot to delta sediments. Sea-level cycles and source material supplies play an important role in the late Quaternary coast and shelf successions.

Keywords: sedimentary environment , source provenance, deltaic successions, zircon U-Pb ages

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-CG Complex & General

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 301B 3F

[H-CG27] Turbidity current: from triggers for the generation to the depositional and morphologic al processes

convener:Miwa Yokokawa(Osaka Institute of Technology), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Norihiro Izumi(Faculty of Engineering, Hokkaido University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Chairperson:Miwa Yokokawa(Osaka Institute of Technology), Norihiro Izumi(Hokkaido University)

Recent developments of field observation, physical and numerical experiments, and mathematical analysis have brought us a better understanding of the dynamics of turbidity currents and relevant morphology and bedforms. Applying new findings to rock records, more profound understanding of turbidites have been achieved. It has been found that different triggers and/or sources generate distinctive features of turbidity currents, resulting in various appearances of rock records and morphology. The integration of such new knowledge on turbidity currents is important not only from scientific but also practical points of view, such as assessments of natural hazards, and exploration of resources. This international session welcomes all kinds of approaches for the turbidity currents such as field observation, physical and numerical experiments, mathematical analysis, and studies from rock records.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HCG27-01] Inverse analysis of turbidity currents using two dimensional shallow water model

*Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HCG27-02] Inverse Analysis of Experimental Scale Turbidity Currents by Deep Learning Neural Network

*Cai Zhirong[1], Hajime Naruse[1], Qifeng Yao[1] (1.Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HCG27-03] Conditions for development of depositional submarine channels: examination by flume experiments

*Justine Poppeschi[1], Kazushi Nakata[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HCG27-04] Cyclic steps formed by long-runout turbidity currents

*Zhuyuan Wu[1], Norihiro Izumi [1] (1.Hokkaido University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HCG27-05] Is surface sediment remobilization more popular mechanism for generating earthquake-induced turbidity current? Evidence of radiocarbon dates from the westernmost Nankai and Japan Trench subduction zones

*Ken Ikehara[1], Toshiya Kanamatsu[3], Tobias Schwestermann[2], Arata Kioka[2], Michael Strasser[2] (1.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology, 2.Universität Innsbruck, 3.Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HCG27-06] Shallow-subsurface event stratigraphy along the hadal trench axis of the Japan Trench

*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], M. Strasser[1,4] (1.Universität Innsbruck, Austria, 2.GSJ-AIST, Japan, 3.JAMSTEC, Japan, 4.MARUM-U. Bremen, Germany)

Inverse analysis of turbidity currents using two dimensional shallow water model

*Hajime Naruse[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

Quantitative reconstruction of flow properties from turbidites is a long-standing problem in deep-sea sedimentology. If this is realized, magnitudes of past hazardous events may be estimated from geologic records containing seismo-(tsunami-)generated turbidites. Also, entire geometry of turbidite reservoir can be inferred by flow reconstruction. Thus, inverse analysis of turbidity currents contributes to disaster-risk assessment, and is of economic importance. Here we propose a new methodology to reconstruct flow properties of turbidity currents from three-dimensional geometry of deposits. In this method, a two-dimensional shallow-water model of turbidity currents was employed as the forward model. Numerical simulation was repeated to obtain horizontal distribution of thickness of turbidites under various initial conditions, and then this synthetic data set was used for supervised training of a deep-learning neural network (DNN). After the training phase finished, DNN properly estimated initial conditions of turbidity currents (e.g. initial flow height, velocity, etc.) from artificial test data set that was also produced from the forward model. To summarize, the machine learning produced the inverse model of turbidity currents that can estimate paleo-hydraulic conditions from synthetic or ancient turbidites. In previous methods, the computational cost of two dimensional model was too high to be employed as the forward model for turbidite inversion. On the other hand, our methodology can reconstruct initial conditions of turbidity currents instantaneously. Although production of the training data set requires 1000s times repetition of calculation, the problem of calculation efficiency can be easily solved by using PC cluster. In future study, it is expected to apply the new methodology to actual turbidites measured in 3D seismic profiles or by high-resolution sampling on modern sea floor.

Keywords: sediment gravity flow, turbidite, inverse analysis, machine learning

©2019. Japan Geoscience Union. All Right Reserved.

Inverse Analysis of Experimental Scale Turbidity Currents by Deep Learning Neural Network

*Cai Zhirong[1], Hajime Naruse[1], Qifeng Yao[1]

1. Kyoto University

In this study, inverse analysis of turbidite deposited in flume experiments will be performed using a new machine learning method. The results of inverse analysis will serve to verify the accuracy of the machine learning method.

Understanding of the hydraulic conditions of turbidity current remains limited due to its destructive nature and its unpredictable occurrences. Thus, the inverse analysis of turbidity currents from ancient deposits of submarine fans is required for estimating the conditions of flows in the natural environments.

In the past, inverse modeling of turbidity currents was done in a trial and error fashion by adjusting initial conditions of numerical models, which is high in calculation load, making such technique very expensive and highly impractical. Naruse (2017 AGU Fall Meeting) developed a completely new method for inverse analysis of turbidity currents using a deep learning neural network. In this method, training data is generated by a numerical model, and a neural network for reconstructing hydraulic conditions of turbidity currents from turbidite is produced by machine learning of the training dataset. However, the validity of this new inverse model has not yet been tested in actual deposits. Therefore, this study aims to verify the method by flume experiments.

Currently, the initial conditions of a dataset produced by a flume experiment sized forward model program is used to test the applicability of the neural network method when applied to flume experiment size data. Three thousand sets of training data were fed into the neural network as training data. Another two hundred separate cases were used as test data to verify the accuracy of prediction by the neural network. The result shows initial flow velocity can be predicted relatively accurately. The initial concentrations of the finer grain size class and the initial flow height was partially reconstructed. The flow duration, the coarser grain size classes and the slopes within the flume could not be predicted. After tuning of the neural network and the forward model, the neural network trained for flume sized data will be applied to flume experiment results.

Keywords: Machine Learning, Flume Experiment, Turbidite

©2019. Japan Geoscience Union. All Right Reserved.

Conditions for development of depositional submarine channels: examination by flume experiments

*Justine Poppeschi[1], Kazushi Nakata[1], Hajime Naruse[1]

1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University

Although submarine channels are ubiquitously observed in various submarine fans, it is also known that submarine fans lacking continuous leveed channels are common depending on regions. However, the governing parameters to determine this diversity in developments of leveed channels has not been clarified yet. This is because there has been no previous researches that successfully reproduced depositional leveed channel topography in experimental flumes. Therefore, the formative conditions of depositional submarine channels have not been clarified yet. Here, we conducted flume experiments, aiming to reproduce depositional submarine channels for understanding their formative conditions. As a result, we succeeded to form experimental topography that resemble natural depositional submarine channels showing a ceiling river structure with levees in all five experiments. Comparing the experimental topography with the actual submarine fans, the relative depth of the experimental channel was slightly shallow, but features such as the spatial variation of the channel width showed similar trends to those of the actual submarine channels. Thus, we imply that purely depositional submarine channels can be formed without presence of precursor of erosive features. Furthermore, experimental conditions of this study were in the region where the previous study predicted that submarine channels cannot be formed, suggesting that further investigation is needed to discover the governing parameters for developments of submarine leveed channels.

Keywords: turbidity currents, flume experiment, submarine fan

©2019. Japan Geoscience Union. All Right Reserved.

Cyclic steps formed by long-runout turbidity currents

*Zhuyuan Wu[1], Norihiro Izumi [1]

1. Hokkaido University

It has been found that a variety of submarine morphology such as submarine fans, submarine rivers, and submarine canyons, has been formed by turbidity currents which travel relatively long distance (long-run out turbidity currents). The long-run out turbidity currents have a number of features similar to open channel flow. They have an equilibrium (or quasi-equilibrium at least) state, and are accompanied by hydraulic jumps when they transition from supercritical to subcritical flow regimes. In this research, with the use of the assumption that an equilibrium state can be achieved in the high-concentrated lower layer near the bottom of long-run out turbidity currents, we propose an analytical model with the use of the layer-averaged governing equations, which reproduces cyclic steps with relatively long wavelengths accompanied by periodic internal hydraulic jumps.

Integrating the Reynolds-averaged Navier-Stokes equations and continuity equation over the high concentrated lower layer, we obtain the boundary layer approximated (layer-averaged) momentum and continuity equations. In the integration, it is possible to simplify the governing equations by ignoring the entertainment from the top of the high concentrated lower layer with the assumption that the Reynolds stress becomes almost zero and the shear stress almost vanishes there. In addition to the momentum equations and continuity equation, we employ the diffusion/dispersion equation of suspended sediment, and the continuity equation of sediment (Exner equation).

The unknown variables in the problem are four: the velocity, the layer thickness, the layer-averaged suspended sediment concentration, and the bed elevation. The governing equations are the layer-averaged momentum and continuity equations, the layer-averaged diffusion/dispersion equation of suspended sediment, and the continuity equation of sediment (Exner equation). The boundary conditions for this problem are that the momentum has to be continuous before and after each hydraulic jump. More specifically, the velocity and the layer thickness have to satisfy the jump condition before and after each jump. In addition, the suspended sediment concentration has to be continuous at the jump.

We solve the problem numerically, and obtain the wavelengths of steps. The wavelength of a long-run out turbidity current is determined by the thickness of the high-concentration layer near the bottom. It is shown that the wavelengths obtained in the analysis agree relatively well with the observation.

Keywords: cyclic steps, turbidity currents, submarine bedform

©2019. Japan Geoscience Union. All Right Reserved.

Is surface sediment remobilization more popular mechanism for generating earthquake-induced turbidity current? Evidence of radiocarbon dates from the westernmost Nankai and Japan Trench subduction zones

*Ken Ikehara[1], Toshiya Kanamatsu[3], Tobias Schwestermann[2], Arata Kioka[2], Michael Strasser[2]

1. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology, 2. Universität Innsbruck, 3. Japan Agency for Marine-Earth Science and Technology

Deep-sea turbidite has been used for reconstructing past large earthquake history. Surface sediment remobilization is a relatively new idea for generating earthquake-induced turbidite, although submarine landslide has been considered as major mechanism for earthquake-induced turbidite deposition. Surface sediment remobilization has been reported from the Chilean lakes, forearc slopes along the Nankai and Japan Trench subduction zones. However, the detailed mechanism of surface sediment resuspension, remobilization and initiation of turbidity current is still unknown. For better understanding of the mechanism, it is important to understand the spatio-temporal occurrence of surface sediment remobilization. We obtained some cores from a small basin on the forearc slope in Hyuga-nada off Kyushu, and the Japan Trench floor. Fine-grained turbidites were found in the cores. Paired radiocarbon dates of the turbidite muds and hemipelagic muds between the turbidites show only small age differences. This indicates that it is unnecessary to occur bathymetry-scale (with >several meters bathymetric change) submarine landslides by earthquake ground shaking for generation of the turbidites. Large surface sediment resuspension by earthquake ground shaking at the sedimented slope near the depositional area (basin) is thought to be an important process for repeated deposition of earthquake-induced turbidites in the basin.

Keywords: surface sediment remobilization, turbidite, earthquake, radiocarbon dating

©2019. Japan Geoscience Union. All Right Reserved.

Shallow-subsurface event stratigraphy along the hadal trench axis of the Japan Trench

*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], M. Strasser[1,4]

1. Universität Innsbruck, Austria, 2. GSJ-AIST, Japan, 3. JAMSTEC, Japan, 4. MARUM-U. Bremen, Germany

The giant AD 2011 Tohoku-oki earthquake has been documented to remobilize a wide area of surface sediment, redistributing from the slope into the >7 km deep Japan Trench forming distinct event deposits in hadal terminal basins (Ikehara et al., 2016; Kioka et al., 2019). Other than the 2011 earthquake, similarly large earthquakes are historically known along the Japan Trench, and respective deposits have been described in recent studies from cores retrieved from the Japan Trench (Ikehara et al., 2016). Yet, little is understood about (i) the temporal and spatial distribution of event deposits along the entire trench axis, (ii) how the spatial extent may link to the rupture area of historically-reported earthquakes, and (iii) whether older deposits may indicate prehistoric large earthquakes along the Japan Trench. We herein study dm-scale vertical resolution subbottom profiler data acquired during 2012–2018 using PARASOUND and TOPAS recording systems installed on R/Vs Sonne and Shinsei-Maru over the entire Japan Trench area (36.0˚–40.5˚N), in order to investigate the event-stratigraphic distribution of acoustically-transparent layers that represent sediment remobilization event deposits. The subbottom profiler data generally record well up to ~40 m below the seafloor. Transparent bodies of the upper ~10 m correlate well to event layers reported from sediment cores linked to major historic earthquake such as the AD 2011 Tohoku-oki, AD 1454 Kyotoku, and AD 869 Jogan events. Mapping of these event deposits in the spatially-extensive subbottom profiler data allows to study the spatial distribution of these events and its comparison to their reconstructed rupture areas. Furthermore, the lower part of the hitherto only acoustically-imaged stratigraphic succession of isolated trench-floor basins along the Japan Trench also documents several thick acoustically-transparent bodies. Preliminary interpretation suggests several of the bodies could be event deposits triggered by old large earthquakes. While ground-truth of this interpretation and absolute dating requires long coring efforts in the ultra-deep Japan Trench, our study yields relative stratigraphic information and quantitative constraints of along strike variation of sediment volumes redistributed by episodic events along the Tohoku seismogenic margin.

Keywords: Japan Trench, Hadal zone, Event deposit, Bathymetry, Subbottom profiler (SBP)

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-CG Complex & General

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 301B 3F

[H-CG27] Turbidity current: from triggers for the generation to the depositional and morphologic al processes

convener:Miwa Yokokawa(Osaka Institute of Technology), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Norihiro Izumi(Faculty of Engineering, Hokkaido University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Chairperson:Hajime Naruse(Kyoto University), Ken Ikehara(AIST)

Recent developments of field observation, physical and numerical experiments, and mathematical analysis have brought us a better understanding of the dynamics of turbidity currents and relevant morphology and bedforms. Applying new findings to rock records, more profound understanding of turbidites have been achieved. It has been found that different triggers and/or sources generate distinctive features of turbidity currents, resulting in various appearances of rock records and morphology. The integration of such new knowledge on turbidity currents is important not only from scientific but also practical points of view, such as assessments of natural hazards, and exploration of resources. This international session welcomes all kinds of approaches for the turbidity currents such as field observation, physical and numerical experiments, mathematical analysis, and studies from rock records.

10:45 AM - 11:07 AM JST | 1:45 AM - 2:07 AM UTC

[HCG27-07] Canyon changes caused by an earthquake-triggered turbidity current in the 2016 M7.8 Kaikōura Earthquake, New Zealand

★Invited Papers

*Joshu J Mountjoy[1], Jamie D Howarth[2], Alan R Orpin[1], Philip M Barnes[1], David A Bowden[1], Ashley A Rowden[1], Alexander C. G. Schimel[1], Caroline Holden[3], Huw J Horgan[2], Scott D Nodder[1], Jayson R Patton[4], Geoffroy Lamarche[1,5], Matt Gerstenberger[3], Aaron Micallef[6], Arne Pallentin[1], Tim Kane[1] (1.NIWA, Wellington. New Zealand, 2.VUW, Wellington. New Zealand, 3.GNS Science, Lower Hutt. New Zealand, 4.HSU, Arcata CA. USA, 5.UoA, Auckland. New Zealand, 6.UoM, Msida. Malta)

11:07 AM - 11:29 AM JST | 2:07 AM - 2:29 AM UTC

[HCG27-08] Far More Prolonged Deep-sea Turbidity Currents triggered by typhoon and earthquake in the Gaoping Submarine Canyon

★Invited Papers

*Yanwei Zhang[1], Zhifei Liu[1], Yulong Zhao[1], Xiaodong Zhang[1] (1.Tongji University)

11:29 AM - 11:51 AM JST | 2:29 AM - 2:51 AM UTC

[HCG27-09] Filling the gap between turbidity current processes and products in British Columbia fjords

★Invited Papers

*Sophie Hage[1,2,3] (1.School of Ocean and Earth Sciences, University of Southampton, United Kingdom, 2.National Oceanography Centre Southampton, United Kingdom, 3.Department of Geography, Durham University, United Kingdom)

11:51 AM - 12:13 PM JST | 2:51 AM - 3:13 AM UTC

[HCG27-10] Sediment transfer from shelf to abyss through giant ganyons and valleys system in deep-sea carbonate slopes (Bahamas)

★Invited Papers

*Thierry Mulder[1], Hervé Gillet[1], Vincent Hanquiez[1], Audrey Recouvreur[1], Kelly Fauquembergue[1], Johan Le Goff[2], John J.G. Reijmer[2], Emmanuelle Ducassou[1], Margot Joumes, Thibault Cavailhes[1], Elsa Tournadour[5], Jean Borgomano[3], Emmanuelle Poli[4] (1.University of Bordeaux, UMR CNRS 5805 EPOC, Allée Geoffroy Saint Hilaire, Pessac, France, 2.King Fahd Univ. of Petroleum. and Minerals, Dhahran, Saudi

Arabia., 3.Aix Marseille University, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France., 4.Total, CSTJF, avenue Larribau, Pau, France, 5.Ifremer, Centre de Brest, Plouzané)

12:13 PM - 12:15 PM JST | 3:13 AM - 3:15 AM UTC

Discussion

Canyon changes caused by an earthquake-triggered turbidity current in the 2016 M7.8 Kaikōura Earthquake, New Zealand

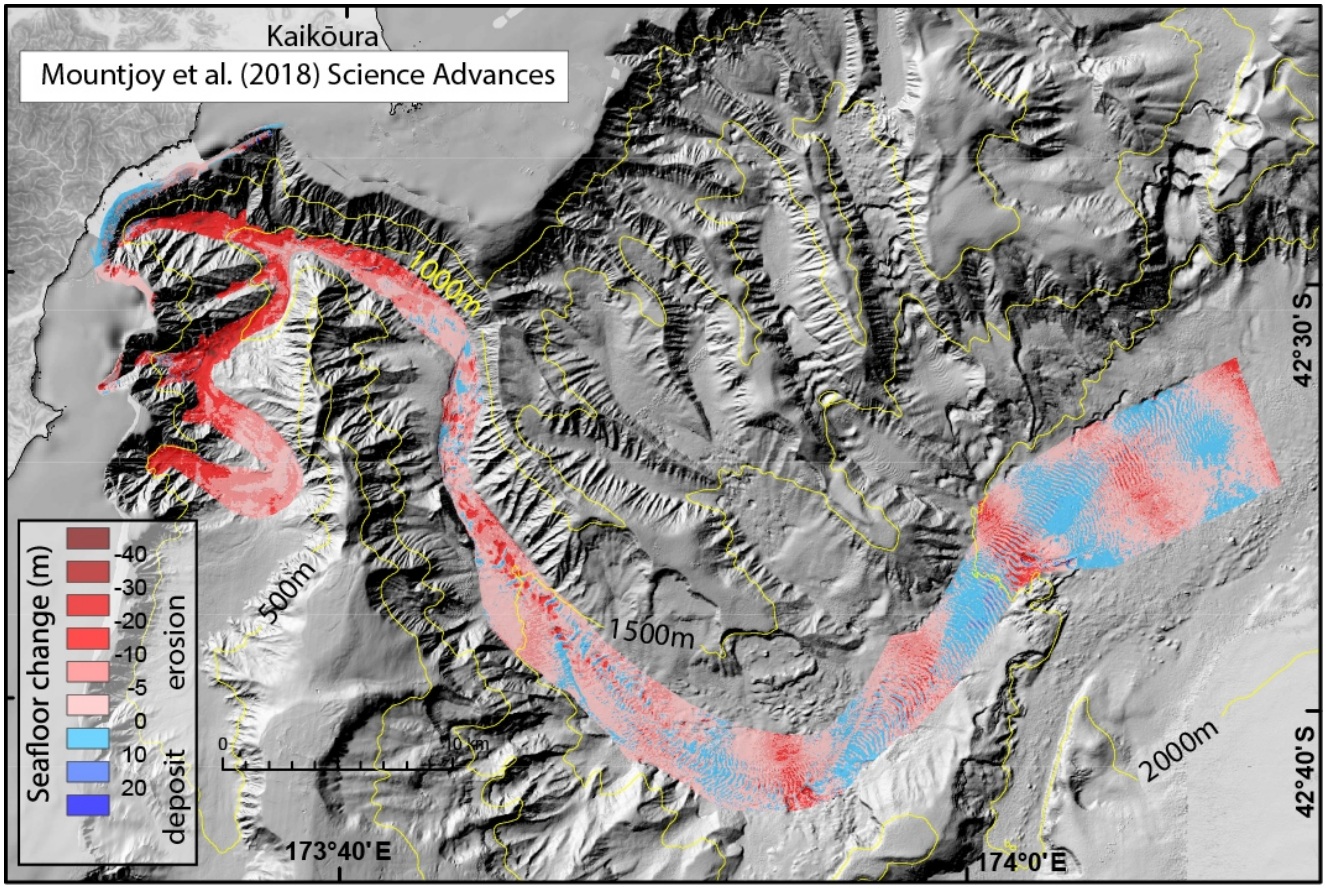
*Joshu J Mountjoy[1], Jamie D Howarth[2], Alan R Orpin[1], Philip M Barnes[1], David A Bowden[1], Ashley A Rowden[1], Alexander C. G. Schimel[1], Caroline Holden[3], Huw J Horgan[2], Scott D Nodder[1], Jayson R Patton[4], Geoffroy Lamarche[1,5], Matt Gerstenberger[3], Aaron Micallef[6], Arne Pallentin[1], Tim Kane[1]

1. NIWA, Wellington. New Zealand, 2. VUW, Wellington. New Zealand, 3. GNS Science, Lower Hutt. New Zealand, 4. HSU, Arcata CA. USA, 5. UoA, Auckland. New Zealand, 6. UoM, Msida. Malta

Based on repeat seafloor measurements and samples we show that the M_w 7.8 November 2016 Kaikōura earthquake (New Zealand) triggered widespread landslides in a large-scale bedrock submarine canyon. These landslides initiated a powerful “canyon-flushing” event and turbidity current that travelled > 680 km along one of the world’s longest deep-sea channels, the Hikurangi Channel. To our knowledge these observations provide the first direct quantification of seafloor landscape change and large-scale sediment transport associated with an earthquake-triggered full canyon flushing event. Our results augment observations from smaller scale turbidites confined to large submarine canyons (e.g. repeat surveying in Monterey Canyon) that move stored material within canyons but do not export sediment to the deep ocean or erode into underlying substrate. The inter-event period for the Kaikōura Canyon flushing event, calculated from back analysis of triggering strong ground motion, is ~140 years. Combined with observed erosion into bedrock this indicates a canyon incision rate of 40 mm y^{-1}, substantially higher than most terrestrial rivers. Significant geomorphic change occurred within the canyon including erosion up to 60m depth in the upper canyon, scour hole formation, and down canyon movement of mega-scale bedforms constructed of gravel-boulder sized sediments. The event synchronously transferred 850 Mt of sediment and 7 Mt organic carbon to the deep ocean. Our observations demonstrate that earthquake-triggered canyon flushing is a primary driver of submarine canyon development and material transfer from active continental margins to the deep ocean.

Keywords: submarine canyon, earthquake, multibeam bathymetry, submarine landslide, seafloor erosion

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Far More Prolonged Deep-sea Turbidity Currents triggered by typhoon and earthquake in the Gaoping Submarine Canyon

*Yanwei Zhang[1], Zhifei Liu[1], Yulong Zhao[1], Xiaodong Zhang[1]

1. Tongji University

Submarine turbidity currents are argued to deliver more sediment along their long-runout propagation than other dynamic processes from shelf to deep sea. The *in situ* temporal and spatial features of turbidity currents are urgently required for a better quantitative constraints on sediment transport and deposition in the deep sea. Here, we document yearlong direct monitoring of turbidity currents in the middle reach at a water depth of 1265 m and the lower reach at 2425 m on the margin of the Gaoping Submarine Canyon off Taiwan, which has the wettest typhoons and active earthquakes. Both the two moorings (~35 km apart) were equipped with sediment traps and various sensors to collect particles consecutively with 18 days interval and to record velocity, sediment concentration, temperature and salinity with 20 min interval. Seven turbidity currents are identified consistently at these two reaches with enhanced sediment flux, which was recorded by a time-series sediment trap at 30 m above the seafloor. By combining the atmospheric measurements and earthquake data, four turbidity currents are triggered by the four powerful typhoons crossed Taiwan during typhoon season in boreal summer 2015, and one event is attributed to the M_L 6.5 Kaohsiung earthquake in southern Taiwan in February 2016. The two types of turbidity currents associated with individual typhoon and earthquake show a sustained duration ranging from 9 to 41 days, far more prolonged than the longest documented deep-sea turbidity currents (~10 days) in other locations. The flow velocity observed on the margin (~0.2 m/s) is much weaker than that in the thalweg of the canyon (> 5.8 m/s) inferred from the break of cables. For the first time, our observation provides the variability of the timing and hydrographic properties of the turbidity currents triggered by individual mechanisms for better constraints on flow capacity and sediment redistribution.

Keywords: in situ mooring observation, prolonged turbidity currents, typhoon and earthquake

©2019. Japan Geoscience Union. All Right Reserved.

Filling the gap between turbidity current processes and products in British Columbia fjords

*Sophie Hage[1,2,3]

1. School of Ocean and Earth Sciences, University of Southampton, United Kingdom, 2. National Oceanography Centre Southampton, United Kingdom, 3. Department of Geography, Durham University, United Kingdom

Turbidity currents are one of the volumetrically most important processes to transfer sediments from land to sea. Fast-moving, powerful turbidity currents can damage seafloor infrastructure and carve submarine channels. These submarine channels feed deep sea fans, which are the largest sediment accumulations on Earth. Such huge sediment accumulations sequester organic carbon over geologic timescales and are thus thought to play a role in the global carbon cycle. Despite the global significance of turbidity currents, the link between flow processes (e.g. triggering mechanisms, seafloor erosion) and depositional products is still poorly constrained. This lack of knowledge is mainly due to the difficulty to monitor flows and to directly sample the associated deposits to these flows. Here we present direct observations of turbidity currents and their deposits in two Canadian fjords: Howe Sound and Bute Inlet in British Columbia. As these two fjords are connected at their head to glacier-fed rivers, they are excellent sites to study the transport and fate of particles from land to submarine sites. Using these new observations, this talk will cover three research themes: 1) How do dilute river plumes generate turbidity currents? 2) What is the depositional architecture/facies resulting from supercritical turbidity currents and crescentic bedforms? 3) How are organic carbon mixtures distributed in turbidites and what are the implications for the carbon cycle?

Keywords: turbidity current, turbidite, organic carbon, crescentic bedforms

©2019. Japan Geoscience Union. All Right Reserved.

Sediment transfer from shelf to abyss through giant ganyons and valleys system in deep-sea carbonate slopes (Bahamas)

*Thierry Mulder[1], Hervé Gillet[1], Vincent Hanquiez[1], Audrey Recouvreur[1], Kelly Fauquembergue[1], Johan Le Goff[2], John J.G. Reijmer[2], Emmanuelle Ducassou[1], Margot Joumes, Thibault Cavailhes[1], Elsa Tournadour[5], Jean Borgomano[3], Emmanuelle Poli[4]

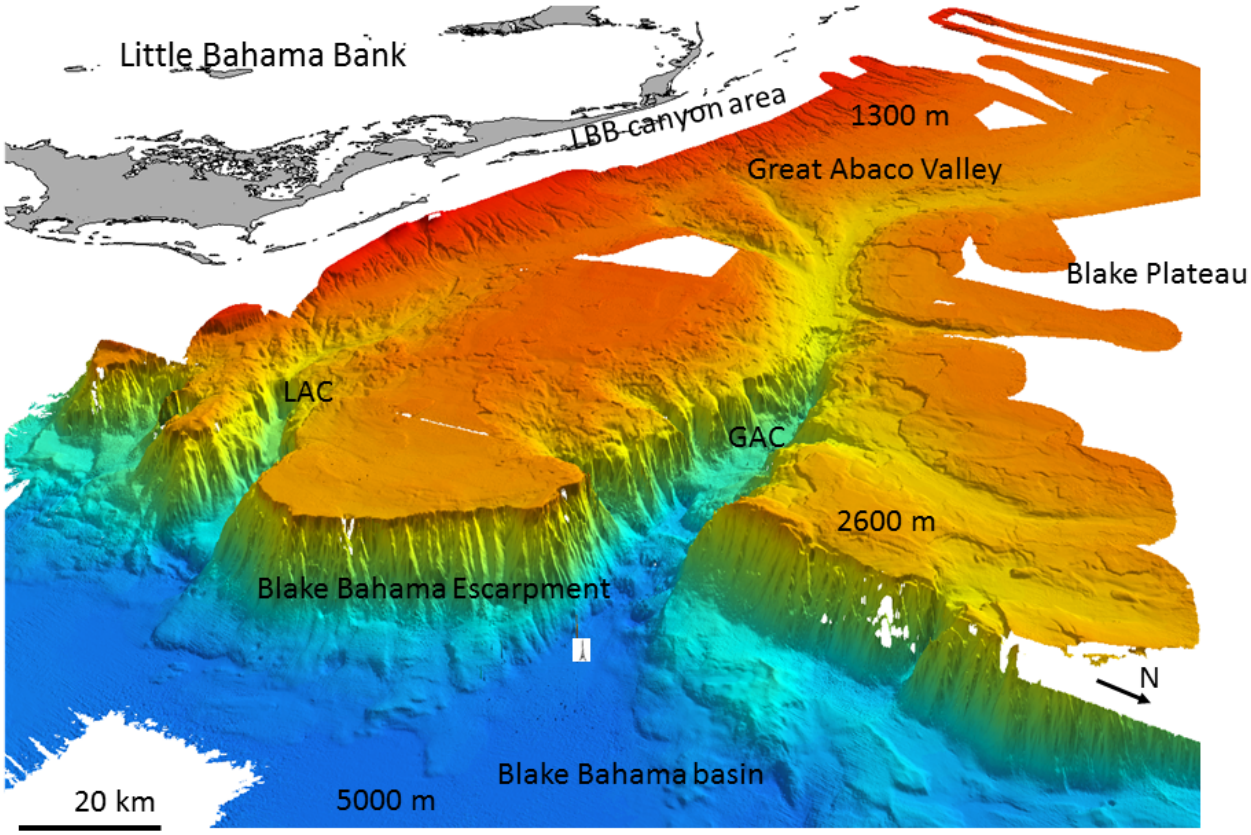
1. University of Bordeaux, UMR CNRS 5805 EPOC, Allée Geoffroy Saint Hilaire, Pessac, France, 2. King Fahd Univ. of Petroleum. and Minerals, Dhahran, Saudi Arabia., 3. Aix Marseille University, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France., 4. Total, CSTJF, avenue Larribau, Pau, France, 5. Ifremer, Centre de Brest, Plouzané

Bahamas are one of the rare present-day study areas in the world that allows to understand carbonate particle transfer from platform to deep-sea. A lot of ancient (DSDP/ODP, Bacar cruises) and recent (Carambar Cruises) dataset have been collected from 30 m to 5,000 m water depth. It includes high-resolution multibeam mapping, backscatter imaging, very-high resolution seismics and gravity cores. These new high-resolution data expose in great details the deep-water sedimentary system in the southern part of Exuma Sound (ES) and the northern part of Little Bahama Bank (LBB, Bahamas). The data reveal the detailed and complex morphology of giant valleys like the Great and Little Abaco canyons (GAC and LAC) along the LBB slope, the Great Bahama Canyon between LBB and Eleuthera Island, being the deepest canyon in the world, and the Exuma Valley/Canyon in the ES area. In all cases, present-day off-bank transport is initiated by two ways: (1) When a cold atmospheric front occurs, high-density, cold surface water sinks and entrains fine-grained particles through density cascading. This process is at the origin of the deposition of the Holocene Prograding Wedge that began to form 13.6 ka ago with a maximum growing at 4 ka when the platform was flooded. (2) During hurricanes when the fine-grained particles deposited on the shelf are resuspended and pushed off the platform through tidal passes. There, acceleration of tidal currents generates tidal flushing. On the LBB smooth slopes, coarse-grained particles (ooids and bioclasts) are trapped in tidal deltas and only fine-grained carbonate particles reach the upper slope. In Exuma area, steeper slopes allow transfer of coarse-grained particles that reach the ES slope and finally supply coarse-grained (bioclasts-rich) turbidity currents and concentrated/hyperconcentrated flows that are channeled down to the Atlantic Abyssal Plain though giant valleys. Along the valley, they form classical spill-over levee deposits. Four of these large valleys extending parallel to the shelf are presented. They all probably extend along structural directions. In GAC, finely-grained sediments originate essentially from the canyon flanks, driven by sediment slides as well as many secondary slope gullies and smaller tributaries. In LAC, gullies directly drain the upper LBB slope providing coarser particles. In the Exuma Valley/Canyon, a part of the material comes from the slope of adjacent islands and cays through small-scale gravity processes and mass failures. A substantial part of the sediments also originate from along-slope sediment flow erosion. In all areas, the valleys abruptly turn into deep canyons incising the Bahama Escarpment (BE). The canyons link the LBB and ES sedimentary systems to the deep abyssal plain of the Western North Atlantic where water depth exceeds 5,000 m. The transition occurs through major knickpoints with outsized chutes exceeding several hundred of meters in height. The sudden transformation from a wide valley to a deep narrow canyon occurs as a result of flow erosion of the underlying lower Cretaceous carbonate platform stack. Huge hydraulic jumps as well as enormous and permanent plunge pools and related deposits were identified at the transition. Dissolution processes in the carbonate deposits may also play a part in the formation of theses outsized plunge pools. In ES, the high kinetic flow energy constrained by narrow and deeply incised canyon formed a wide fan-shaped channel-levee complex on the abyssal plain. The latter is made up of coarse-grained carbonate turbidites and concentrated density-flow deposits that are mixed with fine-grained siliciclastics transported along

©2019. Japan Geoscience Union. All Right Reserved.

the BE by the energetic Western Boundary Undercurrent. Conversely the canyon mouth of the LBB system only reveals a small channeled lobe. Seismic data on this system at water depth > 4500 show the distalmost deposits are younger than mid-Miocene, suggesting that the activity of the canyon is very recent.

Keywords: Turbidity currents, Carbonate slope, giant canyons, Bahamas, Plunge pools



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-SS07] Rigorous Seismicity Modelling and Hypothesis Testing

convener:Jiancang Zhuang(Institute of Statistical Mathematics), Danijel Schorlemmer(GFZ German Research Centre for Geosciences), Matt Gerstenberger(GNS Science), Hiroshi Tsuruoka(Earthquake Research Institute, Tokyo Univ.), Chairperson:Matthew Gerstenberger(GNS Science, New Zealand), Danijel Schorlemmer(GFZ-Potsdam, Germany)

Probabilistic models have been developed for describing, analyzing, and forecasting seismicity since more than 100 years and, with the advent of large-scale digital networks, in high resolution during the last 30 years. These models include recurrence and stress-release models for long-term earthquake hazard assessment, and short-term models describing earthquake clustering, e.g. the ETAS model. Some models have become standard tools in seismic hazard assessment. However, the overall probabilities remain on the low end and the uncertainties of the forecasts are not well described. Rigorous data-based development and testing of models will help further improving forecasting power and accuracy of these models. Similarly, new hypotheses shall be evaluated rigorously using some existing model as the null hypothesis model or in dedicated tests addressing the hypothesis directly. In this context, the Collaboratory for the Study of Earthquake Predictability and its Japan branch provides the necessary testing capabilities for rigorous and unbiased evaluation of models and hypotheses. This session focuses on research that increases information on seismicity, being with respect to a reference model or as an independent hypothesis. We solicit contributions of model developments and hypothesis formulation based on the increased understanding of the physical process of earthquakes, such as the preparation and rupture processes of the earthquake source and the interaction between earthquakes and tectonic environments. We also welcome development and implementation of improved statistical methods for testing and validating physical hypotheses based on observed data. In particular, we welcome contributions about model- or hypothesis-test experiments that could be implemented in the Japan testing center.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS07-01] Improving medium-term earthquake forecasts by compensating the EEPAS model for the time-lag

★Invited Papers

David Rhoades[1], Christophersen Annemarie[1], *Matt Gerstenberger[1] (1.GNS Science)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS07-02] Earthquake probability forecast incorporating non-seismic data

*Peng Han[1], Jiancang Zhuang[2], Yosihiko Ogata[2], Katsumi Hattori[3] (1.Southern University of Science and Technology, Shenzhen, China, 2.The Institute of Statistical Mathematics, Tokyo, Japan , 3.Chiba University, Chiba, Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS07-03] Extended versions of the space-time ETAS model and application to the 2016 Kumamoto earthquake sequence

★Invited Papers

*YICUN GUO[1], Jiancang Zhuang[1], Yosihiko Ogata[1] (1.The Institute of Statistical Mathematics, Tokyo, Japan)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS07-04] CSEP Japan results and future developments

*Naoshi Hirata[1], Hiroshi Tsuruoka[1], Danijel Schorlemmer[3], Jiancang Zhuang[2] (1.Earthquake Research Institute, the University of Tokyo, 2.Institute of Statistical Mathematics, 3.GFZ German Research Centre for Geosciences)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS07-05] From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

★Invited Papers

*Kuo-Fong Ma[1,2,3], Mingshen Yen[1], Yiwun Liao[1], Henyi Su[2] (1.Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC, 2.Department of Earth Sciences, National Central University, Taiwan, ROC, 3.Institute of Earth Sciences, Academia Sinica, Taiwan, ROC)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS07-06] **High resolution space-time models forecasting 3D seismicity beneath the Greater Tokyo Area**

★Invited Papers

*Yosihiko Ogata[1,2], Koichi Katsura, Hiroshi Tsuruoka[2], Naoshi Hirata[2] (1.Research Organization of Information and Systems, The Institute of Statistical Mathematics, 2.Earthquake Research Institute, The University of Tokyo)

Improving medium-term earthquake forecasts by compensating the EEPAS model for the time-lag

David Rhoades[1], Christophersen Annemarie[1], *Matt Gerstenberger[1]

1. GNS Science

The “Every Earthquake a Precursor According to Scale” (EEPAS) model treats every earthquake as a precursor of larger earthquakes to follow it in the medium term. Each earthquake contributes a transient increment to the expected rate of earthquake occurrence in its vicinity, based on empirical predictive scaling relations associated with the precursory scale increase phenomenon. Incomplete information on precursory earthquakes causes the EEPAS model to under-predict the expected number of earthquakes when forecasting across a time-lag. We modify EEPAS to compensate for the time-lag when calculating future forecasts. Given a set of model parameters, the completeness of precursory information can be expressed as a function of the target earthquake magnitude and the time-lag. The EEPAS model has a time-varying component and a background component. We consider two end-members for compensating the model for incompleteness: one entirely in the background component, and the other entirely in the time-varying component. We estimate an optimal mixture of these two end-members for time-lags out to 12 years using several different versions of the EEPAS model and subsets of the New Zealand earthquake catalogue to which EEPAS was previously fitted. Performance is checked on an independent test period. The optimal compensated model having increasingly high information gains over the original EEPAS model with increasing time-lags. Using catalogue data complete to 2018, the compensated models forecast increased annual probabilities of earthquake occurrence above magnitude thresholds from 6.0 to 8.0 in central New Zealand in the period 2019-2030 relative to the preceding period 2008-2018.

Keywords: earthquake forecasting, EEPAS, hypothesis testing, New Zealand

©2019. Japan Geoscience Union. All Right Reserved.

Earthquake probability forecast incorporating non-seismic data

*Peng Han[1], Jiancang Zhuang[2], Yosihiko Ogata[2], Katsumi Hattori[3]

1. Southern University of Science and Technology, Shenzhen, China, 2. The Institute of Statistical Mathematics, Tokyo, Japan , 3. Chiba University, Chiba, Japan

This study aims to develop statistical models for earthquake temporal occurrences based on both earthquake catalogs and other geophysical observations. As an example, the seismomagnetic signals at Kakioka (KAK) station are utilized to illustrate the modeling strategies, because previous studies suggest they might contain certain precursory information of local sizable earthquakes. Self-exciting, external-exciting, and combined models modified from Ogata’ s LIN-LIN algorithm have been applied to forecast the occurrences of M>4.05 earthquakes within 100 km from the KAK station. The self-exciting and external-exciting models perform significantly better than the Poisson Model, implying there are explanatory power in earthquake catalogs and magnetic anomalies, respectively. The combined model, which integrates information from catalogs and magnetic observations, is greatly superior to any of the other three models. Additional tests show that external exciting component derived from the magnetic data is not post-seismic in character, and is more likely to cooperate with large earthquakes. The combined model proposed in this study could also be useful to incorporate other non-catalog observations and may have potential value in improving Time-dependent hazard maps for operational forecasting.

Keywords: Probabilistic forecasting, Seismomagnetic, Modelling and interpretation, Japan

©2019. Japan Geoscience Union. All Right Reserved.

Extended versions of the space-time ETAS model and application to the 2016 Kumamoto earthquake sequence

*YICUN GUO[1], Jiancang Zhuang[1], Yosihiko Ogata[1]

1. The Institute of Statistical Mathematics, Tokyo, Japan

We proposed an extended version of the space-time ETAS model which simultaneously incorporates focal depths and rupture geometries of large earthquakes. The depth component is decoupled from earthquake hypocenters and assumed to follow the Beta distribution. This 3D-hypocenter finite-source ETAS model is applied to the 2016 Kumamoto earthquake sequence. Results from other versions of ETAS models are also obtained as comparisons. To model the dynamically triggered seismicity in Yufuin-Beppu region, an extended source which is more than two times' length of the ruptured fault of the Kumamoto mainshock is taken as its triggering source. Our results show that about 11.2% of the total seismicity is the background rate. Within the triggering source of mainshock, proportions of earthquakes being recognized as direct aftershocks of two foreshocks and the mainshock are 3.6%, 2.7%, and 23.3%, respectively. The reconstructed patterns of aftershock productivity show significant migrations in space and time. In near field (10km from slip > 1m areas), the decay of aftershock productivity follows an inverse power law of distance, verifying that aftershocks occur as an effect of stress changes imparted by the mainshock. Areas of high aftershock productivity form complementary patterns for coseismic slips, meaning that aftershocks contribute to the postseismic relaxation process.

Keywords: ETAS model, aftershock productivity, dynamic triggering

©2019. Japan Geoscience Union. All Right Reserved.

CSEP Japan results and future developments

*Naoshi Hirata[1], Hiroshi Tsuruoka[1], Danijel Schorlemmer[3], Jiancang Zhuang[2]

1. Earthquake Research Institute, the University of Tokyo, 2. Institute of Statistical Mathematics, 3. GFZ German Research Centre for Geosciences

An earthquake predictability experiment based on the Collaboratory for the Study of Earthquake Predictability (CSEP) had started in Japan in November 2009 and ten years have passed. In Japan, three test regions and four testing classes were set up, and more than 160 models are evaluated at the Japan test center operated by Earthquake Research Institute.

Tohoku-oki earthquake occurred immediately after the start of the experiment, and the results of the model’ s forecast were not good, but after that there was a recovery trend. However, it was also found that the model performance improved by model modification considering the influence of the Tohoku-oki earthquake. We also found that the forecast of the number of earthquakes is relatively difficult in many models.

Evaluation of the forecast result is carried out by N-test, M-Test, S-Test, L-test which are the CSEP standard tests, but for comparison between models, log likelihood and information gain (or probability gain) is direct and effective.

Ten years have passed since the experiment was started, testing center hardware replacement are required and some models are required modification about dimension of array according to increase of learning data. In addition, test classes in the current experiment forecasting magnitude 4 or 5 are set, it is necessary to set test classes to forecast larger magnitude such as 6 or 7.

Keywords: Earthquake Predictability, CSEP

©2019. Japan Geoscience Union. All Right Reserved.

From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

*Kuo-Fong Ma[1,2,3], Mingshen Yen[1], Yiwun Liao[1], Henyi Su[2]

1. Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC, 2. Department of Earth Sciences, National Central University, Taiwan, ROC, 3. Institute of Earth Sciences, Academia Sinica, Taiwan, ROC

Historically, significant crustal damaging earthquakes in Taiwan mostly were from complicated fault system rather than from a single fault segment, which was not incorporated in the seismic hazard analysis of TEM PSHA2015, but, included in current developed new seismic hazard map of TEM PSHA2019. The 1906 M7.1 Meishan earthquake, recently, had been resolved to be from a fault system of blind NE strike thrust with EW surface breaching fault (one of the identified seismogenic structures). And, the 1935 M7.1 was occurred with bilateral rupture from a blind fault to strike-slip mechanism to the south and thrusting mechanism to the north. We employed the rupture kinematic modeling to the historical geodetic data with comparison to the intensity pattern to understand the possible involvement of the fault system. In addition to the damaging earthquakes from seismic active region, an ancient 1604 M7.5-M8.0 Quanchao damaging Earthquake in southeastern coast China region was also explored from literature intensity to understand the seismic potential of less seismic active regime in Taiwan strait. These historical and past events suggest that a single fault segment evaluation for seismic hazard might be inadequate. But, we have not yet had solution to solve this inadequacy to pin down the partition of slip rate within an identified fault system. We examined the fault rupture system from kinematic and dynamic modeling of the historical events, and examined the possible partition in slip rate for the fault segments in this identified fault system. We, further then compare its influence to the estimation of seismic hazard analysis. For development in PSHA and its application, we suggest the importance of resolving historical damaging earthquakes from modern developed seismology to seismic hazard assessment and risk management.

Keywords: fault system, seismic hazard analysis

©2019. Japan Geoscience Union. All Right Reserved.

High resolution space-time models forecasting 3D seismicity beneath the Greater Tokyo Area

*Yosihiko Ogata[1,2], Koichi Katsura, Hiroshi Tsuruoka[2], Naoshi Hirata[2]

1. Research Organization of Information and Systems, The Institute of Statistical Mathematics, 2. Earthquake Research Institute, The University of Tokyo

We propose an extended 3D epidemic-type aftershock sequence (ETAS) models of longitude, latitude and depth for short-term forecasts beneath the Metropolitan area (south Kanto region), Japan; this model also takes account of the induced effects by the 2011 Tohoku-Oki earthquake of magnitude 9.0 (M9). Specifically, we use some location-dependent coefficients in the 3D space; which is called as a hierarchical model. Similarly, we consider 3D location-dependent b-value for the Gutenberg-Richter law. In such modeling, we use linear interpolation on each of the 3D Delaunay tetrahedra of the hypocenters to estimate high resolution images in zones where hypocenters are dense. Based on the hypocenter catalog for a century period, we solve the location dependent parameters including the background seismicity rates, the self-exciting (aftershock) productivity rates, and the M9 induced productivity rate. The optimally inverted 3D spatial images of such characteristic parameters represent quite informative seismicity patterns such as in shallow crust and on the surface of subducting plates. In particular, the location-dependent external triggering factor shows the zones where the induced effect took place intensely by the M9 earthquake beneath the region.

Keywords: Akaike Bayesian Information Criterion (ABIC), Earthquake forecast, Extended 3D hierarchical space-time ETAS model, Induced seismicity, Tohoku-Oki Earthquake of M9

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Anselme Borgeaud, Taku Tsuchiya

Recent observational and experimental investigations have significantly advanced our understanding of the structure and constituent materials of the deep Earth. Yet, even fundamental properties intimately linked with formation and evolution of the planet, such as details of the chemical heterogeneity in the mantle and light elements dissolved in the core, remained unclear. Seismological evidence has suggested a vigorous convection in the lower mantle, whereas geochemistry has suggested the presence of stable regions there that hold ancient chemical signatures. The amounts of radioactive isotopes that act as heat sources and drive dynamic behaviors of the deep Earth are also still largely unknown. We provide an opportunity to exchange the achievements and ideas, and encourage persons who try to elucidate these unsolved issues of the core-mantle evolution using various methods, including high-pressure and high-temperature experiments, high-precision geochemical and paleomagnetic analyses, high-resolution geophysical observations, geo-neutrino observations, and large-scale numerical simulations. Papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community are also welcomed.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT21-01] The role of stishovite as a deep nitrogen carrier indicated from high-pressure and high-temperature experiments

*Ko Fukuyama[1], Hiroyuki Kagi[1], Toru Inoue[2,3], Toru Shimei[3], Sho Kakizawa[3], Shunichi Hishita[4], Yuji Sano[5], Naoto Takahata[5] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 3.Geodynamics Research Center, Ehime University, 4.National Institute for Materials Science, 5.Atmosphere and Ocean Research Institute, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT21-02] 3-D P- and S-velocity structure of the D″ layer beneath Central America and the Caribbean using waveform inversion

★Invited Papers

*Anselme F. E. Borgeaud[1,2], Kenji Kawai[1], Robert J. Geller[1] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Institute of Earth Sciences, Academia Sinica)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT21-03] Uniaxial deformation experiments of bridgmanite using D-111 type high pressure apparatus

★Invited Papers

*Noriyoshi Tsujino[1], Daisuke Yamazaki[1], Yu Nishihara[2] (1.Institute for Planetary Materials, Okayama University, 2.Geodynamics Research Center, Ehime University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT21-04] Waveform inversion for 3D anisotropic structure in D″ beneath the Northern Pacific: Constraints on mineralogy and flow in the lowermost mantle

*Yuki Suzuki[1], Kenji Kawai[1], Robert J. Geller[1] (1.Department of Earth and Planetary Sciences, School of Science,The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT21-05] Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

*Sho Kakizawa[1], Toru Inoue[1,2,3], Ryotaro Abe[1], Minami Kuroda[4], Naoya Sakamoto[5], Hisayoshi Yurimoto[4,5,6] (1.Geodynamics Reseach Center, Ehime University, 2.Graduate School of Science, Hiroshima University, 3.Hiroshima Institute of Plate Convergence Region Research, 4.Graduate School of Science, Hokkaido University, 5.Creative Research Institution, Hokkaido University, 6.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SIT21-06] Origin and role of lost continents

*Shigenori Maruyama[1], Kenji Kawai[2], Steeve Gréaux[3], Taku Tsuchiya[3], Dapeng Zhao[4] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, School of Science, University of Tokyo, 3.Ehime University, 4.Department of Geophysics, Tohoku University)

The role of stishovite as a deep nitrogen carrier indicated from high-pressure and high-temperature experiments

*Ko Fukuyama[1], Hiroyuki Kagi[1], Toru Inoue[2,3], Toru Shimei[3], Sho Kakizawa[3], Shunichi Hishita[4], Yuji Sano[5], Naoto Takahata[5]

1. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 3. Geodynamics Research Center, Ehime University, 4. National Institute for Materials Science, 5. Atmosphere and Ocean Research Institute, The University of Tokyo

Nitrogen occupies about 80% in the Earth's atmosphere and is one of essential elements of life. For these reasons, nitrogen is an important volatile element in various aspects of geoscience, including climates (e.g. Goldblatt et al., 2009; Wordsworth and Pierrehumbert, 2013) and the origin of life. However, we couldn't have still understood details of behavior or cycle of nitrogen in the Earth's interior. For example, it is known that the amount of nitrogen in deep Earth is more depleted than that of other volatile elements (Marty, 2012). This is called "missing" nitrogen and suggested to be caused by nitrogen stored in the upper mantle, the mantle transition zone, and the lower mantle through magma ocean from experimental researches (e.g., Li et al., 2013; Yoshioka et al., 2018). However, only two experiments corresponding to the lower mantle were conducted in the previous study (Yoshioka et al., 2018). In addition, subducting slab have played important role for volatile cycle into the deep Earth.

In this research, in order to investigate how much nitrogen is incorporated into stishovite which can carry nitrogen to the lower mantle, we conducted high-pressure and high-temperature experiments using multi-anvil apparatus installed at Geodynamics Research Center, Ehime University. All experimental pressure conditions were 27 GPa and temperature conditions ranged from 1400 ℃ to 1700 ℃. Fe-FeO buffer was used to control the redox state equal to the lower mantle. Nitrogen in recovered samples were analyzed using NanoSIMS installed at Atmosphere and Ocean Research Institute, The University of Tokyo. Nitrogen implanted standard samples were prepared in order to estimate nitrogen solubility in silicate minerals at National Institute for Materials Science.

A series of experimental results revealed that stishovite can incorporate 39-418 ppm nitrogen which is higher than nitrogen solubility in bridgmanite (5-50 ppm nitrogen solubility reported by Yoshioka et al. (2018)). Stishovite is mainly formed by the transition of nitrogen-rich sedimentary rocks transported to the lower mantle via subducting slabs. Our study suggests that nitrogen would continue to be supplied to the lower mantle via subducting slabs since when the plate tectonics had begun. This implies that "hidden" nitrogen reservoir was formed in the lower mantle approximately 4 billion years ago. Furthermore, this " hidden" nitrogen reservoir may play a role in decreasing high-concentration nitrogen which had enhanced greenhouse effect in the early atmosphere (Goldblatt et al., 2009) to the present nitrogen concentration level. Thus, our experimental results support the young faint Sun paradox explained by high-concentration nitrogen in the early Earth (e.g. Goldblatt et al., 2009; Wordsworth and Pierrehumbert, 2013) and suggest that "missing" nitrogen has been caused by forming a "hidden" nitrogen reservoir in the lower mantle.

Keywords: "Missing" nitrogen, Deep nitrogen cycle, Plate techtonics, Stishovite, The faint young Sun paradox

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

3-D P- and S-velocity structure of the D″ layer beneath Central America and the Caribbean using waveform inversion

*Anselme F. E. Borgeaud[1,2], Kenji Kawai[1], Robert J. Geller[1]

1. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2. Institute of Earth Sciences, Academia Sinica

We present 3-D P- and S-velocity models of the lowermost mantle (0–400 km above the core-mantle boundary) beneath Central America and the Caribbean inferred from waveform inversion of a large dataset of ~16,000 USArray waveforms data. The origin of seismic velocity anomalies in the D″ region, e.g., thermal, chemical, or due to the phase transition from Bridgemanite (brg) to post-perovskite (pPv), is still debated. Insights into the origin of velocity anomalies can be obtained by comparison of P- and S-velocity models (Wentzcovitch et al. 2006). Previous tomographic studies have reported large S-to-P velocity ratio in the lowermost mantle based mainly on normal modes, which can constrain the large-scale structure of the mantle (e.g., Masters et al. 2000; Koelemeijer et al. 2018). There are, however, few local high-resolution models of the 3-D P- and S-velocity structure of the lowermost mantle due to the difficulty of measuring the arrival-time of the small-amplitude PcP phase. Since waveform inversion does not require measuring arrival times, it might provide a more robust way of using the PcP phase to constrain the high-resolution structure of the lowermost mantle. In this study, we use ~7000 transverse component and ~7000 vertical component records from ~38 intermediate and deep-focus earthquakes in South-America recorded at USArray stations between 2004–2015. The records are cut ~10 s before the arrival of the P (S) phase, and ~40 s after the arrival of the PcP (ScS) phase. Resolution tests shows that we can resolve separately the P- and S-velocity structure of the lowermost mantle on scales less than ~300 km. Our preliminary results show a relatively good correlation between S- and P-wave anomalies on small-scales, with a large S-to-P velocity ratio in the range 100–300 km above the CMB, and a smaller ratio 0–100 km above the CMB, in general agreement with the results of Koelemeijer et al. (2018).

Keywords: Waveform inversion, Lowermost mantle

©2019. Japan Geoscience Union. All Right Reserved.

Uniaxial deformation experiments of bridgmanite using D-111 type high pressure apparatus

*Noriyoshi Tsujino[1], Daisuke Yamazaki[1], Yu Nishihara[2]

1. Institute for Planetary Materials, Okayama University, 2. Geodynamics Research Center, Ehime University

One dimensional viscosity models of the Earth’s mantle proposed by geophysical observations suggested that the lower mantle had the largest viscosity in the Earth’s mantle. In order to understand mantle dynamics in the Earth’s interior, it is important to know the viscosity of the Earth’s lower mantle. However, there are large variations of viscosity in the lower mantle between suggested models because of limitation of locations for geophysical observations. Therefore it is important to determine viscosity of lower mantle minerals by high pressure experiments in order to discuss mantle dynamics. Bridgmanite would be the most abundant mineral in the lower mantle. This mineral could dominate the lower mantle viscosity. In this study, we conducted in-situ stress-strain measurements of uniaxial deformation experiments of bridgmanite aggregate using D-111 type high pressure apparatus.
In-situ measurements were conducted using MAX III with D111 type guide block at PF-AR NE7A beam line. Mg-pure bridgmanite aggregates were used as starting material. Experimental conditions are 1473-1673 K and 24-27 GPa. WC second cubic anvils with cone (6.5˚) to take 2D X-ray diffraction, was used along X-ray path. Two-dimensional X-ray diffraction patterns were corrected for 240 s using flat panel detector. To calculate pressure and the stress magnitude of bridgmanite, (112) X-ray diffraction peaks were used. Strain of bridgmanite was measured by X-ray radiographies taken using an imaging system composed of a YAG crystal and a CMOS camera.
Largest strain was reached to approximately 20 %. It is confirmed that strain rate can be well controlled using stroke speed of differential rams. Steady state creep were observed at 1473 K –1673 K and 5 $\times 10^{-6}$ –3.8 $\times 10^{-5}$ /s. At normalized strain (10^{-5} /s), the creep strength of bridgmanite in this study is the largest in constituent mantle minerals reported by D-DAI apparatus.

Keywords: Bridgmanite, Deformation experiments, Creep strength

©2019. Japan Geoscience Union. All Right Reserved.

Waveform inversion for 3D anisotropic structure in D″ beneath the Northern Pacific: Constraints on mineralogy and flow in the lowermost mantle

*Yuki Suzuki[1], Kenji Kawai[1], Robert J. Geller[1]

1. Department of Earth and Planetary Sciences, School of Science,The University of Tokyo

The D″ region is the lowermost several hundred km of the mantle immediately above the core-mantle boundary (CMB) and its base is in contact with the liquid outer core composed of iron alloy. Since the D″ region is the thermal boundary layer (TBL) at the base of the Earth's mantle, and the solidus of its constituent materials is thought to be close to the mantle geotherm, vertical and lateral variations of temperature and chemical composition associated with the Earth's thermal evolution are expected. Since chemically and thermally distinct subducted slabs would interact with the hot TBL above the CMB, and disturb the lowermost mantle, understanding the thermal and chemical evolution processes of the D″ region under subduction zones is essential to better understand the Earth's evolution.
The D″ region beneath the northern Pacific is of particular geodynamical interest because the paleo-Izanagi and present Pacific plates have been subducting beneath the northwestern margin of Laurentia since ~250 million years ago (Müller et al. 2016), which implies that paleoslabs could have reached the lowermost mantle. Suzuki et al. (2016) inferred the detailed three-dimensional S-velocity structure in the lowermost 400 km of the mantle beneath the northern Pacific. They hypothesized a prominent sheet-like lateral high-velocity, interpreted as paleoslabs, and a prominent low-velocity anomaly block immediately above the CMB below the high-velocity anomalies, which they interpreted as a TBL. In order to verify the above hypothesis and obtain geodynamical information, we infer 3D anisotropic structure beneath the northern Pacific in this study.
We conduct waveform inversion (Kawai et al. 2014) to infer the variation of the values of the TI (transverse isotropic, i.e. radial anisotropic) elastic constants L and N (Note that L is related to V_{SV} and N is related to V_{SH} when the shear wave propagates horizontally) straightforwardly in the lowermost mantle beneath the Northern Pacific, using a total of ~18,000 (~9,000 transverse and ~9,000 radial component) broadband body-wave seismograms. We used deep- and intermediate-focus events recorded at epicentral distances 70 to100 degrees at seismic stations of the USArray. The data are filtered in the period range of 20 to 200 s (i.e. 0.005 to 0.05 Hz) using a Butterworth bandpass filter. By using an S/ScS time window which is sensitive to the D″ structure we could image small-scale structure with finer resolution than previous tomographic studies.
The observed anisotropy is interpreted as due to the deformation-induced alignment of crystal caused by mantle flow for either Mg-perovskite (Mg-Pv), Mg-post-Perovskite (Mg-pPv), Ferro-periclase (Fp) or a combination thereof. In order to relate the flow geometry to the anisotropic geometry, we assume the dominant glide system and elastic constants of each mineral under the lowermost mantle condition based on high pressure experiment and theoretical calculation studies (e.g., Tsujino et al. 2016, Yamazaki et al. 2006 for deformation experiments; Wentzcovich et al. 2006 for ab initio calculation). We interpret the inferred 3D anisotropic structure based on above assumption, and we find the horizontal flow which could be related to subducted paleo-slabs is dominant in this region, and we also find vertical flow which could be related to the plume induced by slab sinking.

Keywords: the lowermost mantle, waveform inversion, anisotropy, D" region

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

*Sho Kakizawa[1], Toru Inoue[1,2,3], Ryotaro Abe[1], Minami Kuroda[4], Naoya Sakamoto[5], Hisayoshi Yurimoto[4,5,6]

1. Geodynamics Reseach Center, Ehime University, 2. Graduate School of Science, Hiroshima University, 3. Hiroshima Institute of Plate Convergence Region Research, 4. Graduate School of Science, Hokkaido University, 5. Creative Research Institution, Hokkaido University, 6. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

The Earth initially contained ~2 wt% H_2O, if it was formed by the mixture of C1 chondrite and enstatite chondrite [Ringwood, 1977]. However, the mass of the Earth's ocean is only 0.02 wt% of that of the Earth. Thus, most of the H_2O or molecular H may have been lost from the Earth since then, or it may still be stored in the Earth's deep interior. Water significantly influences the physical and chemical properties of the mantle minerals and rocks. Therefore, it is important to clarify the effect of water to understand the evolution and dynamics of the Earth. A part of water in the deep mantle can be dissolved in nominally anhydrous minerals. Wadsleyite and ringwoodite which are the major constituent minerals in the mantle transition zone, can contain ~2-3 wt% H_2O [e.g., Inoue et al., 1995; Kohlstedt et al., 1996]. On the other hand, water solubility of bridgmanite which is the most abundant mineral in the lower mantle, is a matter of debate [e.g., Bolfan-Casanova et al., 2004; Murakami et al., 2003]. Recently, Al-bearing hydrous bridgmanite contained ~0.8 wt% water was synthesized by Inoue et al. (under review). This report suggests that lower mantle can become a water reservoir in the Earth. However, the effects of pressure and Fe content on maximum water solubility of Al-bearing bridgmanite have not been clarified yet.
To determine the maximum water solubility of Al-bearing hydrous bridgmanite, high pressure and high temperature experiments were conducted under the conditions of 25-48 GPa and 1600℃. The starting materials were prepared by the mixtures of MgO, SiO_2, $Mg(OH)_2$, and $Al(OH)_3$ reagents with clinochlore [$Mg_5Al_2Si_3O_{10}(OH)_8$], Fe-bearing natural chlorite [$Mg_{4.9}Al_{1.6}Si_{3.2}Fe_{0.3}O_{10}(OH)_8$], and Fe-bearing hydrous pyrolite compositions. The water contents of the recovered run products were measured by SIMS. The water contents of Al-bearing hydrous bridgmanite increased with increasing pressure, at least up to 48 GPa. This is considered to occur the following two hydrous coupling substitutions with increasing pressure: $Si^{4+} = Al^{3+} + H^+$ and $2Mg^{2+} = Al^{3+} + H^+ + V_{Mg}$. These substitutions were dominant at low Al content, and Tschermak substitution ($Mg^{2+} + Si^{4+} = 2Al^{3+}$) became dominant with increasing Al content above Al = ~0.1 per formula unit (pfu, O = 3). The water content decreased as a result of Tschermak substitution, thus the maximum water solubility of bridgmanite is expected to be about 1.0 wt% at Al = ~0.1 pfu. In addition, the water solubility of Al-bearing hydrous bridgmanite decreased in the presence of Fe, and it became clear that it depends on the amount of Al and Fe in bridgmanite. Because of these properties, the maximum water solubility of bridgmanite in pyrolite and MORB are expected to be ~0.1 and ~0.2 wt%, respectively. When ringwoodite with high H_2O content is subducted to the lower mantle, the dehydration would occur at the top of the lower mantle. The dehydrated water should decrease melting temperature of the surrounding rocks and generates magma. Moreover, when chlorite dominant rock with high Al and low Fe content is subducted to the lower mantle, water heterogeneity would be predicted in the lower mantle, because the water content of bridgmanite generated by chlorite is significantly higher than that generated by pyrolite.

Keywords: deep mantle, lower mantle, bridgmanite, water

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Origin and role of lost continents

*Shigenori Maruyama[1], Kenji Kawai[2], Steeve Gréaux[3], Taku Tsuchiya[3], Dapeng Zhao[4]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Department of Earth and Planetary Science, School of Science, University of Tokyo, 3. Ehime University, 4. Department of Geophysics, Tohoku University

<Purpose>

Continental crust had long been regarded that it cannot subduct into mantle forever because of lower density. If so, the Earth must have extraordinary thick continental crust over 300km in thickness. But, of course, not. We elucidate where continental curst has gone?

<Method>

Recently, on-going process of direct subduction of island arcs off Japan was reported (Yamamoto et al., 2007), as well as tectonic erosion of hanging wall of continental crust (von Huene and Scholl, 1991), the physical process by numerical simulation (Ichikawa et al., 2009), the presence of abundant TTG materials in MTZ (Kawai et al., 2013), and spatial distribution of the second continents in the MTZ over the world (Maruyama et al., 2008).

<Result>

We revealed continental curst is subducted into mantle and accumulated as “lost continent”. The estimated mass of the lost continent in MTZ (depth range of 520-660km) is 7.5 times more than total volume of TTG crust on the surface Kawai et al (2009; 2013), and the existing material is expected to be TTG, not MORB or harzuburgite based on seismology. Kawai et al. (2007) also predicted that D” layer ca. 300km thick right above CMB could be another lost continent, which anorthosite and KREEP dominated. However, this idea cannot explain reasonable enough that the density of KREEP basalt is close to that of surrounding peridotites. According to more recent estimate by Greaux et al. (2018), lost continent on CMB is expected to be fractionated KREEP and anorthosite. If KREEP lower crust of the Hadean continent subducted and segregated at 660km depth, these material could be falling preferentially into lower mantle, and they must have been accumulated on the CMB.

<Discussion>

It is pointed out that those lost continents may have played critical role for the thermal history of Earth, because most radiogenic elements such as U, Th, and K were predominantly concentrated into the primordial continents, whereas these elements were rare in the mantle. Radiogenic elements contained in lost continents must have contributed as the heat generator of the inner Earth and controlled thermal history of the Earth. One of the most significant next research targets is to conduct the quantitative estimates of lost continent. The idea of lost continents would change the concept of mantle dynamics.

Keywords: KREEP basalt, Lost continent, mantle dynamics

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Kenji Ohta, Riko Iizuka

Recent observational and experimental investigations have significantly advanced our understanding of the structure and constituent materials of the deep Earth. Yet, even fundamental properties intimately linked with formation and evolution of the planet, such as details of the chemical heterogeneity in the mantle and light elements dissolved in the core, remained unclear. Seismological evidence has suggested a vigorous convection in the lower mantle, whereas geochemistry has suggested the presence of stable regions there that hold ancient chemical signatures. The amounts of radioactive isotopes that act as heat sources and drive dynamic behaviors of the deep Earth are also still largely unknown. We provide an opportunity to exchange the achievements and ideas, and encourage persons who try to elucidate these unsolved issues of the core-mantle evolution using various methods, including high-pressure and high-temperature experiments, high-precision geochemical and paleomagnetic analyses, high-resolution geophysical observations, geo-neutrino observations, and large-scale numerical simulations. Papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community are also welcomed.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SIT21-07] Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

★Invited Papers

*Zhongqing Wu[1] (1.University of Science and Technology of China)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SIT21-08] Discussion

*Kenji Ohta[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT21-09] ***Ab initio* anharmonic lattice dynamics for Fe-bearing lower mantle minerals**

*Haruhiko Dekura[1], Taku Tsuchiya[1] (1.Geodynamics Research Center, Ehime University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SIT21-10] **Measurements of high pressure-temperature thermal conductivity of the Earth's lower mantle minerals in a laser-heated diamond anvil cell**

*Kenji Ohta[1], Akira Hasegawa[1,2], Takashi Yagi[2], Yoshiyuki Okuda[1], Koutarou Onga[1], Kei Hirose[3,4], Yasuo Ohishi[5] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, 3.Earth-Life Science Institute, Tokyo Institute of Technology, 4.Department of Earth and Planetary Science, The University of Tokyo, 5.Japan Synchrotron Radiation Research Institute)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SIT21-11] Is there evidence for a paleo-LLSVP beneath Eurasia?: Implications for the origin of the Siberian Traps

*Tsubasa Ue[1], Yuki Suzuki[1], Kenji Kawai[1] (1.Department of Earth and Planetary Sciences, Graduate School of Science, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SIT21-12] Possible compositional region of Al-bearing anhydrous bridgmanite

*Toru Inoue[1,2], Masamichi Noda[2], Sho Kakizawa[2] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.Geodynamics Research Center, Ehime University)

Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

*Zhongqing Wu[1]

1. University of Science and Technology of China

Thermal conductivity of the mantle minerals is one of the key parameters that control mantle convection. The heat flux from the core, which is determined by the heat conductivity of the thin layer overlying the core-mantle boundary (CMB), is critical to the understanding of many processes such as the Earth’s evolution, mantle convection, and geodynamo. Iron in ferropericlase experiences a spin crossover from a high spin to a low spin under lower mantle conditions, which generates anomalies in many properties such as the heat capacity and sound velocity (Wu et al., 2009, 2013). Since the thermal conductivity is proportional to the heat capacity and the square of the sound velocity, the spin-state crossover of iron in the lower mantle minerals may profoundly affect the lattice thermal conductivity of the lower mantle. However, knowledge of the spin-crossover effect on the lattice thermal conductivity is very limited.

Here, I found that the spin crossover completely changes the conventional pressure and temperature dependences of the thermal conductivity. The pressure dependence of the thermal conductivity of ferropericlase will show a double-valley feature across the spin-crossover region. Thermal conductivity of ferropericalse may increase with the temperature in some temperature region. The spin crossover can explain the anomalous reduction in thermal conductivity of ferropericlase observed recently by Ohta et al (2017) in the spin crossover region. The unusual effect of spin crossover on the thermal conductivity can be expected in other minerals with spin crossover. Since the spin-crossover region of ferropericlase covers the CMB conditions, the spin crossover effect needs serious consideration when estimating the thermal conductivity at the core-mantle boundary

Wu, Z., J. F. Justo, C. R. S. da Silva, S. de Gironcoli, and R. M. Wentzcovitch (2009), Anomalous thermodynamic properties in ferropericlase throughout its spin crossover transition, *Phys. Rev. B*, *80*(1), 014409.

Wu, Z. Q., J. F. Justo, and R. M. Wentzcovitch (2013), Elastic Anomalies in a Spin-Crossover System: Ferropericlase at Lower Mantle Conditions, *Phys. Rev. Lett.*, *110*(22).

Ohta, K., T. Yagi, K. Hirose, and Y. Ohishi (2017), Thermal conductivity of ferropericlase in the Earth's lower mantle, Earth and Planetary Science Letters, 465, 29-37.

©2019. Japan Geoscience Union. All Right Reserved.

Discussion

*Kenji Ohta[1]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Discussion

©2019. Japan Geoscience Union. All Right Reserved.

Ab initio anharmonic lattice dynamics for Fe-bearing lower mantle minerals

*Haruhiko Dekura[1], Taku Tsuchiya[1]

1. Geodynamics Research Center, Ehime University

Determination of lattice thermal conductivity (κ_{lat}) of lower mantle (LM) minerals is a key to understanding the dynamics and evolution of the earth’ s deep interior. Some recent experimental studies have shown that κ_{lat} of MgO and $MgSiO_3$ bridgmanite (Brg) are substantially reduced by Fe incorporation (Manthilake et al., 2012; Goncharov et al., 2015; Ohta et al., 2017; Hsieh et al., 2017). In contrast, Okuda et al. (2017) reported a very different result on Brg with a marginal effect of Fe. Besides, the effect of Fe on $MgSiO_3$ post-perovskite (PPv) has never been reported. Therefore, in this study, we investigate κ_{lat} of Fe-bearing LM minerals (ferropericlase (FP), Brg, and PPv) in the LM pressure and temperature conditions, based on the *ab initio* anharmonic lattice dynamics techniques with fully solving the phonon Boltzmann transport equation (Dekura and Tsuchiya, 2017) combined with the internally consistent LDA+*U* technique for more precisely describing the Fe-O bond (Wang et al., 2015). Calculations demonstrate strong negative solid solution effects of low-spin Fe on κ_{lat} of FP and high-spin Fe on κ_{lat} of Brg and PPv, as a linear decrease in log κ_{lat} of FP with increasing the Fe concentration. Our detailed analyses indicate that such strong effects occur primarily due to the substantial changes in harmonic properties and are found to be Brg > PPv >FP. The present results improve the conventional estimation of the effective LM conductivity (e.g., Stacey 1992). It is estimated to be ~2-3 $Wm^{-1}K^{-1}$ for the pyrolytic aggregate (FP + Brg) and ~4-5 $Wm^{-1}K^{-1}$ (FP+PPv) at 136 GPa and 4000 K, which are ~60-80% smaller than the conventional value of 10 $Wm^{-1}K^{-1}$.

Keywords: Lower mantle minerals, Lattice thermal conductivity , First-principles calculation

©2019. Japan Geoscience Union. All Right Reserved.

Measurements of high pressure-temperature thermal conductivity of the Earth's lower mantle minerals in a laser-heated diamond anvil cell

*Kenji Ohta[1], Akira Hasegawa[1,2], Takashi Yagi[2], Yoshiyuki Okuda[1], Koutarou Onga[1], Kei Hirose[3,4], Yasuo Ohishi[5]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2. National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, 3. Earth-Life Science Institute, Tokyo Institute of Technology, 4. Department of Earth and Planetary Science, The University of Tokyo, 5. Japan Synchrotron Radiation Research Institute

The thermal transport properties of the Earth's constituents are important information to understand thermal evolution and the heat budget of the Earth. Thus, the experimental determination of thermal conductivity of deep Earth materials are required. The diamond anvil cell (DAC) is capable of accessing the pressure-temperature conditions of the Earth's deep interior, and is compatible with laser optical techniques. The pulsed light heating thermoreflectance (TR) method has been applied to a DAC in order to measure thermal conductivity and diffusivity of condensed material [1,2]. This TR with DAC method successfully obtained the thermal conductivity of the Earth's lower mantle minerals to the pressure condition equal to the Earth's core-mantle boundary (135 GPa) but at room temperature [3]. To extend measurable temperature range, the TR method may be combined with a laser-heated DAC (LHDAC) technique that is able to generate the pressure-temperature condition equivalent to the center of the Earth.

We recently developed a new instrument to measure the thermal diffusivity (and thus thermal conductivity) of sample *in-situ* at high pressure and temperature based on the combination of the TR method and the LHDAC system. We use a double-sided high-power CW laser heating technique to generate stable high temperature conditions of sample in a DAC. A pulsed pump laser and a CW probe laser are also irradiated to the sample to determine heat diffusion time through the sample via the thermoreflectance phenomena. Details of the thermoreflectance technique in a DAC may be found in our previous studies [2]. Using the developed method, we measured the thermal conductivity of the main minerals in the Earth's lower mantle, MgO periclase, $MgSiO_3$ bridgmanite, post-perovskite and $CaSiO_3$ perovskite *in-situ* at high pressures and high temperatures. These are the first experimental demonstrations of thermal conductivity of the lower mantle minerals at the conditions below the mid-part of the Earth's lower mantle. The new thermal conductivity measurement system will shed light on the controversial thermal transport properties of the Earth's deep interior [4].

References:[1] Hsieh, W.-P. et al., *Phys. Rev. B*, **80**, 180302 (2009).[2] Yagi, T. et al., *Meas. Sci. Technol.,* **22**, 024011 (2011). [3] Okuda, Y. et al., *Earth Planet. Sci. Lett.*, **474**, 25–31 (2017). [4] Kavner, A. and Rainey, E.S.G., *Deep Earth: Physics and Chemistry of the Lower Mantle and Core*, 31–42 (2016).

Keywords: Thermal conductivity, Lower mantle, High P-T experiment

©2019. Japan Geoscience Union. All Right Reserved.

Is there evidence for a paleo-LLSVP beneath Eurasia?: Implications for the origin of the Siberian Traps

*Tsubasa Ue[1], Yuki Suzuki[1], Kenji Kawai[1]

1. Department of Earth and Planetary Sciences, Graduate School of Science, The University of Tokyo

The massive eruption during the latest Permian, which precipitated the Earth's most severe known extinction event, is one of the largest known volcanic events on Earth. However, the cause of the active volcanism remains incompletely understood. Recent seismological analysis has revealed that currently active volcanoes are related to seismic low-velocity anomalies which are almost vertically continuous from the core-mantle boundary (CMB) to shallow depths. Here we infer the seismic velocity structure beneath Eurasia in order to confirm whether formerly active volcanism is also related to a mantle upwelling.

We apply the 3-D localized waveform inversion methods to about 5,500 transverse-component of broadband body-wave seismograms observed at Japan for 3 intermediate and deep earthquakes occurred in Europe, European stations for 116 events occurred beneath the western Pacific subduction zone and Canadian stations for 5 events occurred beneath the Hindu Kush. We use waveform data obtained from the National Research Institute for Earth Science and Disaster Prevention (NIED), Observation & Research Facilities for European Seismology (ORFEUS) and Canadian National Data Centre (CNDC).

We found a high-velocity anomaly about 100 km above the CMB beneath Lake Baikal and two low-velocity anomalies immediately above the CMB beneath the cities of Perm and Irkutsk, Russia, respectively. Plate reconstructions show there are some large igneous provinces (LIPs) and slab remnants beneath Eurasia. Our results suggest two scenarios: one where two low-velocity anomalies used to be united and larger than present size but divided and weakened by the subducted cold slab and another where two low-velocity anomalies were originally separated with each other and became different LIPs. In either case, our findings suggest that the cause of a massive eruption during the latest Permian was a plume upwelling from the CMB.

Keywords: D″, Waveform inversion, Perm Anomaly, LIPs, S velocity structure

©2019. Japan Geoscience Union. All Right Reserved.

Possible compositional region of Al-bearing anhydrous bridgmanite

*Toru Inoue[1,2], Masamichi Noda[2], Sho Kakizawa[2]

1. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2. Geodynamics Research Center, Ehime University

Bridgmanite should be a major constituent mineral in the Earth's lower mantle, and Irifune (1994) reported that bridgmanite can incorporate almost Al_2O_3 component in lower mantle. The Al substitution mechanism is supposed to be complicated, because there are two types of Al substitution mechanisms in anhydrous bridgmanite, Tschermak and oxygen vacancy substitutions (e.g. Kojitani et al., 2007). However, the pure Tschermak and oxygen vacancy substitutions bridgmanite has not been reported so far in low Al content, when we checked the previous studies carefully (e.g. Irifune et al, 1996; Kubo and Akaogi, 2000). The previous studies have used powder samples as the starting materials, so we considered that the absorbed water may affect the results, because we have a knowledge of the possible existence of hydrous bridgmanite which has a water content of ~0.8 wt%. Therefore, we tried to investigate the possible existence of the Al substitution mechanism in bridgmanite as a function of Al content in extremely anhydrous condition.

The high pressure experiments were conducted at 28 GPa and 1600-1700℃ for 1 hour using a Kawai type apparatus. Some different Al content samples were prepared as the starting materials along the ideal substitution line of Tschermak and oxygen vacancy substitutions, respectively. Glass rods were used as the starting materials to eliminate the absorbed water on the sample surface. Moreover, the glass rods were enclosed in a rhenium capsule to prevent the water incorporation from the surrounding cell assembly. In addition, all parts of the cell assembly were dried just before the synthesis experiments. The chemical compositions of the starting materials were examined by SEM-EDS, and the recovered samples were identified by X-ray and neutron (in J-PARC) diffractions and SEM-EDS.

Our results show that it is possible to exist both Tschermak and oxygen vacancy substitution bridgmanites in low Al content in anhydrous condition. The maximum Al content for pure oxygen vacancy substitution bridgmanite was ~0.025 pfu in total cation of 2, and the existence of oxygen vacancy substitution component was restricted to be less than Al=~0.1 pfu. The present result combining with our previous study in hydrous condition, shows that hydration in Al-bearing bridgmanite should occur easily if hydrogen exists in the system (lower mantle) in pyrolite (MgO-excess) composition. Thus the large deviation from the Tschermak substitution in the previous studies mainly should come from the hydration from the absorbed water.

Keywords: lower mantle, bridgmanite, Al2O3 component, anhydrous condition, hydrous condition

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Hitoshi Gomi, Tsuyoshi Iizuka

Recent observational and experimental investigations have significantly advanced our understanding of the structure and constituent materials of the deep Earth. Yet, even fundamental properties intimately linked with formation and evolution of the planet, such as details of the chemical heterogeneity in the mantle and light elements dissolved in the core, remained unclear. Seismological evidence has suggested a vigorous convection in the lower mantle, whereas geochemistry has suggested the presence of stable regions there that hold ancient chemical signatures. The amounts of radioactive isotopes that act as heat sources and drive dynamic behaviors of the deep Earth are also still largely unknown. We provide an opportunity to exchange the achievements and ideas, and encourage persons who try to elucidate these unsolved issues of the core-mantle evolution using various methods, including high-pressure and high-temperature experiments, high-precision geochemical and paleomagnetic analyses, high-resolution geophysical observations, geo-neutrino observations, and large-scale numerical simulations. Papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community are also welcomed.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SIT21-13] Evolution of the Earth mantle and its possible interaction with core: view from olivine and its inclusions study

★Invited Papers

*Alexander V Sobolev[1], Valentina G. Batanova[2] (1.ISTerre Institute of Earth Sciences, 2.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygina str. 19, Moscow 119991, Russia.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SIT21-14] Discussion

*Tsuyoshi Iizuka[1] (1.University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SIT21-15] Ultralow-velocity zones possibly explained by light element-enriched iron compounds

*Liang Yuan[1], Eiji Ohtani[1], Xiang Wu[2], Shengxuan Huang[3], Daijo Ikuta[1], Tatsuya Sakamaki[1], Seiji Kamada[1], Hiroshi Fukui[4,5], Satoshi Tsutsui[6], Hiroshi Uchiyama[6], Daisuke Ishikawa[5,6], Naohisa Hirao[6], Alfred Q. R. Baron[5] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan, 2.State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China, 3.Key Laboratory of Orogenic Belts and Crustal Evolution, MOE, Peking University and School of Earth and Space Sciences, Peking University, Beijing 100871, China, 4.Center for Novel Material Science under Multi-Extreme Conditions, Graduate School of Material Science, University of Hyogo, Hyogo 678-1297, Japan, 5.Materials Dynamics Laboratory, RIKEN SPring-8 Center, Hyogo 679-5148, Japan, 6.Japan Synchrotron Radiation Research Institute (JASRI), SPring-8, Hyogo, 679-5198, Japan)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SIT21-16] High-precision $^{142}W/^{144}W$ ratios of oceanic island basalts and Large Igneous Province basalts.

Asako Takamasa[1], *Katsuhiko Suzuki[1], Yusuke Fukami[2], Tsuyoshi Iizuka[3] (1.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 2.Department

of Subsurface Geobiological Analysis and Research, Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Science, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SIT21-17] **Some technological developments in high temperature generation using KMA and precise melting/phase relations of minerals and rocks under deep mantle conditions**

*Tetsuo Irifune[1,2], Youmo Zhou[1], Takeshi Arimoto[1], Hideharu Kuwahara[1], Ryuichi Nomura[3], Masayuki Nishi[1], Momoko Yamaguchi[1], Yoshinori Tange[4], Takahiro Kuribayashi[5], Zhaodong Liu[6] (1.Geodynamics Research Center, Ehime University, 2.Eearth Life Science Institute, Tokyo Institute of Technology, 3.Hakubi Center/ Graduate School of Human and Environmental Studies, Kyoto University, 4.Research & Utilization Division, Japan Synchrotron Research Institute, 5.Graduate School of Science, Tohoku University, 6.Institute of Super Hard Materials, Jilin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SIT21-18] Zr isotope constraints on early Earth differentiation

*Tsuyoshi Iizuka[1], Keita Itano[1], Shinji Yamamoto[2] (1.University of Tokyo, 2.Yokohama National University)

Evolution of the Earth mantle and its possible interaction with core: view from olivine and its inclusions study

*Alexander V Sobolev[1], Valentina G. Batanova[2]

1. ISTerre Institute of Earth Sciences, 2. Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygina str. 19, Moscow 119991, Russia.

The rate and style of mantle convection, as well as production and recycling of crust into the mantle, control the evolution of the Earth. Present knowledge of mantle evolution is mostly restricted to the Phanerozoic, for which fresh mantle-derived lavas and relevant geophysical data are available. Information about the Precambrian mantle comes almost entirely from the compositions of altered rocks, which lack data on the contents of mobile and volatile elements and their isotopes. Such data are crucial for geodynamic reconstructions and understanding of surface rock recycling into the deep mantle. Fortunately, this information is preserved within inclusions of melt in relicts of olivine phenocrysts in komatiites.

In this presentation we will address the compositional evolution of the terrestrial mantle, from the Archean to the Phanerozoic, using compositions and temperatures of primary mantle-derived melts reconstructed from the study of melt inclusions and host olivine. We will report an extensive range of geochemical parameters, including mobile and volatile element (Pb, B, Rb, Ba, Sr, Cl, S, H2O, CO2) concentrations and isotopic compositions of H in homogenized melt inclusions and the elemental compositions of host olivines and inclusions of spinel. We will present data for komatiites and picrites that originated at different depths and cratons between 3.3 and 0.09 Ga. We will apply published and new models to constrain the temperatures and compositions of their mantle sources to relate our observations to the evolution of mantle convection and plate tectonics. We will, therefore, address the following issues: the rate of crustal growth and recycling through time; the timing of the onset of large-scale subduction and plate tectonics; the concentration and origin of H2O and halogens in the deep mantle, and the extent (if any) of core-mantle interaction.

We will present evidence of the significant excess of H2O and Cl in the mantle sources of komatiites and will show that hydrogen isotope composition of komatiites is significantly more depleted in deuterium than all surface reservoirs and typical mantle but resembles that in dehydrated subducted slabs. We will demonstrate temporal trends of Pb/Ce and oxygen fugacity of primary komatiite melts.

Our results suggest that lithosphere recycling into the deep mantle, arguably via subduction, started before 3.3 Ga and interaction of mantle and core probably took place all this time.

©2019. Japan Geoscience Union. All Right Reserved.

Discussion

*Tsuyoshi Iizuka[1]

1. University of Tokyo

Discussion

©2019. Japan Geoscience Union. All Right Reserved.

Ultralow-velocity zones possibly explained by light element-enriched iron compounds

*Liang Yuan[1], Eiji Ohtani[1], Xiang Wu[2], Shengxuan Huang[3], Daijo Ikuta[1], Tatsuya Sakamaki[1], Seiji Kamada[1], Hiroshi Fukui[4,5], Satoshi Tsutsui[6], Hiroshi Uchiyama[6], Daisuke Ishikawa[5,6], Naohisa Hirao[6], Alfred Q. R. Baron[5]

1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan, 2. State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China, 3. Key Laboratory of Orogenic Belts and Crustal Evolution, MOE, Peking University and School of Earth and Space Sciences, Peking University, Beijing 100871, China, 4. Center for Novel Material Science under Multi-Extreme Conditions, Graduate School of Material Science, University of Hyogo, Hyogo 678-1297, Japan, 5. Materials Dynamics Laboratory, RIKEN SPring-8 Center, Hyogo 679-5148, Japan, 6. Japan Synchrotron Radiation Research Institute (JASRI), SPring-8, Hyogo, 679-5198, Japan

The core–mantle boundary (CMB) is the most fundamental chemical discontinuity in the Earth. Recent experiments showed that, when water meets iron at the CMB, hydrogen-bearing iron peroxide FeO_2H_x can be produced. The results indicate that water can interact with iron metal very differently than it does on the surface of the earth. Seismic waves speeds in this hydrogen bearing iron peroxide are much slower compared with lower-mantle silicate solid phases, and therefore it may help explain the seismic anomalies at the CMB.

Given the steep geothermal gradient across the CMB, the hydrogen-bearing iron peroxide FeO_2H_x likely undergoes high-temperature decomposition into anhydrous iron oxides (e.g., Fe_2O_3) and fluids. We measured the sound velocity of Fe_2O_3 post-perovskite (ppv) through inelastic X-ray scattering up to 132 GPa and 1,800 K, relevant to the lowermost mantle. Combined with first-principles investigations, we are able to show that Fe_2O_3 ppv has very low sound velocities and strong anisotropy with respect to lower-mantle silicates. Therefore, both hydrogen-bearing iron peroxide FeO_2H_x and post-perovskite Fe_2O_3 are candidate phases for ultralow-velocity zones at the CMB.

Funding acknowledgment: This work was supported by the JSPS Japanese–German Graduate Externship.

Keywords: Core–mantle boundary, Ultralow-velocity zones, Light elements, Iron compounds

©2019. Japan Geoscience Union. All Right Reserved.

High-precision $^{142}W/^{144}W$ ratios of oceanic island basalts and Large Igneous Province basalts.

Asako Takamasa[1], *Katsuhiko Suzuki[1], Yusuke Fukami[2], Tsuyoshi Iizuka[3]

1. Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 2. Department of Subsurface Geobiological Analysis and Research, Japan Agency for Marine-Earth Science and Technology, 3. Graduate School of Science, The University of Tokyo

Among five W isotopes, ^{182}W is a product of b-decay of ^{182}Hf with the relatively short half life of 8.9 m.y. As Hf and W are lithophile and siderophile, respectively, the ^{182}Hf-^{182}W radiometric system could constrain metal-silicate (core-mantle) differentiation, especially core segregation, in the very early Earth system because of its large fractionation between metal-silicate and the short half life of ^{182}Hf. Recent improvements of analytical techniques of W isotope analyses using TIMS and MC-ICP-MS equipped with a desolvating device allow to obtain highly precise $^{182}W/^{184}W$ ratios of terrestrial rocks. These led to findings of $m^{182}W$ anomalies (mostly positive) in old komatiites (2.4 –3.8 Ga) and young volcanic rocks with positive anomalies of 12 Ma Ontong Java Plateau and 6 Ma Baffin Bay (Rizo et al., 2016) and with negative anomalies of those such as the Loihi and Samoa basalts (Mundl et al., 2017). Recently, Kruijer and Kleine (2018) proposed that the ^{182}W excesses for an OJP sample by Rizo et al. (2016) may result from the nuclear field shift effect leading to defect of ^{183}W, as the NTIMS analyses utilized a double normalization involving the $^{183}W/^{184}W$ ratio.

In our study, high-precision W isotope ratio measurement with MC-ICP-MS (Thermo co. Ltd., NEPTUNE PLUS) equipped with desolvating nebulizer (ARIDAS II) following the chemical separation using both cation and anion exchange resin has been developed. We have measured the W standard solution (SRM 3163) and obtained the isotopic compositions with a precision of ±5ppm. However, the standard solution, which was processed by the cation or anion exchange chemistry in the same way as for rock samples, has systematic $^{182}W/^{184}W$ drift of -5ppm, which was also observed by Willbold et al. (2011) and Kruijer and Kleine (2018). This shift likely resulted from the nuclear field shift effect as mentioned by Kruijer and Kleine (2018). Therefore, we corrected the measured W isotope ratios of samples with the standard solution processed by the same method as that of the samples. This technique led to obtaining of the W isotopic compositions with reproducibility of several ppm. We have obtained negative $\mu^{182}W$ for the basalts with the high $^{3}He/^{4}He$ isotopic composition from the Loihi, Hawaii, through the developed analytical method. This result is consistent with that of Mundl et al., (2017). As the Earth’s core should have a negative $\mu^{182}W$ value of ca. -210, the Loihi sample we analyzed probably contains a component with a signature of core-mantle interaction. We have obtained the high-precision W isotope data for the fresh drilled basalts from Louisville. Louisville is known to have been originated from the primordial deep mantle source. We will discuss the obtained results and the early evolution of the deep mantle.

Acknowledgement –JSPS Grant-in-Aid has supported this project. We are grateful to M. Kawamura for experimental help and Y. Orihashi, T. Hanyu, M. Tejada for providing samples.

Keywords: tungsten isotope, core-mantle interaction

©2019. Japan Geoscience Union. All Right Reserved.

Some technological developments in high temperature generation using KMA and precise melting/phase relations of minerals and rocks under deep mantle conditions

*Tetsuo Irifune[1,2], Youmo Zhou[1], Takeshi Arimoto[1], Hideharu Kuwahara[1], Ryuichi Nomura[3], Masayuki Nishi[1], Momoko Yamaguchi[1], Yoshinori Tange[4], Takahiro Kuribayashi[5], Zhaodong Liu[6]

1. Geodynamics Research Center, Ehime University, 2. Eearth Life Science Institute, Tokyo Institute of Technology, 3. Hakubi Center/ Graduate School of Human and Environmental Studies, Kyoto University, 4. Research & Utilization Division, Japan Synchrotron Research Institute, 5. Graduate School of Science, Tohoku University, 6. Institute of Super Hard Materials, Jilin University

Technological developments in stable and homogeneous high temperature generation have been made using conventional $LaCrO_3$ or Re heater for Kawai-type multianvil apparatus (KMA) with tungusten carbide (WC) and sintered diamond (SD) anvils. For WC-KMA, stable temeperature generation to ~3000 K has been achieved under the pressures up to ~27 GPa mainly for quench experiments. Temperatures of ~2000-2300 K have been produced stably for 20-180 minutes at pressures to ~65 GPa for *in situ* X-ray measurements using SD-KMA, in addition to the *ex situ* experiments.

Some experimental studies for precise determination of subsolidus and melting phase relations have successfully been made for some simple mineral systems, such as $MgSiO_3$-Al_2O_3, $MgSiO_3$-$FeSiO_3$, $MgSiO_3$-$CaSiO_3$, $CaSiO_3$-SiO_2, Al_2O_3-SiO_2, $KAlSi_3O_8$-$NaAlSi_3O_8$, Al_2SiO_5, $Ca_3Al_2Si_3O_{12}$, etc. at temperatures near and above the typical geotherm at pressures corresponding to those of the mantle transition region to the middle part of the lower mantle. These studies have provided firm experimental databases for the mineralogy of the deep mantle, and also led to findings of some new high-pressure phases stable only under the very high-temperture conditions. Melting and associated partioning of some key trace elements in more complex chemical compositions have also been conducted under the pressures of the uppermost lower manlte to constrain the differentiation and evolution of the deep mantle.

Keywords: lower mantle, multianvil apparatus, melting relations, phase relations, high pressure and high temperature experiment, technological development

©2019. Japan Geoscience Union. All Right Reserved.

Zr isotope constraints on early Earth differentiation

*Tsuyoshi Iizuka[1], Keita Itano[1], Shinji Yamamoto[2]

1. University of Tokyo, 2. Yokohama National University

The radionuclide 92Nb decays to 92Zr with a half-life of 37 Ma [1]. Because Nb and Zr can fractionate from each other during partial melting of the mantle and mineral crystallization as well as metal-silicate differentiation, Nb-Zr isotope systematics can potentially place chronological constraints on early planetary differentiation. Considering the initial abundance of 92Nb in the solar system (92Nb/93Nb = 1.7 ×10-5), yet, the possible Zr isotopic variation on the Earth would be highly restricted [2]. For instance, even a 4.53 Ga reservoir having a Nb/Zr ratio four times higher than that of CHUR is expected to display a 92Zr anomaly of only +10 ppm. Such reservoir with an elevated Nb/Zr ratio might be formed if Fe-Ti oxide and sulfide minerals presented as a liquidus phase during differentiation on the infant Earth.
Here we report our search for a Zr isotopic vestige of early Earth differentiation using ancient terrestrial zircons. Zirconium isotopic ratios in single zircon grains were measured using MC-ICP-MS with the desolvating nebulization technique, which allows us to achieve analytical precision of ±˜10 ppm. So far, the high-precision Zr isotopic analysis has been applied to detrital zircons with ages up to 4.3 Ga from the Jack Hills in the Yilgarn Craton, Western Australia and igneous zircons from the 4.0–3.6 Ga orthogneisses in the Acasta Gneiss Complex, northwestern Canada. These Acasta rock samples were previously studied for zircon Lu–Hf isotope systematics and the results indicated that their magmatic sources contained Hadean crustal components [3]. Our Zr isotopic data for the Jack Hills and Acasta zircons display no 92Zr anomalies larger than 10 ppm. By combining the Hf isotopic data for these zircon grain, we indicate the development of a 4.5 Ga enriched reservoir on the Earth that had a Lu/Hf of 0.07 and a Nb/Zr less than 0.4. Such reservoir could form via fractional crystallization processes within the shallow or upper mantle.
[1] Holden (1990) Pure Appl. Chem. 62, 941–958. [2] Iizuka et al. (2016) Earth Planet. Sci. Lett. 439, 172–181. [3] Iizuka et al. (2009) Chem. Geol. 259, 230–239.

Keywords: Hadean, magma ocean, Zr isotopes, zircon

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-CG49] Hard-Rock Drilling Science: From Continental to Deep Sea Drilling, and Oman Project

convener:Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Eiichi TAKAZAWA(Department of Geology, Faculty of Science, Niigata University), Norikatsu Akizawa(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Katsuyoshi Michibayashi

The Oman Drilling Project (OmDP) has completed to drill numerous hard-rock cores within ancient oceanic lithosphere and the underlying subduction zone of the Samail ophiolite in Oman, with support from ICDP, IODP, Japan Society for the Promotion of Science, the Sloan Foundation's Deep Carbon Observatory, US, and European research agencies. Moreover, a number of IODP expeditions have focused on hard-rock drilling over the last several years including Expedition 352 in 2014, which drilled the volcanic sequence associated with subduction initiation in the Bonin fore-arc, Expedition 357, which drilled the Lost City hydrothermal field, Expedition 360, which drilled the lithosphere associated with ultraslow-spreading at the Southwest Indian Ridge in 2016, and Expedition 366, which drilled the serpentinite seamounts in the Mariana fore-arc. In this session, we invite presentations on the scientific results of hard-rock drilling at these and other sites. We also invite related presentations on oceanic lithosphere, island arc formation, and any other significant issue that could be addressed by future hard-rock drilling. This includes marine studies of oceanic lithosphere and on-land geological investigations of ophiolites, accreted arcs, and subduction complexes. The session is intended to be interdisciplinary, including the fields of geophysics, geochemistry, petrology, engineering, and biology.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG49-01] Geochemical and Geochronological Constraints on the Origin and Emplacement of the East Taiwan Ophiolite: Implication for Subduction Initiation of the South China Sea.

*Chiou-ting Lin[1], Ron A. Harris[2], Wei-dong Sun[1], Guo-liang Zhang[1] (1.Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, 2.Department of Geology, Brigham Young University)

3:45 PM - 4:05 PM JST | 6:45 AM - 7:05 AM UTC

[SCG49-02] Towards a complete profile of hydrothermal alteration in the lower oceanic crust and uppermost mantle; Insights from the Oman Drilling Project and ChikyuOman2017 and 2018

★Invited Papers

*Damon A H Teagle[1], Michelle Harris[2], Gretchen Früh-Green[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Oman Drilling Project Science Team[1] (1.Ocean & Earth Science, National Oceanography Centre Southampton, University of Southampton, SO14-3ZH, Southampton, UK, 2.School of Geography, Earth and Environmental Sciences, Plymouth University, UK, 3.Earth Sciences, ETH Zürich, Switzerland, 4.Geology, Niigata University, Japan, 5.Earth and Planetary Sciences, Nagoya University, Japan, 6.LDEO, Columbia University, New York, USA)

4:05 PM - 4:25 PM JST | 7:05 AM - 7:25 AM UTC

[SCG49-03] Peridotite alteration in OmanDP cores

★Invited Papers

*Peter B Kelemen[1], Juan Carlos de Obeso[1], Craig Manning[2], Marguerite Godard[3], Wolfgang Bach[4], Merry Yue Cai[1], Saebyul Choe[5], Judith Coggon[6], Eric Ellison[7], Alireza Eslami[8], Katy Evans[9], Michelle Harris[10], Wolf-Achim Kahl[4], Jürg Matter[6], Katsu Michibayashi[11], Keichi Okazaki[12], Philippe Pézard[3], Damon A.H. Teagle[6], Alexis Templeton[7], OmanDP Oman Drilling Project Science Team (1.LDEO, 2.UCLA, 3.U. Montpellier, 4.U. Bremen, 5.AMNH, 6.U. Southampton, 7.U. Colorado, 8.U. Tehran, 9.Curtin U., 10.U. Plymouth, 11.Nagoya U., 12.JAMSTEC)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[SCG49-04] Low-salinity aqueous fluid inclusions in dolomite veins of a listvenite of Oman Drilling Project Phase 1

*Tatsuhiko Kawamoto[1], Hiroki Sato[2], Toma Takahashi[3], Juan Miguel Guotana[4], Tomoaki Morishita[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 Science Party (1.Department of Geoscience, Faculty of Science, Shizuoka University, 2.Faculty of Science, Kyoto University, 3.Faculty of Geosciences and Civil Engineering, Kanazawa University, 4.Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa University, 5.Lamont-Doherty Earth Observatory, Columbia University, 6.School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, 7.School of Geography, Earth and Environmental Sciences, Plymouth University, 8.Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 9.Institute of Science and Technology, Niigata University)

4:40 PM - 5:00 PM JST | 7:40 AM - 8:00 AM UTC

[SCG49-05] Hydration and development of fracture network within oceanic lower crust: an evidence from CM1A of Oman Drilling

★Invited Papers

*Atsushi Okamoto[1], Kazuki Yosida[1], Ryosuke Oyanagi[2], Oman Drilling Project Phase 2 Science Party[3] (1.Graduate School of Environmental Studies, 2.JAMSTEC, 3.Oman Drillng Project Phase 2 Science Party)

Geochemical and Geochronological Constraints on the Origin and Emplacement of the East Taiwan Ophiolite: Implication for Subduction Initiation of the South China Sea.

*Chiou-ting Lin[1], Ron A. Harris[2], Wei-dong Sun[1], Guo-liang Zhang[1]

1. Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, 2. Department of Geology, Brigham Young University

The East Taiwan Ophiolite (ETO) occurs as blocks and thrust sheets associated with the Lichi Mélange in the Coastal Range of eastern Taiwan. The blocks consist of serpentinized harzburgite, serpentinite breccia, gabbro, dikes of dolerite and plagiogranite, pillow basalts, and red clay within a mud- and serpentinite-rich mélange matrix. New U-Pb zircon dating of a pegmatite gabbro yields a weighted mean age of 16.65±0.20 Ma. This age is earlier than the North Luzon Arc, but overlaps with the late–stage spreading of the South China Sea. ETO glassy basalt has low K_2O, MgO and high CaO contents, similar to MORB. REE and trace element patterns show both N-MORB patterns with LREE depletion and E-MORB patterns with slight LREE enrichment. A few samples show slight depletion in Nb-Ta, and Ti and enrichment in Rb, Ba, U and Sr, indicating a hint of subduction influence. Most ETO basalt plots within the overlapping fields of N-MORB and BABB on Ti-V, Cr-Y, Nb/Yb- Th/Yb and Hf/3-Th-Ta discrimination diagrams. The geochemical compositions of the ETO basalt are emblematic of mid-ocean ridge or back-arc lava, and the Pb isotope values are similar to those of MORB of the South China Sea from IODP Expedition 349. We interpret ETO basalt as fragments of the subducted South China Sea basement that were scrapped off and accreted to the Luzon forearc during the process of subduction initiation along the nascent Manila Trench. Blocks of mantle material in the mélange may originate from the upper plate of the arc-continent collision and were mixed with lower plate crustal material in a subduction channel now represented by the Lichi Mélange.

Keywords: East Taiwan Ophiolite, Lichi Mélange, South China Sea, back-arc basin, subduction initiation, arc-continent collision

©2019. Japan Geoscience Union. All Right Reserved.

Towards a complete profile of hydrothermal alteration in the lower oceanic crust and uppermost mantle; Insights from the Oman Drilling Project and ChikyuOman2017 and 2018

*Damon A H Teagle[1], Michelle Harris[2], Gretchen Früh-Green[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Oman Drilling Project Science Team[1]

1. Ocean & Earth Science, National Oceanography Centre Southampton, University of Southampton, SO14-3ZH, Southampton, UK, 2. School of Geography, Earth and Environmental Sciences, Plymouth University, UK, 3. Earth Sciences, ETH Zürich, Switzerland, 4. Geology, Niigata University, Japan, 5. Earth and Planetary Sciences, Nagoya University, Japan, 6. LDEO, Columbia University, New York, USA

Drilling a continuous section through the lower oceanic crust and into the uppermost mantle has been an unfulfilled scientific ambition for more than 60 years since before the development of plate tectonics. Although an imperfect analogue of in situ, intact ocean crust, the 96 Ma Samail ophiolite of Oman is the largest and best preserved on-land exposure of ancient ocean crust that formed in some type of fast spreading ocean ridge, in the Tethyan ocean shortly before its obduction on to the Arabian margin. Offset drilling by Oman Drilling Project has now sampled critical intervals of the mid to lower oceanic crust and the uppermost mantle preserved in the Samail ophiolite. In a series of 400 m-deep diamond-cored boreholes the Oman Drilling Project has made with near 100 % rates of recovery, continuous objective observations from the lower sheeted dikes and the dike-gabbro transition zone (Hole GT3A), the mid-crustal transition from foliated to layered cumulate gabbros (Hole GT2A), deep layered gabbros including mineralised fault zones (Hole GT1A), and across the crust-mantle transition from layered gabbros through dunites into residual harzburgites of the Samail upper mantle (Holes CM1A and CM2B). Observations of drillcore, complemented by instrumental (e.g., X-ray CT, Infrared scanning) and geophysical wireline logging, now provide the opportunity to objectively quantify the conditions and extent of seawater-rock exchange in the mid to lower oceanic crust and uppermost mantle. These new observations will lead to better understand the role and influence of deep hydrothermal circulation on the accretion of the lower oceanic crust and the improved quantification of geochemical and isotopic exchanges between the oceans and new crust formed at mid-ocean ridges.

Keywords: ocean crust, hydrothermal alteration, ophiolite, Oman Drilling Project

©2019. Japan Geoscience Union. All Right Reserved.

Peridotite alteration in OmanDP cores

*Peter B Kelemen[1], Juan Carlos de Obeso[1], Craig Manning[2], Marguerite Godard[3], Wolfgang Bach[4], Merry Yue Cai[1], Saebyul Choe[5], Judith Coggon[6], Eric Ellison[7], Alireza Eslami[8], Katy Evans[9], Michelle Harris[10], Wolf-Achim Kahl[4], Jürg Matter[6], Katsu Michibayashi[11], Keichi Okazaki[12], Philippe Pézard[3], Damon A.H. Teagle[6], Alexis Templeton[7], OmanDP Oman Drilling Project Science Team

1. LDEO, 2. UCLA, 3. U. Montpellier, 4. U. Bremen, 5. AMNH, 6. U. Southampton, 7. U. Colorado, 8. U. Tehran, 9. Curtin U., 10. U. Plymouth, 11. Nagoya U., 12. JAMSTEC

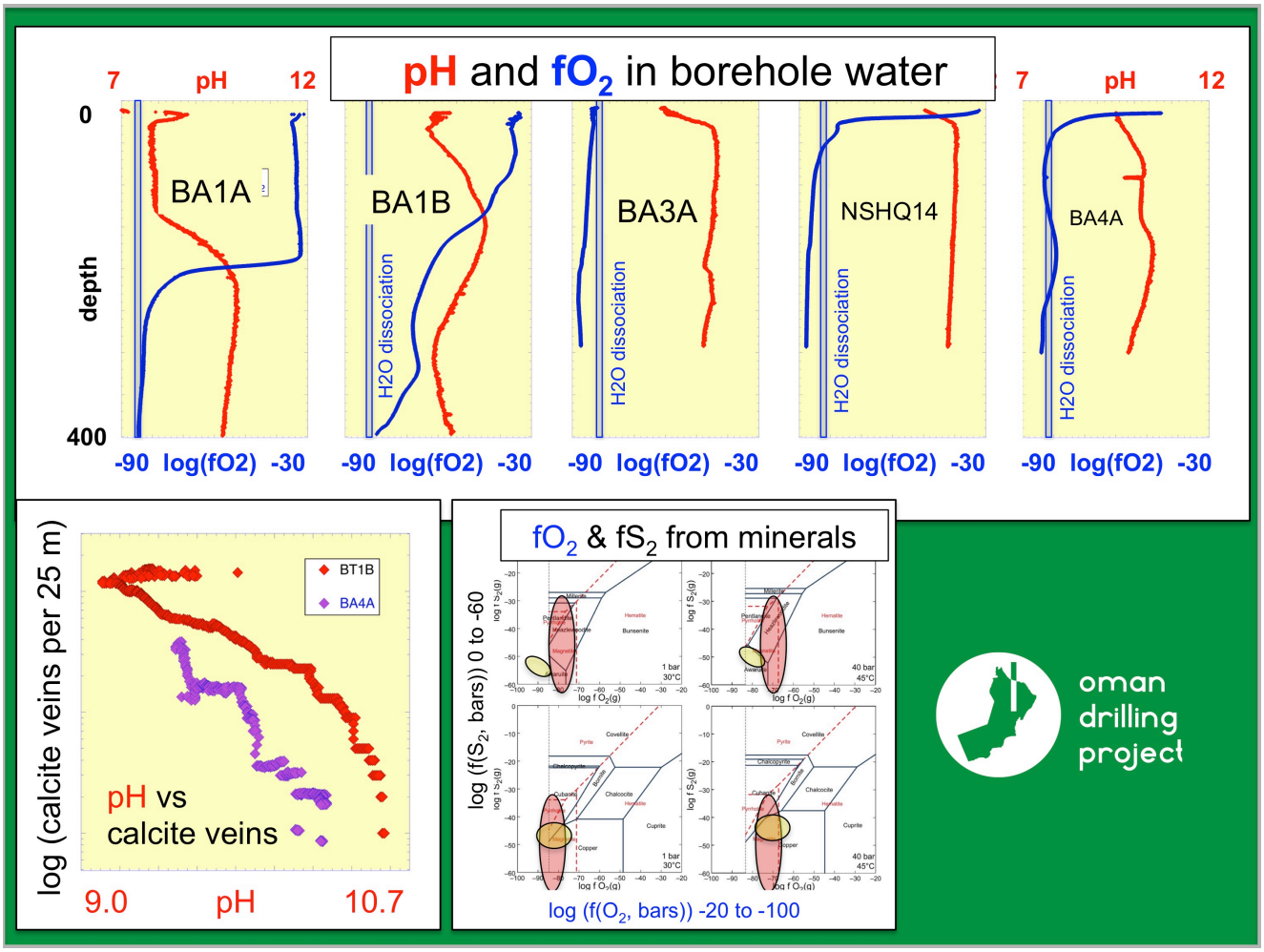
Here we present some preliminary results constraining peridotite alteration in cores from several Oman Drilling Project (OmanDP) boreholes, from the Samail ophiolite in the Sultanate of Oman. Hole BT1B in Wadi Mansah east of Fanjah was drilled through 200 m of fully carbonated and/or serpentinized peridotites of the mantle wedge, through the basal thrust of the ophiolite, into the metamorphic sole. Holes BA1B, BA3A and BA4A were drilled into extensively serpentinized peridotite of the eastern Wadi Tayin massif.

Fully carbonated peridotites (listvenites) and serpentinites of Hole BT1B reflect carbonation and hydration by fluids rising from the Cretaceous subduction zone at the base of the ophiolite, at about 100° C (Falk & Kelemen GCA 2015). Though there is extensive, 0.01-10 m scale chemical variation, the average, volatile-free composition of the listvenites is almost identical to that of partially serpentinized harzburgites throughout the ophiolite mantle section. This observation and thermodynamic modeling indicate that, during addition of CO2, H2O, Ca and K from subduction zone fluids, Mg/Fe/Si ratios were nearly unchanged, suggesting very minor export of dissolved, major elements. In turn, this requires a large increase in solid volume. One possibility is that major volume expansion occurred at a serpentinization front, perhaps advancing via reaction-driven cracking, followed by smaller amounts of expansion at the carbonation front. Observed mineral parageneses and thermodynamic modeling require relatively CO2-rich aqueous fluids, and perhaps an exsolved, CO2-dominated fluid. CO2 contents were higher than for fluids in equilibrium with underlying metasediments at any likely depth for formation of the observed listvenite, and thus suggest that fluids derived from higher temperature and pressure devolatilization migrated up the subduction zone to this site.

Highly serpentinized peridotites from Holes BA1B, BA3A and BA4A record steep chemical gradients, with sharply decreasing f(O2) and f(CO2) downhole, beginning at the present-day erosional surface. Moreover, inferred conditions based on mineral parageneses are consistent with present-day borehole water compositions. Oxygen fugacity reaches the limit for H2 production from H2O at < 100 meters below the surface. These borehole observations are consistent with previous observations (14C in carbonates, reduced sulfides, oxides and metals, highly alkaline and reduced fluids, H2 gas) and thermodynamic modeling indicating that carbonation and serpentinization-related redox reactions are ongoing. Given experimental data suggesting that serpentinization of olivine is slow, evidence for low temperature “serpentinization” raises interesting questions about natural rates, and the nature of reactants and products, in the present-day weathering environment.

Keywords: Global carbon cycle, Oman Drilling Project, Peridotite weathering, Serpentinization, Carbon mineralization aka mineral carbonation, Natural production of H2 hydrogen gas

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Low-salinity aqueous fluid inclusions in dolomite veins of a listvenite of Oman Drilling Project Phase 1

*Tatsuhiko Kawamoto[1], Hiroki Sato[2], Toma Takahashi[3], Juan Miguel Guotana[4], Tomoaki Morishita[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 Science Party

1. Department of Geoscience, Faculty of Science, Shizuoka University, 2. Faculty of Science, Kyoto University, 3. Faculty of Geosciences and Civil Engineering, Kanazawa University, 4. Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa University, 5. Lamont-Doherty Earth Observatory, Columbia University, 6. School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, 7. School of Geography, Earth and Environmental Sciences, Plymouth University, 8. Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 9. Institute of Science and Technology, Niigata University

There are numerous gas and liquid, two-phase inclusions in dolomite crystals in a white-green-colored listvenite recovered through Oman Drilling Project Phase 1 (specimen name z68w). Most of the fluid inclusions are tiny, <6 micrometer across and seems to be too small to provide detectable Raman spectra of fluids. Fluid inclusions >6 micrometer across in dolomite provide Raman spectra of H_2O, but they become dark possibly due to destruction during the cooling processes and usually prohibit from observation of melting ices. So far, Raman microscopy indicated that they are filled with H_2O and do not detect any other gasses such as CH_4 or CO_2. Melting temperature of ice in the tiny fluid inclusions, on a Linkam THM600 heating stage with a Nikon 100X objective lens indicates that they are filled with saline fluids with 1.1 ±0.5 wt% NaCl equivalent (n=42, Figure 1), which is much lower than that of seawater (3.5 wt% NaCl). Homogenization temperature of vapor-liquid suggests that the fluid inclusions were formed at temperature >139 ±31˚C (n=8, Figure 2). The fluid inclusions are mainly in dolomite veins, which cut magnesite and quartz (Figure 3, Raman mapping of magnesite, quartz, and dolomite). The present data indicate that low-salinity aqueous fluids were available during the crystallization of dolomite veins after the formation of magnesite-quartz assemblage. If seawater carries carbon to form listvenite from peridotite or serpentinite, the present low-salinity data suggest that chlorine needs to be absorbed by some phases during the fluid migration or be diluted by mixing with meteoric water.

Keywords: seawater, carbon cycling, serpentinite, serpentine, carbonate, carbonation

©2019. Japan Geoscience Union. All Right Reserved.

Figure 1 Histogram of salinity.

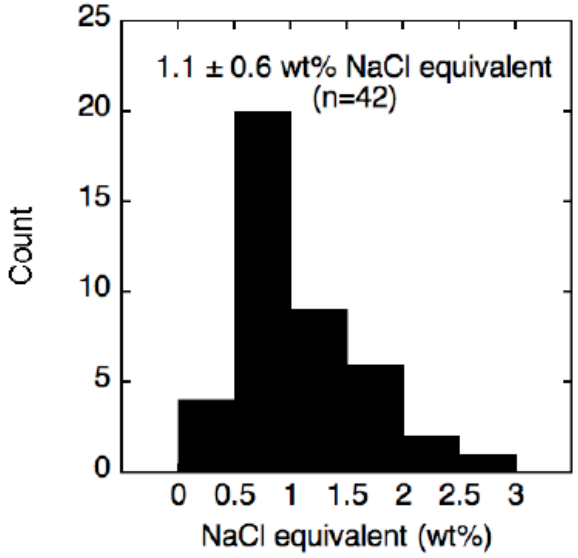


Figure 2 Homogenization T vs salinity.

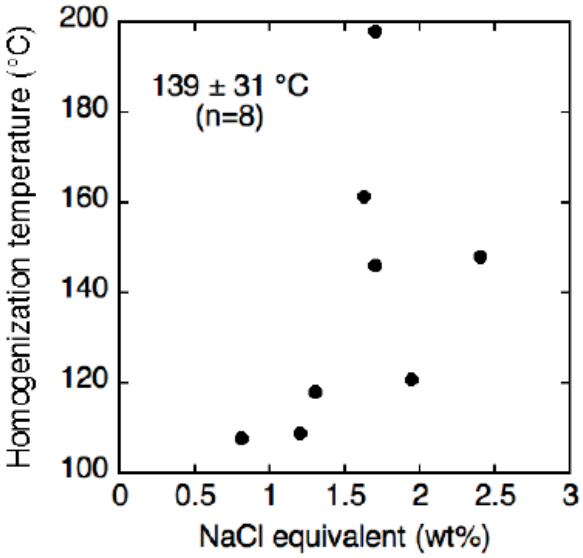
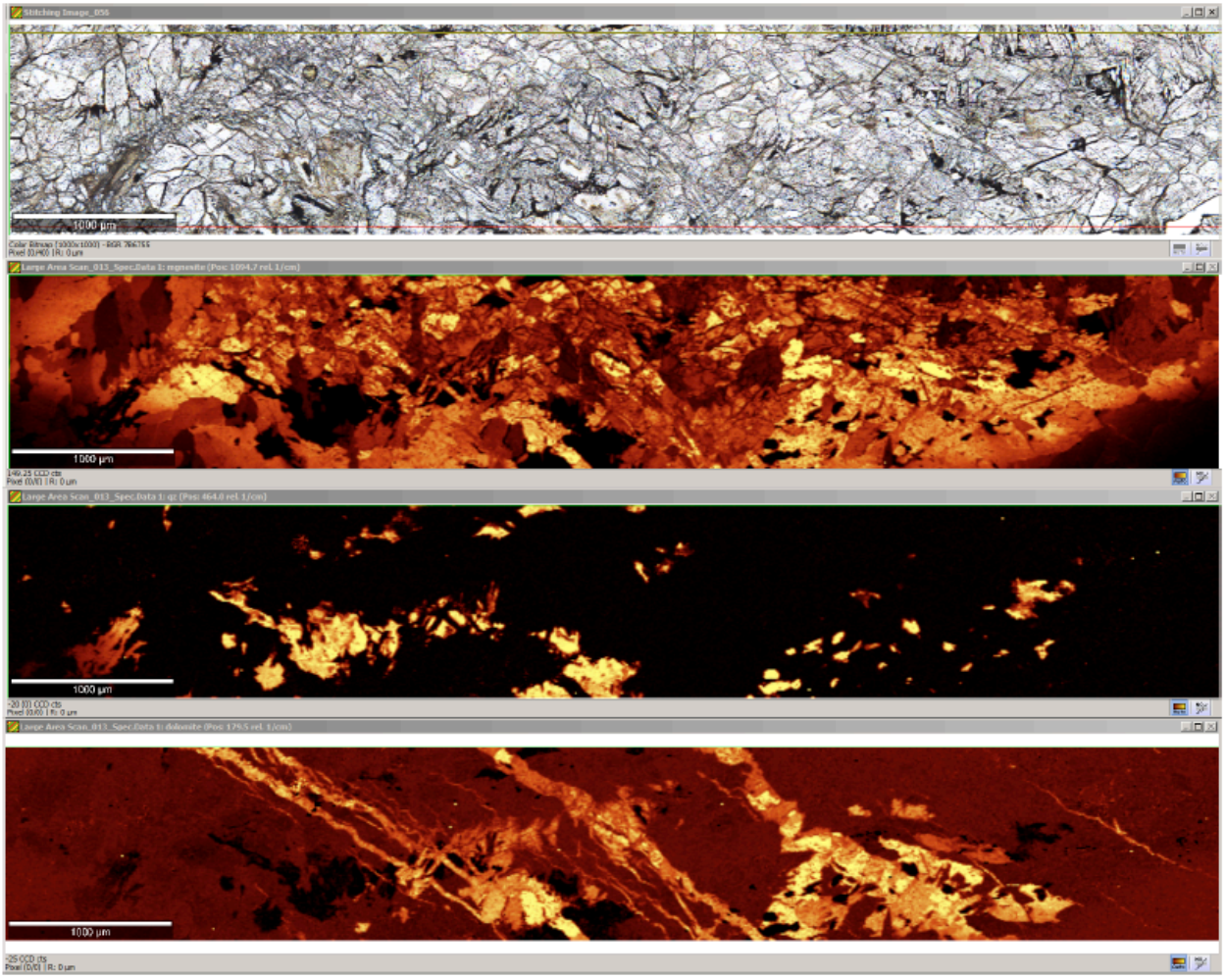


Figure 3 Microphotograph of a listvenite under transparent light (7.5mm wide) and Raman mapping images showing the distribution of magnesite, quartz, and dolomite.



©2019. Japan Geoscience Union. All Right Reserved.

Hydration and development of fracture network within oceanic lower crust: an evidence from CM1A of Oman Drilling

*Atsushi Okamoto[1], Kazuki Yosida[1], Ryosuke Oyanagi[2], Oman Drilling Project Phase 2 Science Party[3]

1. Graduate School of Environmental Studies, 2. JAMSTEC, 3. Oman Drillng Project Phase 2 Science Party

The rate and extent of hydration of oceanic lithosphere are of special importance for understanding of the global water budget, the physical properties of crust-mantle boundary and potential limit of microbial activities in the crusts. It has been suggested that Moho transition zone and uppermost mantle has been highly serpentinized. If the fluid source for serpentinization is seawater, the fluid infiltration through the “less permeable” lower crust should occur. In this study, we report the nature of serpentinization in olivine within the lower crusts that was recovered from the CM1A site of the Oman Drilling Project, and discuss the relationship between hydration, fluid flow and fracturing based on the modeling of distinct element method (DEM).

The gabbroic rocks of the lower crust showed layer structures composed of light and dark colored layers with few to several tens millimeter thickness. The former is mainly composed of plagioclase and clinopyroxnene and the latter is enriched in olivine. The olivine grains were serpentinized with forming mesh-like textures, and the extent of serpentinization increases with increasing the modal abundance of olivine. The serpentine veins within the olivine grains do not always contain brucite, and show the zoning of Al, indicating an influx of silica and aluminum from plagioclase during serpentinization. The large amount of magnetite was formed in the serpentine mesh veins, indicating that olivine with high Fe content (Mg# = ~0.82) effectively produce hydrogen compared to the common mantle peridotite (Mg# = ~0.9). Radial cracks, which are filled with chlorite, are also developed around the serpentinized olivine grains. These features indicated that the reaction-induced fracturing occurred as the force of crystallization exceeds the tensile strength of the matrix minerals as suggested by the previous studies (Jamtveit et al., 2008; Kelemen and Hirth, 2012). It is also noted that fractures in olivine tends to developed in horizontal direction (parallel to the gabbroic layering) whereas those with in the plagioclase developed in vertical direction.

We conducted the DEM simulation on serpentinization in layered gabbro, which treats the reaction, advective fluid flow and fracturing, and the reaction rate is defined as a function of fluid pressure (Okamoto and Shimizu, 2015; Shimizu and Okamoto, 2016). The model reproduces a simultaneous development of contrasting fracture patterns inside and outside of the olivine grains, and shows the development of fracture network connecting the olivine grains, and shows the positive feedback of serpentinization, fracturing and permeability enhancement in vertical direction. These results indicate that the reaction-induced fracturing play essential roles on the fluid infiltration through the lower crusts and mantle hydration.

References

Kelemen, P.B., Hirth, G., 2012. Earth Planet Sci Let, 81-89. Jamtveit B., Malthe-Sorenssen, A., Kostenko, O., 2008. Earth Planet Sci Let, 267, 620-627. Okamoto, A., Shimizu, H., 2015. Earth Planet Sci Let, 417, 9-18. Shimizu, H., Okamoto, A., 2016. Contrib Mineral Petrol, 171, 73.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: layered gabbro, distinct element method, serpentinization, Oman Drilling Project, reaction induced fracturing

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | B (Biogeosciences)：B-BG Biogeosciences & Geosphere-Biosphere Interactions

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 201A 2F

[B-BG01] Elemental cycling in terrestrial and coastal ecosystems- Carbon and Nitrogen perspectives

convener:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata), Chairperson:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata)

Biogeochemical cycling of carbon and nitrogen hold the key to cropping cycle, monsoonal patterns and climate globally. Biological communities that make up the biosphere are essential for cycling of carbon and nitrogen and their functions are regulated by numerous factors including redox conditions, trace metal availability, and energy sources. At the same time temporal and spatial variability of biological communities such as those observed in microbes strongly affect the rate of carbon and nitrogen cycling in various environments including land and marine systems. In this session, submissions are welcomed from scientists including early career scientists working on various aspects of carbon and nitrogen cycling across terrestrial, coastal and oceanic environments. Submissions are also encouraged addressing challenges related to estimation of carbon and nitrogen budgets representing local, regional and global scales.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

Introduction

3:35 PM - 4:00 PM JST | 6:35 AM - 7:00 AM UTC

[BBG01-01] **Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem**

★Invited Papers

*Santanu Ray[1] (1.Systems ecology and ecological modelling laboratory, Dept. of Zoology, Visva-Bharati University, Santiniketan 731235, India)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[BBG01-02] ^{17}O-rich nitrate as a tracer for constraining nitrogen transformations in coastal sediments

*Chawalit Charoenpong[1,2], Scott D Wankel[2], Carolyn Buchwald[3,2], Wiebke Ziebis[4] (1.Chulalongkorn University, 2.Woods Hole Oceanographic Institution, 3.Dalhousie University, 4.University of Southern California)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[BBG01-03] **Exploring changes in bacterioplankton community structure in response to tannic acid, a major component of litterfall, in a mangrove ecosystem: a laboratory mesocosm approach**

*Anwesha Ghosh[1] (1.Integrative Tax Microb Ecol Res Group, Dept. of Biol Sci, IISERK)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[BBG01-04] **Diel variations of dissolved inorganic carbon in the Pearl River plume and the northern South China Sea shelf upwelling during summer**

*Wei-Jen Huang[1], Kai-Jung Kao[1], Yu-Shih Lin[1], James T. Liu[1], Chen-Tung Arthur Chen[1] (1.National Sun Yat-sen University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[BBG01-05] **Spatial and vertical variations of carbon and nitrogen isotopes of larch forest and NDVI in Eastern Siberia**

*Aleksandr Nogovitcyn[1], Atsuko Sugimoto[2], Ruslan Shakhmatov[1], Tomoki Morozumi[1], Shunsuke Tei[2], Yumiko Miyamoto[2], Trofim Maximov[3,4] (1.Graduate School of Environmental Science, Hokkaido University, Sapporo, Hokkaido, Japan, 2.Arctic Research Center, Hokkaido University, Sapporo,

Hokkaido, Japan, 3.Institute for Biological Problems of Cryolithozone, Siberian Blanch of Russian Academy of Sciences, Yakutsk, Yakutia, Russia, 4.International Center for Biogeoscience Educational and Scientific Trainings (BEST), North-Eastern Federal University, Yakutsk, Yakutia, Russia)

Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem

*Santanu Ray[1]

1. Systems ecology and ecological modelling laboratory, Dept. of Zoology, Visva-Bharati University, Santiniketan 731235, India

Hooghly estuary of India is very rich in natural resources and receives large amountof nutrients through litterfall from adjacent mangrove forest. Nitrogen and carbon as important nutrients occur in various forms and plays a crucial role in the regulation of productivity in this estuarine system. Modelling of nitrogen and carbon dynamics from mangrove litterfall and particularly the release of dissolved inorganic nitrogen and carbon in this estuarine system is important because of their roles in augmenting growth of phytoplankton and other higher plants and all other biological components of grazing food chain. Considering the importance of nitrogen and cabron, two dynamic models both with seven compartmentsare proposed. In these models, nitrogen and carbon of the mangrove litterfall are considered as source and its conversion into different organic and inorganic forms are considered as state variables. Some physical and chemical factors and also rate parameters such as nitrogen fraction of litter biomass, litter biomass, redox potential, soil temperature, conversion rates of nitrogen of one form to another form, phytoplankton uptake rate of dissolved inorganic nitrogen and carbon, dissolved oxygen, water temperature and water pH are considered as graph-time functions in this model. These data are collected over two years from field works and experiments. Other rate parameters are calibrated following standard procedure. Sensitivity analysis is performed before calibration. Model simulation results are properly validated with observed data. Sensitivity analysis reveals that the leaching rate of soil organic nitrogen to total organic nitrogen of water and loss rate of soil organic nitrogen as humic acid and fulvic acids are very sensitive parameters in this system. Redox potential plays an important role in the conversion of soil total nitrogen to soil inorganic nitrogen whereas soil temperature is considered to be key factor regulating the microbial activity for the conversion of soil organic nitrogen to soil inorganic nitrogen. Similarly inwater, total organic nitrogen of water including dissolved organic nitrogen and particulate organic nitrogen is dependent on soil organic nitrogen. The dissolved organic nitrogen, particulate organic nitrogen and soil inorganic nitrogen ultimately get converted into dissolved inorganic nitrogen and accumulated in water which is taken by phytoplankton and microflora as minerals.For carbon cycle model results show seasonal variations of litterfall and which is the main source of SOC pool and ultimately transportedto the estuary. Other than litterfall, the death of organisms in soil and water enriches the SOC and POC respectively. pH of water is governing factor and depending on this factor, DIC is converted to DCO_2 and DBC, which are taken up by phytoplankton during photosynthesis. Mineralization rate of SOC to SIC and uptake rate of DCO_2 and DBC are the sensitive parameters.

Keywords: Dynamic models, litterfall, inorganic, organic, tropical estuary

©2019. Japan Geoscience Union. All Right Reserved.

Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem

Santanu Ray
[1]Ecological Modelling Laboratory, Department of Zoology, Visva-Bharati University, Santiniketan 731235, India
[2]Department of Environmental Science, Burdwan University, Burdwan, India

Abstract

Hooghly estuary of India is very rich in natural resources and receives large amountof nutrients through litterfall from adjacent mangrove forest. Nitrogen and carbon as important nutrients occur in various forms and plays a crucial role in the regulation of productivity in this estuarine system. Modelling of nitrogen and carbon dynamics from mangrove litterfall and particularly the release of dissolved inorganic nitrogen and carbon in this estuarine system is important because of their roles in augmenting growth of phytoplankton and other higher plants and all other biological components of grazing food chain. Considering the importance of nitrogen and cabron, two dynamic models both with seven compartmentsare proposed. In these models, nitrogen and carbon of the mangrove litterfall are considered as source and its conversion into different organic and inorganic forms are considered as state variables. Some physical and chemical factors and also rate parameters such as nitrogen fraction of litter biomass, litter biomass, redox potential, soil temperature, conversion rates of nitrogen of one form to another form, phytoplankton uptake rate of dissolved inorganic nitrogen and carbon, dissolved oxygen, water temperature and water pH are considered as graph-time functions in this model. These data are collected over two years from field works and experiments. Other rate parameters are calibrated following standard procedure. Sensitivity analysis is performed before calibration. Model simulation results are properly validated with observed data. Sensitivity analysis reveals that the leaching rate of soil organic nitrogen to total organic nitrogen of water and loss rate of soil organic nitrogen as humic acid and fulvic acids are very sensitive parameters in this system. Redox potential plays an important role in the conversion of soil total nitrogen to soil inorganic nitrogen whereas soil temperature is considered to be key factor regulating the microbial activity for the conversion of soil organic nitrogen to soil inorganic nitrogen. Similarly inwater, total organic nitrogen of water including dissolved organic nitrogen and particulate organic nitrogen is dependent on soil organic nitrogen. The dissolved organic nitrogen, particulate organic nitrogen and soil inorganic nitrogen ultimately get converted into dissolved inorganic nitrogen and accumulated in water which is taken by phytoplankton and microflora as minerals.For carbon cycle model results show seasonal variations of litterfall and which is the main source of SOC pool and ultimately transportedto the estuary. Other than litterfall, the death of organisms in soil and water enriches the SOC and POC respectively. pH of water is governing factor and depending on this factor, DIC is converted to DCO_2 and DBC, which are taken up by phytoplankton during photosynthesis. Mineralization rate of SOC to SIC and uptake rate of DCO_2 and DBC are the sensitive parameters

Keywords: Dynamic models; litterfall; inorganic; organic; tropical estuary

©2019. Japan Geoscience Union. All Right Reserved.

^{17}O-rich nitrate as a tracer for constraining nitrogen transformations in coastal sediments

*Chawalit Charoenpong[1,2], Scott D Wankel[2], Carolyn Buchwald[3,2], Wiebke Ziebis[4]

1. Chulalongkorn University, 2. Woods Hole Oceanographic Institution, 3. Dalhousie University, 4. University of Southern California

Coastal sediments are often replete in organic matter and exhibit sharp gradient in redox conditions. In addition, the oxic-anoxic interfaces are often around a few centimeters if not less below the sediment surface. This make this environment poised to harbor both oxidative and reductive nitrogen transformations. As such, the use of a single or a couple of isotope-labeling tracers to determine the rates of these many processes might suffer from the systems being underconstrained. In this work, we demonstrate how naturally-occurring, ^{17}O-rich nitrate can aid in the studying these complex systems through the ability to follow the transformations of added nitrate (NO_3^-) into other different pools of N-species and closely investigate the triple isotopic compositions (δ^{15}N, δ^{18}O, and Δ^{17}O). While we followed five different pools of N-species namely NO_3^-, NO_2^-, N_2O, NH_4^+, and total reduced N (NH_4^+ plus DON), we chose to focus this work on the intermediate nitrite, NO_2^-. For all intact flow-through core incubations done on the sediments collected from Sylt Island, Germany, sediments acted as sources for NO_2^- in all experimental manipulations including sediment type, dissolved oxygen level, and NO_3^- loading. Unlike in the environments that are solely driven by reductive processes where the changes in δ^{15}N and δ^{18}O are coupled, the co-occurrence of both oxic and anoxic in the sediments such as ones from this study cause the δ^{15}N and δ^{18}O to decouple primarily because O is often subject to more processes than N. By using three isotope systems along with the change in concentrations, we demonstrate how we can use a natural abundance appraoch and rely on a series of mathematical equations to solve for different N transformation rates.

Keywords: nitrogen, isotope, 17O, sediments

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Exploring changes in bacterioplankton community structure in response to tannic acid, a major component of litterfall, in a mangrove ecosystem: a laboratory mesocosm approach

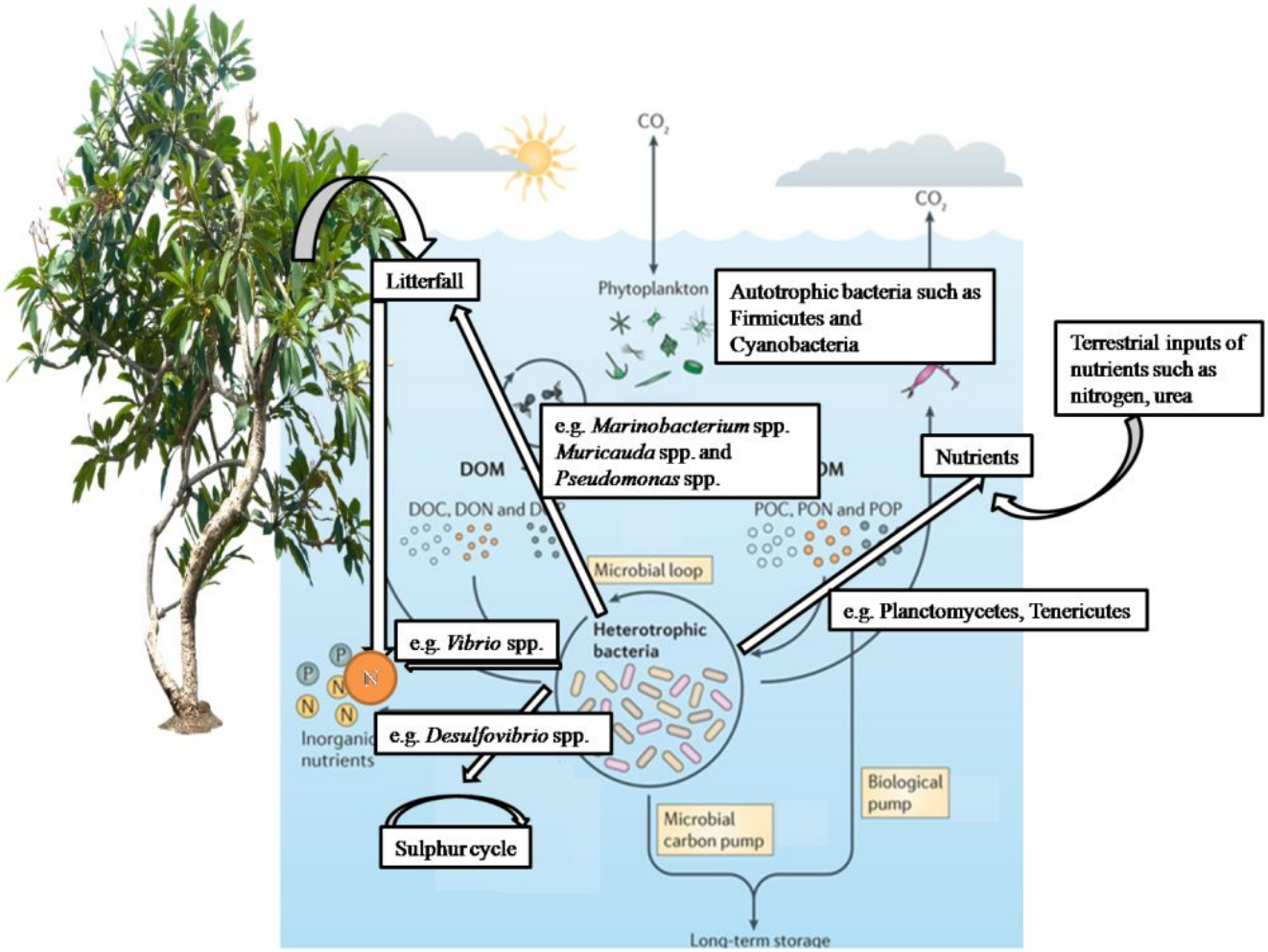
*Anwesha Ghosh[1]

1. Integrative Tax Microb Ecol Res Group, Dept. of Biol Sci, IISERK

Litterfall constitutes a major source of allochthonous matter for bacterioplankton communities in estuarine mangroves. Tannic acid, an abundant component of mangrove litterfall, leaches out and contributes substantially to DOC and DOM pools of the adjacent estuaries. About 50% of mangrove litterfall maybe degraded and channelized into the marine microbial loop. Estuarine conditions of Sundarbans, world’ s largest contiguous mangrove, was mimicked in a laboratory mescocosm set-up using barrels to understand the influence of tannic acid on bacterioplankton communities. Estuarine water from a station, Stn3 of Sundarbans Biological Observatory Time Series (SBOTS) was enriched with tannic acid and the change in functional bacterioplankton community structure was analysed on the start (Day 0), intermediate (Day 7) and end (Day 15) of the experiment. Bacterioplankton community structure was elucidated by sequencing the V3-V4 region of 16S rRNA on an Illumina MiSeq platform. Concentration of tannic acid, gallic acid, trace elements, dissolved nutrients such as nitrate and *ortho* -phosphate along with hydrological parameters were determined on a daily basis. Degradation of tannic acid was tracked by decrease in concentration of tannic acid and generation of gallic acid, one of the final products of tannic acid degradation. Tannic acid was shown to significantly affect the concentration of dissolved nitrate and trace elements in the barrels. Proteobacteria was found to be the most dominant bacterial phylum in Control and tannic acid enriched barrels (Barrel 1 and 2) on Day 0. With the progression of experiment, the abundance of Proteobacteria decreased significantly in the Control barrel indicating the dependence of this phylum on steady flux of nutrients. The abundance of Proteobacteria in the tannic acid enriched barrels remained high indicating that members of Proteobacteria may be capable of using tannic acid as a source of carbon and nitrogen. Tannic acid appeared to inhibit other bacterioplankton phyla including Actinobacteria, Acidobacteria and Verrucomicrobia that existed in large abundance in the Control barrel on Day 15 but were absent in the tannic acid enriched barrels. At class level, Bacteroides was found to be present in highest abundance in the tannic acid enriched barrels. Bacteroides are capable of breaking down tannic acid using tannase as an enzyme. This experiment indicated that bacterioplankton communities of Sundarbans could harbour genes necessary for breakdown of complex components of litterfall and recycle them into the marine microbial loop. Breakdown of tannic acid could influence the marine nitrogen and carbon cycling by releasing DON and DOC respectively into the adjacent estuaries. An understanding of the breakdown of tannic acid and other components of mangrove litterfall and its influence on the resident biological communities of estuarine mangroves could be essential for our understanding of functioning of coastal ecosystems.

Keywords: bacterioplankton, mangrove, litterfall

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Diel variations of dissolved inorganic carbon in the Pearl River plume and the northern South China Sea shelf upwelling during summer

*Wei-Jen Huang[1], Kai-Jung Kao[1], Yu-Shih Lin[1], James T. Liu[1], Chen-Tung Arthur Chen[1]

1. National Sun Yat-sen University

Strong river-to-sea mixing, stratification, and coastal eutrophication are usually observed on a plume dominated-continental shelf, but the effects of diel variations and upwelling on the carbonate system are still unclear on the northern South China Sea continental shelf. The Pearl River plume and upwelling at the northern South China Sea were surveyed at the near-field (1 day), the mid-field (6 days), and the far-field sites (1day) along the plume trajectory. We sampled total alkalinity (TA) and dissolved inorganic carbon (DIC) and calculated buffer capacity at the near-surface and near-bottom waters. We also estimated primary productivity (PP, based on $d^{13}C$) at the near-field site and calculated net community productivity (NCP) in the mid-field site after removing the mixing effect. At this plume-upwelling hybrid system, lower salinity, TA, and DIC value and higher buffer capacity and NCP were observed in the near-surface water than the values in the near-bottom water. A good correlation between the common logarithm of light intensity and PP was observed; suggesting that the diel variation of PP was dominated by day-night light cycle. Moreover, the changes of net biological uptake (36% to 76%) were higher than the changes of salinities (3% to 8%) during the subsurface upwelling (from development, maxima, and decline stages at the middle-field site). We suggest that respiration-associated biological activities in addition to PP and physical mixing dominated the near-surface water during subsurface upwelling. Finally, at this coupled plume and upwelling system, the diel variation of carbonate system can be dominated by PP induced by periodic sunlight cycle and further affected by respiration strengthened by intensive upwelling.

Keywords: Pearl River plume, inorganic carbon, upwelling, CO2

©2019. Japan Geoscience Union. All Right Reserved.

Spatial and vertical variations of carbon and nitrogen isotopes of larch forest and NDVI in Eastern Siberia

*Aleksandr Nogovitcyn[1], Atsuko Sugimoto[2], Ruslan Shakhmatov[1], Tomoki Morozumi[1], Shunsuke Tei[2], Yumiko Miyamoto[2], Trofim Maximov[3,4]

1. Graduate School of Environmental Science, Hokkaido University, Sapporo, Hokkaido, Japan, 2. Arctic Research Center, Hokkaido University, Sapporo, Hokkaido, Japan, 3. Institute for Biological Problems of Cryolithozone, Siberian Blanch of Russian Academy of Sciences, Yakutsk, Yakutia, Russia, 4. International Center for Biogeoscience Educational and Scientific Trainings (BEST), North-Eastern Federal University, Yakutsk, Yakutia, Russia

Under a global climate change, taiga forest ecosystem is expected to change. Tree ring data obtained at northeast Siberian Taiga indicated tree growth decrease during warm climate (Tei et al., 2014), consequently primary production may decrease in the future. As tools for monitoring ecosystem changes, stable isotope of carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$ are widely applied in ecological research. The $\delta^{13}C$ is a common proxy for water use efficiency in plants, and the $\delta^{15}N$ is for nitrogen availability that is important because boreal forest on permafrost is usually poor in the nitrogen (Popova et al., 2013).

Observations were conducted at Spasskaya Pad forest station (62˚25’ N, 129˚62’ E) near Yakutsk, Russia. The forest is usually dry, but after the extreme wet event in 2007, wet sites were distributed in the forest. Transect (60m x 510m) with 30m x 30m plots, in total 33, was set including dry sites and wet sites, to obtain needle samples from 104 trees at the height of 5-6 m were obtained in order to investigate spatial variations in $\delta^{13}C$, $\delta^{15}N$, and N contents. These spatial variations were compared with satellite-derived Normalized difference vegetation index (NDVI) using Landsat images with the resolution of 30 m. Lower NDVI and lower foliar N content were observed at wet sites than those at dry sites. A high $\delta^{13}C$ and high $\delta^{15}N$ were also observed at a wet site. After extreme wet event happened, ecosystem (and N availability) changes and NDVI also changes. We also obtained the needles from two trees at different heights in a jungle gym to investigate the vertical variations in $\delta^{13}C$ and $\delta^{15}N$. There were large differences in $\delta^{13}C$, $\delta^{15}N$ and N contents vertically.

Tei, S., A. Sugimoto, H. Yonenobu, T. Ohta, T. C. Maximov. Growth and physiological responses of larch trees to climate changes deduced from tree-ring widths and $\delta^{13}C$ at two forest sites in eastern Siberia. *Polar Science*, 8, 183-195, doi:10.1016/j.polar.2013.12.002, 2014

Popova A.S., N. Tokuchi, N. Ohte, M.U. Ueda, K. Osaka, T.Ch. Maximov and A. Sugimoto. Nitrogen availability in the taiga forest ecosystem of northeastern Siberia. *Soil Science and Plant Nutrition*, 59, 427-441, doi:10.1080/00380768.2013.772495, 2013

Keywords: taiga (boreal) forest, NDVI, carbon isotope, nitrogen isotope

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS02] Drilling Earth Science

convener:Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Azumi Kuroyanagi(Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku University), Kosei E. Yamaguchi(Toho University and NASA Astrobiology Institute), Chairperson:Azumi Kuroyanagi(Tohoku University), Kan Hsiung(JAMSTEC)

"Earth Drilling Science" session aims to exchange the latest information and scientific achievements in Ocean/Continental drilling projects and to promote the interdisciplinary science. The session covers a wide range of drilling sciences, earth dynamics, environments, and the drilling-related technologies. The overview of the recent IODP cruises as well as future projects of any types of scientific drilling will be reported.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS02-01] Planktonic foraminiferal biostratigraphy in the South China Sea IODP Exp. 367 U 1499

*Akira Furusawa[1], Hiroki Hayashi[1] (1.Interdisciplinary Graduate School of Science and Engineering, Shimane University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS02-02] High heat with slow cooling of rift margin in the South China Sea, IODP Exp.368

*Arito Sakaguchi[1,2], Nobuaki Osono[1], Keita Nakano[1] (1.Yamaguchi Univ., 2.JAMSTEC)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS02-03] Abundant ferromanganese microparticles in oxic pelagic sediments (IODP Exp. 329)

*Go-Ichiro Uramoto[1,2], Yuki Morono[2], Naotaka Tomioka[2], Shigeyuki Wakaki[2], Ryoichi Nakada[2], Rota Wagai[3], Kentaro Uesugi[4], Akihisa Takeuchi[4], Masato Hoshino[4], Yoshio Suzuki[4,5], Satoshi Mitsunobu[6], Fumito Shiraishi[7], Hiroki Suga[5], Yasuo Takeichi[8], Yoshio Takahashi[5], Fumio Inagaki[2] (1.Kochi University, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Agriculture and Food Research Organization, 4.Japan Synchrotron Radiation Research Institute, 5.University of Tokyo, 6.Ehime University, 7.Hiroshima University, 8.High Energy Accelerator Research Organization)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS02-04] **Regional stratigraphic framework, Gas Hydrate occurrence and distribution of National Gas Hydrate Program Expedition 02 (NGHP-02) Area-B, offshore eastern India**

*KanHsi Hsiung[1], Saneatsu Saito[1], Toshiya Kanamatsu[1], Yoshinori Sanada[1], Yasuhiro Yamada[1], KYAW MOE[1], Yohei Hamada[1], Yasuyuki Nakamura[1], HungYu Wu[1] (1.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS02-05] Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

*Akira Ijiri[1], Shigeyuki Wakaki[1], Yoshiro Nishio[2], Yohei Hamada[1], Tsuyoshi Ishikawa[1], Fumio Inagaki[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kochi University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS02-06] Recent progress and perspective on paleomagnetism by means of deep-sea drilling

*Toshitsugu Yamazaki[1], Yuhji Yamamoto[2], Toshiya Kanamatsu[3], Yuho Kumagai[4], Norihiro Nakamura[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Center for Advanced Marine Core

Research, Kochi University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Tohoku University)

Planktonic foraminiferal biostratigraphy in the South China Sea IODP Exp. 367 U 1499

*Akira Furusawa[1], Hiroki Hayashi[1]

1. Interdisciplinary Graduate School of Science and Engineering, Shimane University

In the IODP Exp. 367 voyage in the South China Sea, I certified several floating foraminiferal biostratigraphy from the core catcher sample in shipboard analysis when I carried on research as a micro-paleontologist. I finished the voyage and brought the sample home and examined the more detailed chronology using buoyant foraminiferal fossils based on the samples obtained from the excavated U 1499 core.

Keywords: International Ocean Discovery Program: IODP, Planktonic foraminiferal biostratigraphy

©2019. Japan Geoscience Union. All Right Reserved.

High heat with slow cooling of rift margin in the South China Sea, IODP Exp.368

*Arito Sakaguchi[1,2], Nobuaki Osono[1], Keita Nakano[1]

1. Yamaguchi Univ., 2. JAMSTEC

The cooling rate of the crust may depend on thermal setting including heat source, heat transportation system and thermal properties. The heat flow of the ocean plate decreases with reversed root of the plate age, and this implies that the plate tectonics is thermo dynamic system. Thermal analysis can be applied to more complex tectonic region such as marginal sea and continental divisions.

The IODP Exp. 368 has carried out at the Paleogene South China Sea, and the sediment must record thermal history of the formation of rift margin. The site U1501 is located at the most landward outer margin high of the continent-ocean transition of the rift zone. It is expected that the sediment records thermal history of initial stage of rifting. During the cruise, early Oligocene to late Eocene sediment was cored to 697 m, and high geothermal gradient of 81.4˚C/km was obtained using in-situ temperature measurement (Jian et al., 2018). The terrigenous sediment of this core includes many vitrinite fragment, and its reflectance is sensitive geo-thermometer for sediment.

The result of vitrinite reflectance from 0.21 to 0.34 % are obtained from 340 to 510 mbsf. The estimated maximum paleo-temperature is from approximately 27 to 70˚C, and obtained paleo-geothermal gradient is >250˚C/km. This is higher than present measurement value, and quite higher than world average value of the crust. In case of hot basement covers with thin sediment, apparent geo-thermal gradient gets higher, and thickening history of sediment can be measured from the deposition rate of 11mm/Ky in average (Jian et al., 2018). To satisfy the obtained vitrinite reflectance profile, this site must cool by 2.8% in million years. This cooling rate is much slower than general rate of reversed root of the plate age. This might be due to heat being transferred for a long time or being warmed by the cover sediment layer.

Keywords: Rift margin, heat flow, cooling rate, Joides Resolution, vitrinite reflectance, South China Sea

©2019. Japan Geoscience Union. All Right Reserved.

Abundant ferromanganese microparticles in oxic pelagic sediments (IODP Exp. 329)

*Go-Ichiro Uramoto[1,2], Yuki Morono[2], Naotaka Tomioka[2], Shigeyuki Wakaki[2], Ryoichi Nakada[2], Rota Wagai[3], Kentaro Uesugi[4], Akihisa Takeuchi[4], Masato Hoshino[4], Yoshio Suzuki[4,5], Satoshi Mitsunobu[6], Fumito Shiraishi[7], Hiroki Suga[5], Yasuo Takeichi[8], Yoshio Takahashi[5], Fumio Inagaki[2]

1. Kochi University, 2. Japan Agency for Marine-Earth Science and Technology, 3. National Agriculture and Food Research Organization, 4. Japan Synchrotron Radiation Research Institute, 5. University of Tokyo, 6. Ehime University, 7. Hiroshima University, 8. High Energy Accelerator Research Organization

Manganese is the third most abundant metallic element, after iron and titanium, in the Earth’ s crust, and ferromanganese minerals are sensitive to changes in redox condition. Assessing the formation and preservation of ferromanganese minerals is important for understanding the global marine cycles of manganese and numerous associated trace elements. The most extensive manganese mineral deposits occur on abyssal plains, including those below open-ocean gyres. However, the extent of ferromanganese minerals buried in subseafloor sediments remains unclear. During the Integrated Ocean Drilling Program (IODP) Expedition 329, we drilled the entire sedimentary sequence at 6 sites in the ultra-oligotrophic region of the South Pacific Gyre (SPG), where dissolved O_2 and aerobic microbial communities are present from the seafloor to the sediment-basement interface [1]. By using high-resolution imaging techniques, we found abundant (10^8-10^9 particles cm^{-3}) micrometer-scale ferromanganese mineral particles (Mn-microparticles) in the oxic pelagic clays of the South Pacific Gyre [2]. Furthermore, we established microparticle separation technique by the combined use of density concentration and flowcytometer/particles sorting techniques. Major and trace element compositional analyses revealed that iron and manganese were the major components of Mn-microparticles, while they also contained rare-earth elements. From the number of Mn-microparticles per unit volume of sediment and the global distribution of oxic pelagic clays, we estimated the number of Mn-microparticles to be 1.5-8.8 $\times 10^{28}$ particles, which accounted for 1.28-7.62 Tt of manganese. This estimate is at least 2 orders of magnitude larger than the manganese budget for manganese nodules and manganese crusts on the seafloor. Along with the examination of manganese input, formation, and preservation, this study provides new insights into the global budget of metallic elements in the abundant Mn-microparticles present in deep subseafloor environments.

[1] D’ Hondt, S., Inagaki, F., Zarikian, C. A., Abrams, L. J., Dubois, N., Engelhardt, T., Evans, H., Ferdelman, T., Gribsholt, B., Harris, R. N., Hoppie, B. W., Hyun, J.-H., Kallmeyer, J., Kim. J., Lynch, J. E., McKinley, C. C., Mitsunobu, S., Morono, Y., Murray, R. W., Pockalny, R., Sauvage, J., Shimono, T., Shiraishi, F., Smith, D. C., Smith-Duque, C., Spivack, A. J., Steinsbu, B. O., Suzuki, Y., Szpak, M., Toffin, L., Uramoto, G., Yamaguchi, T. Y., Zhang, G., Zhang, X.-H., and Ziebis, W. Presence of oxygen and aerobic communities from seafloor to basement in deep-sea sediment. *Nature Geosciences,* 8(4), 299-304, 2015.
[2] Uramoto, G.-I., Morono, Y., Tomioka, N., Wakaki, S., Wagai, R., Uesugi, K., Takeuchi, A., Hoshino, M., Suzuki, Y., Shiraishi, F., Mitsunobu, S., Suga, H., Nakada, R., Takeichi, Y., Takahashi, Y., and Inagaki, F., Significant contribution of subseafloor microparticles to the global manganese budget. *Nature Communications*. **10**, 400, https://doi.org/10.1038/s41467-019-08347-2, 2019

Keywords: Mn-microparticle, oxic pelagic clay, IODP Exp. 329

©2019. Japan Geoscience Union. All Right Reserved.

Regional stratigraphic framework, Gas Hydrate occurrence and distribution of National Gas Hydrate Program Expedition 02 (NGHP-02) Area-B, offshore eastern India

*KanHsi Hsiung[1], Saneatsu Saito[1], Toshiya Kanamatsu[1], Yoshinori Sanada[1], Yasuhiro Yamada[1], KYAW MOE[1], Yohei Hamada[1], Yasuyuki Nakamura[1], HungYu Wu[1]

1. Japan Agency for Marine-Earth Science and Technology

Gas hydrates, one of the important resources for the future energy, are abundant in nature existing in a wide variety of forms in land and marine environments. Krishna-Godavari Basin was formed along the rifted eastern continental margin of India in the Late Jurassic to Early Cretaceous, receiving amount sediments with numerous tilted fault blocks and growth faults. The offshore Krishna–Godavari Basin is considered a potential gas hydrate province as well as the presence of bottom-simulating-reflectors. The Indian National Gas Hydrate Program Expedition 02 (NGHP-02) was designed to study the occurrence of gas hydrate along the margin. Area-B of NGHP-02 contains important world-class gas hydrate accumulations and represent ideal sites for the consideration of future gas hydrate production testing. The primary goal was to explore for highly saturated gas hydrate occurrences and distribution in seismic reflectors that would become targets for future production tests.

Twelve holes were logged and measured with logging-while-drilling (LWD) and five holes were cored in Area-B of NGHP-02. This study summarized the log- and litho-units in Area-B and establish the Integrated-Units A, B and C based on the data from twelve LWD and five coring sites in Area-B. Most of the downhole log and core inferred gas hydrate occurrences are in the Late Miocene Integrated-Unit B with several sets of reservoir sections exhibiting favorable conditions for hosting gas hydrate. Based on the core-log-seismic integration, the LWD and coring results in Area-B helped to understand the geological significance of sequence stratigraphy in Krishna-Godavari Basin and identified the occurrence of gas hydrate. The thickness variations associated with the Reflectors R1 and R2 are possibly associated with the development anticlinal structure and are likely related to syn-sedimentary growth of the folding structures. Major gas hydrate zones exist in and around the Reflectors R1 and R2 near the BSR depth, and mostly have coincident with the fractures and mass-transport deposits. The Hydrate-bearing intervals can be identified by resistivity and sonic velocity logs and classified into pore-filling type, fracture-filling type, and a mixture of pore- and fracture-filling types based on borehole image characteristics. In addition, the spatial distribution of gas hydrate in the Reflectors R1 and R2 reservoirs is highly influenced by the anticlinal structure.

Keywords: NGHP-02, Krishna-Godavari Basin, Logging-while-drilling, Gas hydrate occurrence, Core-log facies analysis, D/V Chikyu

©2019. Japan Geoscience Union. All Right Reserved.

Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

*Akira Ijiri[1], Shigeyuki Wakaki[1], Yoshiro Nishio[2], Yohei Hamada[1], Tsuyoshi Ishikawa[1], Fumio Inagaki[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Kochi University

During the International Ocean Discovery Program (IODP) Expedition 370 “Temperature Limit of the Deep Biosphere off Muroto” (T-Limit) in 2016, the drilling was conducted at the protothrust zone in the Nankai Trough off Cape Muroto by using the D/V *Chikyu*, which penetrated the plate boundary fault (dé collement) between 758.2 and 796.4 meters below seafloor (mbsf) and recovered the accretionary deposits down to the basement. Expedition 370 aimed to explore the limits of subseafloor life and the biosphere where temperature exceeds the known temperature maximum of microbial life (~120ºC) at the sediment/basement interface at ~1.2 km below seafloor. Within the protothrust zone, it is thought that deep sourced water and energy, which are necessary for maintaining microbial activities, are supplied by fluid flow through faults. In order to clarify the origin and migration paths of the fluid, we analyzed the stable hydrogen and oxygen isotopic composition of water (δD and δ^{18}O), the isotopic compositions of $^{87}Sr/^{86}Sr$ and $^{7}Li/^{6}Li$ ratios of the porewaters, and compared those isotopic compositions to the chemical compositions of porewater analyzed on-board. The previous study of the in-situ strength of sediments using drilling parameters shows that there are mechanically strong (potential impermeable layers) and weak (potential fluid pathway) zones at 602–648 mbsf and 800–1050 mbsf, respectively. The especially weak zone is observed between 836 and 870 mbsf. The concentration of chloride ion (Cl^-) suddenly decreases from 530 mM at ~600 mbsf to 480 mM at ~660 mbsf, below which it slightly decreases with depth and shows the minimum value of 450 mM at around ~950 mbsf. The concentration again increases from ~460 mM at ~1000 mbsf to ~550 mM, which is similar to the seawater value, at 1126 mbsf (just above the basement rock). The decrease of Cl^-concentration suggests that the dilution of the original porewater by the addition of fresh water. The depth profiles of δD and δ^{18}O show the trends corresponding to that of Cl^-. The δD value scatters in the range from −12 to −8‰ between 600 and 940 mbsf, and shows the minimum value of −12‰ around ~940 mbsf, below which it increases to −4‰ at 1126 mbsf. The δ^{18}O value increases from −4‰ at ~600 mbsf to −1.5‰ at ~800 mbsf with depth. Then the value increases to −0.6‰ at ~960 mbsf. Below the depth, it decreases to −1.2‰ at 1126 mbsf. The decrease of δD and increase of δ^{18}O accompanied with the depletion of Cl^-between ~600 and ~1000 mbsf suggest the addition of freshwater derived from in-situ clay mineral dehydration and the lateral fluid flow. The sharp decrease of the Cl^-concentration between ~600 and ~650 mbsf suggests that the sediments at this interval is a boundary of low permeability, corresponding to the mechanically strong zone estimated by the drilling parameters. Around décollement (758.2–796.4 mbsf), no remarkable changes were observed in chemical compositions in porewater. Instead, the vicinity of ~900 to ~1000 mbsf, where the lowest Cl^-concentration was observed, is probably associated with the main fluid pathway at present. On the other hand, the depth profiles of the isotopic compositions of Sr and Li as well as their concentrations were not corresponding to that of the Cl^-concentration. The maximum concentrations of Sr and Li, ~620 μM and ~790 μM, respectively, were observed at ~1080 mbsf, together with the high $^{87}Sr/^{86}Sr$ and the lowest $^{7}Li/^{6}Li$ ratio. The high concentration of Li and low δ^{7}Li around ~1080 mbsf indicate that the fluid was experienced by relatively high temperature conditions; i.e., presumably the deep sourced fluid. The discrepancy between the depth profile of $Cl^-$and those of Li and Sr suggests that there is (or was) another fluid pathway at the vicinity around ~1080 mbsf.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: ptotothrust zone, fluid flow, porewater chemistry

©2019. Japan Geoscience Union. All Right Reserved.

Recent progress and perspective on paleomagnetism by means of deep-sea drilling

*Toshitsugu Yamazaki[1], Yuhji Yamamoto[2], Toshiya Kanamatsu[3], Yuho Kumagai[4], Norihiro Nakamura[4]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Center for Advanced Marine Core Research, Kochi University, 3. Japan Agency for Marine-Earth Science and Technology, 4. Tohoku University

We review recent progress of paleomagnetism using deep-sea drilling cores since the beginning of IODP in 2003, in particular for estimations of paleomagnetic-field intensity (paleointensity) from sediments, and discuss problems to be resolved and perspectives.

For the establishment of the high-resolution relative paleointensity stack for the last 1.5 m.y., sediment cores of Exp. 303/306 from the North Atlantic were utilized. While only few records were available before about 3 m.y. previously, some Eocene to Miocene relative paleointensity records were obtained from the cores in the east equatorial Pacific taken during Exp. 320/321. Applicability of relative paleointensity to inter-core correlations and age estimations has extended to older ages accordingly. On the other hand, contamination of sediment lithological variations induced by paleoclimate changes, in particular fluctuations of the proportion of biogenic and terrigenous magnetites, to paleointensity estimations has become widely recognized. It is urgently necessary to resolve this problem and recover reliable long-term paleointensity records for tackling fundamental issues in geomagnetism such as possible dependence of field intensity to the length of polarity intervals and a possible relation between Earth’s orbital parameters and the geomagnetic field. Better understanding of the role of biogenic magnetite in remanent magnetization acquisition processes is important to solve the contamination problem. Information on the variations of time-averaged field in 10^5 to 10^6 year time-scales is also important for geomagnetism. Departure from the geocentric axial dipole (GAD) field of these time-scales may reflect boundary conditions of the geodynamo at the core-mantle boundary. The departure from GAD emerges as inclination anomalies in sediment cores. IODP cores may be useful for such studies although little studied before.

Acquisition of long deep-sea sediment cores is still required for obtaining continuous paleomagnetic records of Miocene and older ages, and IODP will continue to be the only means for this. Paleointensity estimations from sediments of older ages are hindered by dissolution of magnetite by reductive diagenesis; as sediments are buried deeper, reductive diagenesis becomes more serious. Successful expeditions resulted from the strategic selections of drilling sites; for example, the sediments of target ages are not covered with thick younger sediments (Exp. 320/321), and sediments in relatively oxic environments exist even buried under thick sediments (drift sediments of Exp. 363). Recently, the importance of silicate-hosted magnetic minerals as a carrier of remanent magnetization of sediments becomes recognized; they could escape from dissolution even in anoxic conditions. We need to revisit anoxic sediment cores to investigate the possibility for recovering paleomagnetic records from such sediments. Previously paleomagnetists just discarded them without detailed studies.

Keywords: paleomagnetism, paleointensity, IODP

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS02] Drilling Earth Science

convener:Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Azumi Kuroyanagi(Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku University), Kosei E. Yamaguchi(Toho University and NASA Astrobiology Institute), Chairperson:Kosei Yamaguchi(Toho University), Yasuhiro Yamada(JAMSTEC)

"Earth Drilling Science" session aims to exchange the latest information and scientific achievements in Ocean/Continental drilling projects and to promote the interdisciplinary science. The session covers a wide range of drilling sciences, earth dynamics, environments, and the drilling-related technologies. The overview of the recent IODP cruises as well as future projects of any types of scientific drilling will be reported.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS02-07] Patterns in natural fractures during transitions between stress regimes

*Nikita Dubinya[1] (1.The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS02-08] ICDP DSeis 1: Introduction into JpGU 2019 papers on Drilling into Seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

*Hiroshi Ogasawara[1], Bennie Liebenberg[2], Martin Ziegler[3], Yasuo Yabe[4], Ray Durrheim[5], Musa Manzi[5], Tullis C Onstott[6], Thomas Weirsberg[7] (1.Faculty of Science and Engineering, Ritsumeikan University, 2.Moab Khotsong mine, South Africa, 3.ETH, Zurich Dep. Earth Sciences, 4.Graduate School of Science, Tohoku Univ., 5.Univ. Witwatersrand, School of Geoscience, South Africa, 6.Princeton Univ., Dept. Geoscience, USA, 7.GFZ, Potzdam, Germany)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS02-09] ICDP DSeis 2: Preliminary results of physical property measurement and XRD analysis of the M5.5 fault material recovered from DSeis Project

*Tetsuro Hirono[1], Yuki Yukoyama[1], Shunya Kaneki[2], Hiroshi Ogasawara[3], Yasuo Yabe[4], Takuya Matsuzaki[5], Yuhji Yamamoto[5], Hidekazu Tokuyama[5], Tullis C. Onstott[6], Martin Ziegler[7], Durrheim Ray[8], Esterhuizen van Heerden[9], Bennie Liebenberg[9], The ICDP DSeis team (1.Department of Earth and Space Science, Graduate School of Science, Osaka University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Ritsumeikan University, 4.Tohoku University, 5.Center for Advanced Marine Core Research, Kochi University, 6.Princeton University, 7.ETH Zurich, 8.Witwatersrand University, 9.Moab Khotsong mine)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS02-10] ICDP DSeis 3: Spatial variation in stress state in the source region of Orkeny earthqauke (M5.5) based on analyses of the ICDP-DSeis borehole cores

*Yasuo Yabe[1], Akimasa Ishida[2], Kosuke Sugimura[2], Kanematsu Makoto[2], Mitsuya Higashi[2], Shunsuke YOSHIDA[2], Bennie Liebenberg[7], Takatoshi Ito[3], Akio Funato[5], Bryan Watson[6], Raymond Durrheim[4], Hiroshi Ogasawara[2] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.Faculty of Science and Engeneer, Ritsumeikan University, 3.Institute of Fluid Science, Tohoku University, 4.School of Geoscience, University of the Witwatersrand, 5.Fukada Geological Institute, 6.School of Mining Engeneering, University of the Witwatersrand, 7.Moab Khotsong mine)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS02-11] Applications of DCDA method for in-situ crustal stress measurement - Rock core samples from NIED seismic observation wells -

*Kentaro Omura[1], Weiren Lin[2], Takatoshi Ito[3], Akio Funato[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Graduate School of Engineering, Kyoto University, 3.Institute of Fluid Science, Tohoku University, 4.Fukada Geological Institute)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS02-12] Temperature depth profile in a 700 m deep vertical borehole in Aso volcanic zone

*Weiren Lin[1], Susumu Shibutani[1,2], Koichiro Sado[2], Nana Kamiya[1], Tatsuhiro Sugimoto[1], Terasu Sano[1], Kazuya Ishitsuka[1], Xiaoqiu Yang[4], Aiming Lin[3] (1.Graduate School of Engineering, Kyoto University, 2.Chiken Sogo Consultants Co., Ltd., 3.Graduate School of Science, Kyoto University, 4.South China Sea Institute of Oceanology, Chinese Academy of Sciences)

Patterns in natural fractures during transitions between stress regimes

*Nikita Dubinya[1]

1. The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences

The study is aimed at analysis of transitions between different stress regimes –Normal Fault, Strike-Slip and Reverse Fault following Anderson’s classification –in terms of natural shear fractures corresponding to each regime. The study is mostly focused on spatial orientations of shear fractures emerging at each stress regime.

It is clear that not all natural fractures existing in a rock mass have the same response to changes in surrounding stresses. Some fractures are considered to be critically stressed in the given stress state which means that a small increase in differential stress (difference between maximum and minimum principal stresses) leads to fracture growth. The fracture is considered as critically stressed if shear stress acting on its plane exceeds normal stress multiplied by internal fraction coefficient of the medium. Normal and shear stresses are calculated from principal stresses’ values and fracture spatial orientation with regard to stress tensor principal axes. That means that for any given stress tensor one is capable of obtaining all the possible spatial orientations of critically stressed fractures.

In the current paper this problem is solved for different stress states for obtaining the typical patterns of fractures’ spatial orientations when stresses are varied considerably enough to change the stress regime. Figure 1 represents a transition between Normal Fault and Strike-Slip regimes: a series of contours on Wolff nets serve as borderlines for poles to critically stressed fractures’ planes. Each color represents its own triad of principal stresses (tables provide necessary match between color and stresses’ values); maximum horizontal stress σ_H is assumed to act in North-South direction. Minimum horizontal stress σ_h and vertical stress σ_V are fixed at the values of 10 and 50 MPa respectively, while transition is caused by increase in σ_H magnitude from 10 to 160 MPa. During the first stage of transition (fig. 1(A), σ_H is between 10 and 30 MPa) poles to fractures tend to gather in Eastern and Western parts of the stereonet. On the second stage (fig. 1(B), σ_H is between 40 and 90 MPa) fractures’ orientation remains stable with slight increase observed in east-northeast, west-northwest, west-southwest, and east-southeast directions. This tendency continues at final stage of transition (fig. 1(C), σ_H is between 100 and 120 MPa) where four main areas typical for Strike-Slip fracture orientation emerge. The same analysis may be completed for other analogous transitions with two fixed principal stresses and one being varied.

Transition between stress regimes may also be observed if principal axes of stress tensor rotate with principal stresses’ magnitudes remaining constant. This scenario may take place near Earth's surface or near large faults due to changes in principal stresses' trajectories. Figure 2 represents transition from Normal Fault to Strike-Slip with principal stresses being fixed at 50, 20, and 10 MPa, while angle ϕ –angle between maximum principal stress direction and vertical –is varied between 0 and 90 degrees. Blue lines still serve as borderlines for the orientations of critically stressed fractures in each case; circles represent the directions of principal stresses (red for maximum, yellow for intermediate, and green for minimum principal stress). It should be noted that lower hemisphere Lambert equal area stereonet is used in this case.

Analogous constructions may be completed for any given stress tensor broadening the understanding of natural fractures’ patterns and their relation to stress geomechanics providing a possibility to solve the

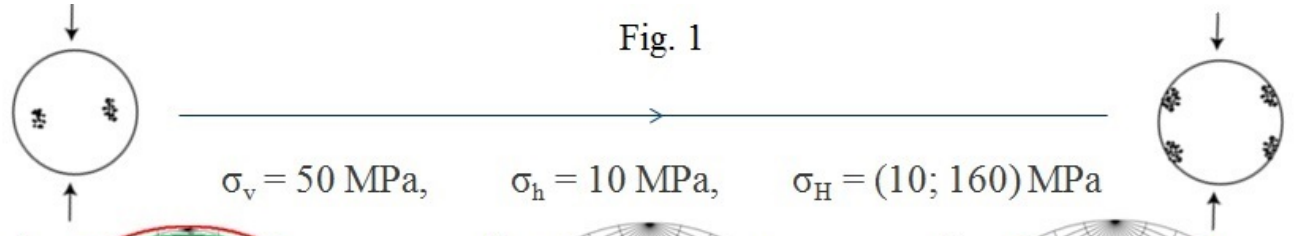
©2019. Japan Geoscience Union. All Right Reserved.

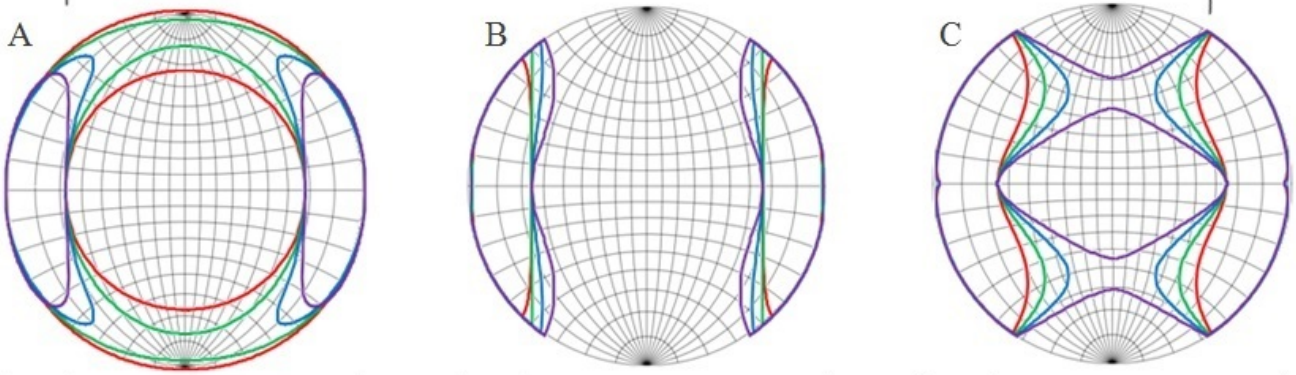
inverse problem of in-situ stresses estimation and their changes near geological structures utilizing the previously developed methods. As a result, some problems of drilling in vicinity of faults - one of primary objects for scientific drilling - may be solved, reducing the drilling risks and costs.

Keywords: Critically stressed fractures, Stress regimes, Stereonet, Drilling near faults

©2019. Japan Geoscience Union. All Right Reserved.

Fig. 1



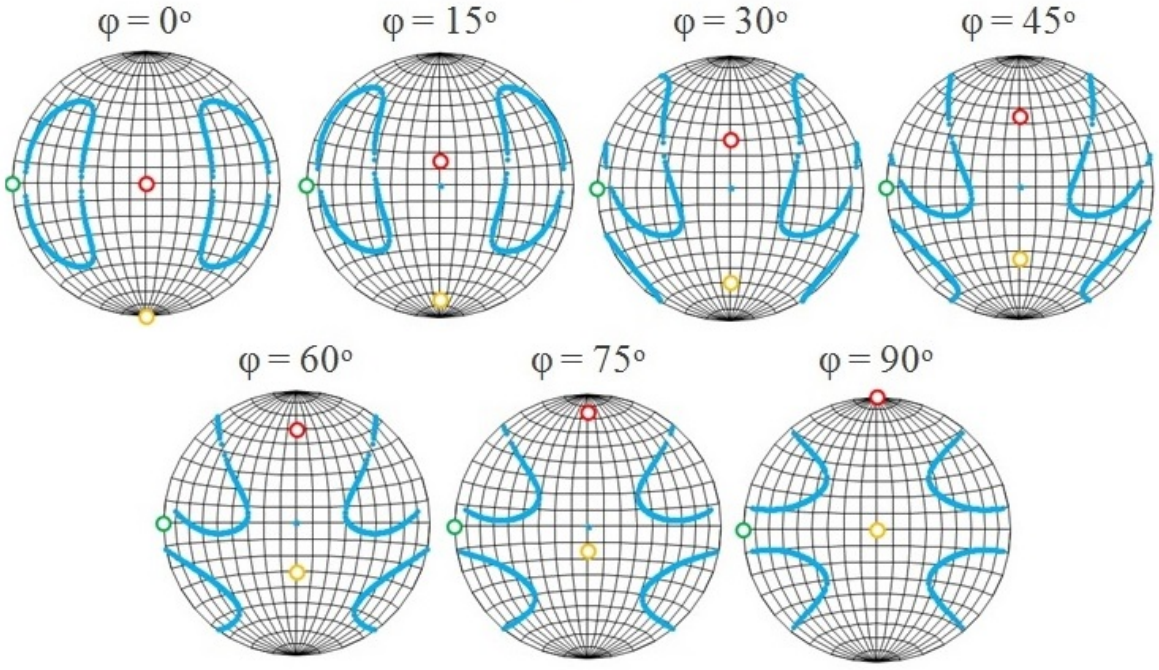


A	σ_H [MPa]
	10
	15
	20
	30

B	σ_H [MPa]
	40
	50
	70
	90

C	σ_H [MPa]
	100
	120
	140
	160

Fig. 2



©2019. Japan Geoscience Union. All Right Reserved.

ICDP DSeis 1: Introduction into JpGU 2019 papers on Drilling into Seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

*Hiroshi Ogasawara[1], Bennie Liebenberg[2], Martin Ziegler[3], Yasuo Yabe[4], Ray Durrheim[5], Musa Manzi[5], Tullis C Onstott[6], Thomas Weirsberg[7]

1. Faculty of Science and Engineering, Ritsumeikan University, 2. Moab Khotsong mine, South Africa, 3. ETH, Zurich Dep. Earth Sciences, 4. Graduate School of Science, Tohoku Univ., 5. Univ. Witwatersrand, School of Geoscience, South Africa, 6. Princeton Univ., Dept. Geoscience, USA, 7. GFZ, Potzdam, Germany

The 2014-2019 ICDP Science plan states: “reaching the depths of the seismogenic zone where earthquakes nucleate has always been a challenge for fault-zone drilling projects” (Mori and Ellsworth, 2013). However, during 2016-2018, we could recover cores with a total length of about 1.6 km from seismogenic zones ahead of mining faces, M3.5 and M5.5 earthquakes by drilling collared from depths of 1.0 to 3.3 km below surface in deep South African gold mines. The drilling targets had been already elucidated by tens of near-field seismic sensors. Talc, biotite, and amorphous were found at the M5.5 fault intersection (Kaneki et al. SSJ 2018).

The reliable measurement of the magnitude and orientation of stress at depth is a significant challenge (Brodsky et al., 2009). However, we overcame the difficulty. We intersected hypersaline water where geomicrobiologists started water and gas monitoring.

This paper reviews the scientific drilling and associated activities and briefly introduces the other reports (ICDP DSeis 2-10) presented in JpGU 2019 as shown below:

Hirono et al. (ICDP DSeis 2) ICDP DSeis 2: Preliminary results of physical property measurement

and XRD analysis of the M5.5 fault material recovered from DSeis Project,

Yabe et al. (ICDP DSeis 3) on the spatial variation of stress in the seismogenic zones,

Yoshida et al. (poster; ICDP DSeis 4): drilling, core logging, and in-hole geophysical logging of ICDP DSeis drilling into the M5.5 aftershock zones in a South African gold mines.

Sugimura et al. (poster) ICDP DSeis 5: Diametrical Core Deformation Analysis of the M5.5 aftershock zone core - stress concentration at reflective intrusives and transition in stress regimes.

Kanematsu et al (poster) ICDP DSeis 6: Deformation Rate Analysis of the M5.5 aftershock zone core - stress concentration at reflective intrusives.
Higashi et al. (poster) ICDP DSeis 7: compilation of stress information and comparison with calculated stresses in the M5.5 aftershock zones,

Noda et al. (poster) ICDP DSeis 8: the M5.5 fault structure and reflective intrusives in legacy 3D seismic

©2019. Japan Geoscience Union. All Right Reserved.

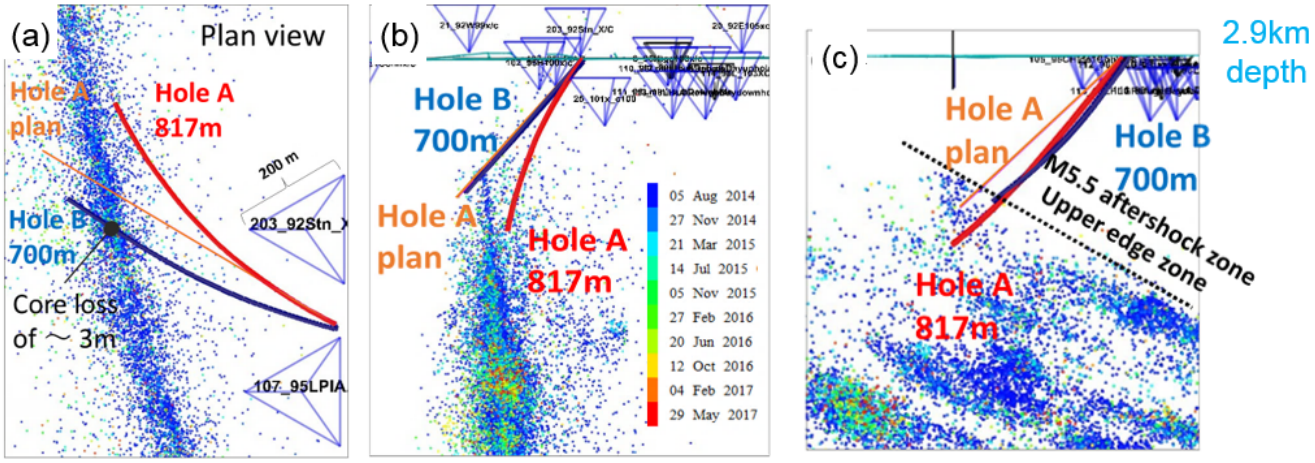
reflection data

Tadokoro et al. (poster) ICDP DSeis 9: streaks in the M5.5 aftershocks potentially located on highly stressed intrusive

Mori et al. ICDP DSeis 10: Near-field Observations for the M5.5 Orkney, South Africa Earthquake

Acknowledgement: The DSeis team includes co-authors of the papers ICDP DSeis 2-9 and members shown at https://www.icdp-online.org/projects/world/africa/orkney-s-africa/details/. We thank Harmony Gold, Anglogold Ashanthi, Lesedi, Digital Surveying, OHMS, Seismogen, 3D Geoscience. ICDP, JSPS, SA NRF, MEXT Japan, US NSF, German DRF, and Ritsumeikan Univ. financially support the project.

Keywords: ICDP DSeis, Seismogenic zone drilling, South African gold mines



©2019. Japan Geoscience Union. All Right Reserved.

ICDP DSeis 2: Preliminary results of physical property measurement and XRD analysis of the M5.5 fault material recovered from DSeis Project

*Tetsuro Hirono[1], Yuki Yukoyama[1], Shunya Kaneki[2], Hiroshi Ogasawara[3], Yasuo Yabe[4], Takuya Matsuzaki[5], Yuhji Yamamoto[5], Hidekazu Tokuyama[5], Tullis C. Onstott[6], Martin Ziegler[7], Durrheim Ray[8], Esterhuizen van Heerden[9], Bennie Liebenberg[9], The ICDP DSeis team

1. Department of Earth and Space Science, Graduate School of Science, Osaka University, 2. Disaster Prevention Research Institute, Kyoto University, 3. Ritsumeikan University, 4. Tohoku University, 5. Center for Advanced Marine Core Research, Kochi University, 6. Princeton University, 7. ETH Zurich, 8. Witwatersrand University, 9. Moab Khotsong mine

Drilling into seismogenic zones of M2.0-M5.5 earthquakes in deep South Africa gold mines (DSeis Project) was undertaken in 2017–2018 near Orkney, South Africa, to understand principal mechanism of earthquakes nucleate and propagate. Drilling at two main holes, Hole A (817 m) and Hole B (700 m), was completed at the Moab Khotsong mine, and the latter hole penetrated the fault zone that slipped at the 2014 M5.5 earthquake. Fault-related material and its surrounding host rocks were successfully recovered from the hole, and the samples were analyzed in the Center for Advanced Marine Core Research, Kochi University, Japan. The main damaged zone is characterized by highly fragmented fault breccia with high amount of talc and amorphous material, which is likely to related to recent earthquake event. Nondestructive continuous measurements of physical properties (X-ray CT image, density, magnetic susceptibility, and natural gamma ray) are in progress. We will show the preliminary results about the characteristics of the M5.5 fault zone and its implication for generation of the M5.5 earthquake.

Keywords: Deep fault drilling, ICDP

©2019. Japan Geoscience Union. All Right Reserved.

ICDP DSeis 3: Spatial variation in stress state in the source region of Orkeny earthqauke (M5.5) based on analyses of the ICDP-DSeis borehole cores

*Yasuo Yabe[1], Akimasa Ishida[2], Kosuke Sugimura[2], Kanematsu Makoto[2], Mitsuya Higashi[2], Shunsuke YOSHIDA[2], Bennie Liebenberg[7], Takatoshi Ito[3], Akio Funato[5], Bryan Watson[6], Raymond Durrheim[4], Hiroshi Ogasawara[2]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2. Faculty of Science and Engeneer, Ritsumeikan University, 3. Institute of Fluid Science, Tohoku University, 4. School of Geoscience, University of the Witwatersrand, 5. Fukada Geological Institute, 6. School of Mining Engeneering, University of the Witwatersrand, 7. Moab Khotsong mine

The Orkney earthquake (M5.5), South Africa, occurred on 5 August 2014 beneath a deep gold mine, of which the deepest mining horizon is ~3 km depth from ground surface. Hypocenter of the Orkney earthquake and the shallowest aftershocks were located at ~5 km and ~3.5 km depths from ground surface. Therefore, the ICDP-DSeis project was devised to investigate the geological, geomechanical and geochemical environments in and around the source region of the Orkney earthquake. Two 800 m-long boreholes (Holes A and B) were drilled from a drilling site established on a tunnel at a depth of 2.8 km in the mine. While Hole A reached the seismogenic depth, it did not intersect the aftershock cluster. Hole B success fully penetrated to the aftershock cluster. Borehole cores were almost fully recovered from these holes, though they were not oriented during drilling. Therefore, the core orientation was determined by comparing in-hole optical images and unrolled core images in this study. Then, Diametrical Core Deformation Analysis (DCDA, Funato and Ito, 2017) and Deformation Rate Analysis (DRA, Yamamoto et al., 1990) were applied to borehole cores to evaluate a spatial variation in stress state in and around the aftershock cluster. Finally, a numerical elastic model in which the depth variations along Hole A and B were reproduced was developed to understand a spatial distribution of stress state in and around the aftershock cluster that extended along upper extension of the source fault of the Orkney earthquake.

Acknowledgement. This study was supported by ICDP, JSPS-NRF bilateral research project, JSPS Core-to-Core program, Ritsumeikan University and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Earthquake and Volcano Hazards Observation and Research Program. The authors thank Harmony Gold Ltd. for kindly providing an opportunity of drilling from Moab Khotsong mine.

Keywords: ICDP-DSeis, Stress measurement, DRA, DCDA, Deep mines in South Africa

©2019. Japan Geoscience Union. All Right Reserved.

Applications of DCDA method for in-situ crustal stress measurement - Rock core samples from NIED seismic observation wells -

*Kentaro Omura[1], Weiren Lin[2], Takatoshi Ito[3], Akio Funato[4]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Graduate School of Engineering, Kyoto University, 3. Institute of Fluid Science, Tohoku University, 4. Fukada Geological Institute

In-situ crustal stress is an important factor to understand earthquake mechanism and tectonic activities. However, the reliable in-situ stress data seems to be poor related with seismic or strain observation data. We tried to apply the DCDA (Diametrical Core Deformation Analysis) method for in-situ crustal stress measurement using boring rock core samples. DCDA method measures the circumferential diameter variation and elastic constants of core sample without complicate procedures in the borehole. We expect the method can be applied to old-time boring rock cores from seismic observation wells, and we may collect global in-situ crustal stress data in Japan island.
We used recovered hard rock cores from 7 Hi-net obsevation wells of NIED (more than 10 years ago) from the depth about 100m - 200m (one is from the depth of 2000m). The circumferential core diameter variation was measured by an especially designed apparatus that consists of an optical micrometer, a pair of motor-driven rollers and a data processing system (Funato and Ito, 2017, IJRMMS). We got the sine curves of circumferential diameter variation associated with stress relief. However, in some cases, we got the sine curve of circumferential diameter variation obviously related petrogical suructure of sedimetary rocks.The data suggest that the DCDA method is applicable to boring cores from shallow seismic obsevation wells, except for sedimetary rock cores.

Keywords: DCDA method, in-sitsu crustal stress, rock core, seismic observation well

©2019. Japan Geoscience Union. All Right Reserved.

Temperature depth profile in a 700 m deep vertical borehole in Aso volcanic zone

*Weiren Lin[1], Susumu Shibutani[1,2], Koichiro Sado[2], Nana Kamiya[1], Tatsuhiro Sugimoto[1], Terasu Sano[1], Kazuya Ishitsuka[1], Xiaoqiu Yang[4], Aiming Lin[3]

1. Graduate School of Engineering, Kyoto University, 2. Chi-ken Sogo Consultants Co., Ltd., 3. Graduate School of Science, Kyoto University, 4. South China Sea Institute of Oceanology, Chinese Academy of Sciences

Temperature profile measurements in scientific-drilling boreholes and determination of heat flow from the measured temperature profiles are important approaches to understand the temperature distribution and thermal structure around volcanic regions and seismogenic fault zones. A scientific-drilling borehole down to ~700 m deep was penetrated through the Futagawa Fault ruptured during the 2016 Mw 7.1 Kumamoto, Japan earthquake in Aso volcanic region. To obtain the fundamental features of the temperature profile in the borehole, we repeated measurements of temperature depth profile totally four times, i.e., once per two –three months from the borehole penetration was completed in March 2018. As a preliminary result, the temperature depth profile showed a popular trend between depth ranges of 200 –310 m and 430 –650 m where the formation temperature may not be influenced by weather and seasonal temperature change on surface. The temperature in the two depth ranges linearly increased with depth increasing, and showed a geothermal gradient of ~55 ˚C/km. This geothermal gradient is much higher than the global average geothermal gradient 20 –30 ˚C/km, being considered reasonable in a volcanic region. However, a very unexpected temperature distribution feature was observed in the depth range of 310 –430 m. The temperature was almost the same in the ~120 m depth interval; and the geothermal gradient was only ~1 ˚C/km. To make sure if this special temperature distribution is a natural phenomenon, we will continuous our temperature measurements and monitoring in the borehole.

Keywords: Drilling , Temperature, Geothermal gradient

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS02] Drilling Earth Science

convener:Yasuhiro Yamada(Japan Agency for Marine-Earth Science and Technology (JAMSTEC), R&D Center for Ocean Drilling Science (ODS)), Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Azumi Kuroyanagi(Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku University), Kosei E. Yamaguchi(Toho University and NASA Astrobiology Institute), Chairperson:Yumiko Harigane(産総研), Natsue Abe(R&D Center for Ocean Drilling Science, JAMSTEC)

"Earth Drilling Science" session aims to exchange the latest information and scientific achievements in Ocean/Continental drilling projects and to promote the interdisciplinary science. The session covers a wide range of drilling sciences, earth dynamics, environments, and the drilling-related technologies. The overview of the recent IODP cruises as well as future projects of any types of scientific drilling will be reported.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS02-13] Estimation of Shear Stress and Lithology Prediction Using Machine Learning and Surface Drilling Data

Tomoya Inoue[1], *Ryuta Tanaka[1], Junya Ishiwata[1] (1.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS02-14] Overview of drilling of crust-mantle boundary of Oman ophiolite: the ICDP Oman Drilling Project

*Eiichi TAKAZAWA[1,4], Damon A H Teagle[2], Katsuyoshi Michibayashi[3], Yoshihiko Tamura[4], Jude Ann Coggon[2], Juerg Matter[2], Peter B Kelemen[5], Oman Drilling Project Phase 2 Science Party (1.Department of Geology, Faculty of Science, Niigata University, 2.University of Sauthampton, 3.Nagoya University, 4.JAMSTEC, 5.Columbia University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS02-15] Geophysical Logging of Crust-Mantle boundary at Oman Ophiolite

*Yasuhiro Yamada[1], Kyaw Moe[1], Philippe Pezard[2], Juerg Matter[3], OmanDP Science Party (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Géosciences Montpellier, Université de Montpellier, 3.Southampton University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS02-16] Overview of the physical property measurements, ChikyuOman 2017 and 2018: Crust and Mantle sections from ICDP Oman Drilling Project Phase I and II

*Natsue Abe[1], Keishi Okazaki[1,11], Ikuo Katayama[2], Kohei Hatakeyama[2], Yuya Akamatsu[2], Benoit Ildefonse[3], Ole Ivar ulven[4], Gilbert Hong[5], Wenlu Zhu[6], Benoit Cordonnier[4], Katsuyoshi Michibayashi[7], Eiichi TAKAZAWA[8], Michell Harris[12], Damon Teagle[10], Peter Kelemen[9], Marguerite Goddard[3], Jurg Matter[10], Jude Coggon[10], The Oman Drilling Project Science Party (1.Japan Agency for Marine-Earth Science and Technology, 2.Hiroshima University, 3.Universitè de Montpellier, 4.University of Oslo, 5.Seoul National University, 6.University of Maryland, 7.Nagoya University, 8.Niigata University, 9.Columbia University, 10.University of Southampton, 11.Kanazawa University, 12.Polymouth University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS02-17] Exploring the deep subseafloor biosphere and biogeochemical carbon cycling beneath the Arctic ocean

*Fumio Inagaki[1], Steffen Leth Jørgensen[2], Rolf Birger Pedersen[2] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Department of Earth Science, University of Bergen, Norway)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC
Discussion

Estimation of Shear Stress and Lithology Prediction Using Machine Learning and Surface Drilling Data

Tomoya Inoue[1], *Ryuta Tanaka[1], Junya Ishiwata[1]

1. Japan Agency for Marine-Earth Science and Technology

Introduction

JAMSTEC operates the scientific deep-sea drilling vessel Chikyu. Chikyu conducted the Japan Trench Fast Drilling Program (JFAST) for study on the Tohoku earthquake. Chikyu has also started to conduct the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE).
The main purpose of the scientific drillings is to obtain core samples from sediment layers under the seabed. However, we are facing the situation that we cannot have enough core samples because the operation philosophy defines that core samples are generally assigned for a lot of separate examinations including geological, chemical, and biological examinations. It is also the reason that the coring operations are conducted at spots. This means that analyzed data, for example the shear stress, can be obtained just at spot(s).
As one of the primary goals of scientific drilling is to evaluate sediment properties, it is highly beneficial to obtain the properties of drilling layers and to characterize the lithology over the full drilling depth during drilling operations. Even an approximation of these properties could potentially provide valuable information for conducting coring operations.

Methods/Procedure

A previous study attempted to discuss the properties of sediment layers using surface drilling data, and estimated the shear stress of the sediment. In this study, we first summarize the method applied in the previous paper for estimating the torque at the drill bit, which leads to estimation of shear stress of sediment layer from the surface measured drilling data for NanTroSEIZE deep riser drilling operation.
The surface drilling data was obtatined using the surface drilling data acquisition system that we developed. The surface drilling data includes the torque of the power swivel (HPS torque) that is equipmenti to provide a torque and rotation to the drillstring. This HPS torque includes not only the drilling torque but also other torques such as friction toque between riser and drill pipe, and mechanical torque inside HPS. This paper proposes to estimate the drilling torque at the drill bit from the surface drilling data by removing other torques based the torque during a “bottom’s” up operations.
We also used machine-learning approaches to predict the lithology, where learning data was created from surface drilling data and lithology information from core samples obtained during past scientific drilling operations. Machine learning was then applied using neural network algorithms by tuning L1 regularization coefficient and the number of layers to create a predictive model. This paper discusses the preliminary attempt to predict the lithology using machine-learning approaches for NanTroSEIZE and JFAST data.

Result/Conclusions

We presented a method for estimating the drilling torque, which was compared to downhole-measured data with logging while drilling (LWD). The result of the calculation shows that the drilling torque at the bit differed from the surface measured torque, where this difference increased with increasing drilling depth. In addition, the estimated drilling torque was validated using downhole-measured torque data obtained from LWD operations. Although the deviation of the mean values between the drilling torque and the downhole measured torque was large, our method is considered valid from the viewpoint of correcting

©2019. Japan Geoscience Union. All Right Reserved.

the characteristics of the depth for the surface measured torque.
This study also presented the lithilogy predicution from machine learning approaches. Preliminary results were presented using NanTroSEIZE and JFAST data including surface drilling data and core sample data. The prediction performance obtained from the generated neural networks indicated that the lithology properties could be predicted by machine learning approaches as an interpolation problem; however, the prediction is sensitive to the structure and parameters of the neural network, along with the selection of training data due to the small learning dataset. In addition, it can be difficult to clearly classify the lithology from core samples as the core sometimes contains several rock types, leading to uncertain classification. We will continue to study lithology prediction using machine-learning methods in future studies.

Acknowledgments
This research was partially supported by a Grant-in-Aid for Scientific Research (B) [grant number 16H04610].

Keywords: surface drilling data, lithology prediction, machine Learning, shear stress, ocean drilling

©2019. Japan Geoscience Union. All Right Reserved.

Overview of drilling of crust-mantle boundary of Oman ophiolite: the ICDP Oman Drilling Project

*Eiichi TAKAZAWA[1,4], Damon A H Teagle[2], Katsuyoshi Michibayashi[3], Yoshihiko Tamura[4], Jude Ann Coggon[2], Juerg Matter[2], Peter B Kelemen[5], Oman Drilling Project Phase 2 Science Party

1. Department of Geology, Faculty of Science, Niigata University, 2. University of Sauthampton, 3. Nagoya University, 4. JAMSTEC, 5. Columbia University

From the winter of 2017 to 2018 the drilling of crust-mantle transition zone (MTZ) was conducted at Wadi Zeeb (CM1&2 sites) in Wadi Tayin massif by the International Continental Scientific Drilling ProgramOman Drilling Project [6]. The MTZ of Oman ophiolite has been characterized by thick dunites accompanied by thin veins or clots of plagioclase and clinopyroxene and several centimeters to meters thick gabbro sills and wehrlite intrusions. The origin of MTZ is still under debate [2-5]. To clarify this origin, more detailed research by continuous core through MTZ is necessary.

Geological mapping on ground associated with information from the recovered cores in CM1&2 sites the thickness of the MTZ is estimated as about 150 m. The upper and lower boundaries of the MTZ has a strike in the east-west direction, and it is inclined about 30 degrees south. In the summer of 2018, the drilled cores were carefully described by scientists on the deep-sea drilling vessel "CHIKYU". The stratigraphy has been divided into four igneous sequences based on the abundance of different lithologies: Layered Gabbro Sequence, Dunite Sequence, Dunite with Gabbro Sequence, and Mantle Sequence. Dunite Sequence and Dunite with Gabbro Sequence are summarized as Crust - Mantle Transition.

Hole CM1A is inclined 60˚ northward. The upper 160 m of the core is the Layered Gabbro Sequence, mostly composed of olivine gabbro, interlayered with gabbro and a small amount of wehrlite, dunite, anorthosite and troctolite. From 160 to 310 m the Crust-Mantle Transition is divided into an upper 90 m Dunite Sequence and a lower 60 m Dunite with Gabbro Sequence containing small lenses of gabbro, troctolite and wehrlite. The dunites are highly serpentinized, and rodingite and diopsidite commonly replace minor gabbroic rocks in these sequences. The lower 80 m of the hole is the Mantle Sequence, with alternating layers of dunite and increasingly abundant, residual mantle harzburgite.

Hole CM2B is a vertical hole located 400 m north of CM1A, and samples the Crust-Mantle Transition and the Mantle Sequence. As in CM1A, the transition is divided into an upper Dunite Sequence and a lower Dunite with Gabbro Sequence. In contrast to Hole CM1A, a small amount of olivine has escaped complete serpentinization in the lower portions of the CM2B transition zone. In the Mantle Sequence, harzburgite is dominant. Dunite accounts for about 25% of this Sequence, less than in CM1A. The lowermost peridoties in Hole CM2B are strongly altered to talc+carbonate.

[1] Boudier and Nicolas, 1995, J. Petrol., 36, 777-796, [2] Pallister and Hopson, 1981, J. Geophys. Res., 86, 2593-2644, [3] Kelemen et al., 1995, Nature, 375, 747-753, [4] Abily and Ceuleneer, 2013, Geology, 41, 67-70, [5] Rospabé et al., 2017, Geol. Soc. Am., Data Rep. 2017139, [6] Kelemen et al., 2013, Scientific Drilling, 15, 64-71.

Keywords: Oman ophiolite, ICDP, Oman Drilling Project, crust-mantle transition, Moho Transition Zone

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Geophysical Logging of Crust-Mantle boundary at Oman Ophiolite

*Yasuhiro Yamada[1], Kyaw Moe[1], Philippe Pezard[2], Juerg Matter[3], OmanDP Science Party

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2. Géosciences Montpellier, Université de Montpellier, 3. Southampton University

The boundary between the crust and mantle is a horizon that human being can reach in the Earth interior. The nature of this surface has been proposed from viewpoints of petrology, geochemistry and geophysics, and the answer needs to wait until future scientific drilling.

The Samail ophiolite exposed in Oman is one of most well-known surface exposures of the exhumed lowest part of the oceanic crust and upper part of mantle.

The Oman Drilling Project (OmanDP) drilled 12 holes at 7 sites in this ophiolite from 2016 to 2018, and has conducted a comprehensive borehole geophysical survey as logging operation in most of these holes in 2017 and 2018. The data acquired include: electrical resistivity, spectral gamma ray, magnetic susceptibility, full waveform sonic, optical / acoustic / resistivity borehole wall imaging. The extensive logging operation also includes high-definition spectroscopy measurements that contribute to further geochemical investigations. The outline of these datasets and our preliminary analysis will be presented.

Keywords: oceanic crust, upper oceanic mantle, borehole geophysics, alteration

©2019. Japan Geoscience Union. All Right Reserved.

Overview of the physical property measurements, ChikyuOman 2017 and 2018: Crust and Mantle sections from ICDP Oman Drilling Project Phase I and II

*Natsue Abe[1], Keishi Okazaki[1,11], Ikuo Katayama[2], Kohei Hatakeyama[2], Yuya Akamatsu[2], Benoit Ildefonse[3], Ole Ivar ulven[4], Gilbert Hong[5], Wenlu Zhu[6], Benoit Cordonnier[4], Katsuyoshi Michibayashi[7], Eiichi TAKAZAWA[8], Michell Harris[12], Damon Teagle[10], Peter Kelemen[9], Marguerite Goddard[3], Jurg Matter[10], Jude Coggon[10], The Oman Drilling Project Science Party

1. Japan Agency for Marine-Earth Science and Technology, 2. Hiroshima University, 3. Universitè de Montpellier, 4. University of Oslo, 5. Seoul National University, 6. University of Maryland, 7. Nagoya University, 8. Niigata University, 9. Columbia University, 10. University of Southampton, 11. Kanazawa University, 12. Polymouth University

We report physical property measurements of core samples from the Samail ophiolite in Oman, drilled by the ICDP Oman Drilling Project. Onboard core logging was conducted on D/V Chikyu for 4 months in total in the summers of 2017 and 2018. We analyzed 4 holes (GT1A, GT2A, GT3A and BT1B) in 2017, and 5 holes (CM1A, CM2B, BA1B, BA3A and BA4A) in 2018. The total core length of those 9 holes is about 3200 m. Cores from Holes GT1A and GT2A in the lower crust section of the ophiolite are mainly composed of gabbros (gabbro and olivine gabbro), with small amounts of ultramafic rocks (wehrlite and dunite), whereas those from Hole GT3A at the boundary between the sheeted dikes and gabbro are mainly composed of basalt and diabase, followed by gabbros (gabbro, olivine gabbro and oxide gabbro). Minor felsic trondhjemite and tonalite dikes intrude the mafic rocks. In contrast, Hole BT1B penetrated from mantle section through the basal thrust and into the metamorphic sole. The CM holes were drilled through the crust-mantle transition, from gabbroic lower crust, through dunite with minor gabbros, and in to residual mantle harzburgite. BA holes were taken from the mantle section and are composed of dunite and harzburgite intruded by minor gabbroic and pyroxenite dikes. Ultramafic rocks at both sites were extensively serpentinized, but the names of igneous protoliths are used here.

Whole-round data, including X-ray CT images, natural gamma radiation (NGR), gamma ray attenuation (GRA) density, magnetic susceptibility (MS), P-wave velocity (Vp) and noncontact electrical resistivity were obtained. Split core color spectroscopy data were also collected. Magnetic susceptibility, electrical resistivity under both nominally dry and brine-saturated conditions, P-wave velocity, bulk/grain density, porosity and thermal conductivity were measured in discrete samples. Nearly 100% core recovery allowed us to take a large data set of petrophysical data on the cores from Oman ophiolite including fault zones and highly altered intervals.
Generally, gabbroic rock types have higher density, P-wave velocity, and electrical resistivity, and lower porosity than ultramafic lithologies. Serpentinized dunite have lower density, P-wave velocity and electrical resistivity, and higher porosity than serpentinized harzburgite, and these physical properties are correlated with magnetic susceptibility, probably due to crystallization of magnetite during alteration. Average X-ray CT values are also correlated with many other physical properties in most lithologies.

Keywords: ICDP, D/V Chikyu, Oman Drilling Project, ophiolite, oceanic crust

©2019. Japan Geoscience Union. All Right Reserved.

Exploring the deep subseafloor biosphere and biogeochemical carbon cycling beneath the Arctic ocean

*Fumio Inagaki[1], Steffen Leth Jørgensen[2], Rolf Birger Pedersen[2]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2. Department of Earth Science, University of Bergen, Norway

Despite the Arctic cryosphere is the most sensitive and vulnerable to the global environmental change, the nature of deep subseafloor arctic environments remains largely unknown. Active processes on the drastic climate change, including the anthropogenic global warming and subsequent ice melt, are presumably similar to those mechanisms that formed some of the major hydrocarbon resources we presently use, deeply buried in the subseafloor sediment over millions of years at high atmospheric CO_2 and global warm conditions. Continuing to advance understanding of the natural analogues beneath the Arctic ocean through scientific drilling is a powerful approach for the discoveries and understanding of life and Earth co-operating systems, and consequently will illuminate the possible resilience and sustainable strategies adopted by human society towards the future. Here, we are keenly interested in the Arctic deep biosphere and biogeochemical carbon cycling, which presumably be tightly associated with tectonics and biotic/abiotic processes through paleoceanographic events of seawater stagnations, perturbations and fertilizations in the Paleogene to Cretaceous period, and perhaps still continuing in situ over geologic time. How is diagenetic activity and microbial diversity linked to variability in Cenozoic climate and environmental changes? To what degree is carbon diagenesis linked to biotic/abiotic and tectonic processes? What fluid flow and energy transformation processes support microbial activity in situ and govern carbon sink in the Arctic sedimentary basin? How does alternation of deep oceanic crust contribute to microbial life and biogeochemical carbon cycling in the shallower habitat? In addition, what is the nature of the Arctic basement? These important scientific issues on the most climate-sensitive place on Earth remain to be explored, but using the *Chikyu*' s riser-drilling and onboard facilities, it can be addressed by the state-of-the-art interdisciplinary analyses of core samples and the long-term borehole observatory.

Keywords: Arctic ocean, scientific ocean drilling, deep subseafloor biosphere, biogeochemical carbon cycle

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 104 1F

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Yusaku Ohta

GNSS has become a fundamental tool for studies on atmosphere, ionosphere, and solid earth. Ground and space-based GNSS measurements have operationally contributed to improve global and regional NWP since 2006. In recent years, studies utilizing reflected GNSS signals to derive altimetric height, surface roughness, soil moisture, snow depth, humidity or vegetation index have been evolving. Ocean-platform GNSS observations have been demonstrating their capability of real-time monitoring of maritime water vapor as well as sea level. Increasing observations provided through Multi-GNSS (GPS, GLONASS, BEIDOU, GALILEO, QZSS etc.) enhances capability of the GNSS as an integrated earth observation system.
The purpose of this session is to share the latest development of GNSS researches on monitoring the earth system and to stimulate synergetic interdisciplinary studies. Contributions on atmosphere (troposphere and ionosphere) studies, reflectometry (GNSS-R), and integrations of different observation techniques like GNSS-Acoustic measurement to monitor ocean floor positioning are welcome.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[MTT46-01] The latest status of Quasi-Zenith Satellite System (QZSS) and its future expansion

★Invited Papers

*Satoshi Kogure[1] (1.QZSS Straetegy Office, National Space Policy Secretariate, Cabinet Office)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MTT46-02] Application of the GNSS-A for other academic fields and fundamental marine information network

*Yusuke Yokota[1], Tadashi Ishikawa[2], Shun-ichi Watanabe[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic department, Japan Coast Guard)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MTT46-03] Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

*Yusuke Tanaka[1], Yusaku Ohta[1], SHINICHI MIYAZAKI[2] (1.Tohoku University, 2.Kyoto University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MTT46-04] Assimilation experiments of GNSS-derived ZTD and Sentinel-derived products into WRF to improve forecasts of severe rain events in Italy

*Eugenio Realini[1], Martina Lagasio[2], Luca Pulvirenti[2], Antonio Parodi[2], Andrea Gatti[1], Giulio Tagliaferro[1], Giovanna Venuti[3], Stefano Barindelli[3], Emanuele Passera[4], Alessio Rucci[4], Nazzareno Pierdicca[5], Bjorn Rommen[6] (1.Geomatics Research & Development srl, 2.CIMA Research Foundation, 3.Dept. of Civil and Environmental Engineering, Politecnico di Milano, 4.TRE Altamira srl, 5.Dept. of Information Engineering, Electronics and Telecommunications, Sapienza Univ. of Rome, 6.European Space Agency (ESA-ESTEC))

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MTT46-05] An analysis of tropospheric delays using goGPS software on all GEONET stations during the passage of Typhoon Jebi in September 2018

*Andrea Gatti[1], Eugenio Realini[1], Giulio Tagliaferro[1] (1.Geomatics Research & Development srl)

The latest status of Quasi-Zenith Satellite System (QZSS) and its future expansion

*Satoshi Kogure[1]

1. QZSS Straetegy Office, National Space Policy Secretariate, Cabinet Office

The Quasi-Zenith Satellite System (QZSS) is a regional space-based Position, Navigation and Timing (PNT) system developed and operated by Japanese government as their important national infrastructure. Three consecutive launches were successfully conducted in 2017. The official operational service has been launched since November 1, 2018. The expansion to 7 satellite constellation is now being investigated. The presentation shows the latest status of the QZSS program as well as its future expansion.

Keywords: QZSS, Space-cased Position Navigation and Timing system, GNSS

©2019. Japan Geoscience Union. All Right Reserved.

Application of the GNSS-A for other academic fields and fundamental marine information network

*Yusuke Yokota[1], Tadashi Ishikawa[2], Shun-ichi Watanabe[2]

1. Institute of Industrial Science, The University of Tokyo, 2. Hydrographic and Oceanographic department, Japan Coast Guard

The GNSS-A observation technology had detected coseismic deformation fields just above the megathrust earthquake [Sato et al., 2011, Science; Kido et al., 2011, GRL], postseismic deformations [Watanabe et al., 2014, GRL; Tomita et al., 2017, Sci. Adv.] and interseismic coupling condition [Yokota et al., 2016, Nature]. In addition, we recently upgraded the GNSS-A methodology in aspects of observation frequency and accuracy and detected a longer-term sequence of slow slip events (SSEs). The detected undersea SSEs led a new discussion about a diverse behavior of SEQs and provide many questions, i.e., their stress loading for coupling region and difference of geological condition in the SSE, other SEQs and coupling regions, to be solved by the future seafloor, submarine and onshore geophysical monitoring.

In the development process of this new GNSS-A system, new oceanographic information in km scale region was found to be extractable from the GNSS-A data [Yokota et al., 2018, MGR]. This data has features consistent and inconsistent with the JCOPE2 model [Miyazawa et al., 2009, JO], so the GNSS-A system has a potential to provide new observation data of very narrow marine region.

These observations have extremely high scientific potential from the viewpoint of seismology, earthquake disaster prevention engineering and submarine geology about megathrust subduction zones and unknown potential about new multidisciplinary aspects called the nano-scale GNSS-A oceanography and the marine GNSS meteorology. In order to promote the distribution of data to the earthquake science community and different academic fields, it is necessary to establish a simple data format and manage using doi. In particular, for carrying out long-term and stable observation, we must construct strong management and evaluation system to perform appropriately data collection and observation operation. The realization of such a solid fundamental marine observation network will also have a positive effect on new research and development.

Moreover, it is necessary to enhance the GNSS-A observation system to upgrade the observation density, continuity and real-time property for understanding the subduction zone and disaster prevention. Eventually, we should construct next-generation fundamental network that aggregates the marine information system that utilize total data in real time based on numerical simulation and data assimilation.

Keywords: GNSS-A, seafloor geodetic observation network, marine observation

©2019. Japan Geoscience Union. All Right Reserved.

Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

*Yusuke Tanaka[1], Yusaku Ohta[1], SHINICHI MIYAZAKI[2]

1. Tohoku University, 2. Kyoto University

Precise detection of coseismic deformation and estimation of its source model are especially important in the case of earthquake occur in subduction zones, because it is directly related to accurate tsunami forecasting. Recent years, many researchers have tried to estimate earthquake source model and/or tsunami wave field in real-time using Global Navigation Satellite System (GNSS). However, conventional GNSS-based monitoring requires huge computational cost for positioning analysis. Using coordinate time series for observation also causes difficulty to evaluate accuracy of separation between deformation and other unknown parameters such as tropospheric delay. Additionally, current positioning analysis strongly depends on precise orbit information which is provided externally.

According to such background, we investigate the feasibility of deformation monitoring based on the GNSS carrier phase to fault slip approach for subduction zone. This method, which we call PTS (Phase To Slip) detects fault slip directly from GNSS carrier phase variation without positioning analysis. As PTS method estimates all unknown parameters in parallel, computational costs for real-time seismic monitoring can be reduced. Moreover, PTS does not require high-quality satellite orbit because it relies only on changes in azimuthal site-to-satellite ranges (Tanaka, Ohta, and Miyazaki, GRL, 2019).

Here we applied the PTS method to the largest aftershock of the 2011 Tohoku-Oki earthquake. In the analysis, we used both precise orbit provided by International GNSS Service (IGS) and broadcast orbit submitted from satellite without any network connection. As a result, we obtained very similar coseismic slip distribution in the two cases. Inferred fault slip showed clear thrust slip and was equivalent to M_w 7.8. These results well agree with the estimation based on conventional GNSS analysis such as Nishimura et al. (EPS, 2011). Calculated surface displacements also agree with independent conventional GNSS analysis result. These results indicate that the PTS method can be useful as a supplementary system of current deformation monitoring, which does not require any external information. Furthermore, once we could obtain slip distribution, we can also convert it into deformation of sea bottom, which is equivalent to initial tsunami source. Thus, our results suggest potential feasibility of PTS method for tsunami forecasting.
In the presentation, we will describe application of the PTS method to whole process of Tohoku-Oki earthquake, including its foreshock, mainshock and following aftershocks. Beside detail of its result, we will also demonstrate quantitative evaluation of parameter separation accuracy inside PTS analysis.

©2019. Japan Geoscience Union. All Right Reserved.

Assimilation experiments of GNSS-derived ZTD and Sentinel-derived products into WRF to improve forecasts of severe rain events in Italy

*Eugenio Realini[1], Martina Lagasio[2], Luca Pulvirenti[2], Antonio Parodi[2], Andrea Gatti[1], Giulio Tagliaferro[1], Giovanna Venuti[3], Stefano Barindelli[3], Emanuele Passera[4], Alessio Rucci[4], Nazzareno Pierdicca[5], Bjorn Rommen[6]

1. Geomatics Research & Development srl, 2. CIMA Research Foundation, 3. Dept. of Civil and Environmental Engineering, Politecnico di Milano, 4. TRE Altamira srl, 5. Dept. of Information Engineering, Electronics and Telecommunications, Sapienza Univ. of Rome, 6. European Space Agency (ESA-ESTEC)

The Italian peninsula is frequently struck by severe floods and flash floods causing losses of lives and significant damages every year. Improving the accuracy of rain forecasts is a fundamental goal to limit social and economic damages. Forecasts based on numerical weather prediction (NWP) models are challenged by the uncertainty related to the initial state of the atmosphere at small spatial-temporal scales. The inevitable model spin-up often results in an inaccurate simulation of the timing, the location and the severity of convective events. This challenge becomes even more relevant when the model grid spacing is approaching the kilometer scale, mainly because of the lack of high spatiotemporal resolution observations. In this scenario the STEAM (SaTellite Earth observation for Atmospheric Modelling) project, funded by the European Space Agency (ESA), has the aim of investigating to what extent GNSS-derived and Sentinel SAR-derived tropospheric delay data, as well as other Sentinel-derived products (i.e. soil moisture, soil and sea temperature, wind over sea) can be used to better understand and predict, with high spatial-temporal resolution, the atmospheric phenomena resulting in severe rain events and intense atmospheric turbulence. About 400 GNSS stations distributed throughout Italy were processed by the precise point positioning (PPP) technique, by means of the free and open source software goGPS, to estimate zenith total delay (ZTD) time series. Atmospheric phase screens (APS) were generated from Sentinel-1 observations, calibrated and converted to absolute tropospheric delays by using data from the Generic Atmospheric Correction Online Service for InSAR (GACOS). Surface soil moisture maps were retrieved from Sentinel-1 observations, by means of a multi-temporal algorithm that uses time series of Sentinel-1 data and ancillary data, such as a plant water content map, as inputs. Soil and sea temperature are directly available from ESA as level-2 products based on Sentinel-3, as well as the wind field over sea, based on Sentinel-1.
The experimental results concern two intense rainfall events and subsequent floods that occurred in Italy in Autumn 2017. The best results were obtained by assimilating the wind field (in the first test case) and the GNSS-derived ZTD (in the second test case). Promising results were achieved also by performing a combined assimilation of wind field and ZTD, and direct insertion of soil moisture. The outcomes of this study seem to confirm the synergy between high-resolution numerical weather models and a set of GNSS-derived and Sentinel-derived Earth Observation products, at least for the forecast of severe rain events.

Keywords: GNSS, SAR, Sentinel, NWP, Assimilation

©2019. Japan Geoscience Union. All Right Reserved.

An analysis of tropospheric delays using goGPS software on all GEONET stations during the passage of Typhoon Jebi in September 2018

*Andrea Gatti[1], Eugenio Realini[1], Giulio Tagliaferro[1]

1. Geomatics Research & Development srl

Nowadays, tropospheric delays estimated from GPS observations are widely used for studying weather events all over the world. Some meteorological agencies already use Zenith Tropospheric Delays (ZTD), or similar observables, by assimilation into numerical weather prediction (NWP) models; however, the increasing number of satellites from newer GNSS constellations (Galileo, QZSS, BeiDou, IRNSS), the advent of low-cost receivers and the advancement of techniques and models left space for further studies on the topic.

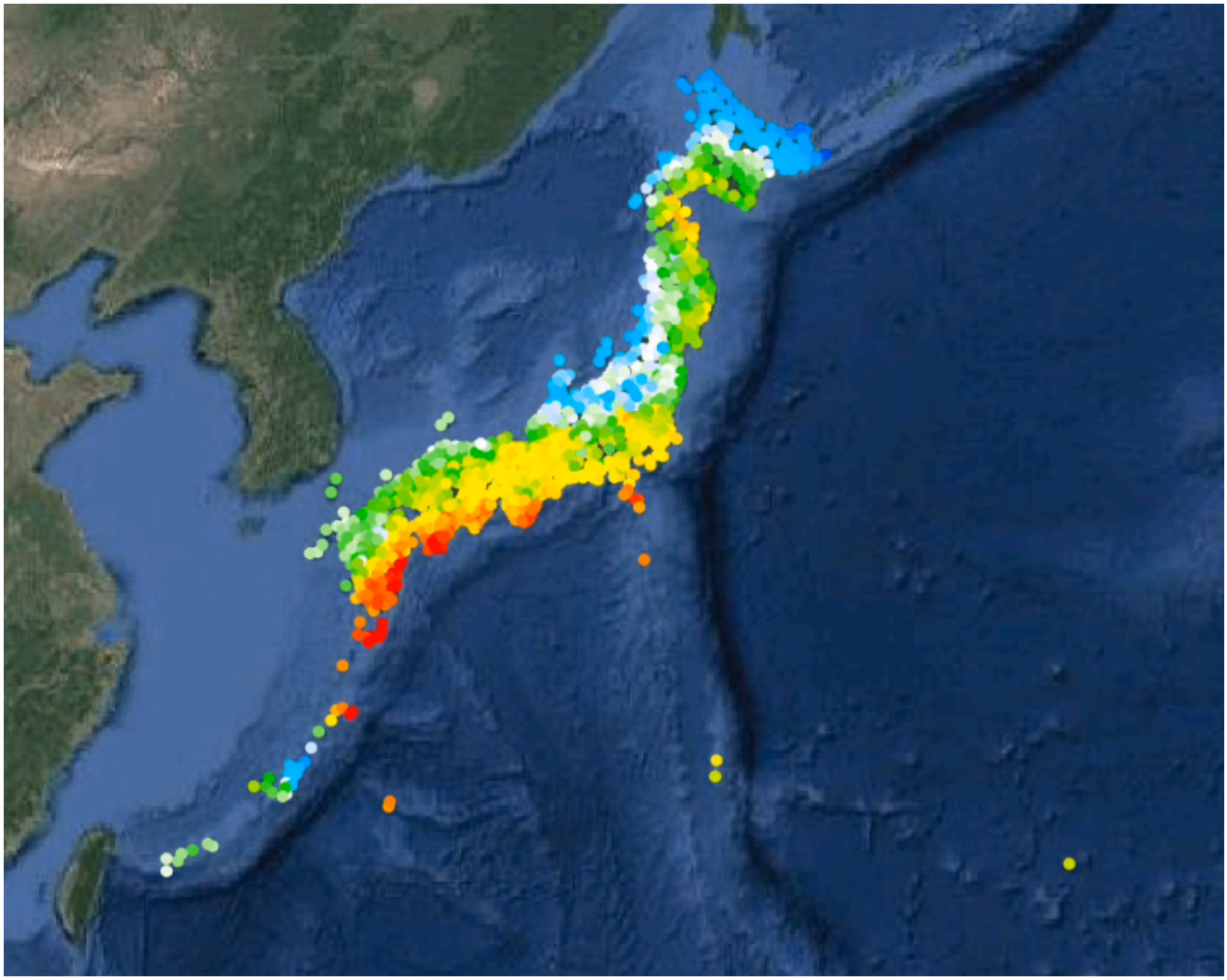
The new version of the open-source goGPS MATLAB software has been written to be a simple tool to perform efficient analysis of GNSS data from both geodetic and low-cost receivers. With its capability to download automatically all the resources needed by the selected algorithms, the relative easiness of use, and its flexibility with the possibility of trying different configurations in a fast way, goGPS presents itself as a convenient tool for students or researches who want to prototype new algorithms or perform studies on GNSS data.

To demonstrate the capabilities of the software, 1312 stations of the Japanese GEONET GNSS network are processed from September 2, 2018, to September 5, 2018, during the passage of Typhoon Jebi.

A 32-core machine running MATLAB 2016a and the latest beta version of goGPS 1.0 is used to process in a single parallel run the entire 4 days of the dataset. The execution performs for all the stations a multi-epoch precise point positioning (PPP) least squares (LS) adjustment in about two hours of computation time. Series of tropospheric delays and gradients are generated and used to produce maps and animations in order to observe the development of the event. Different solutions including multi-constellation results are presented and discussed.

Keywords: GNSS, Troposphere, Software, Typhoon

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 104 1F

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Takuya Tsugawa

GNSS has become a fundamental tool for studies on atmosphere, ionosphere, and solid earth. Ground and space-based GNSS measurements have operationally contributed to improve global and regional NWP since 2006. In recent years, studies utilizing reflected GNSS signals to derive altimetric height, surface roughness, soil moisture, snow depth, humidity or vegetation index have been evolving. Ocean-platform GNSS observations have been demonstrating their capability of real-time monitoring of maritime water vapor as well as sea level. Increasing observations provided through Multi-GNSS (GPS, GLONASS, BEIDOU, GALILEO, QZSS etc.) enhances capability of the GNSS as an integrated earth observation system.
The purpose of this session is to share the latest development of GNSS researches on monitoring the earth system and to stimulate synergetic interdisciplinary studies. Contributions on atmosphere (troposphere and ionosphere) studies, reflectometry (GNSS-R), and integrations of different observation techniques like GNSS-Acoustic measurement to monitor ocean floor positioning are welcome.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[MTT46-06] A new perspective of the storm-time dynamics of the ionosphere using global GNSS-TEC observation data

★Invited Papers

*Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Sori[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2.National Institute of Information and Communications Technology (NICT))

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[MTT46-07] Ionospheric space weather studies for GNSS users

*Takuya Tsugawa[1], Kornyanat Hozumi[1], Punyawi Jamjareegulgarn[2], Supnithi Pornchai [2], Susumu Saito[3], Yuichi Otsuka[3,4], Shinichi Hama[1], Takahiro Naoi[1], Mamoru Ishii[1] (1.NICT, 2.KMITL, 3.ENRI, 4.Nagoya Univ.)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[MTT46-08] QZSS geostationary satellite for ionospheric TEC observations

*Kosuke Heki[1] (1.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[MTT46-09] Precise estimation of total electron content by double-shell model using local receiver network

*Takashi Maruyama[1,2], Kornyanat Hozumi[1], Guanyi Ma[2], Qingtao Wan[2] (1.National Institute of Information and Communications Technology, 2.National Astronomical Observatories, Chinese Academy of Sciences)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[MTT46-10] Investigation of sea surface height detection by Global Navigation Satellite System Reflectometry (GNSS-R)

*Osamu Isoguchi[1], Kaoru Ichikawa[2], Yukihito Kitazawa[3] (1.RESTEC, 2.Kyushu Univ., 3.ISAS/JAXA)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

[MTT46-11] Discussion

A new perspective of the storm-time dynamics of the ionosphere using global GNSS-TEC observation data

*Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Sori[1], Takuya Tsugawa[2], Michi Nishioka[2]

1. Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2. National Institute of Information and Communications Technology (NICT)

The Earth’ s atmosphere is divided into four regions: troposphere, stratosphere, mesosphere and thermosphere by the temperature structure. A part of neutral gases in the mesosphere and thermosphere is ionized by solar extreme ultraviolet (EUV) radiation in a wavelength of less than 100 nm. The region having the ionized gasses (plasmas) is called the ionosphere. The height profile of the electron density in the ionosphere becomes maximum at a height of 300 km is determined by the chemical and dynamical processes in addition to the solar EUV ionization. Due to the interaction between the ionospheric electrons and electric fields of electromagnetic waves, the ionosphere gives a significant influence on the ionospheric transmissions with satellites for communications, positioning, and navigation. The ionosphere changes greatly in association with the activities of the sun, magnetosphere, and the lower atmosphere, and their ionospheric variations interfere with satellite communication and enhances satellite positioning errors in the Global Navigation Satellite System (GNSS), including GPS. The most major factor of the positioning errors is the propagation delay of GNSS signals in the ionosphere. Therefore, a global total electron content (TEC) map or ionospheric model is required to investigate global ionospheric variations associated with geomagnetic storms and lower atmospheric activities and to evaluate the ionospheric delay for GNSS positioning. A scale of the ionospheric variations (traveling ionospheric disturbances (TIDs), equatorial plasma bubbles (EPB), auroral ionospheric irregularity) is in a range between several 100 km and 1000 km. A storm enhanced density (SED) phenomena observed in the mid- and low-latitude ionosphere during the main phase of geomagnetic storms appears with a wide longitudinal extent. In order to clarify generation and propagation mechanisms of these ionospheric phenomena and to investigate their effects on the GNSS positioning, dense and wide-coverage ionospheric observations and the corresponding TEC data are needed. Under these backgrounds, we have built a global TEC database (absolute TEC, detrended TEC, and ROTI) with high time and spatial resolutions and developed a TEC data analysis system in a corroboration with NICT and the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) and PWING (Study of dynamical variation of particles and waves in the inner magnetosphere using ground-based network observations) projects. For the development of the TEC database, we have collected all the available GNSS receiver data in the world. The number of the GNSS stations reaches more than 8500 in January 2019. These GNSS data are provided by the International Geoscience Services (IGS), the University NAVSTAR Consortium (UNAVCO), Scripps Orbit and Permanent Array Center (SOPAC), and other global and regional data centers (more than 50 data providers in all). In this talk, we introduce an overview of recent new scientific results of temporal and spatial variations in the ionosphere during the development and decay of geomagnetic storms as seen in the global GNSS-TEC variations.

Keywords: Global Navigation Satellite System (GNSS), Ionosphere, Geomagnetic storm, Positioning error, Total electron content (TEC), Database

©2019. Japan Geoscience Union. All Right Reserved.

Ionospheric space weather studies for GNSS users

*Takuya Tsugawa[1], Kornyanat Hozumi[1], Punyawi Jamjareegulgarn[2], Supnithi Pornchai [2], Susumu Saito[3], Yuichi Otsuka[3,4], Shinichi Hama[1], Takahiro Naoi[1], Mamoru Ishii[1]

1. NICT, 2. KMITL, 3. ENRI, 4. Nagoya Univ.

NICT has observed ionosphere using Ionosondes and GNSS receiver networks in Japan and Southeast Asia for the nowcast and forecast of the ionospheric condition.Two-dimensional ionospheric total electron content (TEC) maps have been derived from dense ground-based GNSS receiver networks and applied to studies of various ionospheric disturbances since mid-1990s. For the purpose of monitoring and researching ionospheric conditions and ionospheric space weather phenomena, we have developed TEC maps over Japan using GEONET. Currently, we are providing high-resolution two-dimensional maps of absolute TEC, detrended TEC, rate of TEC change index (ROTI), and loss-of-lock on GPS signal over Japan in real-time basis.

We have collected all the available GNSS receiver data in the world to expand the TEC observation area. To expand the two-dimensional TEC observation are with high-resolution, we have conducted Dense Regional And Worldwide International GNSS TEC observation (DRAWING-TEC) project, which consists of the three items: (1) standardizing GNSS-TEC data, (2) developing a new high-resolution TEC mapping technique, and (3) sharing the standardized TEC data or the information of GNSS receiver network. One of other effective methods to expand TEC observation area would be to use the maritime GNSS buoys.

NICT have started a new research project to validate the ionospheric effect of precise positioning technique using GNSS including quasi-zenith satellite (QZSS) since 2017. In this project, we will investigate ionospheric effects on individual positioning techniques (single frequency, DGPS, and RTK-PPP) and consider methods to mitigate and/or prevent the positioning errors under sever ionospheric conditions. We have tried to use multi-GNSS data including GPS and QZSS for routine data collection and processing. In the Southeast Asia, it is important to identify which satellite-receiver path suffers from plasma bubble structures for verifying the ionospheric effects on GNSS positioning. we have a plan to install VHF radar at Chumphon (Thailand) and multi-GNSS receivers at Chumphon, Bac Lieu (Vietnam), and Cebu (Philippines) at the magnetic equator.

Keywords: Ionosphere, GNSS, Space Weather

©2019. Japan Geoscience Union. All Right Reserved.

QZSS geostationary satellite for ionospheric TEC observations

*Kosuke Heki[1]

1. Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

Most Global Navigation Satellite System (GNSS) satellites employ orbital periods with a half sidereal day. This makes the satellites move rapidly in the sky when observed from ground receivers. This is important in relative positioning by observing carrier phases and in estimating zenith tropospheric delays. However, measurement of ionospheric total electron content (TEC) could be done instantaneously by comparing phases of the two carrier waves, and the changes in the satellite azimuth and elevation becomes a nuisance. The change in STEC (slant TEC) comes from (1) temporal change and (2) spatial changes of ionosphere, and (3) apparent U-shaped changes coming from the elevation changes. We can mitigate (3) by using VTEC, i.e. removing the inter-frequency biases and multiplying the bias-free STEC with cosine of the line-of-sight penetration angle. Nevertheless, discrimination of (1) and (2) is difficult and becomes possible only by processing the whole data sets of dense networks. The Japanese Quasi-zenith Satellite System (QZSS) is currently composed of four satellites, 3 satellites with quasi-zenith orbits (PRN01, 02, 03) and 1 satellite with geostationary orbit (PRN07). The latter enables continuous observation of certain points in ionosphere fixed to the Earth, i.e. the changes in TEC come entirely from temporal changes.

The Japanese GEONET network GNSS receivers continuously track GPS, GLONASS, Galileo, and QZSS, and their raw data are available on line as the RINEX (Receiver independent exchange format) Ver.3.02 files. I made a software system to read them and convert the phase data to TEC time series. With TEC observations from the geostationary satellite, we could study temporal changes in ionosphere without being bothered by spatial variations. This implies certain benefits in studying ionospheric disturbances, such as LSTID (Large-Scale TID), MSTID (Medium-scale TID) (Otsuka et al., 2011), Es (sporadic-E) (Maeda & Heki, 2015), artificial ionospheric electron depletion due to launches of satellites and ballistic missiles (Hashimoto & Heki, 2018), and preseismic ionospheric anomalies (Heki, 2019). In contrast, geostationary satellites are not suitable for studying coseismic ionospheric disturbances by acoustic waves (Cahyadi & Heki, 2015) and those by volcanic eruptions (Nakashima et al., 2015). This is because stronger signals always appear in poleward line-of-sights from ground stations located at the equatorward side of the epicenters/volcanoes (Heki, 2019).

References

Cahyadi, M. N., and K. Heki (2015), Coseismic ionospheric disturbance of the large strike-slip earthquakes in North Sumatra in 2012: Mw dependence of the disturbance amplitudes, Geophys. J. Int., 200(1), 116-129.

Hashimoto, M. and K. Heki (2018), Estimation of thrust powers of missiles/rockets by GNSS-TEC observations, J. Geod. Soc. Japan, in press.

Heki, K. (2019), Ionospheric disturbances related to Earthquakes, in “Advances in Ionospheric Research: Current Understanding and Challenges”, Wiley/AGU Book, in press.

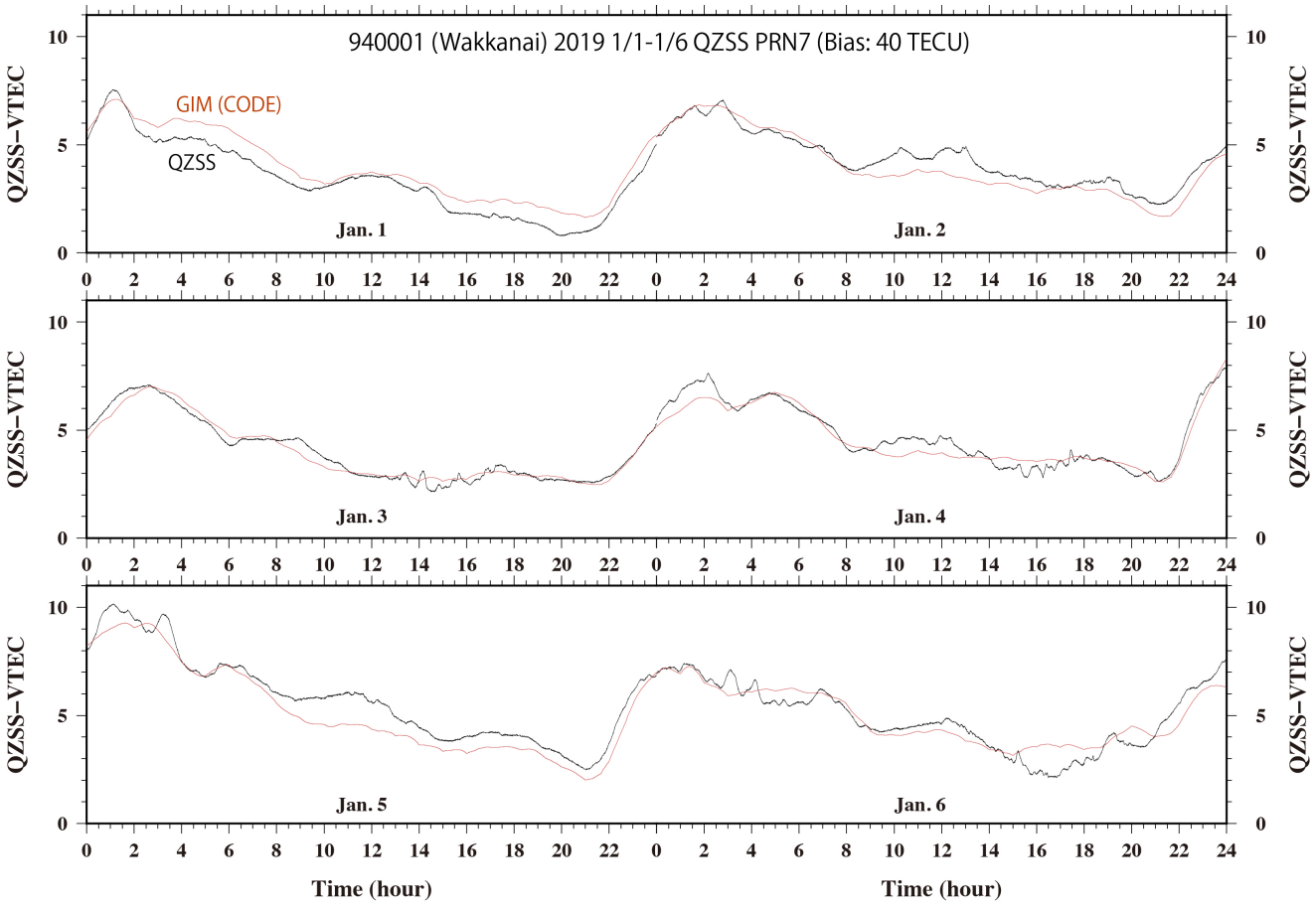
©2019. Japan Geoscience Union. All Right Reserved.

Nakashima, Y., K. Heki, A. Takeo, M. N. Cahyadi, A. Aditiya, & K. Yoshizawa (2016), Atmospheric resonant oscillations by the 2014 eruption of the Kelud volcano, Indonesia, observed with the ionospheric Total Electron Contents and seismic signal, Earth Planet. Sci. Lett., 434, 112-116.

Maeda, J. & K. Heki (2015), Morphology and dynamics of daytime mid-latitude sporadic-E plasma patches revealed by GPS total electron content observations in Japan, Earth Planets Space, 67, 89, doi:10.1186/s40623-015-0257-4.

Otsuka, Y., N. Kotake, K. Shiokawa, T. Ogawa, T. Tsugawa, & A. Saito (2011), Statistical study of mediumscale traveling ionospheric disturbances observed with a GPS receiver network in Japan, in Aeronomy of the Earth’ s Atmosphere and Ionosphere, edited by M. A. Abdu and D. Pancheva, IAGA Special Sopron Book Series 2, doi:10.1007/978-94-007-0326-1_21, Springer.

Keywords: GNSS-TEC, QZSS, ionospheric disturbance



©2019. Japan Geoscience Union. All Right Reserved.

Precise estimation of total electron content by double-shell model using local receiver network

*Takashi Maruyama[1,2], Kornyanat Hozumi[1], Guanyi Ma[2], Qingtao Wan[2]

1. National Institute of Information and Communications Technology, 2. National Astronomical Observatories, Chinese Academy of Sciences

The total electron content (TEC) derived from the differential group delay of the code signals of GNSS on two frequencies has been a basic parameter in ionospheric studies. In most applications, the thin-layer approximation is used to convert the measured slant TEC to vertical TEC at the ionosphere pierce point. Usually the thin-layer height is assumed to be constant regardless of the location and time, which is unrealistic and can be a source of error in TEC estimations. This is a serious problem at low latitudes where the ionospheric height greatly varies by the action of the vertical EXB drift due to the zonal electric field and field-aligned transport due to the meridional neutral wind drag. In this paper, we parameterized the ionosphere by two thin-layers (double-shell model) at 250 and 1100 km to avoid this inconvenience. The variation of partial electron content related to each layer was approximated by the spherical harmonics expansion to minimize the error of slant TEC between the measurements and the sum of contribution from the two layers. In the harmonics expansion calculation, the longitude parameter was the sun-fixed longitude or the local time measured in angle. Thus data obtained in a whole day were used. Another problem with the conventional technique is the leveling procedure, where phase measurements with a small noise are leveled to the noisy code signal data. Therefore, noises and multipath effect on the code delay are not resolved by the leveling. To avoid this inconvenience, the leveling to the code data was not applied in our study. Instead, the total bias including instrumental (satellite and receiver) code biases and phase ambiguity for each arc (i.e., total arc bias) was determined in conjunction with TEC.
The technique was applied to datasets obtained by a local receiver network near the magnetic equator. Results were compared with those of the conventional (single) thin-layer model. A significant difference was found in the ratio of TECs at the equatorial anomaly crests and trough. The double-shell model captured the equatorial anomaly more correctly than the conventional method. Another outcome of the double-shell model was the different patterns of TEC variations at the two heights, as expected. Equatorial anomaly crests and the evening TEC bite-out at the equator were prominent in the lower shell. The TEC peak at the higher shell appeared later than the lower shell. Two shells exhibited different features of north-south asymmetry of TEC, depending on the local time. These results provide information on the ionospheric dynamics, such as the ionosphere-thermosphere coupling through the field-aligned transport and variations of the evening enhancement of zonal electric field.

Keywords: TEC, double-shell model, equatorial anomaly

©2019. Japan Geoscience Union. All Right Reserved.

Investigation of sea surface height detection by Global Navigation Satellite System Reflectometry (GNSS-R)

*Osamu Isoguchi[1], Kaoru Ichikawa[2], Yukihito Kitazawa[3]

1. RESTEC, 2. Kyushu Univ., 3. ISAS/JAXA

In recent years, the possibility of detecting ocean parameters such as sea surface height (SSH), ocean wind from the Global Navigation Satellite System reflectometry (GNSS-R) was shown. The Cyclone GNSS (CYGNSS) mission aiming to contribute to the forecast of extreme weather phenomena by observing the sea surface wind in the cyclone is in progress operating eight small satellites and ocean wind speed products are being delivered. In GNSS-R, it is theoretically possible to measure the SSH from the ellipsoid by measuring the delay of the reflected wave and the direct wave. The investigation of SSH detection using TDS-1 which was developed and operated mainly by Surrey Satellite Technology Ltd (SSTL) in the UK has been reported. Even in our group, SSH detection was performed using TDS-1 data observed near Japan and the detected ones was compared with the mean SSH constructed by the altimeter observations. It was confirmed that the SSH can be detected with an error of about 1m at observation with good conditions (antenna gain is 7.5 dBi or more). Regarding CYGNSS, SSH is not calculated as an official product and it is limited to detectability study. In this report, we used CYGNSS data to investigate SSH detection from GNSS-R like TDS-1.

The CYGNSS data used for the present study is a full resolution Delayed Doppler Map (DDM) provided as special data through the GNSS Reflectometry for Ocean Waves, Tides and Height (GROWTH) project, which is a member of NASA CYGNSS External Science Member. The size of DDM is 20 (Doppler) ×128 (Delay) bin. On the other hand, the size of the normal DDM is 11 (Doppler) ×17 (Delay) bin in the Level 1 ver 2.1 data provided by NASA's The Physical Oceanography Distributed Active Archive Center (PO.DAAC). Thus, the data are compressed to 1/2 in the doppler direction and 1/8 in the delay one. Since the resolution in the delay direction affects the range measurement, it is expected that the detection resolution by the full DDM will be improved over the usual L1 data. The data provided was data acquired mainly in the East China Sea and acquired for the purpose of demonstrating the possibility of detecting the SSH related to the large tide amplitude.

Since the provided full resolution data are those in which only a part of data on DDM is stored, L1 ver 2.1 data at the same time were collected and the positions of the transmitting GNSS satellite and the receiving CYGNSS, the position of the reflection point and the delay information of the reflection point corresponding to the full DDM were extracted to calculate the SSH. A random variation of about 6m in standard deviation was confirmed in the delay information of the reflection point, so we with calculated weighed average with the 1/e scale of 75 km after excluding the abnormal values. Based on the above information, the SSH along the reflection point was calculated and compared with the mean SSH data calculated based on the altimeter data. A large spatial error that can be approximated by a linear equation of the distance was confirmed for the difference between the two SSHs, and therefore the relative SSH was evaluated by subtracting the approximate expression. The RMS error along the 4 passes of the observation on April 18, 2018 was about 0.8 m to 1.5 m, which was almost the same accuracy as TDS-1.

In the present study, the possibility of SSH detection as a spatial relative altitude was suggested. However since the large spatial error remains, whether the SSH variation in the East China Sea with O (1 m) can be detected will be a subject for further study. In particular, since corrections to the ionosphere and the

©2019. Japan Geoscience Union. All Right Reserved.

troposphere delays have not been made at the stage of this study, it is considered necessary to estimate their influences from model data.

Keywords: GNSS-R, Sea surface height, CYGNSS

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary) | M-TT Technology & Techniques

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Takuya Tsugawa
Mon. May 27, 2019 10:45 AM - 12:15 PM 104 (1F)

GNSS has become a fundamental tool for studies on atmosphere, ionosphere, and solid earth. Ground and space-based GNSS measurements have operationally contributed to improve global and regional NWP since 2006. In recent years, studies utilizing reflected GNSS signals to derive altimetric height, surface roughness, soil moisture, snow depth, humidity or vegetation index have been evolving. Ocean-platform GNSS observations have been demonstrating their capability of real-time monitoring of maritime water vapor as well as sea level. Increasing observations provided through Multi-GNSS (GPS, GLONASS, BEIDOU, GALILEO, QZSS etc.) enhances capability of the GNSS as an integrated earth observation system.
The purpose of this session is to share the latest development of GNSS researches on monitoring the earth system and to stimulate synergetic interdisciplinary studies. Contributions on atmosphere (troposphere and ionosphere) studies, reflectometry (GNSS-R), and integrations of different observation techniques like GNSS-Acoustic measurement to monitor ocean floor positioning are welcome.

12:05 PM - 12:15 PM

[MTT46-11]Discussion

©Japan Geoscience Union

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 106 1F

[M-TT46] New phase of GPS/GNSS application as an integrated earth observation system

convener:Yoshinori Shoji(The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute), Kaoru Ichikawa(Research Institute for Applied Mechanics, Kyushu University), Yusaku Ohta(Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University), Takuya Tsugawa(National Institute of Information and Communications Technology), Chairperson:Yoshinori Shoji(Meteorological Research Institute)

GNSS has become a fundamental tool for studies on atmosphere, ionosphere, and solid earth. Ground and space-based GNSS measurements have operationally contributed to improve global and regional NWP since 2006. In recent years, studies utilizing reflected GNSS signals to derive altimetric height, surface roughness, soil moisture, snow depth, humidity or vegetation index have been evolving. Ocean-platform GNSS observations have been demonstrating their capability of real-time monitoring of maritime water vapor as well as sea level. Increasing observations provided through Multi-GNSS (GPS, GLONASS, BEIDOU, GALILEO, QZSS etc.) enhances capability of the GNSS as an integrated earth observation system.
The purpose of this session is to share the latest development of GNSS researches on monitoring the earth system and to stimulate synergetic interdisciplinary studies. Contributions on atmosphere (troposphere and ionosphere) studies, reflectometry (GNSS-R), and integrations of different observation techniques like GNSS-Acoustic measurement to monitor ocean floor positioning are welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MTT46-12] Study on tropospheric delay variations extracted from a short baseline analysis and their application to meteorological observation

*Takayuki Yoshihara[1], Susumu Saito[1], Atsushi Kezuka[1], Shinji Saitoh[1] (1.Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MTT46-13] Water vapor estimation using digital terrestrial broadcasting waves - Field test in Tokyo metropolitan area and trial production of small devices -

*Seiji Kawamura[1], Hiroshi HANADO[1], Hiroki Ohta[1], Yoshinobu Matsumura[2], Ryosuke Mori[2], Kazuyoshi Noda[2], Teruaki Hasegawa[2] (1.National Institute of Information and Communications Technology, 2.Socionext Inc.)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MTT46-14] Water vapor estimation via propagation delay of 920MHz wireless communication signal

*Nobuyasu Shiga[1], Satoshi Yasuda[1], Seiji Kawamura[1], Hiroshi HANADO[1], Ryuichi Ichikawa[1], Hironori Iwai[1], Shinsuke Satoh[1] (1.National Institute of Information and communications technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MTT46-15] Comparison of a water vapor observation with GPS and high sensitivity microwave radiometer, KUMODeS

*Taketo Nagasaki[1], Osamu Tajima[2], Ryuichi Ichikawa[3], Hiroshi Takiguchi[4], Kentaro Araki[5], Hiroshi Ishimoto[5] (1.High Energy Accelerator Research Organization, IPNS, 2.Kyoto University, 3.National Institute of Information and Communications Technology, 4.Japan Aerospace Exploration Agency, 5.Meteorological Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MTT46-16] Development and Observation of Water Vapor Raman Lidars for Localized Torrential Rainfall Prediction

*Tomohiro Nagai[1], Tetsu Sakai[1], Satoru Yoshida[1], Toshiharu Izumi[2], Sho Yokota[1], Hiromu Seko[1], Yoshinori Shoji[1], Koichi Shiraishi[3] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Japan Meteorological Agency, 3.Fukuoka University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MTT46-17] Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

*Yoshinori Shoji[1], Teruyuki Kato[2], Yukihiro Terada[3], Toshitaka Tsuda[4], Masanori Yabuki[4] (1.The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute, 2.Hot Springs Research Institute/Kanagawa Prefectural Government, 3.Natinal Institute of Technology, Kochi College, 4.Research Institute for Sustainable Humanosphere/Kyoto Unversity)

Study on tropospheric delay variations extracted from a short baseline analysis and their application to meteorological observation

*Takayuki Yoshihara[1], Susumu Saito[1], Atsushi Kezuka[1], Shinji Saitoh[1]

1. Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology

This paper discusses variation of 10cm order in tropospheric delay differences between two ground-based GNSS stations, which are located with a horizontal scale of about 2km. This typical value of tropospheric delay differences is represented as a tropospheric delay difference projected to the zenith direction for a common satellite between the two stations. The variation also corresponds to an order of 50 mm/km in tropospheric delay spatial gradient. Such large differences of tropospheric delay with short baselines of several 100m had been reported in safety assessment and validation activities for aircraft high category precision approach and landing system called as GBAS (Ground-Based Augmentation System) [1,2,3]. They also reported that their temporal variations are highly correlated with the surface wind velocities under fine weather conditions.

A GBAS ground station typically has four GNSS stations with separation of several 100m each other. Electronic Navigation Research Institute (ENRI) participated in the safety assessment and validation activities, which were performed to validate draft international standards for high category GBAS. As one of the activities, ENRI developed a prototype system and installed it in New Ishigaki airport (24.40N, 124.25E). The system has the typical four GNSS stations within a horizontal scale of 400m and an additional GNSS station called as ionosphere field monitor (IFM), which is located as about 2km away from the four stations. These GNSS stations consists of dual frequency antenna and receiver and continuously collect GNSS data. Additionally, we set up a different GNSS receiver which can accept multi-RF signal inputs. Combining the receiver with Radio-over-Fiber (RoF) devices, we can use a common clock for signal processing two GNSS signals received at the both ends of the baseline with a length of 2.3km [4]. This additional system enables us to examine a tropospheric difference for each GNSS satellite without correction of difference of receiver clock drift components between two received signals although it is required to distinguish tropospheric delay differences from ionospheric effects and multipath errors using dual frequency measurements and characteristics of multipath variations [5].

In this study, we mainly examine tropospheric delay difference data with the baseline length of 2.3km, including GNSS data collected from the prototype system. Considering geometry of GNSS satellite propagation paths and observational errors, we will discuss candidate meteorological phenomena and application to future meteorological observation.

[1] K. Alexander et al., WP16, ICAO NSP/WGW, May 2014.
[2] F. Salbert et al., ICAO NSP WG1&2, Sept. 2014.
[3] S. Saito et al., Proc. of ION 2015 Pacific PNT, pp. 815-820, Honolulu, HI, April 2015.
[4] T. Yoshihara, et al., Proc. of the ION 2017 Pacific PNT, pp. 885-896, Honolulu, Hawaii, May 2017.
[5] T. Yoshihara et al., IEICE Technical Report, vol.118, no.105, pp.19-24, SANE2018-16, June 2018 (Japanese).

Keywords: GNSS, Tropospheric delay, Short baseline, Application to meteorological observation

©2019. Japan Geoscience Union. All Right Reserved.

Water vapor estimation using digital terrestrial broadcasting waves - Field test in Tokyo metropolitan area and trial production of small devices -

*Seiji Kawamura[1], Hiroshi HANADO[1], Hiroki Ohta[1], Yoshinobu Matsumura[2], Ryosuke Mori[2], Kazuyoshi Noda[2], Teruaki Hasegawa[2]

1. National Institute of Information and Communications Technology, 2. Socionext Inc.

We have developed a method to measure water vapor in horizontal direction using digital terrestrial broadcasting waves [1]. Radio waves are delayed due to water vapor through propagation. Water vapor can be estimated using propagation delay of digital terrestrial broadcasting waves. The basic idea of using propagation delay is the same as that of retrieving PWV by using GNSS. In this study, we estimate water vapor near a ground surface from the horizontal propagation delay of digital terrestrial broadcasting waves. The main features of this observation are, no need for transmitters (small and low cost due to receiving only), applicability wherever digital terrestrial broadcasting is available, and its high time resolution. Our target is to improve the accuracy of numerical weather forecast for severe weather phenomena such as localized heavy rainstorms in urban areas through data assimilation.
We have developed a real-time delay measurement system with a software-defined radio (SDR) technique, whose main components are USRP-N210 and PC (prototype). Seven measurement systems are now under operation around Tokyo metropolitan area. Although the main source of digital terrestrial broadcasting waves in Tokyo area is the Tokyo Skytree, some small radio towers that transmit Television Saitama, Chiba Television, Television Kanagawa, and do on can be also available. If plural radio waves from different radio towers are available, we can use plural base-lines to estimate water vapor. Outline of demonstration experiment in Tokyo metropolitan area and its initial results are introduced.
Small devices which can measure propagation delay using digital terrestrial broadcasting waves are now under trial production through a joint research by NICT and Socionext. These devices use FPGA for calculate propagation delay of digital terrestrial broadcasting waves. Their size and electricity consumption is smaller than those of prototype. If many small receivers are deployed, 2-D water vapor variations can be monitored with high time and space resolutions. Such a network system will contribute to increasing the accuracy of numerical weather forecast for severe weather phenomena such as localized heavy rainstorms.

Reference
[1] Kawamura, S., et al. (2017), Water vapor estimation using digital terrestrial broadcasting waves, *Radio Sci.*, *52*, 367-377, doi:10.1002/2016RS006191.

Keywords: water vapor, propagation delay, digital terrestrial broadcasting

©2019. Japan Geoscience Union. All Right Reserved.

Water vapor estimation via propagation delay of 920MHz wireless communication signal

*Nobuyasu Shiga[1], Satoshi Yasuda[1], Seiji Kawamura[1], Hiroshi HANADO[1], Ryuichi Ichikawa[1], Hironori Iwai[1], Shinsuke Satoh[1]

1. National Institute of Information and communications technology

We have developed a 920MHz wireless communication module that can measure the variation of propagation delay precisely (6mm precision) and frequently (20 times/second). We have monitored the variation of propagation delay between 2 places that are 4.25km apart with line-of-sight. The result agreed well with the estimated propagation delay using the data obtained by meteorological observation equipment. This technique is suited to monitor the distribution of surface water vapor, compared to GNSS that primarily measures the propagation delay in vertical direction.
We are seeking the right path for social impremention of this technology, aiming to provide a mean to measure the surface water vapor with high precision, high frequency and high resolution in a cost-effective way.

Keywords: water vapor estimation, space-time synchronization, propagation delay measurement, wireless communication module



©2019. Japan Geoscience Union. All Right Reserved.

Comparison of a water vapor observation with GPS and high sensitivity microwave radiometer, KUMODeS

*Taketo Nagasaki[1], Osamu Tajima[2], Ryuichi Ichikawa[3], Hiroshi Takiguchi[4], Kentaro Araki[5], Hiroshi Ishimoto[5]

1. High Energy Accelerator Research Organization, IPNS, 2. Kyoto University, 3. National Institute of Information and Communications Technology, 4. Japan Aerospace Exploration Agency, 5. Meteorological Research Institute

GPS is one of the useful technique which is using electromagnetic waves in the atmosphere. However, radio waves through the atmosphere and have a delay due to water vapor then. It is a major factor of indeterminacy in some measurement. On the other hand, as a device for identifying the amount of water vapor is a microwave radiometer.
We have developed a new microwave radiometer "KUMODeS" to detect local and sudden natural disasters such as tornadoes. This system observes radiation from water molecules present in the atmosphere (20-30 GHz band) and the emission line from the oxygen molecule (50-60 GHz band) are measured at the same time. As a result, the amount of water vapor in the atmosphere is estimated with high accuracy. As a characteristic of KUMODeS, high sensitivity (low noise) was employed as a cooling receiver by application of radio astronomical observation technology. In order to improve convenience, we employed a low-temperature(45K) calibration source in the cryostat and can be operated by remote control. And we are able to select a higher spatial resolution. We conducted long-term observations for more than half a year in Tsukuba city using KUMODeS. At the same point, we measured the amount of water vapor by GPS antenna and confirmed the validity of the observation result. In addition, we have also developed the second device that aimed at a smaller size and lower power consumption as a development of KUMODeS. In this presentation, we report the outline of the system and the results of atmospheric observation in Tsukuba City.
This research has been funded by “Program for Creating STart-ups from Advance Research and Technology (START Program)” from the Ministry of Education, Culture, Sports, Science and Technology, Japan, http://www.jst.go.jp/start/en/index.html.

Keywords: water vapor, microwave radiometer

©2019. Japan Geoscience Union. All Right Reserved.

Development and Observation of Water Vapor Raman Lidars for Localized Torrential Rainfall Prediction

*Tomohiro Nagai[1], Tetsu Sakai[1], Satoru Yoshida[1], Toshiharu Izumi[2], Sho Yokota[1], Hiromu Seko[1], Yoshinori Shoji[1], Koichi Shiraishi[3]

1. Meteorological Research Institute, Japan Meteorological Agency, 2. Japan Meteorological Agency, 3. Fukuoka University

In recent years, the way of rain has been localized and concentrated, and disasters caused by localized torrential rain are increasing accordingly. One of the causes of these rains is thought to be the continuous supply of water vapor rich air through the lower atmosphere to the area where the rainfall is occurring. Therefore, it is very important to continuously observe the vertical distribution of water vaper in the lower atmosphere on the windward side to predict the localized torrential rainfalls. Water vapor Raman lidars are developed and observations are carried out in the Tokyo metropolitan area during summer time in 2017 and 2018. The lidars are carefully designed to potentiate the measurement of the water vapor near the ground as well as to have the capability on the daytime measurement. One of the lidars has the mobility so that we could make measurement at three observational sites in the seashore of the Tokyo metropolitan area that are located on the windward side of prospective area of the heavy rain in the Tokyo metropolitan area. Feasibility study of the impact of the water vapor mixing ratio profiles taken by the lidars on the numerical experiment for the precipitation prediction was carried out. We conducted water vapor assimilation experiment with use of the water vapor mixing ratio measured with the lidars. The assimilation results indicate that water vapor distribution in the analysis field was greatly changed by water vapor assimilation in the downwind side of the lidar observation site. Furthermore, a new research project has been just started to improve quantitative precipitation forecast for heavy rains in Kyushu island of Japan by means of data assimilation of water vapor lidars.

Keywords: water vapor, lidar, heavy rain, data assimilation , weather prediction

©2019. Japan Geoscience Union. All Right Reserved.

Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

*Yoshinori Shoji[1], Teruyuki Kato[2], Yukihiro Terada[3], Toshitaka Tsuda[4], Masanori Yabuki[4]

1. The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute, 2. Hot Springs Research Institute/Kanagawa Prefectural Government, 3. Natinal Institute of Technology, Kochi College, 4. Research Institute for Sustainable Humanosphere/Kyoto Unversity

Japan is an archipelago located easternmost of East Asia and influenced by the East Asian monsoon, which is characterized by moist air inflow coming from the ocean that often causes heavy rainfall (Kato 2006, Tsuguti and Kato 2014, Kato 2018). From June 28 to July 8, 2018, extreme rainfall frequented western Japan to the Tokai region, wherein more than 1,000 mm, at the maximum of 1,852.5 mm, precipitation was recorded in several regions (Tsuguti et al. 2018). A press release of Japan Meteorological Agency (JMA) (JMA, 2018) attributed the event to the concentration of two massively moist air streams over western Japan and persistent upward flow. With the frequency of extreme precipitation events, water vapor monitoring over the ocean becomes one of the important issues in Japan. Shoji et al. 2009 exhibited the improvement of a heavy rainfall prediction method by assimilating precipitable water vapor (PWV) estimated via the Global Positioning System (GPS) observation network in East Asia, as well as Japan’s nationwide dense GPS network. The result insisted the importance of water vapor monitoring upstream.

Unlike ground-based fixed GNSS stations, ocean-platform (ship and buoy) GNSS measurements face difficulties in analyzing the variable antenna position simultaneously with the atmospheric delay. However, recent advancement of kinematic precise point positioning technology is beginning to overcome these difficulties. Shoji et al (2017) installed two GNSS antennas on a research vessel, the RYOFU MARU of the Japan Meteorological Agency (JMA), and conducted experimental observations to assess the GNSS derived precipitable water vapor (PWV) from October 19, 2016, to August 6, 2017. The GNSS derived PWVs showed good agreement with the radiosonde observations on the vessel (1.7 mm root mean square difference, −0.7 mm bias, and 3.6% rejection rate).

Kato et al. (2018) introduced a GNSS buoy system for a synthetic geohazard monitoring. The buoy is located about 40 km south of Cape Ashizuri, west of Shikoku, Japan. We succeeded continuous PWV retrieval from June to September 2018. Retrieved PWVs vividly captured water vapor variations associated with north-south shifting of the “BAIU” seasonal rain front and passages of heavy rainfalls and typhoons. The GNSS buoy PWVs also suggest that, compared to over land, uncertainty of water vapor field in JMA’s objective analysis is larger over the ocean (Shoji et al. 2019).

In the year of 2018, we started a new research project to monitor PWV over the ocean west of Kyushu, Japan, getting supports from eight vessels (six regular line cargo vessels, one fisheries research vessel, and one JMA’s research vessel). The purpose of this study is to assess the impact of water vapor monitoring in upward of west Japan on heavy rainfall prediction. Preliminary PWV analyses show about 3 mm rms with about -1 mm bias against JMA’s operational regional objective analysis.

Acknowledgements

The shipborne GNSS campaign observation was funded by a research grant for Mission Research for

©2019. Japan Geoscience Union. All Right Reserved.

Sustainable Humanosphere from the Research Institute for Sustainable Humanosphere (RISH) at Kyoto University, “Study on accuracy improvement of shipborne GNSS water vapor measurement.”

GNSS observation on top of a floating buoy is funded by JSPS KAKENHI Grants 16H06310. A part of this study is supported by JSPS KAKENHI Grants 17H00852.

Keywords: Water Vapor, Heavy rainfall, GNSS

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

convener:Jun Kimura(Osaka University), Yasumasa Kasaba(Planetary Plasma and Atmospheric Research Center, Tohoku University), Kunio M. Sayanagi(Hampton University), Chairperson:Kunio Sayanagi(Hampton University), Takeshi Kuroda

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Cassini, Juno, New Horizons, JUICE, and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its trojan asteroids.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS01-06] Radiative transfer simulation including a non-LTE model for terahertz observations of Ganymede's atmosphere

*Takayoshi Yamada[1], Ladislav Rezac[2], Richard Larsson[2], Paul Hartogh[2], Naohiro Yoshida[3], Yasuko Kasai[1,3] (1.National Institute of Information and Communications Technology, 2.Max Planck Institute for Solar System Research, 3.Tokyo Institute of Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS01-07] Vertical Mass Flux by the 2010-2011 Great Storm of Saturn

*Kunio M. Sayanagi[1], Jacob L. Gunnarson[1], John J. Blalock[1], Richard K. Achterberg[2], F. Michael Flasar[2], Andrew P. Ingersoll.[3], Shawn P. Ewald[3], Ulyana A. Dyudina[3] (1.Hampton University, 2.NASA Goddard Space Flight Center, 3.California Institute of Technology)

9:30 AM - 9:48 AM JST | 12:30 AM - 12:48 AM UTC

[PPS01-08] Microwave observations of the giant planets - Cassini/Radar and Juno/MWR

★Invited Papers

*Cheng Li[1], Virgil Adumitroaie[2], John Arballo[2], Sushil K Atreya[3], Scott J Bolton[4], Andrew Ingersoll[1], Michael Janssen[2], Steven Levin[2], Jonathan Lunine[5], Glenn Orton[2], Paul Steffes[6], Hunter Waite[4] (1.California Institute of Technology, 2.Jet Propulsion Laboratory, 3.University of Michigan Ann Arbor, 4.Southwest Research Institute, 5.Cornell University, 6.Georgia Institute of Technology)

9:48 AM - 10:06 AM JST | 12:48 AM - 1:06 AM UTC

[PPS01-09] Tracing Formation and Evolution of Outer Solar System Bodies through Stable Isotopes and Noble Gas Abundances

★Invited Papers

*Kathleen Mandt[1] (1.Johns Hopkins University Applied Physics Laboratory)

10:06 AM - 10:24 AM JST | 1:06 AM - 1:24 AM UTC

[PPS01-10] Icy Giant Planet Exploration

★Invited Papers

*Sushil K Atreya[1], Mark D. Hofstadter[2], Amy Simon[3], Kim R. Reh[2], Olivier Mousis[4], Krista Soderlund[5] (1.University of Michigan Ann Arbor, 2.Jet Propulsion Laboratory, 3.Goddard Space Flight Center, 4.Laboratoire d'Astrophysique de Marseille, 5.University of Texas at Austin)

10:24 AM - 10:30 AM JST | 1:24 AM - 1:30 AM UTC

Discussion

Radiative transfer simulation including a non-LTE model for terahertz observations of Ganymede's atmosphere

*Takayoshi Yamada[1], Ladislav Rezac[2], Richard Larsson[2], Paul Hartogh[2], Naohiro Yoshida[3], Yasuko Kasai[1,3]

1. National Institute of Information and Communications Technology, 2. Max Planck Institute for Solar System Research, 3. Tokyo Institute of Technology

We are developing a teraherz radiative transfer code, named Atmospheric Teraherz Radiation Simulator (ATRASU), for simulations of sub-millimeter observations of planetary atmospheres.
Because of the tenuous Ganymede atmosphere we need to include non-local thermodynamic equilibrium (non-LTE) conditions of H_2O rotational levels to simulate observations by the Submillimeter Wave Instrument (SWI) on the JUpiter ICy moon Explorer (JUICE). The frequency windows of the JUICE/SWI are 530 to 625 GHz and 1080 to 1275 GHz with 100 kHz spectral resolution.
We developed a deterministic non-LTE solution based on the multilevel Gauss–Seidel method. The simulated energy level populations of H_2O for SWI observations start to deviate from LTE at 100 to 200 km altitude around sub-solar latitudes of 10 degrees. At sub-solar latitudes around 60 degrees the populations are in non-LTE over the entire range, starting from the surface. The difference of the simulated spectra between LTE and non-LTE conditions, and their sensitivity to various parameters, such as collisional rates for H_2O, will be presented.

Keywords: THz, Radiative trasfer

©2019. Japan Geoscience Union. All Right Reserved.

Vertical Mass Flux by the 2010-2011 Great Storm of Saturn

*Kunio M. Sayanagi[1], Jacob L. Gunnarson[1], John J. Blalock[1], Richard K. Achterberg[2], F. Michael Flasar[2], Andrew P. Ingersoll.[3], Shawn P. Ewald[3], Ulyana A. Dyudina[3]

1. Hampton University, 2. NASA Goddard Space Flight Center, 3. California Institute of Technology

We present a re-analysis of Cassini Composite Infrared Spectrometer (CIRS) data captured during the 2010-2011 Great Storm of Saturn to calculate the vertical mass flux caused by the storm. The intense cumulus outburst started on December 5, 2010 at 33ºN planetocentric latitude, and the clouds that emanated from the storm engulfed the entire latitude band over the subsequent months. The CIRS observation captured the storm's impact on the tropospheric thermal structure (Achterberg et al. 2014). The change in the thermal structure detected by Achterberg et al. (2014) is caused by the vertical uplifting of mass by the cumulus convection in the storm. We re-analyze the CIRS data processed by Achterberg et al. (2014) to determine the vertical mass flux. Images captured by the Imaging Science Subsystem (ISS) camera showed that active convective phase of the storm lasted until August 2011 (Sayanagi et al. 2013). Our preliminary analysis of CIRS data shows that, by August 2011, between 15ºN and 45ºN latitudes, the storm lifted about 1.65×10^{19} kg of mass to levels above the 700-mbar pressure altitude from levels below.

Analyzing images captured by ISS using the CB2 (750 nm) filter and Cassini Visible and Infrared Mapping Spectrometer (VIMS)' s 5-micron channel reveals that, after August 2011, cumulus activities ceased in the storm's latitudes, and a vast cloudless area grew until it encircled the entire band between 30ºN and 40ºN latitude by January 2012. The cloudless region further grew to the south and reached 20ºN by December 2012. Interestingly, analysis of the CIRS data indicates that the vertical mass flux continued as the clouds cleared after the storm. Our preliminary analysis shows that, between August 2011 and August 2012, 1.9×10^{18} kg more mass was lifted to altitudes above the ~700-mbar level. We hypothesize that the vertical mass flux during the cloud clearing was caused when the tropospheric air parcels became buoyant when they were relieved from the mass loading of the storm clouds.

We note that measuring vertical mass flux caused by a cumulus storm is extremely difficult for storms on Earth because the mass uplifted by the storms is rapidly dispersed and diluted by the storm's environment. In comparison, Saturn's Great Storm of 2010-2011 completely filled the latitude zone between 20˚N and 40˚N; thus, the storm was essentially contained in a closed box, and allowed us to measure the storm's vertical mass flux.

References:

Achterberg, R. K., Gierasch, P. J., Conrath, B. J., Fletcher, L. N., Hesman, B. E., Bjoraker, G. L., Flasar, F. M., 2014. Changes to Saturn's Zonal-mean Tropospheric Thermal Structure after the 2010-2011 Northern Hemisphere Storm. Astrophysical Journal 786, 92.

Sayanagi, K. M., Dyudina, U. A., Ewald, S. P., Fischer, G., Ingersoll, A. P., Kurth, W. S., Muro, G. D., Porco, C. C., West, R. A., 2013. Dynamics of Saturn's great storm of 2010-2011 from Cassini ISS and RPWS. Icarus 223, 460-478.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Saturn, Planetary Atmospheres, Cassini Mission

©2019. Japan Geoscience Union. All Right Reserved.

Microwave observations of the giant planets - Cassini/Radar and Juno/MWR

*Cheng Li[1], Virgil Adumitroaie[2], John Arballo[2], Sushil K Atreya[3], Scott J Bolton[4], Andrew Ingersoll[1], Michael Janssen[2], Steven Levin[2], Jonathan Lunine[5], Glenn Orton[2], Paul Steffes[6], Hunter Waite[4]

1. California Institute of Technology, 2. Jet Propulsion Laboratory, 3. University of Michigan Ann Arbor, 4. Southwest Research Institute, 5. Cornell University, 6. Georgia Institute of Technology

The thermal emission of a giant planet's atmosphere in the microwave region reveals the thermal structure and composition of the atmosphere below the clouds. During the last decade, the Cassini/Radar instrument mapped Saturn's global thermal radiation at 2.2 cm wavelength. Particularly, in the year 2010, the planet-encircling giant storm on Saturn appeared 16 K brighter than average, revealing desiccation of ammonia gas due to convection and atmospheric dynamics. More recently at Jupiter, the Juno spacecraft has completed a dozen orbits around the planet, making detailed observations of Jupiter's troposphere from north to south and down to pressures of about 200 bars. The results are both astonishing and stimulating. Jupiter's equatorial zone appears cold in all six channels of Juno/MWR, which range from 1.2 –50 cm, whereas the other latitudes are significantly warmer than what was predicted by an adiabatic model. The internal structure of the GRS has also been mapped during orbit 7th close approach. Yet, the interpretation is partly confounded by the inhomogeneous distribution of ammonia gas. We will give an overview of the previous findings, current challenges, and future opportunities of microwave sounding of the giant planets.

Keywords: Jupiter, Saturn, Cassini, Juno, microwave, composition

©2019. Japan Geoscience Union. All Right Reserved.

Tracing Formation and Evolution of Outer Solar System Bodies through Stable Isotopes and Noble Gas Abundances

*Kathleen Mandt[1]

1. Johns Hopkins University Applied Physics Laboratory

Comparative planetology using isotope geochemistry has played a critical role in understanding processes at work in and the history of outer Solar System bodies [see 1, and references therein]. The $^{12}C/^{13}C$ measured in methane on Titan has enabled us to determine the maximum length of time that methane has been present in the atmosphere [2,3], showing that methane has not been present in Titan's atmosphere throughout the history of the solar system and is limited to no more than 1 billion years (Gyr) [3]. We have also determined how much methane has been converted to organics over that were then deposited on the surface [3] and find agreement with estimates of surface inventories [4]. Observations of $^{14}N/^{15}N$ in HCN and N_2 in the atmosphere of Titan provides direct evidence of how photochemistry influences stable isotopes [5,6]. We have used these observations to determine that Titan's nitrogen originated as NH_3 in the protosolar nebula [7]. All of this work relies on spacecraft-based observations made at Titan. Ground-based observations combined with spacecraft observations are also of high value. The lower limit observed for $^{14}N/^{15}N$ in HCN in Pluto's atmosphere by ALMA [8] combined with New Horizons observations of the atmospheric composition [9] provides a valuable tool for determining the origin of nitrogen for Pluto if the influences of condensation and aerosol trapping on isotopes can be constrained [10] for which work is ongoing. All of this work is relevant to a future Ice Giants mission to Neptune, where the same methods could be applied to Triton and combined with ALMA observations. Furthermore, a mission to Io that makes in situ observations of the isotopic composition of the atmosphere could provide important information about volatile loss and interior processes at Io, assuming production and loss processes can be well constrained. Finally, noble gas abundances have been an important tool for understanding the origin and evolution of volatiles in the terrestrial planet atmospheres [see review in 1]. The recent measurement of cometary noble gas abundances [11] provides important information on the composition of the icy bodies that contributed to the formation of the gas giants, providing constraints for future in situ measurements that should be made with an atmospheric probe [12].

[1] Mandt K. E. et al. (2015a) *SSRv, 197,* 297–342. [2] Mandt K. E. et al., (2009) *PSS, 57,* 1917–1930. [3] Mandt K. E. et al., (2012) *ApJ, 749,* 160. [4] Lorenz, R. D. et al. (2008). *GRL*, *35*(2), L02206. [5] Liang et al. (2007) *ApJL, 664*, L115-L118. [6] Mandt et al. (2012b) *JGR, 117*, E10006. [7] Mandt K. E. et al., (2014) *ApJL, 788,* L24. [8] Lellouch et al. (2017) *Icarus, 286*, 289-307. [9] Young et al. (2017). [10] Mandt et al. (2017) *MNRAS*, *472*, 118-128. [11] Rubin et al. (2017) *Sci Adv*, *4*(7), eaar6297. [12] Mandt et al., in preparation.

Keywords: Titan, Pluto, Triton, Ice Giants, Stable Isotopes, Noble Gases

©2019. Japan Geoscience Union. All Right Reserved.

Icy Giant Planet Exploration

*Sushil K Atreya[1], Mark D. Hofstadter[2], Amy Simon[3], Kim R. Reh[2], Olivier Mousis[4], Krista Soderlund[5]

1. University of Michigan Ann Arbor, 2. Jet Propulsion Laboratory, 3. Goddard Space Flight Center, 4. Laboratoire d'Astrophysique de Marseille, 5. University of Texas at Austin

Giant planets hold the secrets of solar system formation, and there is much interest in their exploration. They also serve as analogs for the giant planets in extrasolar systems. While Saturn-Jupiter sized exoplanets number about 500, mini-Neptune and Neptune sized objects (2-5 times Earth) comprise nearly half of approximately 4000 confirmed exoplanets to date. Since the early 1970’s, spacecraft have explored the gas giants, Jupiter and Saturn, extensively using flybys, orbiters and an entry probe (at Jupiter). Voyager 2 is the only spacecraft ever to visit the two icy giants, with a flyby of Uranus in 1986 and Neptune in 1989. Though the Voyager instruments were optimized for observations of Jupiter and Saturn, tantalizing data were collected at Uranus and Neptune as well. Those data have raised such fundamental questions as: did Uranus and Neptune form in the same manner as the gas giants, did they form at their present orbital locations or not, what role did migration play in their formation and evolution, why (and how) does Neptune generate internal heat, whereas Uranus does not, what is responsible for their intrinsic magnetic fields in the absence of a metallic hydrogen phase, why are the rings of Uranus different from Neptune’s rings and what’s maintaining them, why does Neptune’s moon Triton possess an atmosphere of nitrogen and methane, etc. To address these questions and others requires a comprehensive exploration of the icy giant planet systems by an orbiter-probe spacecraft at Uranus or Neptune or both [1], like the Galileo orbiter-probe mission at Jupiter. International partnership is most desirable for maximizing the science return of such a mission. [1] M. Hofstadter, A. Simon, K. Reh, J. Elliott, and the NASA Ice Giants Science Definition Team, Ice Giants Pre-Decadal Survey Report (2017) NASA-JPL-ID-100520, https://www.lpi.usra.edu/icegiants/mission_study/Full-Report.pdf

Keywords: Giant Planets, Origin and Evolution, Uranus and Neptune Missions, Extrasolar Planets, International Partnerships

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

convener:Jun Kimura(Osaka University), Yasumasa Kasaba(Planetary Plasma and Atmospheric Research Center, Tohoku University), Kunio M. Sayanagi(Hampton University), Chairperson:Jun Kimura(Osaka University), 鎌田 俊一(北海道大学創成研究機構)

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Cassini, Juno, New Horizons, JUICE, and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its trojan asteroids.

10:45 AM - 11:03 AM JST | 1:45 AM - 2:03 AM UTC

[PPS01-11] Saturn's ring rain and Enceladus' subsurface ocean as seen by the Cassini Cosmic Dust Analyser

★Invited Papers

*Sean Hsu[1], Sascha Kempf[1], Mihaly Horanyi[1], Ralf Srama[2], James O'Donoghue[3] (1.LASP, University of Colorado, Boulder, CO, USA, 2.IRS, University of Stuttgart, Stuttgart, Germany, 3.NASA Goddard Space Flight Center, Greenbelt, Maryland, USA)

11:03 AM - 11:18 AM JST | 2:03 AM - 2:18 AM UTC

[PPS01-12] **Titan Trek: A New Online NASA Visualization and Analysis Portal for Saturn's Largest Moon**

*Emily Law[1], Brian Hamilton Day[2] (1.NASA Jet Propulsion Laboratory, 2.NASA Ames Research Center)

11:18 AM - 11:36 AM JST | 2:18 AM - 2:36 AM UTC

[PPS01-13] Internal structure of icy moons: ice-ocean systems as commonly seen in the outer solar system

★Invited Papers

*Hauke Hussmann[1] (1.DLR Institute of Planetary Research)

11:36 AM - 11:51 AM JST | 2:36 AM - 2:51 AM UTC

[PPS01-14] Callisto as a keystone to reproduce the formation process of the Jovian system

*Yasuhito Sekine[1], Shunichi Kamata[2], Yuhiko Aoyama[3], Masahiro Ikoma[3], Takayuki Tanigawa[4] (1.Earth-Life Science Insitute, Tokyo Institute of Technology, 2.Creative Res. Institution, Hokkaido Univerisity, 3.Dept of Earth and Planetary Sci., University of Tokyo, 4.Nat'l Inst. Tech., Ichinoseki Col.)

11:51 AM - 12:09 PM JST | 2:51 AM - 3:09 AM UTC

[PPS01-15] Origin of Jupiter Trojan asteroids: To be explored by OKEANOS

★Invited Papers

*Yoko Kebukawa[1], Tatsuaki Okada[2], Motoo Ito[3], Jun Aoki[4], Yosuke Kawai[4], Jun Matsumoto[2], Noel Grand[5], Arnaud Buch[6], Michisato Toyoda[4], Hervé Cottin[5], Hisayoshi Yurimoto[7,2], Hajime Yano[2], Takahiro Iwata[2], Osamu Mori[2] (1.Yokohama National University, 2.Japan Aerospace Exploration Agency, 3.Kochi Institute for Core Sample Research JAMSTEC, 4.Osaka University, 5.LISA, Université Paris-Est Créteil, 6.Ecole Centrale Paris, 7.Hokkaido University)

12:09 PM - 12:15 PM JST | 3:09 AM - 3:15 AM UTC

Discussion

Saturn's ring rain and Enceladus' subsurface ocean as seen by the Cassini Cosmic Dust Analyser

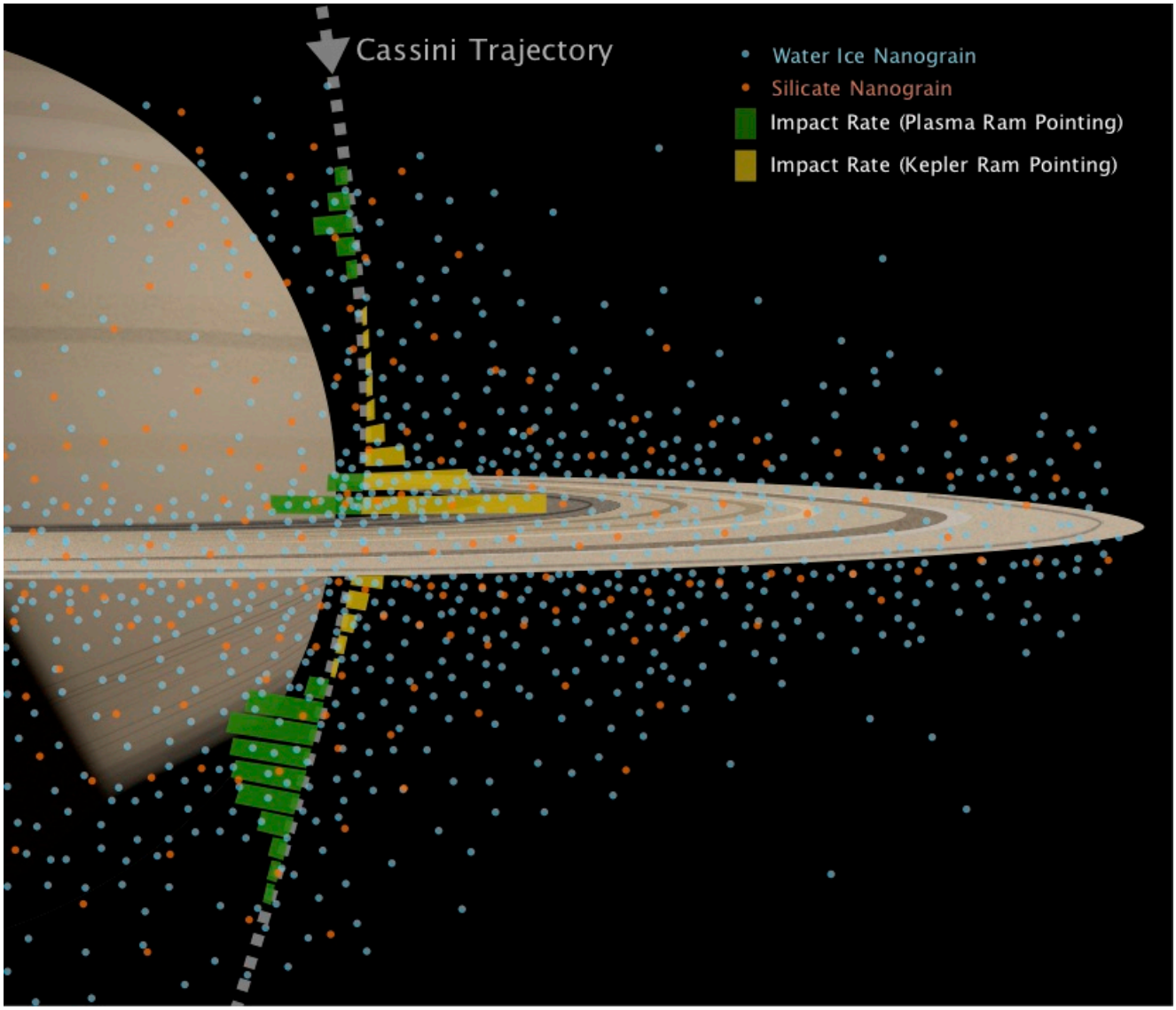
*Sean Hsu[1], Sascha Kempf[1], Mihaly Horanyi[1], Ralf Srama[2], James O'Donoghue[3]

1. LASP, University of Colorado, Boulder, CO, USA, 2. IRS, University of Stuttgart, Stuttgart, Germany, 3. NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Dust particles serve as microscopic messengers carrying information from sources inaccessible by space probes. The compositional and dynamical information of various dust populations provided by the Cosmic Dust Analyser offer a unique perspective to examine the rings, moons, and their interactions in the Saturnian system. In this talk I will focus on the latest results from the Cassini Grand Finale mission about Saturn's ring rain, i.e., the ring-planet interactions driven by the infall of ring material to Saturn's atmosphere, and its implications about Saturn and its magnificent ring system. I will also provide a brief summary of other major findings by the Cassini Cosmic Dust Analyser, including the discovery of the subsurface ocean and hydrothermal activities within the geologically active moon Enceladus, the composition of interstellar grains, Saturn's diffuse rings, and the electromagnetic interactions of charged nanodust particles with the magnetosphere and the solar wind.

Keywords: Saturn, Dust, Planetary Rings

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Titan Trek: A New Online NASA Visualization and Analysis Portal for Saturn's Largest Moon

*Emily Law[1], Brian Hamilton Day[2]

1. NASA Jet Propulsion Laboratory, 2. NASA Ames Research Center

In its investigations of Saturn's moons, NASA's Cassini mission and ESA's Huygens lander have returned an immense amount of data detailing the dynamic surface of Saturn's largest moon, Titan. In order to greatly facilitate dissemination, visualization, and analysis of this data, the Cassini mission has partnered with NASA's Solar System Treks Project (SSTP). SSTP has recently released a new online portal (https://trek.nasa.gov/titan/), Titan Trek, that enables mission planners, planetary scientists, engineers, students, and the general public to interactively access, visualize, and analyze Cassini's mapped data products of Saturn's largest moon.

The initial release of Titan Trek provides a suite of interactive tools and incorporates over 130,000 data products from the range of Cassini encounters with Titan, creating a comprehensive Titan research and educational web portal. Titan Trek data products include: Global Radar mosaic, Radar SAR BIDR BIFQI swaths, Global VIMS mosaics, Global ISS mosaic, Vector data (geological units of Afekan region, material flux based on dune orientation, fluvial networks), Nomenclature, ISS footprints, VIMS footprints, and Global radar topography.

We intend to continue to enhance the new Titan Trek portal with new data products as they are released by the Cassini mission including Huygens DISR, Global radiometry, scatterometry, VIMS, ISS, UVIS, CIRS, and other topography products.

Titan Trek is the latest addition to the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools providing access to mapped data products from past and current missions for the Moon, Mars, Vesta, etc. As web-based toolsets, the portals do not require users to purchase or install any software beyond current web browsers. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions.

Keywords: Titan, Cassini, Visualization, Analysis

©2019. Japan Geoscience Union. All Right Reserved.

Internal structure of icy moons: ice-ocean systems as commonly seen in the outer solar system

*Hauke Hussmann[1]

1. DLR Institute of Planetary Research

Among the icy satellites in the outer solar system, several objects have been identified that may contain substantial amounts of liquid water in their interiors. In particular the large satellites, e.g., Europa, Ganymede, Callisto, and Titan may contain subsurface oceans until the present day. However, the example of Enceladus shows that also smaller satellites can have sufficient internal heat sources to maintain liquid water layers. Also Pluto and Triton are potential ocean candidates. The available heat sources differ considerably among the icy moons depending on their initial composition, and thus the amount of radiogenic heating, the tidal interaction with the primary planet, their rheological states and -in some cases- their interaction with other satellites due to orbital resonances. In this talk the current knowledge on the ice-ocean systems in the outer solar system will be summarized. Prospects for their investigation with future planetary missions will be discussed.

Keywords: solar system, icy satellites, oceans

©2019. Japan Geoscience Union. All Right Reserved.

Callisto as a keystone to reproduce the formation process of the Jovian system

*Yasuhito Sekine[1], Shunichi Kamata[2], Yuhiko Aoyama[3], Masahiro Ikoma[3], Takayuki Tanigawa[4]

1. Earth-Life Science Insitute, Tokyo Institute of Technology, 2. Creative Res. Institution, Hokkaido Univerisity, 3. Dept of Earth and Planetary Sci., University of Tokyo, 4. Nat'l Inst. Tech., Ichinoseki Col.

Callisto is the outermost Galilean satellite, with 2410 km of radius and 1.83 g/cc of density. The size and mass are comparable to those of another Jovian moon, Ganymede and the largest moon of Saturn, Titan. Unlike Ganymede and Titan, however, heavily-cratered Callisto may have experienced only limited geological activities since its formation. Owing to the low geological activities, Callisto may serve as a “fossil” of the Jovian system formation in the early Solar System. Volatile and isotope compositions of ice materials on Callisto would reflect ice compositions of the building materials of the Jovian satellites, which is critical to constrain the disk temperature of the formation region of proto-Jupiter as well as both shock heating and size of infalling materials onto proto-Jupiter. The interior structure, namely degree of differentiation, of Callisto is essential to constrain the inflow rate of the building materials from the protoplanetary disk. In this talk, we discuss the key observations, e.g., surface materials and interior structure of Callisto, in future missions to constrain the formation process of the Jovian system.

Keywords: icy satellite, Solar System exploration, planetary formation

©2019. Japan Geoscience Union. All Right Reserved.

Origin of Jupiter Trojan asteroids: To be explored by OKEANOS

*Yoko Kebukawa[1], Tatsuaki Okada[2], Motoo Ito[3], Jun Aoki[4], Yosuke Kawai[4], Jun Matsumoto[2], Noel Grand[5], Arnaud Buch[6], Michisato Toyoda[4], Hervé Cottin[5], Hisayoshi Yurimoto[7,2], Hajime Yano[2], Takahiro Iwata[2], Osamu Mori[2]

1. Yokohama National University, 2. Japan Aerospace Exploration Agency, 3. Kochi Institute for Core Sample Research JAMSTEC, 4. Osaka University, 5. LISA, Université Paris-Est Créteil, 6. Ecole Centrale Paris, 7. Hokkaido University

The Jupiter Trojan asteroids are expected to be a key to understand planet formation and solar system evolution. The Jupiter Trojan asteroids are an asteroid group at the Lagrangian point (L4 and L5) on the Jupiter's orbit, and their spectral types are mainly D and P type, also called "Red" and "Less red", respectively [1,2]. The origin of these asteroids was considered to be trapped by Jupiter according to the classical planet formation theory [3,4]. On the other hand, according to a relatively new theoretical study such as Nice model, the small bodies formed at the Kuiper belt region are disturbed by giant planet migrations, and some of them trapped at the current Jupiter orbit [5]. Thus, constraining planetary formation theories can be possible by investigating whether the Jupiter Trojan asteroids originated from the outer region of the solar system such as the Kuiper belt area or originated from the current Jupiter orbit region (the extension of the main belt asteroids). The stable isotopic ratios of light elements are expected to be an indicator of the origin of the Jupiter Trojan asteroids. Because heavy isotopes such as ^{2}H (D) and ^{15}N tend to incorporate into water and organic matter in low temperatures (<10-100 K) such as in the outer region of the solar system [6,7]. In fact, heavy isotopes are concentrated in materials from the outer region of the solar system such as comets, and materials from main belt asteroids such as chondrites often show relatively light isotopic ratios [8].

The OKEANOS (Outsized Kite-craft for Exploration and AstroNautics in the Outer Solar system) is a candidate for the upcoming strategic middle-class space exploration to rendezvous with and land on a Jupiter Trojan asteroid using a Solar Power Sail (SPS). The mission concept includes sampling and in-situ analysis of the materials of a Jupiter Trojan asteroid [9]. We plan to analyze isotopic and molecular compositions of volatile materials from organic matter, hydrated minerals, and ice, in order to understand origin and evolution of the Jupiter Trojan asteroids, using a multi-turn time-of-flight type high-resolution mass spectrometry (HRMS) system. Our goal is to improve our understanding of (1) planet formation/migration theories, (2) distribution and evolution of volatile substances in protoplanetary disks, (3) origins and evolution of organic matter, and (4) origin and evolution of the Solar System small bodies beyond the snow line.

References: [1] J. P. Emery et al., *Astronomical Journal*, 141, 25, 2011. [2] F. E. DeMeo and B. Carry, *Nature*, 505, 629, 2014. [3] F. Marzari and H. Scholl, *Astronomy & Astrophysics*, 339, 278, 1998. [4] F. Marzari and H. Scholl, *Icarus*, 131, 41, 1998. [5] A. Morbidelli et al., *Nature*, 435, 462, 2005. [6] T. Millar et al., *The Astrophysical Journal*, 340, 906, 1989. [7] R. Terzieva and E. Herbst, *Monthly Notices of the Royal Astronomical Society*, 317, 563, 2000. [8] B. Marty, *Earth. Planet. Sci. Lett.,* 313-314, 56, 2012. [9] T. Okada et al., *Planetary and Space Science*, 161, 99, 2018.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Masateru Ishiguro(Seoul National University)

In June 2018, the Hayabusa 2 spacecraft arrived at the target asteroid Ryugu after three and half years journey. In addition, another spacecraft, OSIRIS-REx will soon arrive at its destination Bennu. With these arrivals, the solar system research is about to enter a new era. We have organized this small bodies session since 2012 and had a broad range of discussions from viewpoints of laboratory experiments, observations, space explorations, theoretical modeling, and sample analyses. In particular, this time, we aim to hold this session to bring the latest research on solar system small bodies, focusing on the initial results of Hayabusa 2 and OSIRIS-REx. Presentations in the related fields other than these two asteroidal missions are also welcomed.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS03-01] The shape and origin of the rubble-pile asteroid Ryugu

★Invited Papers

*Sei-ichiro WATANABE[1,5], Masatoshi Hirabayashi[2], Naru Hirata[3], Naoyuki Hirata[4], Rina Noguchi[5], Yuri Shimaki[5], Hitoshi Ikeda[6], Eri Tatsumi[7], Makoto Yoshikawa[5], Shota Kikuchi[5], Hikaru Yabuta[8], Tomoki Nakamura[9], Shogo Tachibana[7,5], Yoshiaki Ishihara[10], Tomokatsu Morota[1], Kohei Kitazato[3], Naoya Sakatani[5], Koji Matsumoto[11,12], Koji Wada[13], Hiroki Senshu[13], Chikatoshi Honda[3], Tatsuhiro Michikami[14], Hiroshi Takeuchi[5], Toru Kouyama[15], Rie Honda[16], Robert Gaskell[17], Eric Palmer[17], Olivier S. Barnouin[18], Patrick Michel[19], Paul Abell[20], Yukio Yamamoto[5], Satoshi Tanaka[5], Kei Shirai[5], Moe Matsuoka[5], Seiji Sugita[5,7], Tatsuaki Okada[5], Noriyuki Namiki[11], Masahiko Arakawa[4], Masateru Ishiguro[21], Kazunori Ogawa[4], Fuyuto Terui[5], Takanao Saiki[5], Satoru Nakazawa[5], Yuichi Tsuda[5], Hayabusa2 Science Team (1.Division of Earth and Planetary Sciences, Graduate School of Science, Nagoya University, 2.Auburn University, 3.University of Aizu, 4.Kobe University, 5.ISAS, JAXA, 6.Research and Development Directorate, JAXA, 7.University of Tokyo, 8.Hiroshima University, 9.Tohoku University, 10.National Institute for Environmental Studies, 11.National Astronomical Observatory of Japan, 12.SOKENDAI, 13.Chiba Institute of Technology, 14.Kindai University, 15.National Institute of Advanced Industrial Science and Technology, 16.Kochi University, 17.Planetary Science Institute, 18.John Hopkins University, 19.Universite Cote d'Azur, Observatorie de la Cote d'Azur, 20.NASA, Johnson Space Center, 21.Seoul National University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS03-02] Results of Hayabusa2 Near Infrared Spectroscopy at Asteroid Ryugu

*Takahiro Iwata[1], Kohei Kitazato[2], Masanao Abe[1], Makiko Ohtake[1], Yusuke Nakauchi[1], Moe Matsuoka[1], KOHJI TSUMURA[3], Shuji Matsuura[4], Lucie Riu[1], NIRS3 Team (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.The University of Aizu, 3.Tohoku University, 4.Kwansei Gakuin University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS03-03] Impact experiment on asteroid Ryugu by Small-Carry on impactor of Hayabusa-2 and observation of the impact ejecta by a Deployable CAMera-3

★Invited Papers

*Masahiko Arakawa[1], Takanao Saiki[2], Toshihiko Kadono[3], Yasuhiko Takagi[4], Koji Wada[5], Yu-ichi Iijima[2], Hiroshi Imamura[2], Chisato Okamoto[1], Yuri Shimaki[2], Kei Shirai[2], Satoru Nakazawa[2], Masahiko Hayakawa[2], Naru Hirata[6], Hajime Yano[2], Hirotaka Sawada[2], Kazunori Ogawa[1], Ko Ishibashi[5], Hiroshi

Kimura[5], Masanori Kobayashi[5], Naoya Sakatani[2], Hajime Hayakawa[2], Rie Honda[7], Seiji Sugita[8], Tomokatsu Morota[9], Shingo Kameda[10], ERI TATSUMI[8], Chikatoshi Honda[6], yokota yasuhiro[2], Toru Kouyama[11], Manabu Yamada[5], Hidehiko Suzuki[12], Kazuo Yoshioka[13], Yuichiro Cho[8], Moe Matsuoka[2] (1.Graduate School of Science, Kobe University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.University of Occupational and Environmental Health, 4.Aichi Toho University, 5.Planetary Exploration Research Center, Chiba Institute of Technology, 6.Dep. of Computer Science and Engineering, Univ. of Aizu, 7.Department of Science and Technology, System of Natual Science, Kochi University, 8.Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo, 9.Graduate School of Environmental Studies, Nagoya University, 10.School of Science, Rikkyo University, 11.National Institute of Advanced Industrial Science and Technology, 12.Department of physics, Meiji university, 13.Graduate School of frontier Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS03-04] Impact cratering experiments on glass beads with bead size frequency distribution: Implications for cratering process on asteroid Ryugu

*Minami Yasui[1], Masahiko Arakawa[1], Sunao Hasegawa[2], Yuya Yamamoto[1], Ryo Sugimura[1] (1.Graduate School of Science, Kobe University, 2.ISAS, JAXA)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS03-05] Enhancement of impact heating in strength-supported media

*Kosuke Kurosawa[1], Hidenori Genda[2], Shigeru Wakita[2], Thomas M Davison[3], Ryuki Hyodo[2], Tomoki Nakamura[4] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Department of Earth Science & Engineering, Imperial College London, 4.Department of Earth Science, Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS03-06] Global Thermal Inertia and Surface Roughness of Asteroid 162173 Ryugu by TIR on Hayabusa2

*Yuri Shimaki[1], Hiroki Senshu[2], Naoya Sakatani[1], Tatsuaki Okada[1,3], Tetsuya Fukuhara[4], Satoshi Tanaka[1], Makoto Taguchi[4], Takehiko Arai[5], Hirohide Demura[6], Yoshiko Ogawa[6], Kentaro Suko[6], Tomohiko Sekiguchi[7], Toru Kouyama[8], Jun Takita[9], Tsuneo Matsunaga[10], Takeshi Imamura[3], Takehiko Wada[1], Sunao Hasegawa[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Chiba Institute of Technology, 3.University of Tokyo, 4.Rikkyo University, 5.Ashikaga University, 6.University of Aizu, 7.Hokkaido University of Education, 8.National Institute of Advanced Industrial Science and Technology, 9.Hokkaido Kitami Hokuto High School, 10.National Institute for Environmental Studies)

The shape and origin of the rubble-pile asteroid Ryugu

*Sei-ichiro WATANABE[1,5], Masatoshi Hirabayashi[2], Naru Hirata[3], Naoyuki Hirata[4], Rina Noguchi[5], Yuri Shimaki[5], Hitoshi Ikeda[6], Eri Tatsumi[7], Makoto Yoshikawa[5], Shota Kikuchi[5], Hikaru Yabuta[8], Tomoki Nakamura[9], Shogo Tachibana[7,5], Yoshiaki Ishihara[10], Tomokatsu Morota[1], Kohei Kitazato[3], Naoya Sakatani[5], Koji Matsumoto[11,12], Koji Wada[13], Hiroki Senshu[13], Chikatoshi Honda[3], Tatsuhiro Michikami[14], Hiroshi Takeuchi[5], Toru Kouyama[15], Rie Honda[16], Robert Gaskell[17], Eric Palmer[17], Olivier S. Barnouin[18], Patrick Michel[19], Paul Abell[20], Yukio Yamamoto[5], Satoshi Tanaka[5], Kei Shirai[5], Moe Matsuoka[5], Seiji Sugita[5,7], Tatsuaki Okada[5], Noriyuki Namiki[11], Masahiko Arakawa[4], Masateru Ishiguro[21], Kazunori Ogawa[4], Fuyuto Terui[5], Takanao Saiki[5], Satoru Nakazawa[5], Yuichi Tsuda[5], Hayabusa2 Science Team

1. Division of Earth and Planetary Sciences, Graduate School of Science, Nagoya University, 2. Auburn University, 3. University of Aizu, 4. Kobe University, 5. ISAS, JAXA, 6. Research and Development Directorate, JAXA, 7. University of Tokyo, 8. Hiroshima University, 9. Tohoku University, 10. National Institute for Environmental Studies, 11. National Astronomical Observatory of Japan, 12. SOKENDAI, 13. Chiba Institute of Technology, 14. Kindai University, 15. National Institute of Advanced Industrial Science and Technology, 16. Kochi University, 17. Planetary Science Institute, 18. John Hopkins University, 19. Universite Cote d'Azur, Observatorie de la Cote d'Azur, 20. NASA, Johnson Space Center, 21. Seoul National University

In June 2018 Hayabusa2 arrived at near-Earth asteroid (NEA) Ryugu and has been successfully conducting remote-sensing observations from ~20-km or less altitudes and deploying rovers and a lander. Based on images taken by ONC-T, we constructed global shape models of Ryugu [1, 2]. In order to obtain a reliable shape model in a short period, we used two independent methods; the stereophotoclinometry (SPC) technique [3] and the Structure-from-Motion (SfM) technique [4]. Except for boulders and high latitudes, the two models are in good agreement with each other.

The total volume of Ryugu derived from an SPC-based shape model is 0.377±0.005 km^3. Gravity measurement revealed that the asteroid's mass is (4.50±0.06) $\times 10^{11}$ kg. The bulk density is thus obtained as 1.19±0.03 g cm^{-3}. The density is significantly smaller than bulk densities (1.6-2.4 g cm^{-3}) measured for Ch- and Cgh-type having the 0.7-μm absorption [5]. However, it remains within the 0.8–1.5 g cm^{-3} range measured for BCG-types (B-, C-, Cb-, and Cg-type), which might be related to unheated icy asteroids [5]. The low bulk density of Ryugu is consistent with the spectral type (Cb-type) measured by ONC-T and NIRS3 [2, 6].

NIRS3 observations indicate that hydrated minerals are widely spread on the surface of Ryugu [6]. The presence of water ice, however, is unlikely for NEA Ryugu because the radiative equilibrium temperature (~250 K) is higher than the ice sublimation temperature (~230 K) at its central pressure of ~8 Pa and the thermal diffusion time of Ryugu is estimated to be much shorter than the typical dynamical lifetime of NEAs [1]. Note that the parent body of Ryugu located in the Main Belt might have water ice and low density of Ryugu could be ascribed to loss of volatile components without subsequent compaction. If we adopt the grain densities of CM carbonaceous chondrites (CCs), the derived total porosity is 57-63%. Adopting those of Orgueil CI CC, we predict the total porosity to be 50-52%. The estimated total porosity is even higher than that of rubble-pile asteroid Itokawa (44±4%) [8, 9], indicating that Ryugu is also a rubble pile.

Hayabusa2 reveals that Ryugu is a top-shape asteroid; a prominent elevated ridge around the equator. Although dozens of top-shaped asteroid have been found by ground-based radar, Ryugu is the first top-shape asteroid to be directly observed up close by a spacecraft. Bennu is the second one.

Derived surface slopes to the equipotential surface assuming the present shape and uniform interior

©2019. Japan Geoscience Union. All Right Reserved.

demonstrate least variation with latitude if, at some epoch, Ryugu had a spin period of 3.5 hours (about half of the current value) [1]. This suggests that the top shape was formed by centrifugally induced structural failure during a rapid rotation era. The deformation occurred either in the initial re-accumulation stage [10] or in the later quasi-statically spin-up stage (due to the YORP thermal effect) [11]. In the later stage, a deformation process might be induced either on the surface or in the interior, depending on the internal structure. The high porosity nature of Ryugu as well as no significant offset between the centers of figure and gravity suggest that the internal tensile strength of the asteroid is uniform and low.
NIR absorption feature of Ryugu obtained by NIRS3 is similar to those of heated/hocked CI/CM chondrites [6]. However, these meteorites are relatively rare whereas BCG types are abundant, so that another meteoritic counterpart of BCG types are expected. High porosity nature of Ryugu suggests that meteorites originated from BCG-type asteroids would be very fragile and should be destroyed at the atmospheric entry. This is consistent with the scanty of BCG-originated meteorites and a hypothesis that pyroxene-rich interplanetary dust particles (IDPs) are originate from BCG-types based on the mid-IR spectroscopy [5]. Thus, comparative studies of Ryugu and Bennu, not only in material science but also in physical properties and internal structure, are the key to understand the delivery system of water and organic materials from the snow line to Earth.

References: [1] S. Watanabe+ (2019) *Science,* under review, [2] S. Sugita+ (2019) *Science,* under review, [3] R.W. Gaskell+ (2008) *Meteoritics & Planet Sci.,* 43, 1049. [4] R. Szeliski (2010) *Computer Vision: Algorithms and Applications* (Science & Business Media, Springer, New York), [5] P. Vernazza+ (2015) *Astrophys. J.,* 806, 204, [6] K. Kitazato+ (2019) *Science*, under review, [7] R.J. Macke+ (2011) *Meteoritics & Planet Sci.*, 46, 1842, [8] A. Fujiwara+ (2006) *Science* 312, 1330, [9] A. Tsuchiyama+ (2011), *Science*, 333, 1125, [10] P. Michel+ (2001) *Science*, 294, 1696, [11] K. J. Walsh (2018) *Ann. Rev. Astron. Astrophys.* 56, 593.

Keywords: Planetary exploration, C-type asteroids, Rubble-pile objects, Hayabusa2

©2019. Japan Geoscience Union. All Right Reserved.

Results of Hayabusa2 Near Infrared Spectroscopy at Asteroid Ryugu

*Takahiro Iwata[1], Kohei Kitazato[2], Masanao Abe[1], Makiko Ohtake[1], Yusuke Nakauchi[1], Moe Matsuoka[1], KOHJI TSUMURA[3], Shuji Matsuura[4], Lucie Riu[1], NIRS3 Team

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. The University of Aizu, 3. Tohoku University, 4. Kwansei Gakuin University

The Near Infrared Spectrometer (NIRS3) is installed on the Hayabusa2 spacecraft to observe the target C-type asteroid 162173 Ryugu at near infrared wavelengths of 1.8 to 3.2 μm. It aims to obtain reflectance spectra in order to detect absorption bands of hydrated and hydroxide minerals in the 3 μm-band spectral region. Spectra obtained during the cruising and proximity-operation phases have revealed that the performance of NIRS3, using the newly developed linear-image sensor with indium arsenide (InAs) photodiodes, are good enough as expected from the ground performance tests.
Prior to the touch down of Hayabusa2 on the surface of Ryugu, NIRS3 has completed global observations from the Home Position, where the altitude is about 20 km above the surface. NIRS3 also performed low-altitude observations in several opportunities, such as the separation operation of the small rovers and lander, during which the lowest altitude was less than 30 m. Analyzing the spectra, NIRS3 contributed to estimate the temperature of the asteroid surface. After removing the thermal emission, we successfully detected a weak and narrow absorption feature centered at 2.72 μm, which suggests the existence of hydroxyl (OH)-bearing minerals formed by aqueous alteration. This feature is, however, almost uniform over the whole surface in terms of band depth and position. Additionally, it is remarkable that the albedo of Ryugu is extremely low. These results imply the following hypotheses; 1) dehydration caused by heating or space weathering, or 2) masking effects by dark materials on the surface. We will argue about the inspection of the evolution scenario of Ryugu inferred from the above results.

Keywords: Hayabusa2, Ryugu, NIRS3, hydrated mineral

©2019. Japan Geoscience Union. All Right Reserved.

Impact experiment on asteroid Ryugu by Small-Carry on impactor of Hayabusa-2 and observation of the impact ejecta by a Deployable CAMera-3

*Masahiko Arakawa[1], Takanao Saiki[2], Toshihiko Kadono[3], Yasuhiko Takagi[4], Koji Wada[5], Yu-ichi Iijima[2], Hiroshi Imamura[2], Chisato Okamoto[1], Yuri Shimaki[2], Kei Shirai[2], Satoru Nakazawa[2], Masahiko Hayakawa[2], Naru Hirata[6], Hajime Yano[2], Hirotaka Sawada[2], Kazunori Ogawa[1], Ko Ishibashi[5], Hiroshi Kimura[5], Masanori Kobayashi[5], Naoya Sakatani[2], Hajime Hayakawa[2], Rie Honda[7], Seiji Sugita[8], Tomokatsu Morota[9], Shingo Kameda[10], ERI TATSUMI[8], Chikatoshi Honda[6], yokota yasuhiro[2], Toru Kouyama[11], Manabu Yamada[5], Hidehiko Suzuki[12], Kazuo Yoshioka[13], Yuichiro Cho[8], Moe Matsuoka[2]

1. Graduate School of Science, Kobe University, 2. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3. University of Occupational and Environmental Health, 4. Aichi Toho University, 5. Planetary Exploration Research Center, Chiba Institute of Technology, 6. Dep. of Computer Science and Engineering, Univ. of Aizu, 7. Department of Science and Technology, System of Natual Science, Kochi University, 8. Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo, 9. Graduate School of Environmental Studies, Nagoya University, 10. School of Science, Rikkyo University, 11. National Institute of Advanced Industrial Science and Technology, 12. Department of physics, Meiji university, 13. Graduate School of frontier Science, The University of Tokyo

A small carry-on impactor (SCI) equipped on Hayabusa2 is scheduled to be propelled toward to the surface of asteroid Ryugu this spring. Cratering process on Ryugu made by the impactor will simultaneously observed by a deployable camera 3 (DCAM3) detached from Hayabusa2. The mission objective of the impactor is to excavate the asteroid to expose a subsurface material as ejecta deposits around the crater. Thus, not only it enables us to give a good opportunity for obtaining a fresh or subsurface material by a sampler system, remote sensing instruments such as ONC, TIR, NIRS3 onboard Hayabusa2 will also have a good chance to observe the exposed subsurface material. Furthermore, this impact experiment on Ryugu is also a rare opportunity to verify the crater scaling law in the microgravity environment on the real asteroid materials, and is expected to enable us to improve the conventional scaling law, especially for the crater size and the ejecta velocity distribution.

After arrival at Ryugu, the surface morphology observation through remote sensing has turned out that a plenty of boulders cover throughout the surface, and many of the boulders are larger than 10 m. These boulders are distributed almost uniformly and the size frequency distribution of the boulders is a power law distribution with the power law index around -1, indicating relatively large boulders are dominant on the surface. Therefore, taking into account that the precision of an actual impact point toward an aiming point expands several 10 m, the impactor possibly collides with a large boulder, otherwise with small boulders having the power law size distribution, wherever the impactor would aim at on the surface of Ryugu. If the impactor collides with a large boulder, a crater should be formed in the strength regime, and if the impactor collides into a finer-boulder area, a crater will be formed in the gravity regime. The DCAM3 was designed for the observation of not only the impact cratering in the strength regime but also that in the gravity regime.

We believe that we will success to observe impact ejecta induced by the impactor when the SCI and DCAM3 operations are conducted as scheduled. We are planning to present a first report of the DCAM3

©2019. Japan Geoscience Union. All Right Reserved.

observation in this talk, and discuss how to search the impact point on the Ryugu surface using the DCAM3 images, beforehand the onboard imaging instruments. Moreover, the morphology of the ejecta curtain imaged by DCAM3 will bring us a lot of information about the crater formation process. We report the surface condition around the impact point, such as a large block or a small-boulders area, and an excavated area corresponding to the crater size. The DCAM3 will also observe individual dusts in the ejecta curtain to obtain information of the ejecta velocity distribution, so that we may have a chance to introduce these images. However, please note that this presentation strongly depends on the success of the SCI/DCAM3 operation.

Keywords: Asteroid Ryugu, Impact Experiment, Small carry-on impactor, Deployable camera3, Rubble pile body

©2019. Japan Geoscience Union. All Right Reserved.

Impact cratering experiments on glass beads with bead size frequency distribution: Implications for cratering process on asteroid Ryugu

*Minami Yasui[1], Masahiko Arakawa[1], Sunao Hasegawa[2], Yuya Yamamoto[1], Ryo Sugimura[1]

1. Graduate School of Science, Kobe University, 2. ISAS, JAXA

Some impact craters with a diameter of a few hundred meters are found on asteroid Ryugu while there are few small craters of < several meters on the asteroid. Many boulders are found on Ryugu and they have the size frequency distribution similar to that of impact fragments obtained by the impact experiments of rocky materials [1]. When an impactor collided with a larger boulder compared with the impactor size, the boulder could be disrupted but the crater might not form. Some researchers conducted impact experiments on granular targets with a particle size larger than the projectile size and they found that the crater radius became smaller as the size ratio of the target particle to the projectile was larger [e.g., 2]. In this study, we conducted impact cratering experiments on granular targets having the size frequency distribution similar to that of boulders on Ryugu to examine the relationship between the particle size frequency distribution and the crater size.

We conducted cratering experiments by using a one-stage light gas gun at Kobe University and a two-stage light gas gun at ISAS. We used glass beads having the diameters of 0.1, 1, 3, and 10 mm as a target and prepared four types of target; two targets consist of one size of glass bead (0.1 or 3 mm glass beads) and the others consist of mixing three (1-10 mm) or four (0.1-10 mm) different-sized glass beads with the same mass ratio. We used only four glass bead mixing target at ISAS. At Kobe University, the stainless-steel spheres with a diameter of 2 and 3 mm were used as a projectile and the impact velocity was changed from 53 to 181 m/s. At ISAS, the aluminum projectile with a diameter of 1 mm was used and the impact velocity was changed from 1.2 to 4.4 km/s. The collisional phenomena were recorded by high speed camera to observe the rebound of the projectile and the ejection of glass beads.

We observed the ejection of glass beads from the target surface. In the case of 0.1-mm bead target, the beads were ejected radially and the corn-shaped ejecta curtain was observed. In the case of 3-mm bead target, some intact beads were ejected at lower speed. In the case of four bead mixing target, some 0.1-mm beads were ejected like a smoke passing through other beads. Furthermore, the projectile rebounded from the target surface in most cases of 3-mm bead target and two mixing bead targets. When the projectile collided with a 10-mm bead, the amount of the ejected beads decreased drastically.

We applied our results to the crater scaling law showing as $\pi_R = a \cdot \pi_2^{-b}$, where π_R is the non-dimensional parameter related to the crater radius, π_2 is the non-dimensional parameter related to the gravity, the projectile size, and the impact velocity, and a and b are constants. As a result, the π_R of the 0.1-mm bead target was largest. The π_R of the 3-mm bead target and two mixing bead targets matched each other and a little smaller than that of the 0.1-mm bead target when the projectile did not collide with a 10 mm glass bead. Furthermore, the π_R of mixing bead targets was much smaller when the projectile collided with a 10-mm bead.

Finally, we revised the crater scaling law of mixing bead targets by using the scaling law of the 0.1-mm bead target (a=0.58 and b=0.21). In this study, we assumed that the projectile collided with a 3-mm or 10-mm bead and the momentum of the projectile was transferred to the impacted bead, then the bead penetrated into the target slowly and the cavity was formed. On this assumption, we constructed the revised crater scaling law by using the coefficient of the restitution of projectile, e, and the momentum conservation law. As a result, we could obtain e=0.5-1 to match our experimental results with the revised crater scaling law.

[1] Satakani et al. (2018), 2nd Aqua Planetology Symposium, Kobe University. [2] Tatsumi & Sugita (2018),

©2019. Japan Geoscience Union. All Right Reserved.

Icarus 300, 227-248.

Keywords: cratering mechanism, asteroids, boulders, size frequency distribution, crater scaling law

©2019. Japan Geoscience Union. All Right Reserved.

Enhancement of impact heating in strength-supported media

*Kosuke Kurosawa[1], Hidenori Genda[2], Shigeru Wakita[2], Thomas M Davison[3], Ryuki Hyodo[2], Tomoki Nakamura[4]

1. Planetary Exploration Research Center, Chiba Institute of Technology, 2. Earth-Life Science Institute, Tokyo Institute of Technology, 3. Department of Earth Science & Engineering, Imperial College London, 4. Department of Earth Science, Tohoku University

Hypervelocity mutual collisions between small bodies, which include the asteroid Ryugu,occur throughout the history of the solar system. A strong compression and thermal pulse caused by an impact can produce various unique features, such as a change in spectral properties, mosaicism, planer deformation features, high-pressure minerals, atomic diffusion, volatile loss, shock veins, impact melt, and so on. We can obtain these features in samples returned from Ryugu, collected by the Hayabusa2 spacecraft. When we have a reliable model connecting the degree of shock metamorphism with the impactor/target conditions, we can reveal the impact history of Ryugu more correctly.

Frequently, the table from Stöffler et al. (1991, 2018) is used to deduce the shock stage of meteorites using observed shock features, which are subsequently used to infer impact velocities on target bodies. Recently, Kurosawa and Genda (2018) reported that the degree of heating in low-velocity impacts (<10 km/s) is expected to be much higher than previously expected. This is caused by the irreversible heating during plastic deformation against material strength. Low-velocity impacts do not produce large-scale impact melting, but trigger a comminution of both impactor and target materials. Although the materials experiencing compression do not have a tensile strength, they still have a compressive one. Thus, the required impact velocities for producing the unique features produced mainly by the rise in temperature is greatly lowered as shown by Kurosawa and Genda (2018). Another work also confirmed the importance of plastic deformation during impacts to a target embedding hydrous minerals (Wakita and Genda 2019). The experienced temperature at a given shock stage defined by Stöffler’ s table would be revised to somewhat higher temperatures, which would mean that impact histories derived from shock features using the previous table would need to be revised. For example, the target bodies are likely to experience many fewer high-speed energetic impacts than previously expected.

We are planning to revise the Stöffler’ s table by using the state-of-the-art numerical shock physics code, iSALE, which includes both recent equation-of-state (EOS) models and various constitutive models. The Hayabusa2 spacecraft is planning to return to Earth with Ryugu samples in 2020. The revised table would largely help to reproduce the impact history of Ryugu.

In the presentation, we will introduce the work done by Kurosawa and Genda (2018) using the iSALE-2D model and will present some preliminary results from the three-dimensional (3D) model. We newly investigated the effects of impact obliquity using iSALE-3D. As a preliminary result, the enhancement of the impact heating in strength-supported media at oblique impacts becomes larger than the case at vertical impacts to the tangent plane. Although it is widely accepted that the degree of heating correlates well with the vertical component of the impact velocity, our preliminary results show that oblique impacts (45-degrees) produce nearly the same amount of heated volume as vertical impacts do. We are also going to discuss the strategy for reproducting Ryugu’ s impact history.

©2019. Japan Geoscience Union. All Right Reserved.

Acknowledgement: We appreciate the developers of iSALE, including G. Collins, K. Wünnemann, B. Ivanov, J. Melosh, and D. Elbeshausen.

Keywords: Hypervelocity impacts, Impact heating, Shock physics code, Ryugu’s impact history

©2019. Japan Geoscience Union. All Right Reserved.

Global Thermal Inertia and Surface Roughness of Asteroid 162173 Ryugu by TIR on Hayabusa2

*Yuri Shimaki[1], Hiroki Senshu[2], Naoya Sakatani[1], Tatsuaki Okada[1,3], Tetsuya Fukuhara[4], Satoshi Tanaka[1], Makoto Taguchi[4], Takehiko Arai[5], Hirohide Demura[6], Yoshiko Ogawa[6], Kentaro Suko[6], Tomohiko Sekiguchi[7], Toru Kouyama[8], Jun Takita[9], Tsuneo Matsunaga[10], Takeshi Imamura[3], Takehiko Wada[1], Sunao Hasegawa[1]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Chiba Institute of Technology, 3. University of Tokyo, 4. Rikkyo University, 5. Ashikaga University, 6. University of Aizu, 7. Hokkaido University of Education, 8. National Institute of Advanced Industrial Science and Technology, 9. Hokkaido Kitami Hokuto High School, 10. National Institute for Environmental Studies

Thermal infrared imager TIR onboard the Hayabusa2 spacecraft acquired thermal images of the asteroid 162173 Ryugu for one asteroid rotation during Mid-altitude operation on August 1, 2018, with around 5 m/pixel resolution. The thermal images were converted to brightness temperature maps on a shape model based on the ground tests, then temperature profiles of the surface of Ryugu were obtained. For comparison, thermal calculations by a thermophysical model without roughness using the shape model (TPM1) and by one with roughness using fractal rough surfaces (TPM2) were carried out.

Thermal images by TIR reveled that the surface of Ryugu showed ubiquitously high temperature above 300 K, and its temperature profile showed flat pattern at noon. Thermal calculations by TPM1 did not reproduce observed temperature profiles. By comparing maximum temperatures by TIR with those by TPM1, thermal inertia of Ryugu was estimated to be around 160 in MKS unit and reached maximum at the equatorial ridge. By contrast, thermal calculations by TPM2 successfully created flat temperature profile at noon for various thermal inertia and surface roughness. The temperature profiles were fitted by 4-order function to characterize its pattern. A multi linear regression analysis was carried out to estimate thermal inertia and surface roughness from the fitting coefficients. From the regression equations and fitting coefficients by observed temperature profiles, thermal inertia and surface roughness of Ryugu were estimated. Since the estimation is strongly affected by surface tilt angle of a polygon on a shape model, we carried out tilt angle corrections. Finally, thermal inertia of Ryugu by TPM2 was estimated to be around 330 in MKS unit and showed little variation in latitude, and with moderate homogeneous surface roughness. Thermal inertia of Ryugu determined in this study by two TPMs are consistent with that determined by ground observations. Our results suggest that thermal inertia of Ryugu is consistent with that of boulders, indicating porous nature of the boulders widely distributed on Ryugu.

Keywords: Hayabusa2, Thermal Infrared Imager, Asteroid Ryugu

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Olivier Barnouin(Johns Hopkins University Applied Physics Laboratory)

In June 2018, the Hayabusa 2 spacecraft arrived at the target asteroid Ryugu after three and half years journey. In addition, another spacecraft, OSIRIS-REx will soon arrive at its destination Bennu. With these arrivals, the solar system research is about to enter a new era. We have organized this small bodies session since 2012 and had a broad range of discussions from viewpoints of laboratory experiments, observations, space explorations, theoretical modeling, and sample analyses. In particular, this time, we aim to hold this session to bring the latest research on solar system small bodies, focusing on the initial results of Hayabusa 2 and OSIRIS-REx. Presentations in the related fields other than these two asteroidal missions are also welcomed.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS03-07] Asteroid Ryugu's parent body and its properties inferred from Haybusa2 multi-band imaging observations

★Invited Papers

*Seiji Sugita[1,6], Rie Honda[2], Tomokatsu Morota[3], Shingo Kameda[4], ERI TATSUMI[1], Chikatoshi Honda[7], yokota yasuhiro[2,5], Toru Kouyama[8], Naoya Sakatani[5], Manabu Yamada[6], Hidehiko Suzuki[10], Kazuo Yoshioka[1], Yuichiro Cho[1], Moe Matsuoka[5], Kazunori Ogawa[9], Deborah Domingue[11], Hideaki Miyamoto[1], Olivier Barnouin[12], Patrick Michel[13], Carolyn Ernst[12], Sei-ichiro WATANABE[3], Yuichi Tsuda[5] (1.University of Tokyo, 2.Kochi University, 3.Nagoya University, 4.Rikkyo University, 5.JAXA/ISAS, 6.Chiba Institute of Technology, PERC, 7.University of Aizu, 8.National Institute of Advanced Industrial Science and Technology, 9.Kobe University, 10.Meiji University, 11.Planetary Science Institute, 12.Johns Hopkins University/Applied Physics Laboratory, 13.Observatoire de la Coˆte d'Azur)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS03-08] REDDENING PROCESS OF THE RYUGU SURFACE BASED ON THE CRATER SIZE-FREQUENCY DISTRIBUTION

*Tomokatsu Morota[1], Yuichiro Cho[2], Masanori Kanamaru[3], Rie Honda[4], Shingo Kameda[5], ERI TATSUMI[2], yokota yasuhiro[6], Toru Kouyama[7], Hidehiko Suzuki[8], Manabu Yamada[9], Naoya Sakatani[6], Chikatoshi Honda[10], Masahiko Hayakawa[6], Kazuo Yoshioka[2], Moe Matsuoka[6], Tatsuhiro Michikami[11], Hideaki Miyamoto[2], Hiroshi Kikuchi[2], Ryodo Hemmi[2], Masatoshi Hirabayashi[12], Naoyuki Hirata[13], Naru Hirata[10], Carolyn Ernst[14], Olivier Barnouin[14], Hirotake Sawada[6], Seiji Sugita[2] (1.Nagoya University, 2.The University of Tokyo, 3.Osaka University, 4.Kochi University, 5.Rikky University, 6.JAXA, 7.AIST, 8.Meiji University, 9.Chiba Institute of Technology, 10.The University of Aizu, 11.Kindai University, 12.Auburn University, 13.Kobe University, 14.Johns Hopkins University/Applied Physics Laboratory)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS03-09] Preliminary report on global distribution visible spectra of asteroid Ryugu based on clustering

*Rie Honda[1], Yasuhiro Yokota[1,2], Eri Tatsumi[3], Antonella Barucci[12], Davide Perna[13], Moe Matsuoka[2], Deborah Domingue[14], Tomokatsu Morota[4], Shingo Kameda[5], Toru Kouyama[15], Hidehiko Suzuki[6], Manabu Yamada[10], Naoya Sakatani[2], Chikatoshi Honda[7], Lucille LeCorre[14], Masahiko Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Tomoki Nakamura[9], Takahiro Hiroi[11], Hirotaka Sawada[2], Yuki Fujii[1], Seiji Sugita[3], Ryo Hayashi[1] (1.Kochi University, 2.ISAS/JAXA, 3.University of Tokyo, 4.Nagoya University, 5.Rikkyo University, 6.Meiji University, 7.Aizu University,

8.Kobe University, 9.Tohoku University, 10.Chiba Institute of Technology, 11.Brown University, 12.Paris Observatory, 13.INAF, 14.Planetary Science Institute, 15.National Institute of Advanced Industrial Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS03-10] Visible spectra of small bright spots on asteroid 162173 Ryugu

*Chiho Sugimoto[1], Eri Tatsumi[1], Yuichiro Cho[1], Kazuo Yoshioka[1], Hirotaka Sawada[2], Yasuhiro Yokota[2], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Tomokatsu Morota[4], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Chikatoshi Honda[9], Kazunori Ogawa[10], Deborah Domingue[11], Patrick Michel[12], Seiji Sugita[1] (1.University of Tokyo, 2.JAXA/ISAS, 3.Kochi University, 4.Nagoya University, 5.Rikkyo University, 6.Chiba Institute of Technology, 7.AIST, 8.Meiji University, 9.University of Aizu, 10.Kobe University, 11.Planetary Science Institute, 12.Nice Observatory)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS03-11] Geomorphological characteristics of asteroid Ryugu: implications to its evolutional history

*Hideaki Miyamoto[1], Ryodo Hemmi[1], Hiroshi Kikuchi[1], Goro Komatsu[2], Chikatoshi Honda[3], Tatsuhiro Michikami[4], Tomokatsu Morota[5], Yuichiro Cho[1], Olivier S Barnouin[6], Sho Sasaki[7], Naru Hirata[3], Naoyuki Hirata[8], Rie Honda[10], Shingo Kameda[11], ERI TATSUMI[1], Yasuhiro Yokota[12], Toru Kouyama[13], Hidehiko Suzuki[14], Manabu Yamada[15], Naoya Sakatani[12], Masahiko Hayakawa[12], Kazuo Yoshioka[1], Moe Matsuoka[12], Masatoshi Hirabayashi[9], Hirotaka Sawada[12], Seiji Sugita[1] (1.University of Tokyo, 2.D'Annunzio University, 3.Aizu University, 4.Kinki University, 5.Nagoya University, 6.Johns Hopkins University, 7.Osaka University, 8.Kobe University, 9.Auburn University, 10.Kouchi University, 11.Rikkyo University, 12.ISAS/JAXA, 13.AIST, 14.Meiji University, 15.Chiba Inst Tech)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS03-12] Global distribution of sub-meter boulders measured with texture analysis of Ryugu images

*Naoya Tanabe[1], Yuichiro Cho[1], ERI TATSUMI[1], Tomokatsu Morota[4], Chikatoshi Honda[9], Tatsuhiro Michikami[11], Patrick Michel[12], Carolyn Ernst[13], Olivier S Barnouin[13], Kazuo Yoshioka[1], Sawada Hirotaka[2], yokota yasuhiro[2,3], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Kazunori Ogawa[10], Seiji Sugita[1] (1.University of Tokyo, 2.JAXA/ISAS, 3.Kochi University, 4.Nagoya University, 5.Rikkyo University, 6.Chiba Inst. Tech., PERC, 7.AIST, 8.Meiji University, 9.University of Aizu, 10.Kobe University, 11.Kindai University, 12.Observatoire de la Côte d'Azur, 13.Johns Hopkins University APL)

Asteroid Ryugu's parent body and its properties inferred from Haybusa2 multi-band imaging observations

*Seiji Sugita[1,6], Rie Honda[2], Tomokatsu Morota[3], Shingo Kameda[4], ERI TATSUMI[1], Chikatoshi Honda[7], yokota yasuhiro[2,5], Toru Kouyama[8], Naoya Sakatani[5], Manabu Yamada[6], Hidehiko Suzuki[10], Kazuo Yoshioka[1], Yuichiro Cho[1], Moe Matsuoka[5], Kazunori Ogawa[9], Deborah Domingue[11], Hideaki Miyamoto[1], Olivier Barnouin[12], Patrick Michel[13], Carolyn Ernst[12], Sei-ichiro WATANABE[3], Yuichi Tsuda[5]

1. University of Tokyo, 2. Kochi University, 3. Nagoya University, 4. Rikkyo University, 5. JAXA/ISAS, 6. Chiba Institute of Technology, PERC, 7. University of Aizu, 8. National Institute of Advanced Industrial Science and Technology, 9. Kobe University, 10. Meiji University, 11. Planetary Science Institute, 12. Johns Hopkins University/Applied Physics Laboratory, 13. Observatoire de la Coˆte d’Azur

JAXA’s Hayabusa2 has conducted global observations of Ryugu and revealed many important properties of Ryugu, such as Cb-type average spectrum, the lack of a strong 0.7-um absorption, very low 0.55-um geometric albedo (4.5+/-0.2) %, and very young (< a few Myr) crater retention age for small craters (>10m).

The Cb-type spectrum of Ryugu is consistent with Eulalia and Polana families in the inner main belt, which are dynamically most probable source families. This agreement between the prediction from dynamic calculations and spectral observations suggests that one of the two asteroids is likely Ryugu’s parent body. These families are among the most widely dispersed C-complex families in the inner main belt, allowing to deliver family members at very high flux rate to the resonance zones (nue6 and 3:1) at both inner and outer boundaries of the inner main belt, which are the dominant source of near-Earth objects (NEOs).

Furthermore, high abundance of boulders are found on Ryugu. Evidence for mass wasting indicates mechanically unconsolidated surfaces, allowing surface boulders to move easily. The morphologies of impact craters on Ryugu are consistent with gravity-regime formation, in which impact events produce large ejecta masses. These suggest that large mass of boulders and pebbles can be ejected from Ryugu to space over time.

Consequently, a large mass of Ryugu-like macroscopic objects would enter Earth’s atmosphere, suggesting the presence of counterparts in our meteorite collection. Among such candidates is moderately dehydrated carbonaceous chondrites, which have both very low albedo and flat spectra. They are also found with high abundance in Antarctica, which may represent the long-term average flux of infalling meteorites on Earth. Another is interplanetary dust particles (IDPs), which also have low albedos and account for large influx of extraterrestrial materials to Earth. Although a decisive conclusion may not be obtained before the analysis of Ryugu samples returned to Earth, currently available observational evidence, such as high boulder abundance on Ryugu, favors that its composition may be similar to moderately dehydrated carbonaceous chondrites. This would further suggest that Ryugu’s relatively low abundance of hydrated minerals may be due to partial dehydration on Ryugu’s parent body.

Keywords: Hayabusa2, Ryugu, The evolution of the solar system

©2019. Japan Geoscience Union. All Right Reserved.

REDDENING PROCESS OF THE RYUGU SURFACE BASED ON THE CRATER SIZE-FREQUENCY DISTRIBUTION

*Tomokatsu Morota[1], Yuichiro Cho[2], Masanori Kanamaru[3], Rie Honda[4], Shingo Kameda[5], ERI TATSUMI[2], yokota yasuhiro[6], Toru Kouyama[7], Hidehiko Suzuki[8], Manabu Yamada[9], Naoya Sakatani[6], Chikatoshi Honda[10], Masahiko Hayakawa[6], Kazuo Yoshioka[2], Moe Matsuoka[6], Tatsuhiro Michikami[11], Hideaki Miyamoto[2], Hiroshi Kikuchi[2], Ryodo Hemmi[2], Masatoshi Hirabayashi[12], Naoyuki Hirata[13], Naru Hirata[10], Carolyn Ernst[14], Olivier Barnouin[14], Hirotake Sawada[6], Seiji Sugita[2]

1. Nagoya University, 2. The University of Tokyo, 3. Osaka University, 4. Kochi University, 5. Rikky University, 6. JAXA, 7. AIST, 8. Meiji University, 9. Chiba Institute of Technology, 10. The University of Aizu, 11. Kindai University, 12. Auburn University, 13. Kobe University, 14. Johns Hopkins University/Applied Physics Laboratory

The Hayabusa2 has acquired the high-resolution images and spectra of the Ryugu surface. Although the Ryugu surface has almost homogeneous reflectance and color at the macro scale, the regional variation in the spectral slope is observed by the telescopic optical navigation camera (ONC-T). The redder materials of the Ryugu surface seem to cover bluer materials. Some small craters excavate the red materials on the surface and penetrate the underlying blue materials, suggesting that the craters are younger than the reddening of the surface (space weathering or deposition of red materials). In this study, we performed the crater size-frequency measurements on the Ryugu surface using the ONC image data to constrain the surface age of the Ryugu and the age of reddening event or the timescale of reddening process of the Ryugu surface.

To identify the craters excavating the red materials we used the b-x slope images calculated from multi-band images obtained in the Mid-altitude operation. We identified 15 craters excavating the red materials. These craters have diameters from 10 to 50 m, suggesting that the thickness of the red material layer is less than 1 m.

The cratering chronology models of asteroids have been numerically calculated from the collision rate with other asteroids and scaling laws for crater formation. In this study, we used the intrinsic collision probabilities Pi for the main belt and the NEAs, the population models of the main belt asteroids and NEAs, the mean impact velocities for the main belt (5.3 km/s) and the NEAs (18 km/s), and the new Pi–scaling law developed by Tatsumi and Sugita to develop the cratering chronology model of Ryugu. Because little is known about the bulk strength of materials on Ryugu, we examined two cases (i) the strengthless target (Y = 0 MPa) and (ii) the strength for dry soil (Y = 0.18 MPa).

The density of large craters (D>100 m) on Ryugu is lower than the empirical saturation level and its slope is steeper than that of the saturated distribution, suggesting that craters larger than 100 m are not saturated and the size distribution reflects the crater production function. However, craters smaller than 100 m are significantly under-saturated, suggesting that some crater erasure processes such as seismic shaking and armoring effect are active on the Ryugu surface. Based on cratering chronology model for the main belt, the surface age of Ryugu is estimated to be 5–200 Ma from the size–frequency distribution of craters larger than 100 m.

The observed frequency of craters penetrating the underlying blue materials is ~1/50 of that of craters found on the whole Ryugu. The model age of the reddening is estimated to be 0.1–4 Ma based on the main-belt chronology model and 4–160 Ma based on the NEA chronology model. The NEA model age is roughly close to the median dynamical lifetime of NEAs (~10 Ma), suggesting that the reddening of the Ryugu surface may have some connect with the orbital transition from the main belt to near Earth orbit.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Hayabusa2, Ryugu, crater

©2019. Japan Geoscience Union. All Right Reserved.

Preliminary report on global distribution visible spectra of asteroid Ryugu based on clustering

*Rie Honda[1], Yasuhiro Yokota[1,2], Eri Tatsumi[3], Antonella Barucci[12], Davide Perna[13], Moe Matsuoka[2], Deborah Domingue[14], Tomokatsu Morota[4], Shingo Kameda[5], Toru Kouyama[15], Hidehiko Suzuki[6], Manabu Yamada[10], Naoya Sakatani[2], Chikatoshi Honda[7], Lucille LeCorre[14], Masahiko Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Tomoki Nakamura[9], Takahiro Hiroi[11], Hirotaka Sawada[2], Yuki Fujii[1], Seiji Sugita[3], Ryo Hayashi[1]

1. Kochi University, 2. ISAS/JAXA, 3. University of Tokyo, 4. Nagoya University, 5. Rikkyo University, 6. Meiji University, 7. Aizu University, 8. Kobe University, 9. Tohoku University, 10. Chiba Institute of Technology, 11. Brown University, 12. Paris Observatory, 13. INAF, 14. Planetary Science Institute, 15. National Institute of Advanced Industrial Science and Technology

Preliminary result of global distribution of visible spectra of asteroid Ryugu derived from multi-band images obtained by ONC-T onboard Hayabuasa 2 is presented.
The ONC-T is a telescopic charge-coupled-device (CCD) camera with a 6.27˚ ×6.27˚ field of view (FOV) , having a 1024 pixels x 1024 pixels sensor and seven narrow band filters ranging from 395nm and 950nm and one wide-band filter. Images obtained by ONC-T are spatially aligned and converted into seven-band visible spectra (reflectance factor).

The spectra are clustered, and the obtained cluster id are shown on the global map. As the method of clustering, k-means++, x-means, gaussian mixture model via EM are tested for synthetized data and x-means is selected since this method is stable to obtain a suitable number of components.

The obtained spectra are divided into seven to nine groups depending the slope of the spectra. Flat spectrum group is distributed around the equatorial ridge, the redder and darker groups are in the southern hemisphere and the relatively bright and bluer spectra are observed at the polar region, in particular at Otohime Saxum. The distribution of these spectra groups appears to indicate the surface history such as space weathering and erosion and the supply from different sources.

Keywords: asteroid, Ryugu, visible, Hayabusa2, spectra, clustering

©2019. Japan Geoscience Union. All Right Reserved.

Visible spectra of small bright spots on asteroid 162173 Ryugu

*Chiho Sugimoto[1], Eri Tatsumi[1], Yuichiro Cho[1], Kazuo Yoshioka[1], Hirotaka Sawada[2], Yasuhiro Yokota[2], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Tomokatsu Morota[4], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Chikatoshi Honda[9], Kazunori Ogawa[10], Deborah Domingue[11], Patrick Michel[12], Seiji Sugita[1]

1. University of Tokyo, 2. JAXA/ISAS, 3. Kochi University, 4. Nagoya University, 5. Rikkyo University, 6. Chiba Institute of Technology, 7. AIST, 8. Meiji University, 9. University of Aizu, 10. Kobe University, 11. Planetary Science Institute, 12. Nice Observatory

The Optical Navigation Camera (ONC) onboard the Hayabusa2 spacecraft has obversed asteroid 162173 Ryugu at various scales and found that Ryugu has a uniform spectrum in km-scale and that boulders exhibit a range of albedo (0.89 −1.3 times of the surface average) and spectra [1]. Higher resolution images taken during descent operations revealed the presence of bright spots, which are typically much brighter than the brightest large boulders. Brightness variation may reflect differences in composition, thermal alteration, or space weathering maturity. Such materials would follow spectral trends seen on other materials on Ryugu. In fact, brightest boulders are the end-members in reflectance/slope statistics and Principal Component Analysis (PCA) of boulders on Ryugu. If bright spots are fragments of the parent body at the origin of Ryugu, they may correspond to the fresher components of the boulder population constituting Ryugu, contributing to the spectral variety observed on the asteroid. In contrast, it is also possible that Ryugu contains materials of exogenous origin. In that case, the spectra of bright spots should not follow the spectral trends observed for other materials on Ryugu and should rather be consistent with the spectra of asteroids found in the inner main belt. In either case, bright spots will help us place important constraints on to the formation and evolution of Ryugu.

In this study, we analyzed the brightest spots whose reflectance is ≧ 1.7 times the reflectance global average. The dimensions of these sports are very small: ≦ 3 m. The spectra of these brightest spots were extracted from I/F images taken at altitudes of Hayabusa2 between 100 and 500 m (i.e., low-altitude descent observations) and 3 −4 km (hovering operation after MASCOT deployment) and were compared with meteorite spectra. As for low altitude images, we conducted a photometric correction because the rotation of Ryugu results in a several degrees phase angle gap between different filters. The spectra of meteorites include 250 carbonaceous chondrite spectra and 106 ordinary chondrite spectra from RELAB of Brown University and they are linearly interpolated to match the bands of ONC-T [2]. We searched for meteorite spectrum that gives minimum residual sum of squares (RSS) of spectra among the 356 samples.

Analysis results indicate that 5 out of 10 bright spots have spectra consistent with carbonaceous chondrites (CC), such as CM2 and CV3, and that the other half are consistent with ordinary chondrite (OC) such as LL6. Some of CC-like bright spot spectra are very similar to that of type3 (bright and molted) boulders found in [1], which was one of the end-members in reflectance/slope statistics and PCA of boulders. This suggests that these bright spots can be new members of this boulder group.

Because Ryugu most likely comes from the inner main bet, OC-like bright spots are consistent with exogenous origin. Preliminary results indicate that two types of spectra are present. One has a spectral peak at v-band (centered at 0.55 micron) and the other has a peak at w-band (0.86 micron). If this spectral variation is large enough to require the delivery of meteoritic materials from asteroids, it would reflect the variety in composition among many projectiles that collided with Ryugu after its formation. In

©2019. Japan Geoscience Union. All Right Reserved.

contrast, if the shift in spectral peak is consistent with spectral modification mechanisms within a large OC-like projectile, such as thermal metamorphism, these bright spots could be remnants of one projectile only. In either case, however, because the average impact velocity in the main belt is very high ~5km/s [3], the fact that we may observe remnants of projectiles impacting at such speeds on the surface of Ryugu has strong implications in our understanding of the impact process and in our interpretation of the compositional heterogeneity of small bodies and meteorites.

[1] Sugita, S. et al., (2019) submitted to *Science*
[2] Tatsumi et al., (2019) *Icarus*
[3] Bottke et al., (1994) *Icarus*

©2019. Japan Geoscience Union. All Right Reserved.

Geomorphological characteristics of asteroid Ryugu: implications to its evolutional history

*Hideaki Miyamoto[1], Ryodo Hemmi[1], Hiroshi Kikuchi[1], Goro Komatsu[2], Chikatoshi Honda[3], Tatsuhiro Michikami[4], Tomokatsu Morota[5], Yuichiro Cho[1], Olivier S Barnouin[6], Sho Sasaki[7], Naru Hirata[3], Naoyuki Hirata[8], Rie Honda[10], Shingo Kameda[11], ERI TATSUMI[1], Yasuhiro Yokota[12], Toru Kouyama[13], Hidehiko Suzuki[14], Manabu Yamada[15], Naoya Sakatani[12], Masahiko Hayakawa[12], Kazuo Yoshioka[1], Moe Matsuoka[12], Masatoshi Hirabayashi[9], Hirotaka Sawada[12], Seiji Sugita[1]

1. University of Tokyo, 2. D'Annunzio University, 3. Aizu University, 4. Kinki University, 5. Nagoya University, 6. Johns Hopkins University, 7. Osaka University, 8. Kobe University, 9. Auburn University, 10. Kouchi University, 11. Rikkyo University, 12. ISAS/JAXA, 13. AIST, 14. Meiji University, 15. Chiba Inst Tech

Observations by Hayabusa 2 spacecraft indicate that Ryugu is a highly porous C-type asteroid. Ryugu’s surface is covered by numerous boulders. These are consistent with the idea that Ryugu is a rubble-pile asteroid. Interestingly, Itokawa, the only other similarly-sized rubble-pile asteroid closely observed by spacecraft, is different from Ryugu in many aspects. For example, while the shape of Ryugu is a top-shape, that of Itokawa is somehow elongated cigar-like. Though Ryugu is generally homogeneous in terms of roughness, Itokawa has two distinctive areas such as smooth and rough terrains. Ryugu has an almost continuous equatorial ridge, though Itokawa does not have such a large-scale topographic feature.

These differences may come from the difference in evolutional processes; a top-shape of rubble pile asteroid is believed to result of rotationally induced deformation or from re-accumulation. Another possibility is that the differences may come from variations in mechanical properties of asteroid forming materials. We are investigating geological characteristics of Ryugu, which may hold clues for these aspects. In this talk, we report initial results of geological investigations mostly using visible images obtained by the Optical Navigation Camera (ONC) onboard the Hayabusa2 spacecraft, and discuss about their implications to evolutional history of Ryugu..

Keywords: asteroid, Hayabusa 2, Ryugu

©2019. Japan Geoscience Union. All Right Reserved.

Global distribution of sub-meter boulders measured with texture analysis of Ryugu images

*Naoya Tanabe[1], Yuichiro Cho[1], ERI TATSUMI[1], Tomokatsu Morota[4], Chikatoshi Honda[9], Tatsuhiro Michikami[11], Patrick Michel[12], Carolyn Ernst[13], Olivier S Barnouin[13], Kazuo Yoshioka[1], Sawada Hirotaka[2], yokota yasuhiro[2,3], Naoya Sakatani[2], Masahiko Hayakawa[2], Moe Matsuoka[2], Rie Honda[3], Shingo Kameda[5], Manabu Yamada[6], Toru Kouyama[7], Hidehiko Suzuki[8], Kazunori Ogawa[10], Seiji Sugita[1]

1. University of Tokyo, 2. JAXA/ISAS, 3. Kochi University, 4. Nagoya University, 5. Rikkyo University, 6. Chiba Inst. Tech., PERC, 7. AIST, 8. Meiji University, 9. University of Aizu, 10. Kobe University, 11. Kindai University, 12. Observatoire de la Côte d'Azur, 13. Johns Hopkins University APL

The spacecraft Hayabusa2 arrived at a C-type asteroid Ryugu on June 27, 2018 and is currently conducting both global and high-resolution observations. These observations have revealed that Ryugu has a very high abundance of boulders; the number density of boulders >20m in diameter is about twice that on Itokawa. However, the sizes of boulders detected in global and regional observations are limited to several to ten meters because the image resolution is 0.5 –2 m in these observations.

In this study, in order to push the limits of boulder detetion, we developed a method that automatically evaluates the abundance of small boulders (sub-pixel to a few pixels in diameter) and applied it to both Ryugu and Itokawa.

The analysis results show that Ryugu has a relatively uniform distribution of boulders over its globe. More specifically, both the power-law index and the coefficient for the boulder cumulative size frequency distribution are very uniform over the entire surface. The power-law index average is -2.53 and the standard deviation due to regional scatter is 0.03 over the globe for boulders > 75 cm. This power-law index is consistent with the result (-2.65 ±0.05) of visual counting for boulders > 5 m [Michikami et al. 2019]. In contrast, Itokawa has a very heterogeneous boulder distribution. The power-law index average is -3.6, and the standard deviation due to regional scatter is 0.83 over the globe. This large regional variation of boulder size distribution on Itokawa strongly suggests the presence of size sorting on its surface, which may be induced by granular convection [Miyamoto et al. 2007].

More detailed analysis has revealed a large variation in boulder number density in both longitudinal and latitudinal directions. In the longitudinal direction, dichotomic contrast in boulder abundance is seen. The boulder density of the eastern hemisphere is ~1.4 times higher than that of the western hemisphere. A similar dichotomic pattern is seen in crater number density [Cho et al. 2019 LPSC] and v-band albedo distribution [Sugita et al. 2019]. Furthermore, the boulder number density is the lowest in troughs surrounding the western hemisphere. The troughs are bluer in the visible wavelengths, similar to the equatorial ridge and polar regions, where newer surfaces are expected to be exposed because of their high geopotential. These lines of evidence suggest that the western hemisphere may be separated from the eastern hemisphere by high mobility zones.

Global observations have revealed that Ryugu exhibits a small but significant latitudinal size sorting in boulders; a larger number of boulders is found at higher latitudes [Sugita et al. 2019]. Our new analysis found a more detailed trend in latitudinal direction. The top of the equatorial ridge exhibits a higher boulder number density, and both southern and northern slopes of the ridge have lower boulder density.

©2019. Japan Geoscience Union. All Right Reserved.

This trend is opposite from the general trend from the equator to the poles and is more pronounced in the eastern hemisphere. We found a significant correlation (R ~ -0.73) between the boulder abundance and the topographic slope with respect to the geopotential. This suggests that the observed boulder distribution is controlled by the current geopotential and not by the paleo-geopotential during a possible past high-spin-rate era.

Keywords: Ryugu, Hayabusa2, boulder

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Masanao Abe(Institute of Space and Astronautical Science, JAXA)

In June 2018, the Hayabusa 2 spacecraft arrived at the target asteroid Ryugu after three and half years journey. In addition, another spacecraft, OSIRIS-REx will soon arrive at its destination Bennu. With these arrivals, the solar system research is about to enter a new era. We have organized this small bodies session since 2012 and had a broad range of discussions from viewpoints of laboratory experiments, observations, space explorations, theoretical modeling, and sample analyses. In particular, this time, we aim to hold this session to bring the latest research on solar system small bodies, focusing on the initial results of Hayabusa 2 and OSIRIS-REx. Presentations in the related fields other than these two asteroidal missions are also welcomed.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS03-13] Brightness and morphology variations on surface boulders of 162173 Ryugu: Space Weathering, Breccia, and Thermal Cracks

*Sho Sasaki[1], Seiji Sugita[2], Eri Tatsumi[2], Hideaki Miyamoto[3], Chikatoshi Honda[4], Tomokatsu Morota[5], Masatoshi Hirabayashi[6], Shiho Kanda[1], Naru Hirata[4], Takahiro Hiroi[7], Tomoki Nakamura[8], Takaaki Noguchi[9], Rie Honda[10], Tatsuhiro Michikami[11], Sei-ichiro Watanabe[5], Noriyuki Namiki[12], Patrick Michel[13], Shingo Kameda[14], Toru Kouyama[15], Hidehiko Suzuki[16], Manabu Yamada[17], Hiroshi Kikuchi[3], Yuichiro Cho[2], Kazuo Yoshioka[18], Masahiko Hayakawa[19], Moe Matsuoka[19], Rina Noguchi[19], Naoya Sakatani[19], Hirotaka Sawada[19], yokota yasuhiro[19,10], Makoto Yoshikawa[19] (1.Department of Earth and Space Science, School of Science, Osaka University, 2.Department of Earth and Planetary Science, School of Science, University of Tokyo, 3.Department of Systems Innovation, School of Engineering, University of Tokyo, 4.University of Aizu, 5.Graduate School of Environmental Studies, Nagoya University, 6.Auburn University, 7.Brown University, 8.Department of Earth and Planetary Materials Sciences, Faculty of Science, Tohoku University, 9.Department of Arts and Science, Kyushu University, 10.Department of Science and Technology, System of Natural Science, Kochi University, 11.Faculty of Engineering, Kinki University, 12.RISE Project, National Astronomical Observatory of Japan, 13.Observatoire de la Cote d'Azur, 14.School of Science, Rikkyo University, 15.National Institute of Advanced Industrial Science and Technology, 16.Department of physics, Meiji university, 17.Planetary Exploration Research Center, Chiba Institute of Technology, 18.School of frontier Science, University of Tokyo, 19.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS03-14] Topography of large craters and equatorial bulge of 162173 Ryugu

*Noriyuki Namiki[1,2], Takahide Mizuno[3], Hiroki Senshu[4], Hirotomo Noda[1,2], Koji Matsumoto[1,2], Naru Hirata[5], Ryuhei Yamada[5], Yoshiaki Ishihara[6], HItoshi Ikeda[3], Hiroshi Araki[1,2], Keiko Yamamoto[1,2], Shinsuke Abe[7], Fumi Yoshida[4], Arika Higuchi[1], Sho Sasaki[10], Shoko Oshigami[1], Seiitsu Tsuruta[1], Kazuyoshi Asari[1], Seiichi Tazawa[1], Makoto Shizugami[1], Hideaki Miyamoto[8], Hirohide Demura[5], Jun Kimura[10], Toshimichi Otsubo[9] (1.National Astronomical Observatory of Japan, 2.SOKENDAI (The Graduate University for Advanced Studies), 3.Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science, 4.Chiba Institute of Technology, 5.The University of Aizu, 6.National Institute of Advanced Industrial Science and Technology, 7.Nihon University,8Osaka University, 8.The University of Tokyo, 9.Hitotsubashi University, 10.Osaka University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS03-15] Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

*Ryuhei Yamada[1], Keiko Yamamoto[2], Hiroshi Araki[2], Hirotomo Noda[2], Hiroki Senshu[3], Noriyuki Namiki[2], Koji Matsumoto[2], Fumi Yoshida[3], Shinsuke Abe[4], Naru Hirata[1] (1.The University of Aizu, Department of Computer Science and Engineering, 2.National Astronomical Observatory of Japan, 3.Chiba Institute of Technology, 4.Nihon University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS03-16] Improved Trajectory of Hayabusa2 by Combining LIDAR Data and a Shape Model

*Koji Matsumoto[1], Hirotomo Noda[1], Yoshiaki Ishihara[2], Hiroki Senshu[3], Keiko Yamamoto[1], Naru Hirata[4], Naoyuki Hirata[5], Noriyuki Namiki[1], Toshimichi Otsubo[6], Sei-ichiro WATANABE[7], Takahide Mizuno[8], Yukio Yamamoto[8], Hitoshi Ikeda[8], Naoko Ogawa[8], Shota Kikuchi[8], Takanao Saiki[8], Yuichi Tsuda[8] (1.RISE Project, National Astronomical Observatory of Japan, 2.National Institute for Environmental Studie, 3.Chiba Institute of Technology, 4.The University of Aizu, 5.Kobe University, 6.Hitotsubashi University, 7.Nagoya University, 8.JAXA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS03-17] Present status of preparation for the Ryugu sample curation returned by the Hayabusa2

*Toru Yada[1], Masanao Abe[1], Aiko Nakato[1], Kasumi Yogata[1], Kanako Sakamoto[1], Masahiro Nishimura[1], Tatsuaki Okada[1], Yuki Nakano[2], Miwa Yoshitake[1], Kazuya Kumagai[3], Ayako Iwamae[3], Shizuho Furuya[1], Shogo Tachibana[4,1], Hisayoshi Yurimoto[1,2] (1.Japan Aerospace Exploration Agency, 2.Hokkaido University, 3.Marine Works Japan Ltd., 4.University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS03-18] Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

*Motoo Ito[1], Naotaka Tomioka[1], Masayuki Uesugi[2], Kentaro Uesugi[2], Ohigashi Takuji[3], Akira Yamaguchi[4], Naoya Imae[4], Yuzuru Karouji[5], Naoki Shirai[6], Toru Yada[5], Masanao Abe[5] (1.Kochi Institute for Core Sample Research, JAMSTEC, 2.JASRI, 3.UVSOR Synchrotron Facility, Institute for Molecular Science, 4.National Institute Polar Research, 5.JAXA, 6.Tokyo Metropolitan University)

Brightness and morphology variations on surface boulders of 162173 Ryugu: Space Weathering, Breccia, and Thermal Cracks

*Sho Sasaki[1], Seiji Sugita[2], Eri Tatsumi[2], Hideaki Miyamoto[3], Chikatoshi Honda[4], Tomokatsu Morota[5], Masatoshi Hirabayashi[6], Shiho Kanda[1], Naru Hirata[4], Takahiro Hiroi[7], Tomoki Nakamura[8], Takaaki Noguchi[9], Rie Honda[10], Tatsuhiro Michikami[11], Sei-ichiro Watanabe[5], Noriyuki Namiki[12], Patrick Michel[13], Shingo Kameda[14], Toru Kouyama[15], Hidehiko Suzuki[16], Manabu Yamada[17], Hiroshi Kikuchi[3], Yuichiro Cho[2], Kazuo Yoshioka[18], Masahiko Hayakawa[19], Moe Matsuoka[19], Rina Noguchi[19], Naoya Sakatani[19], Hirotaka Sawada[19], yokota yasuhiro[19,10], Makoto Yoshikawa[19]

1. Department of Earth and Space Science, School of Science, Osaka University, 2. Department of Earth and Planetary Science, School of Science, University of Tokyo, 3. Department of Systems Innovation, School of Engineering, University of Tokyo, 4. University of Aizu, 5. Graduate School of Environmental Studies, Nagoya University, 6. Auburn University, 7. Brown University, 8. Department of Earth and Planetary Materials Sciences, Faculty of Science, Tohoku University, 9. Department of Arts and Science, Kyushu University, 10. Department of Science and Technology, System of Natural Science, Kochi University, 11. Faculty of Engineering, Kinki University, 12. RISE Project, National Astronomical Observatory of Japan, 13. Observatoire de la Cote d'Azur, 14. School of Science, Rikkyo University, 15. National Institute of Advanced Industrial Science and Technology, 16. Department of physics, Meiji university, 17. Planetary Exploration Research Center, Chiba Institute of Technology, 18. School of frontier Science, University of Tokyo, 19. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Hayabusa2 is the second sample return mission from an asteroid after Hayabusa which visited an S-type asteroid Itokawa. The target asteroid of Hayabusa2 is (162173)Ryugu (1999 JU3),which is a C-type asteroid. Since June 2018, Hayabusa2 observed Ryugu including several low altitude operations, where three surface rovers (MINERVA IIA, IIB, MASCOT) have been deployed successfully.

ONC(Optical Navigation Camera) on board Hayabusa2 captured tantalizing features of 162173 Ryugu, which is a top-shaped dark body with overall visible albedo is 4.6% and photometry standard reflectance is lower than 2%. Color Vis-NIR spectra are flat with little variation (close to B-Cb type, darker). Ryugu would be composed of dark CM meteorite.

Brightness Variation: There are brightness (and associated color u/v bands) variations on the surface. Ryugu’s surface is covered with numerous boulders/rocks whose number density is about twice as large as that of Itokawa. Bright, large boulders are on polar regions and smaller ones with similar brightness are scattered globally. Otohime Saxum is the largest boulder (~180m) on Ryugu; it has bright (and blue) smooth surface and darker surface. Around Otomime Saxum, there observed smooth bright boulders and dark rugged boulders.

The equatorial ridge (Ryujin Dorsum) and some of undulated crater rim zones are brighter. In high-resolution images, Ryugu‘s surface is covered with darker regolith materials (with various size particles >cm) that would cover and bury boulders. Ridge/crater brightness can be ascribed to movement of fine darker materials to potentially lower region, or to abundant brighter fragments. Bright crater rims could be explained by the former process, whereas Ryujin brightness could be also explained by the latter process.

©2019. Japan Geoscience Union. All Right Reserved.

The distinct characteristics of brighter and darker boulders are scale-invariant on Ryugu’ s surface. show brighter boulders with smooth and layered surface and darker boulders with rough (rugged/crumbling) surface. High resolution images obtained by MINERVA-II and MASCOT confirmed the characteristics of bright and dark rocks; MASCOT suggested the existence of bright rugged rocks. We do not observe pond-like deposits of relatively similar size grains as we saw on Eros and Itokawa.

Space Weathering: The brightness/color difference may not be due to compositional variation but to the differences of space weathering maturity. Usually bright boulders are a few 10 % brighter than dark boulders and regolith. Sometimes it is 50% and more brighter. We found the evidence that the interior of a dark small rock is 4 times brighter in v-band (550nm). It should be noted that (bi-directional) reflectance of the bright interior is about 8% (~4 x 2%) and still in the range of CM.

The darker boulders with rough (rugged/crumbling) surface, which would have experienced longer exposure and thus more erosion and weathering. Probably the darkening timescale is so short that usual brightness difference is smaller than a few 10 %.

Breccia A lot of rocks on Ryugu show brecciated structure with brightness variation. The breccia formation would take place by impacts on Ryugu’ s parent body, where the layered structure of boulders would be also formed.

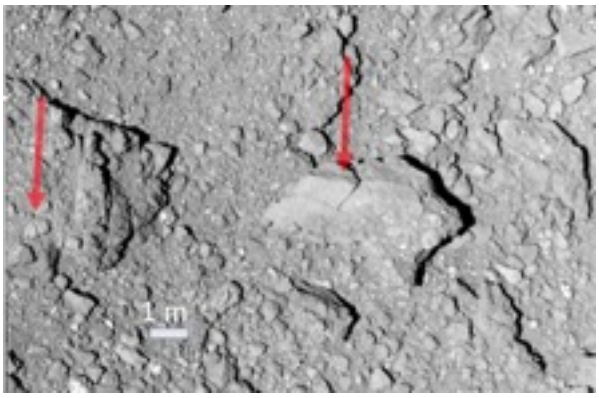
Meridional Cracks: High resolution images show that more than 10 boulders/rocks have a crack in the meridional direction (north –south) on Ryugu. The size range of cracked rocks is a few 10cm to 10m. Boulders with a crack in the meridional direction suggest that thermal stress would play a role in the boulder disruption. Thermal fatigue is an advocated process where difference of thermal properties among minerals should cause disintegration of rocks and it is effective in a smaller scale. Actually thermal timescale of diurnal temperature change is as small as or smaller than 10cm.

In the terrestrial desert area, however, meridional fractures are frequently observed on rocks. Since Ryugu has a large orbital eccentricity 0.19, annual temperature change might bring about thermal stress in longer length scales.

Figure: Rocks with a crack in the meridional direction.

Keywords: Near Earth asteroids, Hayabusa 2, Space weathering, Thermal fatigue, Carbonaceous meteorites

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Topography of large craters and equatorial bulge of 162173 Ryugu

*Noriyuki Namiki[1,2], Takahide Mizuno[3], Hiroki Senshu[4], Hirotomo Noda[1,2], Koji Matsumoto[1,2], Naru Hirata[5], Ryuhei Yamada[5], Yoshiaki Ishihara[6], HItoshi Ikeda[3], Hiroshi Araki[1,2], Keiko Yamamoto[1,2], Shinsuke Abe[7], Fumi Yoshida[4], Arika Higuchi[1], Sho Sasaki[10], Shoko Oshigami[1], Seiitsu Tsuruta[1], Kazuyoshi Asari[1], Seiichi Tazawa[1], Makoto Shizugami[1], Hideaki Miyamoto[8], Hirohide Demura[5], Jun Kimura[10], Toshimichi Otsubo[9]

1. National Astronomical Observatory of Japan, 2. SOKENDAI (The Graduate University for Advanced Studies), 3. Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science, 4. Chiba Institute of Technology, 5. The University of Aizu, 6. National Institute of Advanced Industrial Science and Technology, 7. Nihon University,8Osaka University, 8. The University of Tokyo, 9. Hitotsubashi University, 10. Osaka University

In LIDAR topography data, 3 circular depressions are recognized near the equatorial bulge. All of these circular depressions are identified as craters and have been given names approved by IAU, namely Urashima, Kolobok, and Brabo craters. After careful calibration for different passes, consistent and precise cross sections of the craters are derived.

For Urashima crater, topography data of 4 passes are merged. Because these passes are taken in different days of operation, altitude of the spacecraft and sampling rate vary widely from 6 to 21 km and from 1/32 Hz to 1 Hz, respectively. Nonetheless, the cross sections show a good match. Similarly, three passes are merged for Kolobok and Brabo craters, and the match among different passes is very good for these craters, too, except for topography over large boulders.

Depth-to-diameter ratios (d/D) of Urashima, Kolobok, and Brabo craters are 0.2, 0.14, and 0.155, respectively, and are consistent with previous in situ observations of asteroid topography, while there seems marked difference from craters on Itokawa and Bennu. Both Itokawa and Bennu are comparable in size and surface gravity to Ryugu, and these 3 asteroids are regarded as rubble pile bodies. On the contrary, the d/D of Itokawa craters, 0.08 +- 0.03, is significantly shallower than that of Ryugu and other asteroids. The d/D of Bennu is apparently shallower, too. In addition, craters on Ryugu have topographically distinctive raised rim while those on Itokawa do not.

The low d/D of Itokawa is regarded as a result of either an influence of curvature of small body, a lack of raised rim, or fine grains infilling the craters, but has been unsolved. On the other hand, craters of Mathilde have characteristics much alike to those on Ryugu; the d/D ranging from 0.12 to 0.25, prominent raised rim, and a lack of ejecta blanket. While Mathilde is 50 times larger than Ryugu, the bulk density of Mathilde is only 1.34 +- 0.2 g cm^{-3}. Such low density is likely suggesting that Mathilde is as porous as 50 %.

The shapes of the four craters are neither bowl-shaped like 951 Gaspra and Eros nor flat like Itokawa. It is notable that slopes of inner wall of Ryugu craters are linear rather than paraboloidal, and that Kolobok and Brabo craters are flat-bottomed. 3D topography model of Urashima crater shows a central cavity on Urashima crater indicating an agreement with impact cratering experiments into porous targets, while the d/D of Ryugu crates is lower than experimental results which is between 0.2 and 0.5. It is interesting that slopes of the 3 craters are almost identical. Such nearly identical conical shape indicates that either the crater shape is well relaxed, or in the contrary, is holding initial shape.

©2019. Japan Geoscience Union. All Right Reserved.

The slopes of inner walls are measured with respect to local gravity estimated by taking GM of 30.0 m^3 s^{-2} and assuming a constant density inside of Ryugu. The mode of the slopes of inner wall of Urahisma, Kolobok, and Breabo craters are between 16 and 20 degrees, 7 and 15 degrees, 16 and 18 degrees, respectively. The mode of slopes is shallower than the repose angle of regolith which is between 30 and 35 degrees. The shallow slopes and flat bottom may indicate that morphology of Ryugu craters is sufficiently relaxed. However, preservation of entire conical shape as well as central cavity of Urashima crater instead suggest that modification of crater topography on Ryugu is limited volumetrically and is less effective than Itokawa.

Keywords: Hayabusa2, Crater, Ea\quatorial bulge, topography, Ryugu

©2019. Japan Geoscience Union. All Right Reserved.

Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

*Ryuhei Yamada[1], Keiko Yamamoto[2], Hiroshi Araki[2], Hirotomo Noda[2], Hiroki Senshu[3], Noriyuki Namiki[2], Koji Matsumoto[2], Fumi Yoshida[3], Shinsuke Abe[4], Naru Hirata[1]

1. The University of Aizu, Department of Computer Science and Engineering, 2. National Astronomical Observatory of Japan, 3. Chiba Institute of Technology, 4. Nihon University

In June 2018, the Japanese asteroid explore Hayabusa2 has arrived to C-type asteroid 162173 Ryugu after three and half years journey. The Hayabusa2 has the laser altimeter (light detection and ranging: LIDAR) for navigation of the spacecraft and scientific uses. The main purpose of the LIDAR is to measure the distance between the spacecraft and the asteroid using time delay between the transmission and reception of the laser. In addition, the Hayabusa2 LIDAR has the function of measuring the intensities of a transmitted laser pulse and received laser pulse reflected from the asteroid surface. In this study, we have derived the normal albedo of the Ryugu at the laser wavelength of 1064 nm using the intensity data. The observation of normal albedo using the LIDAR has never been performed on C-type asteroid. Our observation will provide first knowledge of normal albedo variation at 1064 nm on C-type asteroid.

Usually, the Hayabusa2 spacecraft stands at home position (altitude of 20 km) and the intensity and ranging data are obtained with 1/32 Hz. As special operation, the spacecraft moves to latitudinal and longitudinal direction or descend to low altitude. Then, the LIDAR data are sampled at 1Hz. For analysis of normal albedo, we have selected the data obtained in altitude lower than 7 km. The size of the footprint become smaller with descent of the spacecraft, and mapping resolution is higher. Then, less size of footprint is effective to reduce effect of the surface terrain on the LIDAR return pulse. We have applied the data obtained at July 20, August 1, 6, 7, September 11, 20, 21, October 2, 3, 4, 15, 24, 31 and November 1, 2018 for normal albedo analysis. In these days, the spacecraft has been operated at low altitude, for example, rehearsal of touchdown for sample sampling has been performed in October 15 and 24. From the selected data, we have derived the normal albedo around equator of the Ryugu in range of about 10 degrees in latitude. The total data number is 37,5151.

For calculation of normal albedo, we applied some reflectance models; they are the Lambert, the Lommel-Seeliger and the Oren-Nayar models. The intensity of the reflected pulse calculated by the Oren-Nayar model depends on the applied value of roughness () in degree. We have applied 9 Oren-Nayar model changing the roughness from 10 to 90 degrees with interval of 10 degrees. On a footprint, 11 types of normal albedo have calculated for 11 reflectance models, respectively.

Firstly, we have found that the derived values of the 1064 nm normal albedo are different for each model. The lowest albedo is derived for the Lommel-Seeliger model, and the highest albedo is derived for the Oren-Nayar model with roughness of 90 degrees. Secondary, it has been found that values of normal albedo depend on the incident angle of the laser pulse for some reflectance models. Especially, the normal albedo using the Lambert model are evidently higher with increase in incident angle at many areas

©2019. Japan Geoscience Union. All Right Reserved.

around the equator. This is impossible phenomena for real material as rocks, and this means the Lambert model is inappropriate to represent reflectance of a lot of areas on the Ryugu. Therefore, we have investigated relation between the normal albedo and incident angle in each grid with resolution of 5 5 degrees. In the investigation, slope of normal albedo for incident angle were derived for 11 reflectance models in each grid, and the model which have the smallest slope would be appropriate in the area. From the results, we found that the Lommel-Seeliger model is dominant around equator of the Ryugu. When we apply the Lommel-Seeliger model, the average of normal albedo in the equator area is 0.042, and the deviation is 9.0 %. It corresponds to typical albedo of C-type asteroid (0.03-0.06) observed by ground telescope. In this presentation, we will also discuss regionality of the normal albedo on Ryugu and relation with surface terrain.

Keywords: C-type asteroid , Ryugu, Hayabusa2, LIDAR, Normal albedo

©2019. Japan Geoscience Union. All Right Reserved.

Improved Trajectory of Hayabusa2 by Combining LIDAR Data and a Shape Model

*Koji Matsumoto[1], Hirotomo Noda[1], Yoshiaki Ishihara[2], Hiroki Senshu[3], Keiko Yamamoto[1], Naru Hirata[4], Naoyuki Hirata[5], Noriyuki Namiki[1], Toshimichi Otsubo[6], Sei-ichiro WATANABE[7], Takahide Mizuno[8], Yukio Yamamoto[8], Hitoshi Ikeda[8], Naoko Ogawa[8], Shota Kikuchi[8], Takanao Saiki[8], Yuichi Tsuda[8]

1. RISE Project, National Astronomical Observatory of Japan, 2. National Institute for Environmental Studie, 3. Chiba Institute of Technology, 4. The University of Aizu, 5. Kobe University, 6. Hitotsubashi University, 7. Nagoya University, 8. JAXA

Hayabusa2 spacecraft successfully arrived at the target C-type asteroid 162173 Ryugu on 27 June, 2018, with its “home position” being about 20 km above the sub-Earth point. Soon after arrival, Hayabusa2’s remote sensing instruments started near-global observations. Because map products from these instruments depend on the spacecraft position with respect to the asteroid, it is necessary to provide precise spacecraft trajectory in a timely manner. The basic idea is to find a trajectory correction which makes “LIDAR-derived topography” fit to the reference shape model. The LIDAR-derived topography is, in other words, a sequence of LIDAR footprint positions expressed in asteroid-centered body-fixed rotating frame. The footprints can be computed by using the following information; spacecraft position with respect to the asteroid, spacecraft attitude, LIDAR range, rotational information of the asteroid (orientation and spin period). If all the information above was perfect, the collective footprints would delineate the shape of the asteroid. In reality, however, there are various errors affecting the footprint positions, among which the largest is generally the trajectory error, making the resultant LIDAR footprints deviate from the shape model. We call the deviation as residual. A shape model constructed by stereo photoclinometry (SPC) method is used as reference. We obtain trajectory correction by minimizing the residuals with polynomial functions. We made use of Markov chain Monte Carlo (MCMC) algorithm to explore better parameters. We compared the LIDAR-corrected trajectory with camera positions that are determined through SPC shape modeling. The two estimates agree with each other within about 40 m on 10 July 2018, and 20 m on 20 July 2018. LIDAR-derived topography with such an improved trajectory can be used for analysis of boulder height, crater shape, surface roughness, etc.

Keywords: Hayabusa2, spacecraft trajectory, LIDAR

©2019. Japan Geoscience Union. All Right Reserved.

Present status of preparation for the Ryugu sample curation returned by the Hayabusa2

*Toru Yada[1], Masanao Abe[1], Aiko Nakato[1], Kasumi Yogata[1], Kanako Sakamoto[1], Masahiro Nishimura[1], Tatsuaki Okada[1], Yuki Nakano[2], Miwa Yoshitake[1], Kazuya Kumagai[3], Ayako Iwamae[3], Shizuho Furuya[1], Shogo Tachibana[4,1], Hisayoshi Yurimoto[1,2]

1. Japan Aerospace Exploration Agency, 2. Hokkaido University, 3. Marine Works Japan Ltd., 4. University of Tokyo

Hayabusa2 spacecraft had launched in Dec. 2014 and reached the C-type asteroid Ryugu in June 2018 [1]. It has been observing the asteroid with a series of remote-sensing instruments and plans to perform the first touchdown for sampling at the beginning of this year [1, 2]. It will depart from the asteroid at the end of 2019, and return its re-entry capsule encapsulating Ryugu's surface samples back to the Earth at the end of 2020 [1, 2].

In parallel with the spacecraft operation, JAXA has been preparing for the curation of the samples returned from the asteroid. A new class-1000 clean room for Hayabusa2-returned Ryugu samples was established in Sept. 2017. Installation of newly developed sample-handling clean chamber system (CCs) was accomplished by last Oct. The entire sample-handling system consists of five chambers (CC3-1, CC3-2, CC3-3, CC4-1 and CC4-2).

Because C-type asteroids are likely to be parent bodies of hydrated carbonaceous chondrites [3], volatile components such as water and organic matter are one of essential science target for sample analysis [4]. To return volatile-containing samples without contamination of terrestrial volatiles, a new metal sealing system was developed for the Hayabusa2 sample container [5, 6]. Although the sealing system using double Viton O-rings for the Hayabusa container could not prevent terrestrial air contamination [7], the metal sealing system can keep the air contamination less than 1 Pa for 100 hour in the air [5, 6].

After the recovery of re-entry capsule at the landing point, it will first be transferred to the quick look facility (QLC) nearby there. Following the securing processes to the capsule, the sample container will be extracted, cleaned up and connected to a gas sampling system in a clean booth to extract gaseous volatiles inside the container. After the gaseous volatile recovery from the container, the container will then be delivered to the JAXA's curation facility with being kept in a nitrogen atmosphere during the travel from the QLC to Japan. Then the parts of the container which should not be introduced into the CCs will be removed in the cleanroom. Finally, the sample container will be set to the container opening system and installed into CC3-1.

The container will be opened at the CC3-1 in vacuum condition to take out the sample catcher that encapsulates Ryugu grains. The extracted sample catcher will be transferred to CC3-2. The sample catcher has three chambers for keeping samples collected at different surface locations separately [5, 6], and a lid of the chamber for samples obtained at the first sampling location will be taken apart to pick up a small fraction of grains. The picked-up samples will be kept in CC3-2 for future generations under a vacuum condition. The catcher will be transferred from the CC3-2 to CC3-3 under a vacuum condition, and then CC3-3 will be purged with purified nitrogen. The catcher will be transported to CC4-1 and CC4-2 to take out grains from three chambers of the container. As the initial description called 'phase-1' curation work under purified nitrogen environment in CCs, the grains will be weighed, observed with a stereomicroscope, and examined with visible to near-infrared spectrometers in CC3-3

©2019. Japan Geoscience Union. All Right Reserved.

and CC4-2.

Functional checks of the sample handling system and rehearsals of receiving and handling samples will be initiated in April 2019. The sample handling system will be reconditioned in early 2020 based on feedbacks from the preparation activities to be ready for the sample return in late 2020.

References: [1] Watanabe S. et al. (2018). AGU 2018 fall meet., present. #P21A-02. [2] Watanabe S. et al. (2017) Space Sci. Rev. 208, 3–16. [3] Vilas et al. (2008) Astron. J. 135, 1101–1105. [4] Tachibana S. et al. (2014) Geochem. J., 48, 571-587. [5] Sawada T. et al. (2017) Space Sci. Rev. 208, 81-106. [6] Okazaki R. et al. (2017) Space Sci. Rev. 208, 107-124. [7] Okazaki R. et al. (2011) LPS XLII, abstract #1653.

Keywords: Hayabusa2, C-type asteroid, Ryugu, sample curation, carbonaceous chondrite, Near Earth asteroid

©2019. Japan Geoscience Union. All Right Reserved.

Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

*Motoo Ito[1], Naotaka Tomioka[1], Masayuki Uesugi[2], Kentaro Uesugi[2], Ohigashi Takuji[3], Akira Yamaguchi[4], Naoya Imae[4], Yuzuru Karouji[5], Naoki Shirai[6], Toru Yada[5], Masanao Abe[5]

1. Kochi Institute for Core Sample Research, JAMSTEC, 2. JASRI, 3. UVSOR Synchrotron Facility, Institute for Molecular Science, 4. National Institute Polar Research, 5. JAXA, 6. Tokyo Metropolitan University

Returned samples from asteroids and comets have provided unique characteristics to investigate their origin and nature of the Solar System [1-3]. For example, analytical studies of the S-type asteroid Itokawa by the Hayabusa mission provided new insights for the asteroid-meteorite connections, space weathering processes, small asteroidal body formation in the Solar System [e.g., 1, 3, 4]. JAXA Hayabusa2 and NASA Osiris-REx are both on-going sample return missions from the primitive asteroids, Ryugu (C-type) and Bennu (B-type), respectively [5, 6]. Both missions have complementary scientific goals that are to understand the Solar System evolution in the point of view of organics, water, and associated minerals (i.e., hydrous minerals).

Phase 2 curation teams will be acting under the scientific direction and strong ethic of the Astromaterial Science Research Group (ASRG) of JAXA and was authorized 2 institutes by the steering committee of the ASRG in 2017: (1) Kochi Institute for Core Sample Research (KOCHI), JAMSTEC in collaboration with JASRI/SPring-8, UVSOR Synchrotron Facility/National Institutes of Natural Sciences, Institute for Molecular Science, National Institute of Polar Research (NIPR) and Tokyo Metropolitan University, and (2) the Institute for Planetary Materials, Okayama University at Misasa. The JAXA Curation requested us to make an in-depth analysis of a few grains by the state-of-the-art instruments/techniques and nationwide collaborative research activities. We will conduct on analyses in parallel with the initial analysis team led by the Hayabusa2 project.

Recent reports by the Near-IR Spectrometer (NIRS3) on Hayabusa2 spacecraft presented that the asteroid Ryugu may consist of either CM chondritic materials [8] or shocked/heated carbonaceous chondrites [9]. Matsuoka et al. [9] pointed out that the low albedo of the asteroid Ryugu could be explained by a combination of C-rich material, grains size, porosity and space weathering effects on the asteroid surface materials. This implies that the avoiding terrestrial contaminations (i.e., atmospheric water/air, organics) during sample curation, transportation and analysis are important to obtain original chemical characteristics of Hayabusa2 returned samples.

We have developed novel and universal sample holders (KOCHI grid and KOCHI clamp) for a linkage analysis utilizing micro-analytical instruments of FIB, TEM, STXM and NanoSIMS minimizing terrestrial contaminations and sample lost or broken. We also made an additional sample holder (Okazaki cell) for STXM analysis (Ohigashi T. et al. in preparation), and a sample transport vessel (FFTC: facility to facility transfer container; Uesugi K. et al. in preparation) under vacuum or inert gas in parallel.

We have carried out the development of coordinated synchrotron based-CT (SPring-8) –XRD (SPring-8) –FIB (JAMSTEC KOCHI) –STXM (UVSOR Synchrotron Facility) –NanoSIMS (JAMSTEC KOCHI) –TEM (JAMSTEC KOCHI) analysis to obtain complex structure inside of the sample, light element/isotope images to obtain their spatial distributions, speciation of elements: type of bonding, chemical species, redox state and ultra-fine textural observation: mineralogy and crystallography in fine-grained mineral and

©2019. Japan Geoscience Union. All Right Reserved.

organic assemblages in few tens to hundreds of micrometer-scale Hayabusa2 samples. We, therefore, have chosen Antarctic micrometeorites provided by NIPR as analogues of Hayabusa2 sample because of their size (50 to 800 μm, as an example of small particle) and chemical characteristics.

We will report the current status, ethic and motivation of "Team KOCHI" of Phase2 Curation. In addition, we will present newly developed universal sample holders for FIB, TEM, NanoSIMS, STXM, and a sample transport vessel under vacuum or inert gas among nationwide/international universities and institutes.

References: [1] Nakamura T. et al. (2011) Science 333, 1113–1116. [2] Brownlee D.E. et al. (2006) Science 314, 1711–1716. [3] Yurimoto H. et al. (2011) Science 333, 1116–1119. [4] Noguchi T. et al. (2011) Science 333, 1121–1125. [5] Tachibana S. et al. (2014) Geochem. J. 48, 571–587. [6] Lauretta D.S. et al. (2014) Meteorit. Planet. Sci. 50, 834–849. [7] Uesugi M. et al. (2019) Meteorit. Planet. Sci. 1, 1–29. [8] Hiroi T. et al. (2019) 50th LPSC (LPI Contrib. No. 2132), abstract#1129. [9] Matsuoka et al. (2019) 50th LPSC (LPI Contrib. No. 2132), abstract#1534.

Keywords: Hayabusa2 returned sample, Linkage analysis utilizing micro-analytical instruments

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Ryuho Kataoka(National Institute of Polar Research)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM12-25] Variation of carbon-14 in tree rings around the onset of the Spoerer Minimum

★Invited Papers

*Hiroko Miyahara[1], Fuyuki Tokanai[2], Toru Moriya[2], Motonari Ohyama[3], Masataka Hakozaki[4], Mirei Takeyama[2], Hirohisa Sakurai[2] (1.Musashino Art University, 2.Yamagata University, 3.Tohoku University, 4.Nagoya University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM12-26] Current Status of WASAVIES: Warning System for Aviation Exposure to Solar Energetic Particles

★Invited Papers

*Tatsuhiko Sato[1], Ryuho Kataoka[2,3], Daikou Shiota[4,5], Yuki Kubo[4], Mamoru Ishii[4], Hiroshi Yasuda[6], Shoko Miyake[7], InChun Park[5], Yoshizumi Miyoshi[5] (1.Japan Atomic Energy Agency, 2.National Institute of Polar Research, 3.SOKENDAI, 4.National Institute of Information and Communications Technology, 5.Nagoya University, 6.Hiroshima University, 7.National Institute of Technology, Ibaraki College)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM12-27] Statistical analysis of solar energetic particle events

*Kosuke Kihara[1], Yuwei Huang[2], Nobuhiko Nishimura[3], Seiji Yashiro[4], Nariaki Nitta[5], Kiyoshi Ichimoto[2], Ayumi Asai[2] (1.Department of Astronomy, Kyoto University, 2.Astronomical Observatory, Kyoto University, 3.Institute for Space Earth Environmental Research, Nagoya University, 4.The Catholic University of America, 5.Lockheed Martin Advanced Technology Center)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM12-28] Long-term variation of galactic cosmic ray intensity observed with the Nagoya multidirectional muon detector

*Kazuoki Munakata[1], Rafael Mendonca[2], Chihiro Kato[1], Munetoshi Tokumaru[3] (1.Department of Physics, Faculty of Science, Shinshu University, 2.INPE, Brazil, 3.ISEE, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM12-29] Solar modulation of galactic cosmic rays during grand minima: A hybrid simulation

*Shoko Miyake[1], Tomoaki Matsumoto[2,3], Ryuho Kataoka[4,5], Tatsuhiko Sato[6], Daikou Shiota[7], Hiroko Miyahara[8], Shinsuke Imada[9], Haruka Ueno[10] (1.NIT, Ibaraki College, 2.Hosei Univ., 3.Princeton Univ., 4.NIPR, 5.SOKENDAI, 6.JAEA, 7.NICT, 8.Musashino Art Univ., 9.Nagoya Univ., 10.JAXA)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM12-30] Overview of radio propagation project

*Kornyanat Hozumi[1], Hiroyuki Nakata[2], Susumu Saito[3], Takumi Kondo[1], Ryo Nakao[2], Takashi Maruyama[1], Takuya Tsugawa[1], Mamoru Ishii[1] (1.National Institute of Information and Communications Technology, 2.Graduate School of Engineering, Chiba University, Chiba, Japan, 3.National Institute of Maritime, Port and Aviation Technology, Electronic Navigation Research Institute (ENRI), Tokyo, Japan)

Variation of carbon-14 in tree rings around the onset of the Spoerer Minimum

*Hiroko Miyahara[1], Fuyuki Tokanai[2], Toru Moriya[2], Motonari Ohyama[3], Masataka Hakozaki[4], Mirei Takeyama[2], Hirohisa Sakurai[2]

1. Musashino Art University, 2. Yamagata University, 3. Tohoku University, 4. Nagoya University

Solar activity in the past has been reconstructed using carbon-14 in tree rings and beryllium-10 in ice cores, and it has been indicated that the Sun has long-term activity cycles such as Gleissberg cycle (~88 yrs) and the de Vries cycle (~200 yrs). Long-term variations of solar activity sometimes bring the grand minima such as the Dalton Minimum (1800-1820 CE) and the Maunder Minimum (1645-1715 CE). The detailed mechanism of such grand minima, however, remain unsolved. Reconstruction of solar cycles around the onset of the grand minima may shed light on the process of the occurrence of grand minima. We therefore have been conducting high-precision measurement of carbon-14 in tree rings with annual resolution using the Accelerator Mass Spectrometer at the Yamagata University. In this paper, we present our recent results on the measurement of carbon-14 around the onset of the Spoerer Minimum.

Keywords: solar cycle , grand solar minima, cosmogenic nuclide

©2019. Japan Geoscience Union. All Right Reserved.

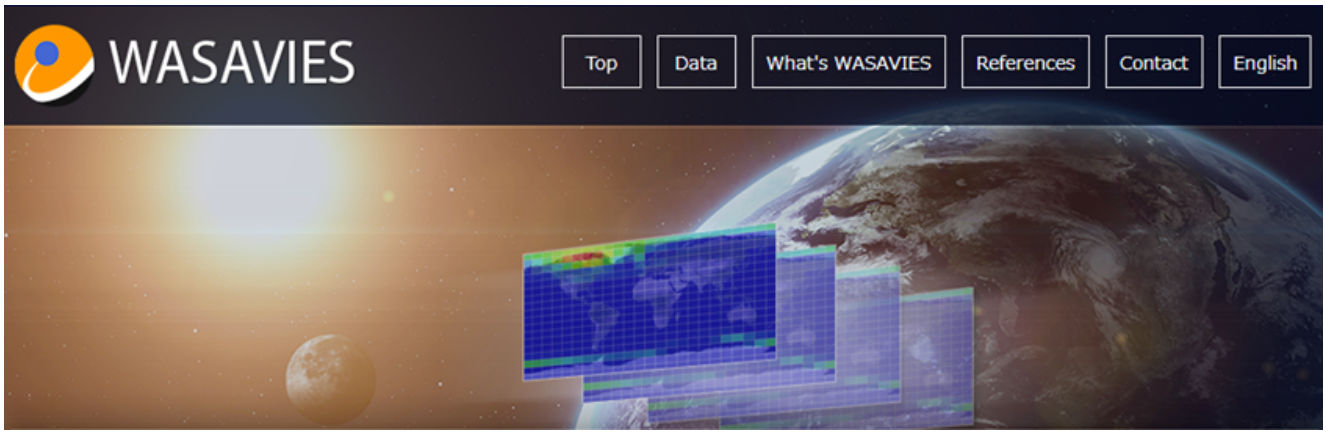
Current Status of WASAVIES: Warning System for Aviation Exposure to Solar Energetic Particles

*Tatsuhiko Sato[1], Ryuho Kataoka[2,3], Daikou Shiota[4,5], Yuki Kubo[4], Mamoru Ishii[4], Hiroshi Yasuda[6], Shoko Miyake[7], InChun Park[5], Yoshizumi Miyoshi[5]

1. Japan Atomic Energy Agency, 2. National Institute of Polar Research, 3. SOKENDAI, 4. National Institute of Information and Communications Technology, 5. Nagoya University, 6. Hiroshima University, 7. National Institute of Technology, Ibaraki College

A physics-based warning system of aviation exposure to solar energetic particles, WASAVIES, is improved to be capable of real-time and automatic analysis. In the improved system, the count rates of several neutron monitors (NM) at the ground level, as well as the proton fluxes measured by the GOES satellite are continuously downloaded at intervals of 5 min and used for checking the occurrence of ground level enhancement (GLE). When a GLE event is detected, the system automatically determines the model parameters for characterizing the profiles of each GLE event, and nowcasts and forecasts the radiation dose rates all over the world up to 24 h after the flare onset. A web-interface of WASAVIES (see picture below) was also developed, which broadcasts radiation dose rates due to cosmic-ray exposure for all over the world as well as on 9 selected flight routes at intervals of 5 min and 1 day during GLE and the other periods, respectively. It is planned to be in operation from March 2019 through the public server of NICT.

Keywords: solar energetic particle, radiation exposure, space weather



©2019. Japan Geoscience Union. All Right Reserved.

Statistical analysis of solar energetic particle events

*Kosuke Kihara[1], Yuwei Huang[2], Nobuhiko Nishimura[3], Seiji Yashiro[4], Nariaki Nitta[5], Kiyoshi Ichimoto[2], Ayumi Asai[2]

1. Department of Astronomy, Kyoto University, 2. Astronomical Observatory, Kyoto University, 3. Institute for Space Earth Environmental Research, Nagoya University, 4. The Catholic University of America, 5. Lockheed Martin Advanced Technology Center

Solar energetic particles (SEPs), which originate in powerful eruptions in the solar corona, give rise to critical radiation hazards for astronauts and airline passengers, causing damages to satellites, which result in serious societal impacts. The SEP phenomenon encompasses many cross-disciplinary fields, so collaborative research is indispensable. As a part of the Japanese space weather project PSTEP (Project for Solar-Terrestrial Environment Prediction), a Coordinated Data Analysis Workshop (CDAW) was held at Kyoto University in August 2018. As a first step toward building the capabilities to predict SEP events, we need to better understand what solar eruptions lead to SEP events of varying magnitudes. One approach, as adopted by this CDAW, is to start from energetic coronal mass ejections (CMEs) regardless of SEP occurrences, rather than from the actual SEP events. We first identified 197 CMEs between 2006 and 2017 that were faster than 900 km/s and wider than 60 degrees, as determined using data from SOHO/LASCO.

Our first objective is to characterize the basic properties of SEP events, such as the occurrence, proton flux intensity, and their time variations. We examined proton peak intensity, duration, and onset time with respect to the extrapolated CME onset time, using GOES >10-MeV proton data. STEREO LET and HET data were also analyzed to study the longitudinal distribution of the SEPs. We investigated the correlations of these SEP properties with the source longitude and speed of the CMEs, and soft X-ray intensity of the associated solar flares. We found that the SEP onset time is correlated with the source longitude of the CMEs. There were correlations between other parameters that we found in our statistical analysis, which will also be discussed. Finally, we will present examples of peculiar SEP events that were found as outliers in some scatter plots.

Keywords: Solar Energetic Particles, Coronal Mass Ejections, Space Weather

©2019. Japan Geoscience Union. All Right Reserved.

Long-term variation of galactic cosmic ray intensity observed with the Nagoya multidirectional muon detector

*Kazuoki Munakata[1], Rafael Mendonca[2], Chihiro Kato[1], Munetoshi Tokumaru[3]

1. Department of Physics, Faculty of Science, Shinshu University, 2. INPE, Brazil, 3. ISEE, Nagoya University

We have recently developed a correction method of the atmospheric temperature effect on muon count rate by using the GMDN (Global Muon Detector Network) data (R. R. S. Mendonca et al., Astrophys. J., 830:88, 2016). This is a significant step, because it makes possible for the first time to analyze the long-term variation of ~50 GeV cosmic ray density (i.e. isotropic intensity) which has been nalyed only for cosmic ray below ~10 GeV using the neutron monitor data nearly free from the temperature effect. In this paper, we report the 11-year and 22-year variations of cosmic ray density observed with Nagoya muon detector in 1970-2016 and discuss the energy dependence of variations by comparing the observation with neutron monitors.

Keywords: long-term variation of galactic cosmic ray intensity, energy spectrum of galactic cosmic rays, solar modulation

©2019. Japan Geoscience Union. All Right Reserved.

Solar modulation of galactic cosmic rays during grand minima: A hybrid simulation

*Shoko Miyake[1], Tomoaki Matsumoto[2,3], Ryuho Kataoka[4,5], Tatsuhiko Sato[6], Daikou Shiota[7], Hiroko Miyahara[8], Shinsuke Imada[9], Haruka Ueno[10]

1. NIT, Ibaraki College, 2. Hosei Univ., 3. Princeton Univ., 4. NIPR, 5. SOKENDAI, 6. JAEA, 7. NICT, 8. Musashino Art Univ., 9. Nagoya Univ., 10. JAXA

In the current and next weak solar cycles, we expect higher flux of galactic cosmic rays than that in the previous solar cycles because of the decreasing trend of the solar activity. It is important to quantitatively evaluate the high flux of galactic cosmic rays because it leads to the increase in the radiation exposure of aircrews and the increasing rates of single event upset events at spacecraft. However, reliable prediction of the increasing galactic cosmic rays in upcoming weak solar cycles is a challenges topic in the field of space weather forecast. We introduce a new project called Grand Minimum 7 (Gm7) for developing a hybrid simulation of galactic cosmic rays in such a weak solar condition, solving the stochastic differential equations of energetic particles in the MHD solar wind resolved by adaptive mesh refinement technique. We also discuss the possible situation of galactic cosmic rays and the radiation dose during the grand minima such as Maunder Minimum.

Keywords: galactic cosmic ray, solar wind

©2019. Japan Geoscience Union. All Right Reserved.

Overview of radio propagation project

*Kornyanat Hozumi[1], Hiroyuki Nakata[2], Susumu Saito[3], Takumi Kondo[1], Ryo Nakao[2], Takashi Maruyama[1], Takuya Tsugawa[1], Mamoru Ishii[1]

1. National Institute of Information and Communications Technology, 2. Graduate School of Engineering, Chiba University, Chiba, Japan, 3. National Institute of Maritime, Port and Aviation Technology, Electronic Navigation Research Institute (ENRI), Tokyo, Japan

Dated back to early 2016, the radio propagation subgroup was started in the A01 group (Space Weather Forecast System) of the PSTEP (Project for Solar-Terrestrial Environment Prediction). This subgroup has been working on clarifying of space weather (ionosphere is particular) effect on the radio propagation. Day-to-day variation of the bottom side of ionosphere has great influence on availability and integrity of radio waves in high frequency (HF, 3-30 MHz) band. HF is used as a backbone of communication systems for aviation during en-route phase and for amateur radio during disaster relief operation. We, therefore, focused on the HF band. The radio propagation simulator named HF-START (HF Simulator Targeting for All-users' Regional Telecommunications) has been developed. Availability and integrity of HF band are expected to be provided through HF-START interface after receiving users' input/ request. The HF-START project activity and its future operation plan will be overviewed in this talk.

Keywords: HF-START, Radio Propagation Simulator, Space Weather, Ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM12] Space Weather and Space Climate

convener:Ryuho Kataoka(National Institute of Polar Research), Antti A Pulkkinen(NASA Goddard Space Flight Center), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Kaori Sakaguchi(National Institute of Information and Communications Technology), Chairperson:Kaori Sakaguchi

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM12-31] Dynamic Spectral Characteristics of Equatorial Plasma Bubbles

★Invited Papers

*Tatsuhiro Yokoyama[1], Charles L Rino[2], Charles S Carrano[2] (1.Kyoto University, 2.Boston College)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM12-32] Recent advances in space weather monitoring using the Super Dual Auroral Radar Network

★Invited Papers

*Evan G Thomas[1], Simon G Shepherd[1] (1.Dartmouth College)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM12-33] **A Study of Solar Flare Effects on Radio Wave Propagation using SuperDARN & riometer**

*Shibaji Chakraborty[1], Joseph Baker[1], John Michael Ruohoniemi[1], Nozomu Nishitani[2] (1.Virginia Tech, 2.Institute for Space-Earth Environmental Research, Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM12-34] Exploring the use of cell phone GNSS receivers for global monitoring of the ionosphere

*Dawn Kellogg Merriman[1], Omar A Nava[1], Jennifer L Meehan[2], Hsien-Liang R Tseng[1] (1.AFIT, 2.NOAA)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM12-35] Large enhancements of global GPS total electron content during a magnetic storm on 7-8 November 2004

*Sori Takuya[1], Yuichi Otsuka[1], Atsuki Shinbori[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Information and Communications Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM12-36] Large scale traveling ionospheric disturbances origin and propagation

*Iurii Cherniak[1,2], Irina Zakharenkova[2,5], Paul Prikryl[3,4], William Schreiner[1] (1.COSMIC Program Office, University Corporation for Atmospheric Research, 2.University of Warmia and Mazury in Olsztyn, 3.Physics Department, University of New Brunswick, 4.Geomagnetic Laboratory, Natural Resources Canada, 5.West Department of IZMIRAN)

Dynamic Spectral Characteristics of Equatorial Plasma Bubbles

*Tatsuhiro Yokoyama[1], Charles L Rino[2], Charles S Carrano[2]

1. Kyoto University, 2. Boston College

Equatorial plasma bubble (EPB) is a well-known phenomenon in the equatorial ionospheric F region. As it causes severe scintillation in the amplitude and phase of radio signals, it is important to understand and forecast the occurrence of EPB from a space weather point of view. In order to simulate the instability in the equatorial ionosphere, a 3D high-resolution bubble (HIRB) model with a grid spacing of as small as 200 m has been developed. It provides a unique opportunity to characterize intermediate-scale EPB structure, which was not well resolved until very recently. Estimation of altitude-dependent power law spectral density function parameters provides an altitude versus time history of the intermediate-scale structure development. Local structure onset is associated with successive bifurcation of rising EPBs. Developed structure characterized by a two-component power law spectral density function ultimately subtends several hundred kilometers in altitude. The EPB simulation data fully support the reported EPB diagnostics from previous in situ measurements. In the near future, HIRB model may be able to directly resolve Fresnel scale of GPS frequency band (300-400m), so that the effects of EPBs on radio wave propagation could be evaluated without any assumption.

Keywords: plasma bubble, scintillation, ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

Recent advances in space weather monitoring using the Super Dual Auroral Radar Network

*Evan G Thomas[1], Simon G Shepherd[1]

1. Dartmouth College

Over the last decade, the Super Dual Auroral Radar Network (SuperDARN) has undergone a dramatic expansion in the Northern Hemisphere with the addition of more than a dozen radars offering improved coverage at midlatitudes (50º–60º magnetic latitude) and in the polar cap (80º–90º magnetic latitude). This has led to the development of new empirical models which better describe both the regional and global morphology of ionospheric convection under a range of solar wind and geomagnetic activity conditions. In addition, real-time measurements of ionospheric plasma motion are once again being collected from more than 15 SuperDARN radar sites to produce nowcasts of the global convection pattern. In this presentation we discuss the operational challenges and space weather applications of these real-time SuperDARN products.

©2019. Japan Geoscience Union. All Right Reserved.

A Study of Solar Flare Effects on Radio Wave Propagation using SuperDARN & riometer

*Shibaji Chakraborty[1], Joseph Baker[1], John Michael Ruohoniemi[1], Nozomu Nishitani[2]

1. Virginia Tech, 2. Institute for Space-Earth Environmental Research, Nagoya University

A prolonged study is underway to improve the understanding of the lower ionospheric (D & lower E layer) response to solar flare and its effects on HF propagation. Over-the-Horizon communication is strongly dependent on the state of the ionosphere, which is fragile to solar X-ray flares. The Super Dual Auroral Radar Network (SuperDARN) is an active HF radio receiver, primarily used to probe ionosphere and upper atmosphere. SuperDARN has one common mode of operation which simulates a ground-to-ground communications link, commonly known as ground scatter. Riometers on the other side are passive HF radio receiver, provides information about HF absorption in the ionosphere by measuring variations in cosmic radio noise. Both instruments' observations get altered due to the well-known effects of Short-Wave Fadeout or SWF. During an SWF the number of SuperDARN ground-scatter echoes drops suddenly (≈1 min) and sharply followed by an apparent increase in Doppler velocity (also known as "Doppler Flash"), often to near zero, reflecting disruption. In addition to that, riometer observe an enhancement in cosmic noise absorption. Since decades, enhanced D and E region electron density are known to be the significant driver of HF radio wave absorption, and we have steadily developed a better understanding of the sources and driving processes of HF absorption. However, the picture is less clear when we talk about the influence of collision frequency in radio wave absorption and Doppler frequency anomaly during SWF. This study aims to propose a relatively newer semi-empirical model to provide insights into the physical significance of collision frequency in HF absorption effect which can be seen in the riometer data. In addition to that, the study also aims to provide physical insights to Doppler frequency anomaly seen in SuperDARN data. Furthermore, this study will help us to advance our understanding of the role of collision frequency in HF absorption and Doppler frequency anomaly, their sources and driving parameters.

Keywords: Solar Flare, Shortwave-Fadeout, HF Absorption

©2019. Japan Geoscience Union. All Right Reserved.

Exploring the use of cell phone GNSS receivers for global monitoring of the ionosphere

*Dawn Kellogg Merriman[1], Omar A Nava[1], Jennifer L Meehan[2], Hsien-Liang R Tseng[1]

1. AFIT, 2. NOAA

Accurate characterization of the ionosphere in response to space weather events has important implications for the effective use of high-frequency (HF) communications in civilian and military operations, including, but not limited to, emergency services, amateur radio, aviation, and over-the-horizon radar. This study investigates the use of cell phone Global Navigation Satellite System (GNSS) technology to monitor and study highly variable phenomena in the ionosphere, such as the aurora at high-latitudes or scintillation at the equator. Field campaigns to high and mid-latitudes will be summarized here, emphasizing the sensitivity of cell phone GNSS receivers to pick up on space weather events such as traveling ionospheric disturbances. Preliminary analysis on the potential to combine data from various cell phone manufacturers (e.g. Hauwei, Samsung, Google, LG and Moto) to enhance data quality will also be presented. Based on this research the potential to collect data from millions of cell phones GNSS technology may allow for real-time monitoring and measuring of the ionosphere to occur on an unprecedented global scale.

Keywords: GNSS, cell phone, space weather

©2019. Japan Geoscience Union. All Right Reserved.

Large enhancements of global GPS total electron content during a magnetic storm on 7-8 November 2004

*Sori Takuya[1], Yuichi Otsuka[1], Atsuki Shinbori[1], Takuya Tsugawa[2], Michi Nishioka[2]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. National Institute of Information and Communications Technology

Storm enhanced density (SED) with a latitudinally narrow structure is one of the storm-time ionospheric disturbances in the mid- and low-latitude regions. Foster and Rideout [2007] reported that the SED plume occurs in magnetically-conjugate regions in both northern and southern hemispheres. In this study, we analyzed geomagnetic storm events from 2000 to 2012 and found that a TEC enhancement over Japan on 8 November 2004 is the largest. Maruyama [2006] reported that the TEC enhancement appeared during this event, and pointed out that the mid-latitude TEC enhancement observed after the sunset is related to SED. However, since most of the previous studies focus on TEC variation in a specific region, the detail features of global TEC variation associated with the development and decay of the geomagnetic storm have not yet been clarified. The purpose of this study is to understand the generation mechanism of the TEC enhancement in the mid- and low-latitude ionosphere during the geomagnetic storm using global GPS-TEC data with high temporal and spatial resolutions provided by NICT. The GPS-TEC data have spatial and temporal resolutions of 0.5˚×0.5˚ in longitude and latitude and 5 minutes, respectively. Here, we first calculated a difference value (dTEC) between storm-time TEC and average TEC of 10 geomagnetically quiet days. In this calculation, we referred to a list of geomagnetically quiet and disturbed days provided by World Data Center for Kyoto University. Next, we created a two-dimensional map of rTEC (dTEC normalized by the average TEC of 10 geomagnetically quiet days), and analyzed the temporal and spatial variations of rTEC for a geomagnetic storm which occurred on 8 November 2004 with the minimum SYM-H value of -400 nT at 6:00 UT. As a result, the rTEC enhancement in Japan was maintained even after the onset of the recovery phase, and the maximum value reached ~17 (~90 TECU). The enhanced rTEC region in Japan propagates westward with a velocity of 317 m/s. In order to investigate the specific signature of rTEC in Japan in detail, we created the latitude-time plot of TEC at a longitude 142˚E. In this plot, two high TEC regions appear near 5:00 UT and 11:00 UT, and propagate from high to low latitudes. Furthermore, the ion drift meter data obtained from the DMSP satellite traveling over Japan show the westward flow with a velocity of 250 m/s, which is almost consistent with that of the enhanced rTEC velocity. In the two-dimensional global map of rTEC, the TEC enhancements over Japan and Australia occurred simultaneously with a magnetic conjugacy. The rTEC enhancements were larger in the northern hemisphere than that in the southern hemisphere. The rTEC enhancements started near 5:00 UT at magnetic latitude of 50˚ in both the hemispheres, and propagated from high to low latitudes. In order to investigate the global signature of rTEC over Japan and America, we created the magnetic latitude-time plot of rTEC. As a result, we found that the rTEC in Japan and America showed a large enhancement at 5:00 UT with the maximum values of more than 6. In the rTEC map at 5:00 UT, the enhanced rTEC region existed between America and Japan. This rTEC enhancement is thought as a cause of SED. SED is thought to be caused by the westward plasma transportation in the mid- and low-latitude ionosphere due to the storm-time enhanced SAPS [Tsurutani et al., 2004]. Assuming that the propagation velocity is 317 m/s, it takes 9.5 hours to move from America to Japan. However, the time difference of the onsets of the rTEC enhancement between America and Japan is 6 hours. Therefore, the rTEC enhancement cannot be explained by the above mechanism of the westward transportation. These results suggest that the enhanced TEC region associated with the TEC peak over Japan existed between America and Japan. Therefore, mechanism different from the SED generation can cause large TEC enhancement

©2019. Japan Geoscience Union. All Right Reserved.

during nighttime and have a wide extent of longitude (100˚~).

Keywords: Ionosphere, Geomagnetic storm, Total electron content, Magnetic conjugacy

©2019. Japan Geoscience Union. All Right Reserved.

Large scale traveling ionospheric disturbances origin and propagation

*Iurii Cherniak[1,2], Irina Zakharenkova[2,5], Paul Prikryl[3,4], William Schreiner[1]

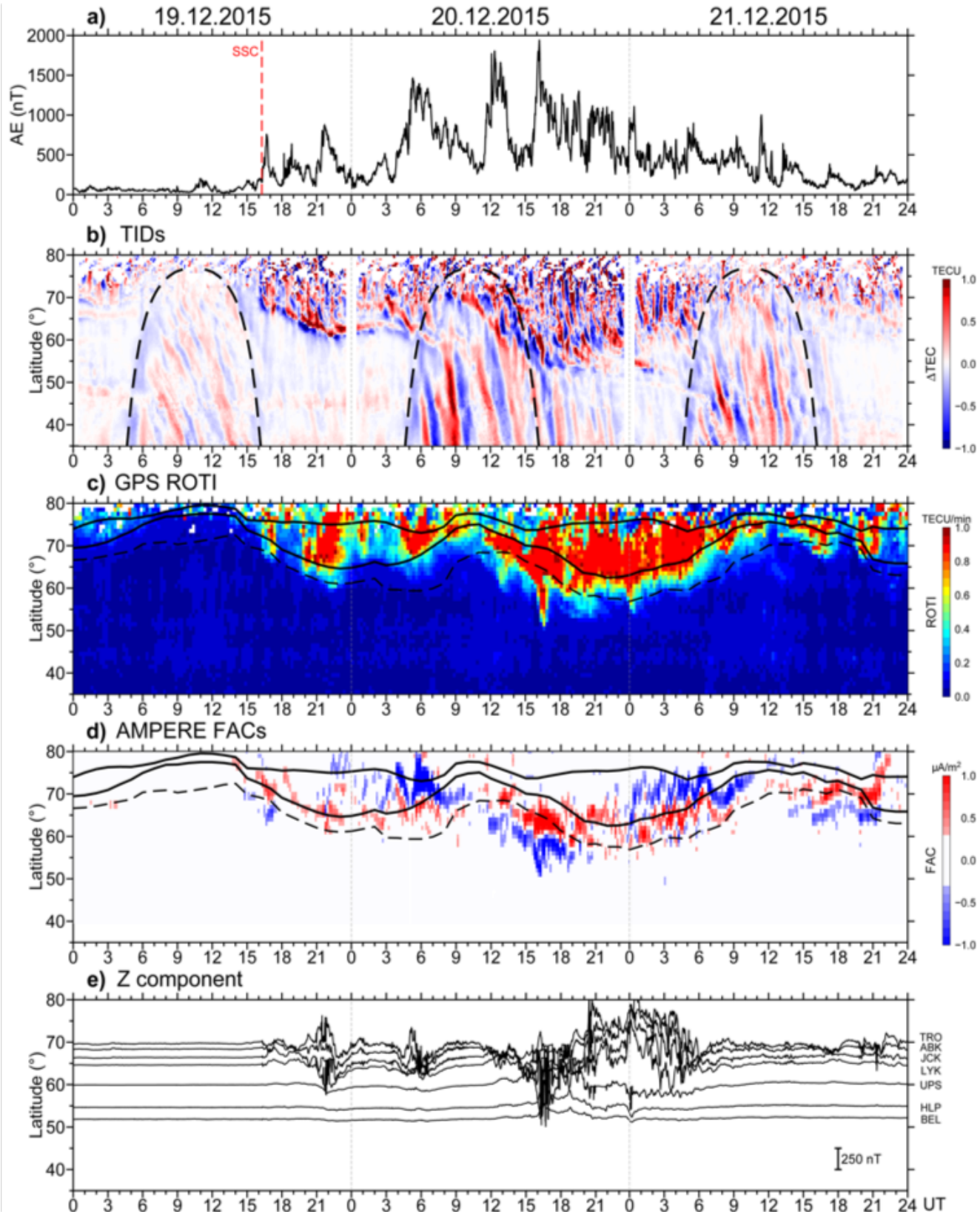
1. COSMIC Program Office, University Corporation for Atmospheric Research, 2. University of Warmia and Mazury in Olsztyn, 3. Physics Department, University of New Brunswick, 4. Geomagnetic Laboratory, Natural Resources Canada, 5. West Department of IZMIRAN

We investigate an origin, occurrence, and propagation of large-scale traveling ionospheric disturbances (LSTIDs) with an analysis of the total electron content (TEC) perturbation component deduced from the ground-based GPS and GLONASS observations. The high spatio-temporal resolution mapping approach provides a very detailed specification of the ionospheric small- to large-scale disturbances associated with two major sources of the LSTIDs generation: the solar terminator passage during the quiet time and auroral activity caused by auroral particle precipitation and field-aligned currents (FACs) intensification during geomagnetic disturbances. For the first time, the joint analysis of the ionospheric plasma irregularities, FACs, and LSTIDs reveals that a zone with the intense FACs and ionospheric irregularities occurred at the same region that represent the most probable source of LSTIDs excitation. The COSMIC RO electron density profiles confirm the E layer plasma density enhancement within LSTIDs excitation area. Such density enhancement leads to an increase of ionospheric conductivity, intensification of currents in the ionosphere, and release of energy by Joule heating into the lower thermosphere.
This approach was demonstrated for the case of the 19-21 December 2015 geomagnetic storm, when LSTIDs propagated over the European region were detected. During the main phase of the storm, the LSTIDs propagated equatorward from European high latitudes to middle latitudes (35-40N) with the horizontal velocities of ~700-800 m/s. The LSTIDs as deduced from the TEC-disturbed component had a much larger magnitude and propagate much longer distances during the daytime (sunlit part) than in the night. We found that an equatorward expansion of the strong ionospheric irregularities zone and an increase of the FACs magnitude led to a simultaneous intensification of the LSTIDs occurrence at high latitudes. The GPS ROTI (rate of TEC index) technique, a sensitive one for detection of the rapid ionospheric gradients and irregularities, could not recognize any signatures of the TIDs structures.

The research is supported by the NSF CAS AGS-1033112, the NASA LWS grant NNX15AB83G, by the National Science Centre, Poland, through grants 2017/25/B/ST10/00479 and 2017/27/B/ST10/02190, and by RFBR Grant 19-05-00570A.

Keywords: LSTIDs, GNSS, ionosphere, geomagnetic storm, FACs, plasma irregularities

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Danny Summers, Yoshizumi Miyoshi(ISEE, Nagoya University)

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PEM13-01] Developing an improved understanding of Earth’s outer radiation belt electrons with combined observations from Van Allen Probes, MMS, and Arase

★Invited Papers

*Drew L Turner[1], Ian Cohen[2], Alexander Boyd[1,3], Joseph Fennell[1], Geoff Reeves[3], Yoshizumi Miyoshi[4] (1.Aerospace Corporation El Segundo, 2.Johns Hopkins University Applied Physics Lab, 3.Los Alamos National Laboratory, 4.Nagoya University)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PEM13-02] Recent results from Van Allen Probes and future prospects from the CeREs Cubesat

★Invited Papers

*Shrikanth G Kanekal[1], Daniel N Baker[2], Ashley Greeley[1], Lauren Blum[1], Quintin Schiller[1], David G Sibeck[1], Hong Zhao[2], Xinlin Li[2], Allison Jaynes[3] (1.NASA Goddard Space Flight Center, 2.LASP, University of Colorado, Boulder, 3.Univeristy of Iowa)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[PEM13-03] Optimal Use of Time Lags Between MMS Spacecraft : Application to the Estimation of Wave-Vectors

*Gerard Marcel CHANTEUR[1,2,3], Drew L. Turner, Olivier Le Contel[1,2,3], Alessandro Retino[1,2,3], Laurent Mirioni[1,2,3] (1.CNRS, 2.SORBONNE UNIVERSITE, 3.ECOLE POLYTECHNIQUE)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[PEM13-04] Conjugate observation of EMIC waves by Arase and RBSP with associated POES and AARDDVARK detected electron precipitation

*Aaron T. Hendry[1], Ondrej Santolik[1,2], Yoshizumi Miyoshi[3], Yoshiya Kasahara[4], Yasumasa Kasaba[5], Ayako Matsuoka[6], Craig J Rodger[7], Mark Clilverd[8], Masafumi Shoji[3], Shoya Matsuda[6], Craig Kletzing[9], Iku Shinohara[6] (1.Dept. of Space Physics, Inst. of Atmospheric Physics, Czech Acad. of Science, 2.Fac. of Mathematics and Physics, Charles Univ., 3.Inst. for Space Earth Environmental Research, Nagoya Univ.,

4.Graduate School of Natural Science and Technology, Kanazawa Univ., 5.Planetary Plasma and Atmospheric Research Center, Tohoku Univ., 6.Inst. of Space and Astronautical Science, Japan Aerospace Exploration Agency, 7.Dept. of Physics, Univ. of Otago, 8.British Antarctic Survey (NERC), 9.Dept. of Physics and Astronomy, Univ. of Iowa)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[PEM13-05] Over-darkening pulsating aurora: simultaneous observations with Arase and an all-sky camera in Scandinavia

*Keisuke Hosokawa[1], Yoshizumi Miyoshi[2], Shin-ichiro Oyama[2], Yasunobu Ogawa[3], Satoshi Kurita[2], Yoshiya Kasahara[4], Mitsunori Ozaki[4], Yasumasa Kasaba[5], Satoshi Yagitani[4], Shoya Matsuda[6], Fuminori Tsuchiya[5], Atsushi Kumamoto[5], Iku Shinohara[6], Ryoichi Fujii[7] (1.Department of Communication Engineering and Informatics, University of Electro-Communications, 2.ISEE, Nagoya University, 3.National Institute of Polar Research, 4.Kanazawa University, 5.Tohoku University, 6.ISAS/JAXA, 7.Research Organization of Information and Systems)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

Discussion

Developing an improved understanding of Earth's outer radiation belt electrons with combined observations from Van Allen Probes, MMS, and Arase

*Drew L Turner[1], Ian Cohen[2], Alexander Boyd[1,3], Joseph Fennell[1], Geoff Reeves[3], Yoshizumi Miyoshi[4]

1. Aerospace Corporation El Segundo, 2. Johns Hopkins University Applied Physics Lab, 3. Los Alamos National Laboratory, 4. Nagoya University

In this presentation, we focus on two aspects of Earth's outer radiation belt electrons: acceleration due to interactions with whistler-mode chorus waves and losses due to magnetopause incursions and outward radial transport. Using a combination of energetic electron intensities and wave data from NASA's Van Allen Probes and MMS missions plus JAXA's Arase (ERG) mission, we evaluate evidence of local acceleration and losses to outward radial transport based on phase space density and multipoint wave analysis. A telltale sign of local acceleration due to interactions between 100s of keV electrons and chorus waves within the heart of the outer radiation belt is a growing peak in electron phase space density for those energies and pitch angles affected by the acceleration. Sometimes that peak in phase space density might occur beyond the apogee of the Van Allen Probes orbit, but MMS and Arase data can be used to disambiguate dominant acceleration processes for such cases. Losses to the magnetopause and from outward radial transport also result in distinct features in the time history of radial distributions of electron phase space density. Again, with their apogees extending to higher L-shells (including into the magnetosheath for MMS), MMS and Arase can supplement the Van Allen Probes dataset by directly observing evidence of these processes beyond Van Allen Probes apogee. In this presentation, we showcase several examples of these processes using multipoint data from these missions.

Keywords: Radiation belts, Relativistic electrons, Wave-particle interactions

©2019. Japan Geoscience Union. All Right Reserved.

Recent results from Van Allen Probes and future prospects from the CeREs Cubesat

*Shrikanth G Kanekal[1], Daniel N Baker[2], Ashley Greeley[1], Lauren Blum[1], Quintin Schiller[1], David G Sibeck[1], Hong Zhao[2], Xinlin Li[2], Allison Jaynes[3]

1. NASA Goddard Space Flight Center, 2. LASP, University of Colorado, Boulder, 3. Univeristy of Iowa

The Van Allen Probes mission, since its launch in August 2012 has advanced our understanding of fundamental questions regarding the acceleration and loss of outer Van Allen belt electron populations. Electron dynamics in the outer radiation belt are driven by a number of physical processes, which affect low energy cold plasma to relativistic and ultra-relativistic particle populations. I will present recent results from Van Allen Probes mission focusing on the energetic electron dynamics. I will also discuss the significant role of CubeSats that may lead to a paradigm shift in the way space-based observations are carried out, e.g., by enabling multipoint observations. I am currently leading a CubeSat mission, CeREs, the Compact Radiation belt Explorer, CeREs that was launched December 2018 and is currently in the commissioning phase. CeREs will provide high quality measurements of radiation belt electrons, especially microbursts.

Keywords: Radiation belts, CubeSat, energetic electrons

©2019. Japan Geoscience Union. All Right Reserved.

Optimal Use of Time Lags Between MMS Spacecraft : Application to the Estimation of Wave-Vectors

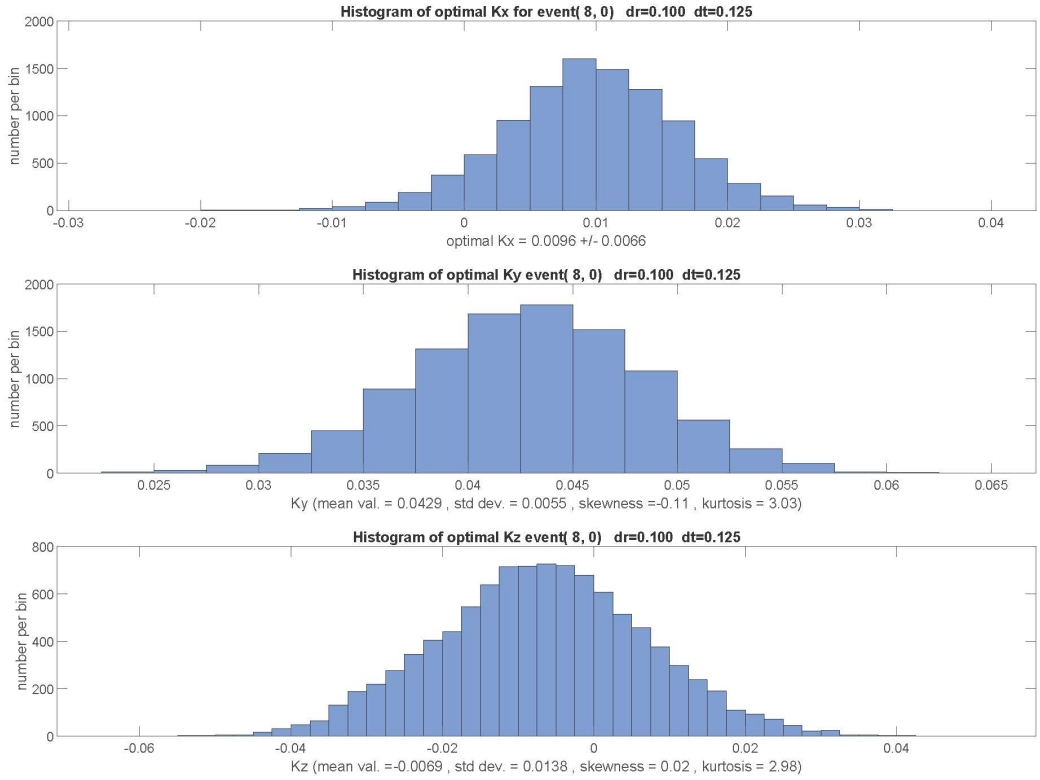
*Gerard Marcel CHANTEUR[1,2,3], Drew L. Turner, Olivier Le Contel[1,2,3], Alessandro Retino[1,2,3], Laurent Mirioni[1,2,3]

1. CNRS, 2. SORBONNE UNIVERSITE, 3. ECOLE POLYTECHNIQUE

Turner et al. (2017) made use of cross-correlations of SCM quasi monochromatic data between pairs of MMS spacecraft to estimate phase lags and to derive wave vectors of whistler mode chorus elements in the inner magnetosphere. A new approach has been developped to revisite this study. For a cluster of four spacecraft there are six pairs of spacecraft, each one giving raise to a scalar equation relating the vector position **R** from the first to the second spacecraft, the wave vector **K** and the phase lag $\Delta\phi$: **R.K**=$\Delta\phi$. A positive weight is attributed to each equation (w_j, j=1 to 6). A statistical ensemble of 6-uplets is built and we look for the 6-uplet giving the lowest condition number of matrix **M**. This procedure warrants the best accuracy of the pseudo-inverse of **M** and hence the best estimate of the wave vector **K**. Adding random perturbations to M and $\Delta\phi$ the procedure allows to estimate the uncertainties on **K.**

Turner, D. L. et al. JGR Space Physics, https://doi.org/10.1002/2017JA024474

Keywords: multi-spacecraft missions, MMS, field analysis, wave vectors, phase shifts



©2019. Japan Geoscience Union. All Right Reserved.

Conjugate observation of EMIC waves by Arase and RBSP with associated POES and AARDDVARK detected electron precipitation

*Aaron T. Hendry[1], Ondrej Santolik[1,2], Yoshizumi Miyoshi[3], Yoshiya Kasahara[4], Yasumasa Kasaba[5], Ayako Matsuoka[6], Craig J Rodger[7], Mark Clilverd[8], Masafumi Shoji[3], Shoya Matsuda[6], Craig Kletzing[9], Iku Shinohara[6]

1. Dept. of Space Physics, Inst. of Atmospheric Physics, Czech Acad. of Science, 2. Fac. of Mathematics and Physics, Charles Univ., 3. Inst. for Space Earth Environmental Research, Nagoya Univ., 4. Graduate School of Natural Science and Technology, Kanazawa Univ., 5. Planetary Plasma and Atmospheric Research Center, Tohoku Univ., 6. Inst. of Space and Astronautical Science, Japan Aerospace Exploration Agency, 7. Dept. of Physics, Univ. of Otago, 8. British Antarctic Survey (NERC), 9. Dept. of Physics and Astronomy, Univ. of Iowa

We present a remarkable case study of strong EMIC wave emissions observed simultaneously by instruments on board the ARASE and RBSP-B satellites, as well as by ground-based observatories, during a period of significant geomagnetic activity. These waves coincided with strong substorm activity (AE>1000 nT) during a southward IMF Bz shift, corresponding to the initial phase of an intense geomagnetic storm (peak Dst < -170 nT). At the time of this observation, the ARASE and RBSP-B satellites were co-located in L and MLT, showing simultaneous observation of the same wave emission, but were significantly separated in magnetic latitude. This separation allows us to examine the evolution of the wave parameters as the wave propagates down the field-line to the Earth.

During this period of wave activity, we also see evidence of energetic electron precipitation into the ionosphere. At the time of the RBSP and ARASE observations, the POES METOP-02 satellite passed through the footprint of the source region and observed bursts of energetic ion and electron precipitation into the ionosphere, matching known signatures of EMIC-driven particle precipitation. This precipitation was then in turn observed from the ground as AARDDVARK-detected sub-ionospheric VLF perturbations. Through analysis of these ground-based observations, we are able to estimate the extent of the EMIC source region.

Keywords: Arase, Van Allen Probes, EMIC, Wave-particle interactions, AARDDVARK

©2019. Japan Geoscience Union. All Right Reserved.

Over-darkening pulsating aurora: simultaneous observations with Arase and an all-sky camera in Scandinavia

*Keisuke Hosokawa[1], Yoshizumi Miyoshi[2], Shin-ichiro Oyama[2], Yasunobu Ogawa[3], Satoshi Kurita[2], Yoshiya Kasahara[4], Mitsunori Ozaki[4], Yasumasa Kasaba[5], Satoshi Yagitani[4], Shoya Matsuda[6], Fuminori Tsuchiya[5], Atsushi Kumamoto[5], Iku Shinohara[6], Ryoichi Fujii[7]

1. Department of Communication Engineering and Informatics, University of Electro-Communications, 2. ISEE, Nagoya University, 3. National Institute of Polar Research, 4. Kanazawa University, 5. Tohoku University, 6. ISAS/JAXA, 7. Research Organization of Information and Systems

Pulsating aurora (PsA) is one of the major classes of aurora often seen in the lower latitude part of the auroral region in the morning side. PsAs are characterized by quasi-periodic variations in the optical intensity whose period typically ranges from a few to a few tens of second. Coordinated ground/satellite observations in the last decade demonstrated that the main optical pulsation well correlates with the intensity modulation of whistler mode chorus waves in the magnetosphere. Recent analyses of high time resolution ground-based optical observations have reported that the brightness of PsA decreases below the diffuse background immediately after the ON phase of the main pulsation. To date, however, the generation mechanism of such “over-darkening PsA” is still unclarified. In this paper, we investigate the characteristics of the over-darkening PsA by using simultaneous observations of PsA with an EMCCD all-sky camera in Sodankylä, Finland (67°N, 26°E, 64°MLAT) and the Arase satellite. The EMCCD all-sky camera captures auroral emission with a temporal resolution of 100 Hz. We make use of data from the PWE/OFA instrument to analyse the temporal variation of chorus wave as a source of PsA. During one of the conjunction events in Scandinavia on March 29, 2017, almost all the PsA pulses showed clear over-darkening characteristics. By analysing the 2D all-sky images at the times of over-darkening we identified that over-darkening areas appeared in the trailing edge of PsA patches and moved in tandem with the poleward propagating patches. It was also found that similar over-darkening characteristics were not seen in the chorus data from PWE/OFA onboard Arase located at the magnetospheric counterpart of PsA. These results indicate that the over-darkening PsA is not caused by a temporal variation of chorus at a fixed point, but is produced by a propagation of over-darkening area with PsA patches. That is, the over-darkening PsA is a spatial structure rather than a temporal variation. In the presentation, we discuss several possible scenarios that can explain the over-darkening along the edge of PsA patches.

Acknowledgement: The operation of the EMCCD camera at Sodankylähas been supported by Sodankylä Geophysical Observatory (SGO).

Keywords: Pulsating Aurora, Chorus Waves

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Yoshizumi Miyoshi(ISEE, Nagoya University), Danny Summers

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[PEM13-06] Deformation of electron pitch angle distributions caused by chorus waves observed by the Arase satellite

★Invited Papers

*Satoshi Kurita[1], Yoshizumi Miyoshi[1], Satoshi Kasahara[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Iku Shinohara[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.The University of Tokyo, 3.Graduate School of Science, Osaka University, 4.Information Media Center, Kanazawa University, 5.ISAS/JAXA)

3:50 PM - 4:10 PM JST | 6:50 AM - 7:10 AM UTC

[PEM13-07] Electron scattering by isolated chorus elements observed near the magnetospheric equator

★Invited Papers

*Satoshi Kasahara[1], Yoshizumi Miyoshi[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Kunihiro Keika[1], Tomoaki Hori[2], Iku Shinohara[5] (1.The university of Tokyo, 2.Nagoya University, 3.Osaka University, 4.Kanazawa University, 5.Institute of Space and Astronautical Science)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[PEM13-08] Continuous precipitation of low-energy electrons associated with pulsating aurora obtained by the Reimei satellite

*Takeshi Sakanoi[1], Fukizawa Mizuki[1], Yoshizumi Miyoshi[2], Yusuke Ebihara[3], Kazushi Asamura[4], Masafumi Hirahara[2] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.ISEE, Nagoya University, 3.RISH, Kyoto University, 4.ISAS/JAXA)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[PEM13-09] Origin of energetic electron precipitation with fast fluctuation: Data-driven simulations using the ERG plasma wave observations

*Shinji Saito[1], Yoshizumi Miyoshi[2], Shoya Matsuda[3], Satoshi Kurita[2], Yoshiya Kasahara[4], Atsushi Kumamoto[5], Fuminori Tsuchiya[5], Ayako Matsuoka[3] (1.Graduate School of Science, Nagoya University, 2.ISEE, Nagoya University , 3.ISAS/JAXA, 4.Kanazawa University, 5.Tohoku University)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[PEM13-10] Conjugated quasi-periodic ELF/VLF emissions between the Arase satellite and both Van Allen Probes

*Claudia Martinez Calderon[1,2], Frantisek Nemec[3], Kazuo Shiokawa[2], Yuto Katoh[1], Yoshiya Kasahara[4], Shoya Matsuda[2], Fuminori Tsuchiya[1], Atsushi Kumamoto[1], Mariko Teramoto[2], Ayako Matsuoka[5], Yoshizumi Miyoshi[2], Ondrej Santolik[6,3], George Hospodarksy[7] (1.Dept. Geophys., Grad. Sch. Sci., Tohoku University, 2.Instute for Space-Earth Environmental Research, Nagoya University, 3.Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic, 4.Kanazawa University, 5.Japan Aerospace Exploration Agency, 6.Institute of Atmospheric Physics, Prague, Czech Republic, 7.Department of Physics and Astronomy, University of Iowa, USA)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

Discussion

Deformation of electron pitch angle distributions caused by chorus waves observed by the Arase satellite

*Satoshi Kurita[1], Yoshizumi Miyoshi[1], Satoshi Kasahara[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Iku Shinohara[5]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. The University of Tokyo, 3. Graduate School of Science, Osaka University, 4. Information Media Center, Kanazawa University, 5. ISAS/JAXA

We report on deformation of electron pitch angle distributions associated with chorus waves observed by the Arase satellite. The deformation is characterized by flux increase of 17-30 keV electrons in a narrow and oblique pitch angle range and by flux decrease in 7-17 keV electron flux in the smaller pitch angle range than the flux increase. Comparison of change in electron pitch angle distributions with resonant ellipses of the upper band chorus shows that the deformation appears where effective wave-particle interaction is expected in the velocity space, and the flux increase takes place along the resonant ellipse of the upper frequency of the wave. This strongly suggests that the deformation is a consequence of wave-particle interactions between electrons and upper band chorus. The Arase observation demonstrates that the deformation occurs within 30 s, which is faster than expected from the quasi-linear diffusion theory.

Keywords: ERG/Arase satellite, Chorus waves, Acceleration

©2019. Japan Geoscience Union. All Right Reserved.

Electron scattering by isolated chorus elements observed near the magnetospheric equator

*Satoshi Kasahara[1], Yoshizumi Miyoshi[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Kunihiro Keika[1], Tomoaki Hori[2], Iku Shinohara[5]

1. The university of Tokyo, 2. Nagoya University, 3. Osaka University, 4. Kanazawa University, 5. Institute of Space and Astronautical Science

Theories have predicted significant pitch angle scattering of electron by chorus waves via cyclotron resonance, resulting in electron precipitation into the atmosphere and consequent auroral illumination. Recent observations of chorus waves at the equator, in conjunction with ground observations, have indicated that even a single chorus element can cause sufficient electron scattering causing auroral flashing. Here we report more direct, in-situ evidence that electrons are indeed scattered into the loss cone up to strong diffusion, by an isolated chorus element. We discuss the scattering rate based on the observed parameters.

Keywords: electron scattering, chorus waves

©2019. Japan Geoscience Union. All Right Reserved.

Continuous precipitation of low-energy electrons associated with pulsating aurora obtained by the Reimei satellite

*Takeshi Sakanoi[1], Fukizawa Mizuki[1], Yoshizumi Miyoshi[2], Yusuke Ebihara[3], Kazushi Asamura[4], Masafumi Hirahara[2]

1. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2. ISEE, Nagoya University, 3. RISH, Kyoto University, 4. ISAS/JAXA

We report the results of event and statistical analyses on continuous precipitation of low-energy electrons associated with pulsating aurora using the data taken by the Reimei satellite. From recent data obtained with a magnetospheric satellite like Arase, it is widely supported that chorus waves interact with plasma sheet electrons that produce diffuse aurora mainly in the post-midnight to morning sectors. In addition, temporal (a few Hz) variation of lower band chorus waves cause modulation of pitch-angle scattering of keV-range electrons that generate pulsating aurora in the ionosphere. On the other hand, such temporal variation is not commonly seen in upper band chorus and electrostatic electron cyclotron harmonic (ECH) waves that expected to interact with lower-energy electrons. However, the characteristics of such low-energy electrons and their relationship to pulsating aurora are not understood.
Reimei is a polar-orbiting sun-synchronous satellite at an altitude of 650 km and obtained simultaneous image and particle data with high-time and spatial resolutions. Thanks to its orbit, Reimei covers wide L-value ranges and measures velocity-dispersed electrons travelling from magnetospheric source region to ionosphere. Miyoshi et al. [2015] showed an event that Reimei observed continuous precipitation of low-energy electrons (mainly in the energy range of hundreds eV) in addition to high energy (more than a few keV) temporal electrons that caused pulsating auroral emission. Here, we investigated the characteristics and generation mechanism of continuous low-energy electron precipitation using all of the electron data (5150 paths) taken by Reimei/ESA from November 2005 to August 2008, and compared the data with simulation results. Event selection criteria are 1) existence of continuous precipitation of low-energy electrons below a few keV range, and 2) high-energy (more than a few keV) electrons that distinguished from the continuous low-energy electrons. We also examined simultaneous auroral image data obtained with Reimei/MAC. Using the criteria, we found 155 events of continuous low-energy electron band. From statistical analysis, the continuous low-energy electron evens occurred in 11 % of total observation paths in the nightside sector, while temporal precipitation of high-energy electrons that produced pulsating aurora appeared in 36 % of total observation paths in the nightside sector. From event analysis for several cases, we found in most cases that energy of continuous low-energy electrons increased from ~200 eV to a few keV as the latitude decreased. However, the electron energy decreased near the lower boundary of plasma sheet. In some cases, multiple electron band structures were seen in the low-latitude region. To understand the characteristics and mechanisms of continuous precipitation of low-energy electrons, we carried out simulations of electron pitch angle scattering with chorus waves and ECH waves, respectively. For the simulation of ECH wave resonance, we calculated wavenumber at ECH wave frequency (e.g., 1.6 fce(cyclotron frequency)) based on the Bernstein mode dispersion relation, and estimated electron energy by the cyclotron resonance equation assuming the electron density with GCPM model and magnetic field with IGRF model. From the comparison between the Reimei data with simulation results, we suggest that latitudinal dependence of low-energy electrons can probably be explained with the chorus wave resonance. The decrease of electron energy near the low-latitude boundary is likely to be caused with decrease of plasma density outside of the plamsapause. On the other hand, we showed the possibility for some cases that low-energy electron precipitations were generated by ECH waves.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: pulsating aurora, inner magnetosphere, Reimei

©2019. Japan Geoscience Union. All Right Reserved.

Origin of energetic electron precipitation with fast fluctuation: Data-driven simulations using the ERG plasma wave observations

*Shinji Saito[1], Yoshizumi Miyoshi[2], Shoya Matsuda[3], Satoshi Kurita[2], Yoshiya Kasahara[4], Atsushi Kumamoto[5], Fuminori Tsuchiya[5], Ayako Matsuoka[3]

1. Graduate School of Science, Nagoya University, 2. ISEE, Nagoya University , 3. ISAS/JAXA, 4. Kanazawa University, 5. Tohoku University

Bursty precipitation of keV electrons can be a source of pulsating aurora which has quasi-periodic on-off switching of luminosity. On the other hand, relativistic electrons also precipitate into the atmosphere with intermittent and bursty nature, which are observed as relativistic electron microbursts. A common cause of the electron bursty precipitation for the pulsating aurora and for the microbursts is expected to be whistler chorus waves propagating along a field line.
In this study, we demonstrate electron precipitation caused by realistic whistler chorus waves using our newly developed test-particle model, GEMSIS-RBW-II simulation code. Wave form data obtained from ERG satellite are applied to the simulation model as a boundary condition at the magnetic equator. The simulation shows that the whistler chorus waves propagating to high magnetic latitudes along the field line can precipitate electrons with energy from keV to MeV. We found that amplitude modulation of a whistler chorus burst observed by ERG causes over ten Hz modulation of keV electron precipitation. At relativistic energies fluctuation with higher frequencies and bursty/intermittent nature appear in time history of precipitation flux. It suggests that whistler chorus bursts can cause electron precipitation associated with pulsating aurora and relativistic electron microbursts.

Keywords: Pulsating Aurora, Relativistic electron microbursts, Whistler chorus bursts, Data-driven test-particle simulation, ERG

©2019. Japan Geoscience Union. All Right Reserved.

Conjugated quasi-periodic ELF/VLF emissions between the Arase satellite and both Van Allen Probes

*Claudia Martinez Calderon[1,2], Frantisek Nemec[3], Kazuo Shiokawa[2], Yuto Katoh[1], Yoshiya Kasahara[4], Shoya Matsuda[2], Fuminori Tsuchiya[1], Atsushi Kumamoto[1], Mariko Teramoto[2], Ayako Matsuoka[5], Yoshizumi Miyoshi[2], Ondrej Santolik[6,3], George Hospodarksy[7]

1. Dept. Geophys., Grad. Sch. Sci., Tohoku University, 2. Instute for Space-Earth Environmental Research, Nagoya University, 3. Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic, 4. Kanazawa University, 5. Japan Aerospace Exploration Agency, 6. Institute of Atmospheric Physics, Prague, Czech Republic, 7. Department of Physics and Astronomy, University of Iowa, USA

Extremely Low (ELF) and Very Low Frequency (VLF) emissions are naturally occurring magnetospheric plasma waves in the frequencies of 3 Hz to 30 kHz. They play a fundamental role in radiation belt dynamics, accelerating or scattering electrons through wave-particle interactions. We report the first quasi-periodic (QP) emission simultaneously observed by the Arase (ERG) satellite and both Van Allen Probes (RBSP). This is one of few known conjugated satellite events where the waves show very similar spectral and temporal features. The event was observed on November 29, 2018 from approximately 11 to 13:30 UT by both RBSP, while ERG observed it from 12 to 14 UT. Using wave analysis, propagation parameters, and intensities simultaneously measured at several locations we will discuss the approximate location of the source region. We will also discuss the eventual timing differences between QP periodicity at different locations. Some slight variation in the spectral shapes is observed. We will discuss possible relationships with the variations of plasma number density, magnetic field, and energetic electron distribution.

Keywords: conjugated event, VLF, QP, Arase, RBSP, plasma waves

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

convener:Toshimori Sekine(Center for High Pressure Science and Technology Advanced Research), Takuo Okuchi(Institute for Planetary Materials, Okayama University), Chairperson:Toshimori Sekine(HPSTAR & Osaka University), Ai-Cheng Zhang(Nanjing University)

Impact phenomena had played essential roles in the process of planetary evolution. Recent analytical and experimental developments reveal a new prospective on the effects of shock-compression process for planetary materials. For deeper understanding of such shock effects, it is necessary to evaluate the detailed shock conditions from the observations of naturally-shocked planetary materials, and to compare them with the results on the planetary materials experienced a wide range of known shock conditions. Several metastable phases, that have not been known before, have recently been identified in shocked meteorites. They suggest that the shock state is often not in equilibrium and that it is more complicated process than ever thought. Experimental techniques including laser-driven shock compression and x-ray free electron laser diagnostics have been progressed to successfully simulate a wide range of shock conditions. The recent results indicate that shocked grains are fractured and rotated at relatively low pressures, and that they are subsequently transformed into denser phases or melts, or their mixtures at pressures of a few 100s GPa. Understanding of such shock dynamics requires another prospect, which is qualitatively different from the static high pressure and high temperature consensus. Therefore, it is timely to have an international symposium on dynamics of planetary materials.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PCG22-01] Shock-induced phase transformation in howardite-eucrite-diogenite meteorites

★Invited Papers

*Ai-Cheng Zhang[1,2], De-Liang Chen[1], Run-Lian Pang[1] (1.School of Earth Sciences and Engineering, Nanjing University, China, 2.CAS Center for Excellence in Comparative Planetary, China)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PCG22-02] Lattice-shear-induced metastable formation of high-pressure silicates in shocked meteorites

★Invited Papers

*Naotaka Tomioka[1], Takuo Okuchi[2], Masaaki Miyahara[3] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.Institute for Planetary Materials, Okayama University, 3.Department of Earth and Planetary Systems Science, Hiroshima University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PCG22-03] Can high-pressure polymorphs clarify an ordinary chondrite parent-body breakup?

*Masaaki Miyahara[1], Akira Yamaguchi[2], Masato Saitoh[1], Kanta Fukimoto[1], Takeshi Sakai[3], Hiroaki Ohfuji[3], Naotaka Tomioka[4], Yu Kodama[5], Eiji Ohtani[6] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.National Institute of Polar Research, 3.Geodynamics Research Center, Ehime University, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 5.Marine Works Japan, 6.Department of Earth Sciences, Graduate School of Science, Tohoku University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PCG22-04] Linking occurrence and texture of dense silicate minerals in shocked meteorites with laser-shock experimental results of Mg_2SiO_4 analyzed by XFEL probe

*Takuo Okuchi[1], Narangoo Purevjav[1], Norimasa Ozaki[2], Takeshi Matsuoka[2], Yusuke Seto[3], Yoshinori Tange[4], Toshinori Yabuuchi[5], Naotaka Tomioka[6], Toshimori Sekine[7], Ryosuke Kodama[2] (1.Institute for Planetary Materials, Okayama University, 2.Graduate School of Engineering, Osaka University, 3.Graduate

School of Science, Kobe University, 4.Japan Synchrotron Radiation Research Institute, 5.RIKEN Harima Branch, 6.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 7.Center for High Pressure Science and Technology Advanced Research)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PCG22-05] **Laser-shock evolution of organic molecules in carbonaceous meteorite**

*Hikaru Yabuta[1], Hikaru Fujioka[2], Tatsuhiro Sakaiya[2], Tadashi Kondo[2], Sohsuke Ohno[3], Kosuke Kurosawa[3], Toshihiko Kadono[4], Keisuke Shigemori[5], Yoichiro Hironaka[5], Takamitsu Yamanaka[6] (1.Hiroshima University, Department of Earth and Planetary Systems Science, 2.Osaka University, Department of Earth and Space Science, 3.Chiba Institute of Technology, Planetary Exploration Research Center (PERC), 4.University of Occupational and Environmental Health, 5.Osaka University, Institute of Laser Engineering, 6.Center for High Pressure Science & Technology Advanced Research, Shanghai, China)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PCG22-06] Shock barometer using cathodoluminescence and synchrotron angle-dispersive x-ray diffraction analyses of minerals

★Invited Papers

*Masahiro KAYAMA[1] (1.Tohoku University)

Shock-induced phase transformation in howardite-eucrite-diogenite meteorites

*Ai-Cheng Zhang[1,2], De-Liang Chen[1], Run-Lian Pang[1]

1. School of Earth Sciences and Engineering, Nanjing University, China, 2. CAS Center for Excellence in Comparative Planetary, China

Phase transformation is an important type of mineralogical respects to shock metamorphism in planets and asteroids. It has been widely used to constrain the dynamic conditions (pressure-temperature-time, P-T-*t*) of shock events and the mineral constituents in deep planets. In the past decades, shock-induced phase transformation has been extensively studied in shocked ordinary chondrites, martian and lunar meteorites. However, shock-induced phase transformation in howardite-eucrite-diogenite (HED) meteorites was less studied. In the past five years, a few high-pressure minerals (coesite, stishovite, tissintite, vacancy-rich clinopyroxene, super-silicic garnet, grossular, and a new mineral vestaite (TiFe)Ti_3O_9) have been reported in shocked eucrites (Miyahara et al., 2014; Pang et al., 2016, 2018; Fudge et al., 2017). In this study, we report a few new observations about shock-induced phase transformation in HED meteorites and discuss their potential implications for constraining the shock metamorphism of Vesta.

Four eucrite meteorites NWA 8003 (unbrecciated), NWA 2650 (brecciated), NWA 10245 (unbrecciated), and Dhofar 007 (brecciated) and two unbrecciated diogenite meteorites NWA 8321 and NWA 8326 were studied with scanning electron microscopy, Raman spectroscopy, Electron backscatter diffraction, and transmission electron microscopy.

The four eucrite meteorites NWA 8003, NWA 2650, NWA 10245, and Dhofar 007 have a few similar shock-induced features. All of them contain coesite, stishovite, vacancy-rich clinopyroxene, and tissintite. NWA 8003, NWA 2650, and Dhofar 007 also contain super-silicic garnet in shock-induced melt veins; however, no super-silicic garnet was observed in NWA 10245. In NWA 8003, unique Ti-rich melt pockets have been observed and contain ilmenite, vacancy-rich clinopyroxene, vestaite, corundum, and kyanite. In NWA 2650, an oval-shaped region in a super-silicic garnet-dominant shock-induced melt vein contains grossular, kyanite, and silica glass. Some kyanite crystals are present in the interstitial glass between surrounding super-silicic garnet grains. Some of the grossular grains occur as overgrowth on super-silicic garnet. These textures indicate that the grossular + kyanite + silica assemblage has formed through shock-induced melting of anorthite and recrystallization. Reidite was observed as irregular region and lamellae in zircon from NWA 2650. It might have formed through solid-state phase transformation at a pressure >20 GPa.

The two unbrecciated diogenite meteorites have different shock-induced features. NWA 8321 contains shock-induced melt veins which contain some mineral fragments of olivine, and pyroxene. No high-pressure minerals were detected within and adjacent to shock-induced melt veins. However, in NWA 8326, a few high-pressure minerals have been observed. They include stishovite, xieite, reidite, tuite, and tissintite. Stishovite was observed with two different textures. Xieite was observed as brighter lamellae in chromite adjacent to a thin shock-induced melt veins. Reidite mainly occurs as lamellar phase in zircon. The textures indicate that stishovite, xieite, and reidite have formed through solid-state phase transformation. Tissintite was also observed, closely adjacent to a shock-induced melt vein. It has probably formed through crystallization from high-pressure and high-temperature melt.

©2019. Japan Geoscience Union. All Right Reserved.

Our new observations reveal that shock-induced phase transformation in HED meteorites are more common than previous thought. Most of these HED meteorites have experienced a low to moderate degree of shock metamorphism. However, the presence of reidite and xieite indicates that some of the HED meteorites (NWA 2650 and NWA 8326 have experienced severe shock metamorphism. Generally, the diversity of high-pressure minerals in HED meteorites is consistent with the relatively low impact velocities in the main asteroid belt. In addition, compared to severe shock metamorphism in ordinary chondrites, martian and lunar meteorites, the high-pressure minerals in HED meteorites open a new window to study low to moderate shock metamorphism.

This work is financially supported by NSFC (grant 41673068) and NSF of Jiangsu Province of China (BK20170017).

Keywords: High-pressure minerals, Shock metamorphism, HED meteorites, Vesta

©2019. Japan Geoscience Union. All Right Reserved.

Lattice-shear-induced metastable formation of high-pressure silicates in shocked meteorites

*Naotaka Tomioka[1], Takuo Okuchi[2], Masaaki Miyahara[3]

1. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2. Institute for Planetary Materials, Okayama University, 3. Department of Earth and Planetary Systems Science, Hiroshima University

Heavily shocked meteorites contain various types of high-pressure polymorphs of silicate minerals. These high-pressure minerals are micron to submicron sized and occurred within and in the vicinity of shock-induced melt in stony meteorites. Their occurrence suggests two types of formation mechanisms: (1) solid-state high-pressure transformation of the host-rock minerals into monomineralic polycrystalline aggregates, and (2) crystallization of chondritic or monomineralic melts under high pressure [1]. In some cases of the former process, high-pressure minerals occur as coherent lamellae within grains of the host low-pressure minerals. A typical example is the (Mg,Fe)SiO_3pyroxene-akimotoite intergrowth in the Tenham meteorite [2]. The akimotoite has relatively high Fe content [Fe/(Mg+Fe)=0.21] but does not have its stability field at any P-T conditions [3]. Therefore, the akimotoite would have been formed metastably due to a rapidly-changing P-T history in the shock event. As another example, a new high-pressure polymorph of olivine, which has been defined as “ε-phase” with a spinelloid structure, was recently discovered as nano-scale lamellae in ringwoodite [$(Mg,Fe)_2SiO_4$-spinel] and wadsleyite [$(Mg,Fe)_2SiO_4$ -spinelloid] grains in Tenham and Miami meteorites, respectively [4]. The phase has never been observed in previous phase equilibrium studies. Both pyroxene-akimotoite and ringwoodite/wadsleyite-ε-phase intergrowths have topotaxy with preserving close-packed oxygen layers for their respective structures. The crystallographic relationships between these host and the product phases suggest that these polymorphic phase transformations are promoted by shear mechanism [5]. This process is achieved by shear deformation of oxygen sublattice associating movements of interstitial cations within single unit-cell dimension. Therefore, shear mechanism is considered to be a favorable mechanism under high differential stress, or under relatively low-temperatures, where atomic diffusion is kinetically hindered. Future experimental studies, which include ultrafast in-situ X-ray diffraction under laser shock compression, and high-resolution electron microscopy on recovered specimens of static high-pressure experiments, would contribute to better understanding of detailed structural changes in naturally shocked samples.

References: [1] Tomioka & Miyahara (2017) *Meteorit. Planet. Sci.*,52, 2017–2039. [2]Tomioka & Fujino (1999) *Amer. Mineral.*, 84, 267–271. [3] e.g. Ito & Yamada (1982) in*High-Pres. Res. Geophys.*, 405–419.[4] e.g. Tomioka & Okuchi (2017) *Sci. Rep.*, 7, 17351. [5] Tomioka (2007) *J. Mineral. Petrol. Sci.* ,102, 226–232.

Keywords: shock metamorphism, meteorites, transformation mechanisms, high-pressure minerals

©2019. Japan Geoscience Union. All Right Reserved.

Can high-pressure polymorphs clarify an ordinary chondrite parent-body breakup?

*Masaaki Miyahara[1], Akira Yamaguchi[2], Masato Saitoh[1], Kanta Fukimoto[1], Takeshi Sakai[3], Hiroaki Ohfuji[3], Naotaka Tomioka[4], Yu Kodama[5], Eiji Ohtani[6]

1. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2. National Institute of Polar Research, 3. Geodynamics Research Center, Ehime University, 4. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 5. Marine Works Japan, 6. Department of Earth Sciences, Graduate School of Science, Tohoku University

An ordinary chondrite is the biggest clan in the meteorites. The ordinary chondrites are the building blocks of an ordinary chondrite parent-body that broke up by an impact in the solar nebula. The breakup process of the ordinary chondrite parent-body is one of the intriguing conundrums. Most ordinary chondrites have evidence for the impact event. Shock-induced melting textures and high-pressure polymorphs are the most distinct clues for the impact event. Chen et al. (1996) suggested that the high-pressure polymorphs occurring in the shock-induced melt can be a clue for clarifying the impact event occurred on the parent-body because we can constrain several parameters for the impact such as shock pressure and impact velocity based on the formation conditions of the high-pressure polymorph assemblage. Accordingly, many previous studies have worked on the high-pressure polymorphs in the ordinary chondrites for several decades. Most previous investigations have focused on the L6 chondrite because the meteorite type is abundantly recovered on the Earth. On the other hand, few previous studies have worked on other petrologic types such as L5 and L4. The inventories of the high-pressure polymorphs in shocked H- and LL-group ordinary chondrites have been barely described. The ordinary chondrite parent-body is expected to have an onion shell-like structure. H-, L-, and LL-group ordinary chondrites originate from their individual parent-bodies. We have to clarify the inventories of the high-pressure polymorphs included in all petrologic types and groups to elucidate the breakup processes of the ordinary chondrite parent-bodies. Accordingly, we initiated the systematic investigations of the high-pressure polymorphs included in the shocked ordinary chondrites. About sixty H-group, eighty L-group, and fifty LL-group ordinary chondrites with the shock-induced melting textures were systematically investigated by SEM and Raman spectrometer. There was the distinct difference in the modes of shock-induced melting between petrologic type 3–4 and type 5–6 in all groups. In the petrologic type 3–4, the melting occurred at the boundaries between the chondrules and surrounding matrices as a melt-pocket. In the petrologic type 5–6, melting occurred as isolated veins or networks. There was also a clear difference in abundance of the high-pressure polymorphs among H-, L-, and LL-groups: the high-pressure polymorphs are abundant in L- and LL-groups, whereas rare in H-group. The species and assemblages of the high-pressure polymorphs depended on the petrologic types. The abundance and assemblages of the high-pressure polymorphs in L- and LL-group were similar to each other, suggesting that both parent-bodies have similar impact histories. The shock-pressure conditions were estimated based on the identified high-pressure polymorph assemblages: from ~13 to ~24 GPa for L/LL6, from ~3 to ~12 GPa for L/LL4 and L/LL5, and less than ~3 GPa for L/LL3. When we adopted the estimations into the onion-shell-structured parent-body, the shock pressure condition on the parent-body surface is much lower than its interior, which is unlikely for a head-on impact. We cannot explain the parent-body breakup phenomenon based only on the estimation using the high-pressure polymorphs. There are clear differences on their petrographic structures between type 3–4 and type 5–6: the former consists of accumulated chondrules and the latter has equilibrated texture. It is also expected that type 3–4 and type 5–6 chondrites have different initial density and porosity. These differences will affect the

©2019. Japan Geoscience Union. All Right Reserved.

response to the shock metamorphism. Unless we take these factors into the estimation, we cannot clarify the parent-body breakup phenomenon by using the high-pressure polymorphs.

Reference: Chen et al. Science 271: 1570–1573 (1996)

Keywords: Shock, Ordinary chondrite, High-pressure polymorph

©2019. Japan Geoscience Union. All Right Reserved.

Linking occurrence and texture of dense silicate minerals in shocked meteorites with laser-shock experimental results of Mg_2SiO_4 analyzed by XFEL probe

*Takuo Okuchi[1], Narangoo Purevjav[1], Norimasa Ozaki[2], Takeshi Matsuoka[2], Yusuke Seto[3], Yoshinori Tange[4], Toshinori Yabuuchi[5], Naotaka Tomioka[6], Toshimori Sekine[7], Ryosuke Kodama[2]

1. Institute for Planetary Materials, Okayama University, 2. Graduate School of Engineering, Osaka University, 3. Graduate School of Science, Kobe University, 4. Japan Synchrotron Radiation Research Institute, 5. RIKEN Harima Branch, 6. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 7. Center for High Pressure Science and Technology Advanced Research

Primitive meteorites often show features of shock metamorphism, including occurrences of dense polymorphs of major mineral phases. By previous transmission electron microscopy studies it was demonstrated that olivine (alpha-Mg_2SiO_4) often had transformed into its denser polymorphs such as ringwoodite (gamma-Mg_2SiO_4), and as a recently-discovered new structure (epsilon-Mg_2SiO_4: Tomioka and Okuchi, Sci. Rep. 2017). The impact events that produced these polymorphs played essential roles in the history of early solar system evolution. Here we tried to reproduce such a dynamic transformation process starting from forsterite olivine single crystals by using very strong laser beam and x-ray free electron laser (XFEL) beam in combination at SACLA, SPring-8, Japan. A transformation process has been successfully observed with sub-nanosecond resolution by x-ray diffraction using femtosecond XFEL pulses. We discovered an ultrafast transformation process completing only within few nanoseconds, which was not expected to occur during shock metamorphism of meteorites. It can be a shear-induced fast lattice slipping proceeding without any atomic diffusion process. We conclude that formation processes and environments of some of dense Mg_2SiO_4 polymorphs in heavily shocked meteorites are needed to be reconsidered to involve this fast process.

Keywords: dense silicate minerals, laser shock experiments, shock metamorphism, Mg2SiO4

©2019. Japan Geoscience Union. All Right Reserved.

Laser-shock evolution of organic molecules in carbonaceous meteorite

*Hikaru Yabuta[1], Hikaru Fujioka[2], Tatsuhiro Sakaiya[2], Tadashi Kondo[2], Sohsuke Ohno[3], Kosuke Kurosawa[3], Toshihiko Kadono[4], Keisuke Shigemori[5], Yoichiro Hironaka[5], Takamitsu Yamanaka[6]

1. Hiroshima University, Department of Earth and Planetary Systems Science, 2. Osaka University, Department of Earth and Space Science, 3. Chiba Institute of Technology, Planetary Exploration Research Center (PERC), 4. University of Occupational and Environmental Health, 5. Osaka University, Institute of Laser Engineering, 6. Center for High Pressure Science & Technology Advanced Research, Shanghai, China

It has been hypothesized that extraterrestrial organic compounds were delivered to the early Earth by meteorites and comets during the Late Heavy Bombardment (LHB). There have been several experiments that simulated the shock synthesis of organic compounds during the LHB. However, in the past studies using gas guns, it is difficult to perform an open system experiment at higher impact velocities than Earth’ s escape velocity (> 17 km/s). In order to understand what compositions of meteoritic organic molecules were produced by the shock energy of LHB and delivered to the Earth, we carried out a high power laser compression experiment (up to 400 GPa) of carbonaceous chondritic meteorite, which contains 2wt% of organic carbon.

Pellets of Murchison carbonaceous meteorite was prepared by diamond anvil cell, respectively. Pellets of the meteorites in 3mm diameter and 1mm thickness were prepared. The titanium foil was located in front of the sample as the ablator for the laser and for preventing the sample from blowing out. The laser-shock experiment was carried using GEKKO XII/HIPER laser system, Institute of Laser Engineering, Osaka University. The laser wavelength, pulse width, and spot diameter were 1053 nm, ~20 ns, and ~0.4 mm, respectively. The shock pressures were 20, 50, and 400 GPa. The collected meteorite samples were extracted with dichloromethane and methanol. The extracts were concentrated and analyzed by a gas chromatography coupled with mass spectrometry (GCMS).

Molecular compositions of polycyclic aromatic hydrocarbons (PAHs) in Murchison meteorite are not changed before and after the shock experiment at 20 GPa, except that the concentration of naphthalene was depleted. At 50 and 400 GPa, the concentrations of pyrene and fluoranthene increased, while those of biphenyl, fluorenone, and anthracene decreased. Molecular compositions of *n*-alkanes (C_{14} –C_{24}) are not largely changed before and after the shock experiment at 20 GPa. However, at 50 GPa, the concentrations of short chain *n*-alkanes (C_{14} - C_{17}) decreased and those of long chain *n*-alkanes (C_{18} - C_{24}) relatively increased. These results indicate that impact processes promote aromatic ring condensation and elongation of carbon chains of *n*-alkanes.

Keywords: High-power laser, Organic compounds in meteorites, Astrobiology

©2019. Japan Geoscience Union. All Right Reserved.

Shock barometer using cathodoluminescence and synchrotron angle-dispersive x-ray diffraction analyses of minerals

*Masahiro KAYAMA[1]

1. Tohoku University

A part of meteorites record collisional history of asteroidal and cometary impacts. Impactites were created in impact craters by the shock event on the Earth. These materials provide vital information on collision and accumulation processes of asteroid and planet and ejection process from the parent body. The shock pressure is one of the most important parameters to interpret these impact history. Various techniques such as optical and electron microscopy and infrared adsorption and Raman spectrometry have been applied for minerals (e.g., feldspar and silica minerals) in meteorites and impactites to estimate the shock pressure that occurs on the Earth, Moon, and Mars. Although there are many works to evaluate the shock pressure using these techniques, quantitative estimation of a wider dynamic range of shock pressure has not been possible for a micrometer-sized grain to date. Here, cathodoluminescence (CL) and synchrotron angle-dispersive x-ray diffraction (SR-XRD) of experimentally shocked feldspars and quartz and these minerals in meteorite and impactite have been investigated to establish a new shock barometer.

Shock experiments were performed for single crystals of synthetic and terrestrial quartz and terrestrial feldspars at the National Institute for Material Science using a one stage propellant gun. Quartz in an impactite from the Chicxulub crater and alkali feldspar and plagioclase in martian meteorites (NWA 2975, Shergotty, Dhofar 019, and Zagami) were selected here. CL spectroscopy of these samples was conducted at Okayama University of Science. SR-XRD was measured for the powder samples at KEK Photon Factory (PF; beam line: PF BL-4B2).

CL spectra of unshocked feldspars (starting material for the shock recovery experiments) consist of blue, yellow, and/or red emission bands in the wavelength range from 300 to 800 nm. The ultraviolet (UV) to blue emission bands at 330 and 380 nm were obtained from CL spectra of only experimentally shocked feldspars at 20 to 40 GPa. The intensities of all UV-blue emissions correlate positively with the shock pressure. Similar UV-blue emission bands were recognized in CL spectra of the shock-induced feldspar glasses in the martian meteorites and impactites.

CL spectra of unshocked synthetic and terrestrial quartz show an extremely weak blue emission band at 400 nm. The blue emission band was also detected in CL spectra of the experimentally shock recovered samples at 5 to 40 GPa and quartz in the impactite, whereas their blue emission intensities are obviously higher than those of the unshocked quartz. The blue emission intensities increase with the pressure due to shock experiments gradually from 5 to 15 GPa and drastically from 20 to 40 GPa. These correlations obtained from CL spectra of experimentally shocked feldspar and quartz would give quantitative values of the shock pressures that the minerals in martian meteorites and impactite have experienced. Therefore, the CL intensity of feldspar has a potential for a shock barometer with high spatial resolution.

SR-XRD analyses of experimentally shocked quartz demonstrated that the diffraction peaks increase in the intensity and become broader with increasing the shock pressure in the range from 5 to 30 GPa. At the shock pressure above 35 GPa, diffraction peak of quartz was no longer undetectable from the pattern, implying its complete amorphization. Moreover, several crystal planes exhibit peak shifts with the pressure in the pressure range from 15 to 30 GPa. Furthermore, the shock experiments enhance micro strain and

©2019. Japan Geoscience Union. All Right Reserved.

reduce crystallite size. This fact indicates that the shock-induced amorphization was initiated by lattice distortion and structural defects induced by shock compression. The SR-XRD response to the shock pressure suggests the possibility of shock barometer using SR-XRD method, at least in the range from 15 to 30 GPa.

Keywords: Shock impact, Feldspar, Quartz, Cathodoluminescence, Synchrotron angle-dispersive x-ray diffraction

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

convener:Toshimori Sekine(Center for High Pressure Science and Technology Advanced Research), Takuo Okuchi(Institute for Planetary Materials, Okayama University), Chairperson:Takuo Okuchi(Okayama University), Yongjae Lee(Yonsei University)

Impact phenomena had played essential roles in the process of planetary evolution. Recent analytical and experimental developments reveal a new prospective on the effects of shock-compression process for planetary materials. For deeper understanding of such shock effects, it is necessary to evaluate the detailed shock conditions from the observations of naturally-shocked planetary materials, and to compare them with the results on the planetary materials experienced a wide range of known shock conditions. Several metastable phases, that have not been known before, have recently been identified in shocked meteorites. They suggest that the shock state is often not in equilibrium and that it is more complicated process than ever thought. Experimental techniques including laser-driven shock compression and x-ray free electron laser diagnostics have been progressed to successfully simulate a wide range of shock conditions. The recent results indicate that shocked grains are fractured and rotated at relatively low pressures, and that they are subsequently transformed into denser phases or melts, or their mixtures at pressures of a few 100s GPa. Understanding of such shock dynamics requires another prospect, which is qualitatively different from the static high pressure and high temperature consensus. Therefore, it is timely to have an international symposium on dynamics of planetary materials.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PCG22-07] Dynamic Compression at Pohang X-ray Free Electron Laser Facility (PAL-XFEL)

★Invited Papers

*Yongjae Lee[1] (1.Yonsei University, Seoul, Korea)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PCG22-08] Exploration of extreme melt states of silicate usign high-power laser and XFEL

★Invited Papers

*Norimasa Ozaki[1] (1.Osaka University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PCG22-09] Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

*Yuhei Umeda[1], Norimasa Ozaki[1], Toshimori Sekine[2], Bruno Albertazzi[3], Alessandra Benuzzi-Mounaix[3], Riccardo Bolis[3], Marco Guaruaglini[3], Kento Katagiri[1], Kodama Ryosuke[1], Michel Koeing[3], Kohei Miyanishi[4], Shintaro Morioka[1], Toyohito Nishikawa[1], Syugo Ohi[5], Alessandra Ravasio[3], Yoichi Sakawa[4], Takayoshi Sano[4], Tomoko Sato[6] (1.Graduate School of Engineering, Osaka Univ., 2.Center for High Pressure Science & Technology Advanced Research, 3.Ecole Polytechnique, 4.Institute of Laser Engineering, Osaka University, 5.Shiga Univ., 6.Graduate School of Science, Hiroshima University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PCG22-10] **An experimental design to determine iron melting at the Earth's core conditions via in-situ X-ray diffraction technique at high power laser facility**

★Invited Papers

*Hao Liu[1] (1.Laser fusion research center)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PCG22-11] **Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique**

*Kohei Miyanishi[1], Norimasa Ozaki[2], Satoshi Ohmura[3], Marion Harmand[4], Andy Krygier[5], Toyohito Nishikawa[2], Yuhei Umeda[2], Shigemori Keisuke[1], Youichi Sakawa[1], Takayoshi Sano[1], Ryosuke Kodama[1,2] (1.Institute for Laser Engineering, Osaka University, 2.Graduate school of engineering, Osaka University, 3.Faculty of Engineering, Hiroshima Institute of Technology, 4.IMPMC, Sorbonne Université, 5.LLNL)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PCG22-12] **Laser shock compression in LFRC**

*Liang Sun[1] (1.Laser Fusion Research Center, CAEP)

Dynamic Compression at Pohang X-ray Free Electron Laser Facility (PAL-XFEL)

*Yongjae Lee[1]

1. Yonsei University, Seoul, Korea

We have successfully commissioned dynamic compression studies at the Pohang X-ray Free Electron Laser facility (PAL-XFEL) in Korea by utilizing instrumentations at FXS (Femtosecond X-ray Scattering) –XSS (X-ray Scattering and Spectroscopy) beamline. As the first experiment, a polycrystalline iron foil has been illuminated by an 800 nm wavelength uncompressed optical laser with ~6 mJ in 150 ps pulse length, focused onto a 100 mm FWHM spot. The shock-compressed sample has then been probed by ca. 50 fs quasi-monochromatic (bandwidth 0.4%) X-ray pulse at an energy of ~10 keV with 10^{11} photons per pulse, focused to ca. 30 mm diameter using a CRL optics. The sample is positioned normal to the X-ray pulse at a distance of ca. 12 cm from a Rayonix mx225 detector in a way to cover 2q angles up to ca. 65 degrees. Single-shot diffraction measurements were performed with ca. 100 ps. increment up to one nanosecond. We demonstrate that PAL-XFEL can provide a unique opportunity in probing ultrafast lattice dynamics with sufficient spatial and temporal resolution in intermediate pressure regime.

Keywords: dynamic compression, laser shock, iron, X-ray free electron laser

©2019. Japan Geoscience Union. All Right Reserved.

Exploration of extreme melt states of silicate usign high-power laser and XFEL

*Norimasa Ozaki[1]

1. Osaka University

Recent experimental studies on silicate using high-power lasers and XFEL are reviewed.

Keywords: Shock compression, High power laser, Silicate, X-ray free electron laser

©2019. Japan Geoscience Union. All Right Reserved.

Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

*Yuhei Umeda[1], Norimasa Ozaki[1], Toshimori Sekine[2], Bruno Albertazzi[3], Alessandra Benuzzi-Mounaix[3], Riccardo Bolis[3], Marco Guaruaglini[3], Kento Katagiri[1], Kodama Ryosuke[1], Michel Koeing[3], Kohei Miyanishi[4], Shintaro Morioka[1], Toyohito Nishikawa[1], Syugo Ohi[5], Alessandra Ravasio[3], Yoichi Sakawa[4], Takayoshi Sano[4], Tomoko Sato[6]

1. Graduate School of Engineering, Osaka Univ., 2. Center for High Pressure Science & Technology Advanced Research, 3. Ecole Polytechnique, 4. Institute of Laser Engineering, Osaka University, 5. Shiga Univ., 6. Graduate School of Science, Hiroshima University

Two magnesium silicates of $MgSiO_3$(Enstatite) and Mg_2SiO_4(Forsterite) are primary mantle constitutions in the Earth and major components in Earth-type exoplanets.The ordinary chondrite, which accounts for about 90 % of all flying meteorites, consists of silicates as main components. The impacts at collision velocities exceeding 10 km/s are known as common events in the universe and such high energy phenomena could have played an important role to form planets or planetesimals and to evolve planetary environments. For example, a large-scale impact such as the giant impact related to the formation of moon was estimated to be at impact velocity of 15-20 km/s [Melosh, 1990].

In this study, Hugoniot equation of state (EOS) of enstatite has been determined at pressures of ~400 to 560 GPa by laser shock experiments. A coupling of both the present study and the previous data by Fratanduono et al. (2018) shows a discontinuity in the shock velocity-particle velocity at ~380-400 GPa. The measured reflectivity of shocked enstatite indicates three different trends relative to that of quartz; less steep slope at 300-345 GPa, parallel at 345-400 GPa, and a rapid increasing above ~400 GPa, suggesting different phases of enstatite melt, a mixture of metal-like liquid of $SiO_2$and crystalline MgO, and fluid-like enstatite melt above ~380 GPa. We also calculated the release state of thin enstatite using quartz on it as a reference. These results on enstatite imply that reactions in silicate magma occur at pressures of 300-400 GPa and that they may affect the current planet formation model in terms of the stratification of interior, the mantle convection, and the formation of magnetic field in Super-Earths.

©2019. Japan Geoscience Union. All Right Reserved.

An experimental design to determine iron melting at the Earth’s core conditions via in-situ X-ray diffraction technique at high power laser facility

*Hao Liu[1]

1. Laser fusion research center

Phase diagram of iron at the Earth’s core conditions is mandatory for determining the states at the core boundaries and the crystal structure of the solid core. Up to date, the iron phase diagram at high pressure has been investigated experimentally by both static compression (diamond-anvil cell) and dynamic compression (shock wave) techniques. However, the discrepancies among different researches on melting line of iron are still irreconciled. Combining in-situ transient X-ray diffraction and laser compression technique, we propose an investigation which could determine the melting line of iron or the high-pressure high-temperature phase from the lattice level. In this research, high power lasers are applied to drive the iron into melting state. X-ray diffraction pattern interpretation and the criteria for judging iron melting are of great importance. Traditionally, the existence of diffraction peak is used as the only criteria to determine if melting occurs. Nevertheless, this is not enough for shock loading with high heating rate, where the pre-melting or superheating phenomenon occurs. Under these conditions, the diffraction peaks could either disappear at temperature below the melting line or remain even above the melting line. This could lead to misinterpretation for melting temperature. However, the two-dimensional shape of diffraction pattern will change. When melting initiates, the shear modulus of the highly stressed material disappears and the diffraction pattern changes into an ideally circled shape. Therefore, with the information of two-dimensional diffraction pattern, we can make the melting criteria, from the lattice level, more sound and clear. This method could provide experimental judgment with higher precision, which might reconcile the discrepancies on melting temperature of iron at the Earth’s core conditions.

Keywords: laser shock, in-situ x-ray diffraction, iron melting, earth core

©2019. Japan Geoscience Union. All Right Reserved.

Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique

*Kohei Miyanishi[1], Norimasa Ozaki[2], Satoshi Ohmura[3], Marion Harmand[4], Andy Krygier[5], Toyohito Nishikawa[2], Yuhei Umeda[2], Shigemori Keisuke[1], Youichi Sakawa[1], Takayoshi Sano[1], Ryosuke Kodama[1,2]

1. Institute for Laser Engineering, Osaka University, 2. Graduate school of engineering, Osaka University, 3. Faculty of Engineering, Hiroshima Institute of Technology, 4. IMPMC, Sorbonne Université, 5. LLNL

Information on the thermal and electrical transport properties of iron alloys under high-pressure and high-temperature conditions corresponding to the earth’ s outer core is necessary to clarify the convection phenomena of the earth and the cooling history. In particular, the transport properties in the outer core–mantle boundary condition strongly influence the mantle convection, the outer core convection generating the earth's magnetic field, the growth and inner flow of the inner core, and so on. However, there are very few experimental examples concerning high-pressure and high-temperature liquid iron/iron-alloy which correspond to the outer core conditions, and only a few cases have been reported for pure iron [1]. It is required to investigate transport coefficients of liquid iron alloys containing light elements to simulate actual outer core, experimentally. Laser shock compression technique has several advantages to exploring iron-alloys under high-pressure and high-temperature condition. As there is no mechanical restriction on pressure generation, producing the pressure of even TPa is easy, and high heating rate exceeding 10^{15}K / s is possible, and it is a closed system that is not affected by surroundings. Therefore the technique is effective for generation and observation of high-pressure and high-temperature liquid iron-alloys. In this research, we report optical reflectivity, pressure and temperature measurements of laser shock compressed iron and iron-silicon (Fe-Si) alloy at and above the earth's outer core conditions.

Target assemblies containing polypropylene (CH), aluminum, quartz, iron or iron-silicon alloy and magnesium oxide (MgO) window were shock compressed by laser ablation at the GEKKO XII laser facility, the Institute of Laser Engineering, Osaka University. Iron and iron-silicon alloy were formed by electron beam evaporation on the MgO window. Laser beams with a wavelength of 527 nm were focused onto the target. A focal spot was 1 mm in diameter with a flat-top spatial intensity distribution resulting in a planar shock front. Temporal shape of the laser pulse was approximately a flat-top with a full-width at half-maximum of 2.5 ns. The velocity interferometer system for any reflector (VISAR) measure a particle velocity and a reflectivity at the interface between iron or iron-silicon alloy and MgO. The Ppressure was evaluated using measured particle velocity and a known equation of state of MgO[2]. The optical pyrometer measures the temperature at the interface through the MgO window.

The pressures determined from the measurement results were from 200 to 400 GPa, and the temperatures were up to 15000 K. In the pressure range exceeding 200 GPa, in the case of iron, a decrease in reflectivity was observed as the pressure increased, whereas in the case of the iron-silicon alloy, a continuous increase following a discontinuous decrease in the reflectivity was observed. The decrease in reflectivity of iron suggests a decrease in electronic conductivity due to temperature rise with increasing pressure. On the other hand, the continuous rise seems to indicate an increase in the density of free electrons derived from silicon.

©2019. Japan Geoscience Union. All Right Reserved.

[1] K. Ohta, Y. Kuwayama, K. Hirose, K. Shimizu, Y. Ohisi: Nature, 534, 95-98 (02 June 2016).

[2] S. Root, L. Shulenburger, R. W. Lemke et al.: Phys. Rev. Lett, 115, 198501 (2015).

Keywords: iron alloy

©2019. Japan Geoscience Union. All Right Reserved.

Laser shock compression in LFRC

*Liang Sun[1]

1. Laser Fusion Research Center, CAEP

Shock compression is a major technique used for achieving high pressures dynamically. High-powered lasers are increasingly being used for dynamic loading of materials, especially for extreme high pressure. Ramp loading, a series of weak compress waves, is an another advantage for laser-based dynamics, which can be realized easily by the laser pulse shape and can be applied to compress material in much lower temperature under exoplanetary condition. In this talk, we will present our shock loading and X-Ray diagnostics abilities in LFRC and our shock experiment results. Our research progress will also be mentioned, especially in laser shock compression of iron and ramp compression of Al to 420 GPa. Several problems in the mineralogy of Super-Earth planets will also be mentioned in the end of this talk.

Keywords: laser shock compression, ramp compression, High-powered lasers

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 104 1F

[A-AS03] Large-scale moisture and organized cloud systems

convener:Hiroaki Miura(The University of Tokyo), Atsushi Hamada(University of Toyama), Satoru Yokoi(Japan Agency for Marine-Earth Science and Technology), Masaki Satoh(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Hiroaki Miura

Water vapor plays a significant role in regulating the global atmospheric circulation, especially in the troposphere. The overturning circulation is directly driven by the longwave radiative cooling of water vapor and the latent heating/cooling through microphysical processes to balance it. This global circulation is composed of diverse atmospheric phenomena with various spatial and temporal scales. Developments of some significant turbulent motions such as 3D isotropic turbulence in clouds, stratocumulus and cumulus convection, squall lines and tropical cyclones, and the Madden-Julian oscillation, are essentially associated with moisture anomaly in each scale. Moisture is accumulated relatively slowly in larger horizontal scales, but is consumed relatively quickly in smaller ones. This significant scale gaps between the accumulation and consumption may be one of the causes of the long-lasting difficulty in developing the theory of the moist atmosphere. The aim of this session is to share the recent researches about the relationships between moisture and organized cloud systems in wider spatial and temporal scales to enhance collaborations between modeling, observational, and theoretical approaches in tackling this challenging task. Research results relating to the Years of the Maritime Continent (YMC) and Radiative-Convective Equilibrium Model Intercomparison Project (RCEMPI) are welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS03-01] Boundary-Layer Control on Convective Self-Aggregation

★Invited Papers

*Da YANG[1,2] (1.University of California, Davis, 2.Lawrence Berkeley National Laboratory)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS03-02] Statistical Properties of Cumulus Ensembles in High-Resolution Radiative-Convective Equilibrium Simulations

*Tomoro Yanase[1,2], Tetsuya Takemi[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS03-03] **The role of interactive SST in the cloud-resolving simulations of aggregated convection**

★Invited Papers

*Chien-Ming Wu[1], Yan-Ting Chen[1] (1.National Taiwan University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS03-04] **Role of coastal convection to moisture buildup during the South China Sea summer monsoon onset**

*Wei-Ting Chen[1], Wei-Ming Tsai[1,2], Chien-Ming Wu[1], Peng-Jen Chen[1] (1.National Taiwan University, 2.University of Miami)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS03-05] Resolution dependencies of tropical convection in a global cloud/cloud-system resolving model

★Invited Papers

*Tomoki Miyakawa[1], Hiroaki Miura[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Graduate School of Science, The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS03-06] Effects of the local convection over the western Maritime Continent on the large-scale: numerical study during the YMC Sumatra campaigns

*Tomoe Nasuno[1] (1.Japan Agency for Marine-Earth Science and Technology)

Boundary-Layer Control on Convective Self-Aggregation

*Da YANG[1,2]

1. University of California, Davis, 2. Lawrence Berkeley National Laboratory

The atmosphere can self-organize into overturning circulations over an ocean surface with uniform temperature in cloud-resolving models. The upwelling branch is associated with humid air and deep convection; the downwelling branch is associated with dry air and clear sky. This phenomenon is referred to as convective self-aggregation, and understanding this phenomenon can advance our understanding of the Madden-Julian Oscillation (MJO). In this talk, I will introduce a boundary-layer centric framework for self-aggregation. This framework helps explain what leads to self-aggregation, and what sets the spatial scale of self-aggregation.

Reference:
1. Yang, D., 2018: JAS, https://doi.org/10.1175/JAS-D-17-0150.1
2. Yang, D., 2018: JAMES, https://doi.org/10.1029/2017MS001261

Keywords: Convection, Boundary layer, Self-aggregation

©2019. Japan Geoscience Union. All Right Reserved.

Statistical Properties of Cumulus Ensembles in High-Resolution Radiative-Convective Equilibrium Simulations

*Tomoro Yanase[1,2], Tetsuya Takemi[2]

1. Graduate School of Science, Kyoto University, 2. Disaster Prevention Research Institute, Kyoto University

This study investigates the statistical properties of cumulus ensembles in radiative-convective equilibrium states. Numerical experiments were conducted with the use of the non-hydrostatic Weather Research and Forecasting (WRF) model version 3.8.1 at horizontal grid spacing varied from 1600 m to 200 m in an area of $(200\ km)^2$, with an interactive radiative flux calculation scheme. The experiment with the horizontal grid spacing of 200 m successfully reproduced the diurnal variability of the trimodal characteristics of cumulus convection. With the decrease in the horizontal resolution, intermittent deep convection accompanied by the strong updraft and rainfall becomes dominant. The middle-to-upper troposphere appears to become stabler and drier with the decrease in the horizontal resolution. We further analyzed the cloud structures by using a three-dimensional cloud detection method. It is suggested that the vertical structure of in-cloud properties and the vertical development of cumulus ensembles are strongly affected by horizontal scales of microstructure which are constrained by horizontal resolution. Furthermore, it is suggested that the statistical properties of cumulus ensemble such as horizontal distances and size distribution are related to the horizontal heterogeneity of water vapor.

Keywords: Cumulus Convection, Radiative-Convective Equilibrium, WRF

©2019. Japan Geoscience Union. All Right Reserved.

The role of interactive SST in the cloud-resolving simulations of aggregated convection

*Chien-Ming Wu[1], Yan-Ting Chen[1]

1. National Taiwan University

This study investigates the role of interactive SST in the early development of aggregated convection using a vector vorticity equation cloud-resolving model (VVM) coupled to a slab ocean. The simulations are initialized by a mock Walker circulation driven by initial SST gradient in the elongated x-axis, with an average of 300K and sinusoidal variation of amplitude ranging from 1.5K to 3K. According to large-scale perturbation strength, which is caused by SST variation, the results can be divided into two groups. Under weak perturbation, convection-SST feedback efficiently eliminates SST gradient and moisture anomaly. The large-scale environment is homogenized within two days. Even though SST in the group with stronger perturbation undergoes a similar process, significant moist static energy (MSE) advection in the boundary produces enough moisture difference to introduce virtual temperature effect and aggregation is triggered. Once dry zone starts to expand, radiative and convective effects regenerate SST gradient, which intensifies circulation and accelerates the process. We further show that the evolution of aggregation or not is captured by the trend of MSE-EIS variance. The results highlight the boundary layer processes on the formation of aggregated convection in the tropics.

Keywords: boundary layer processes, large-scale moisture, aggregated convection

©2019. Japan Geoscience Union. All Right Reserved.

Role of coastal convection to moisture buildup during the South China Sea summer monsoon onset

*Wei-Ting Chen[1], Wei-Ming Tsai[1,2], Chien-Ming Wu[1], Peng-Jen Chen[1]

1. National Taiwan University, 2. University of Miami

In this study, the climatological characteristics of object-based precipitation systems (OPS) and moisture development are analyzed over the South China Sea (SCS) during the sharp transition of summer monsoon onset. The satellite observed OPS statistics showed that during the pre-onset period, small (<100 km) to medium size (100-300 km) OPS are active over surrounding land, while convection over the ocean is mostly suppressed. During post-onset, large OPS develop over the coastal ocean and contribute to over 60% of the total precipitation. The results suggest that when the convection is strong over the surrounding islands, a local circulation with anomalous subsidence over the ocean can develop and suppress convection. The number of observed large OPS significantly increases along with the sharp moisture buildup during the SCS onset period. The moisture budgets suggested that local contribution from convection vertical mixing is the major moisture source during monsoon onset pentad, while large-scale moisture advection tends to be weak. The relationship between moisture buildup and convection organization is then examined using a set of idealized cloud-resolving model (CRM) experiments, with a land-ocean configuration approximating the SCS basin. The CRM appropriated represents the observed development of coastal convection. With a non-shear environment, the strong basin-scale circulation is formed, which suppresses the ocean moisture development. When large-scale vertical wind shear is imposed to represent the changes of large-scale circulation during the onset pentad, organized convection systems are increased over the coastal ocean and propagate toward the open ocean, accompanied by fast ocean moistening. We identified through the CRM simulations that the moistening time-scale by the transition of coastal convection organization is within 5-10 days.

Keywords: Convective Organization, Coastal convection, Moisture, TRMM, CloudSat, Cloud-Resolving Model

©2019. Japan Geoscience Union. All Right Reserved.

Resolution dependencies of tropical convection in a global cloud/cloud-system resolving model

*Tomoki Miyakawa[1], Hiroaki Miura[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Graduate School of Science, The University of Tokyo

The properties of tropical convection are evaluated using one-month long simulation datasets produced by the non-hydrostatic icosahedral atmospheric model (NICAM) using 3.5-, 7-, and 14-km horizontal meshes with identical cloud-microphysics configurations. The simulations are targeted on the 2nd Madden-Julian oscillation (MJO) event observed in the CINDY2011/DYNAMO field campaign. An increase of high cloud fraction at 200 hPa level and a reduction of surface precipitation occur as the horizontal resolution increases, corresponding to the reduction of precipitation efficiency due to the shorter residence time inside stronger updrafts that occur at the higher resolution. The increase of high cloud fraction is followed by the warming of the troposphere, which results in an increase in the column water vapor and an elevation of the freezing level. The total water condensation is decreased at higher resolutions, which is likely due to a balance with the decreased outgoing longwave radiation (OLR). The reproduced MJOs, which accounted for a large portion of the tropical convections, were similar in the 3.5-km and 14-km simulations in terms of eastward propagation speeds and structures, including the characteristic westward tilt of the moisture anomaly with height. However, the amplitude of the anomalous MJO circulation was considerably smaller in the 3.5-km simulation. The robust resolution dependence and the interpretations presented in this study underline the necessity for a resolution-aware cloud-microphysics optimization method that will have value in the coming era of global cloud-resolving simulations.

Keywords: resolution dependency , global cloud-resolving model, tropical convection

©2019. Japan Geoscience Union. All Right Reserved.

Effects of the local convection over the western Maritime Continent on the large-scale: numerical study during the YMC Sumatra campaigns

*Tomoe Nasuno[1]

1. Japan Agency for Marine-Earth Science and Technology

The effects of the high-frequency variability on the large-scale, including the intraseasonal oscillation (ISO), over the western Maritime Continent (MC), was quantified using the global nonhydrostatic simulation datasets that marginally resolve mesoscale convective systems. Moisture transport during the Years of the Maritime Continent (YMC) winter field campaigns in 2015 and in 2017 were analyzed, focusing on the land-ocean contrast and their relationship with the ISO events.

The period-mean profiles indicate moistening by low-frequency upward motion in the deep troposphere and drying (moistening) in the lower (middle and upper) troposphere by high-frequency variability. The advection over ocean was greater in 2017 than in 2015, with the opposite occurring over land with smaller interannual differences. These can be related to the longer preconditioning period (rapid transition from the preconditioning to the active, and decaying phases) for the 2015 (2017) case, as well as the relatively suppressed (enhanced) upward motion over ocean under the strong El Niño (moderate La Niña) conditions during 2015 (2017).

The dependence of the land-ocean contrast on the ISO life cycle was more significant in 2015 than in 2017. In the 2015 simulation, moistening over land preceded the major convective period of the ISO, whereas that over ocean preceded the ISO convection not longer than 1 week, consistent with the arguments by previous studies based on precipitation observations. In this case, a nearly in-phase relationship between the moisture advection by high-frequency variability and by low-frequency variability was found over land. In the 2017 case, the land-ocean contrast was weak in low-frequency advection. The relationship between moisture advection by high-frequency variability and by low-frequency variability was indistinct over land, whereas clear relationship was seen over ocean: the high-frequency variability induced lower to middle tropospheric moistening (enhanced upward transport of moisture) during the preconditioning (active) phases of the ISO convection, in common with the 2015 case. These results highlight clear land-ocean contrasts in sensitivity of local convection to background states and its link with the ISO life cycle.

Keywords: Years of the Maritime Conrtinent (YMC), scale interaction, intraseasonal oscillation (ISO), moisture advection, global cloud-system-resolving simulations

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 104 1F

[A-AS03] Large-scale moisture and organized cloud systems

convener:Hiroaki Miura(The University of Tokyo), Atsushi Hamada(University of Toyama), Satoru Yokoi(Japan Agency for Marine-Earth Science and Technology), Masaki Satoh(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Satoru Yokoi

Water vapor plays a significant role in regulating the global atmospheric circulation, especially in the troposphere. The overturning circulation is directly driven by the longwave radiative cooling of water vapor and the latent heating/cooling through microphysical processes to balance it. This global circulation is composed of diverse atmospheric phenomena with various spatial and temporal scales. Developments of some significant turbulent motions such as 3D isotropic turbulence in clouds, stratocumulus and cumulus convection, squall lines and tropical cyclones, and the Madden-Julian oscillation, are essentially associated with moisture anomaly in each scale. Moisture is accumulated relatively slowly in larger horizontal scales, but is consumed relatively quickly in smaller ones. This significant scale gaps between the accumulation and consumption may be one of the causes of the long-lasting difficulty in developing the theory of the moist atmosphere. The aim of this session is to share the recent researches about the relationships between moisture and organized cloud systems in wider spatial and temporal scales to enhance collaborations between modeling, observational, and theoretical approaches in tackling this challenging task. Research results relating to the Years of the Maritime Continent (YMC) and Radiative-Convective Equilibrium Model Intercomparison Project (RCEMPI) are welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AAS03-07] A Mechanism for the Maintenance of Sharp Tropical Margins

★Invited Papers

*Hirohiko Masunaga[1], Brian Earle Mapes[2] (1.Nagoya University, 2.University of Miami)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AAS03-08] Observational Evidence of Mixed Rossby-Gravity Waves as a Driving Force for the MJO Convective Initiation and Propagation

*Daisuke Takasuka[1,2], Masaki Satoh[1], Satoru Yokoi[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AAS03-09] A characteristic of the MJO as a part of enhanced large-scale zonal circulation

*Tamaki Suematsu[1], Hiroaki Miura[2] (1.Atmosphere and Ocean Reaserch Institute, The University of Tokyo, 2.School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AAS03-10] **The role of the moisture on the occurrences and distribution of the Amazonian mesoscale convective systems**

*Amanda Rehbein[1,2], Masaki Satoh[2], Tercio Ambrizzi[1] (1.Univ. of Sao Paulo, 2.Univ. of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS03-11] Interdecadal Change of the Impact of Eurasian Snow on Spring Precipitation Over Southern China

*Dingrui Cao[1] (1.Zhejiang University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS03-12] Atmospheric Rivers and related atmospheric circulations associated with Japanese disastrous precipitation in warm season

Naho Suetou[1], *Akiyo Yatagai[1], Yukari Takayabu[2] (1.Graduate School of Science and Technology/Hirosaki University, 2.Atmosphere and Ocean Research Institute/The University of Tokyo)

A Mechanism for the Maintenance of Sharp Tropical Margins

*Hirohiko Masunaga[1], Brian Earle Mapes[2]

1. Nagoya University, 2. University of Miami

The deep tropics characterized by moist air and deep convection are separated from the dry, quiescent subtropics often by a sharp horizontal gradient of moisture only loosely tied to SST or other geographical constraints. Mapes et al. (GRL, 2018) showed that this margin of the moist tropics is a true PDF minimum (a regime separatrix), along a column water vapor (CWV) contour around 48 mm in instantaneous data. Quasi-meridional statistical composites of observations across the poleward-most excursion of this sinuous contour retain the sharpness of the margin while increasing signal to noise ratio. Observations primarily from a suite of the A-Train satellites show the meridional structure of thermodynamic state and budget terms across the margin of the moist tropics. Composites are computed around the PDF-minimum CWV value of 48 mm as well as a range of other thresholds from 35 mm to 60 mm for comparison. Major findings are summarized as follows. (1) CWV increases equatorward from the subtropics for all CWV thresholds but eventually converges to 48 mm deep into the tropical side. Precipitation abruptly intensifies on the tropical side of the margin but declines equatorward to 85 W/m2 regardless of the CWV thresholds. (2) The diabatic forcing to the atmosphere (radiative heating plus surface heat fluxes) changes its sign across the CWV=48 mm border, being positive on the tropical side and negative on the subtropics. This contrast is owing to the meridional gradient of radiative heating, principally the longwave effect of high clouds. (3) Vertical mode decomposition reveals a transition from bottom-heavy to top-heavy subsidence on the subtropical side of the margin. These observed features are interpreted in terms of a simple theory from the moisture and heat budget perspectives. The model explains the abrupt moistening at the margin as a singularity where the vertical displacement of air costs little energy within a column.

Keywords: Tropical dynamics, Satellite data analysis, Conceptual theory

©2019. Japan Geoscience Union. All Right Reserved.

Observational Evidence of Mixed Rossby-Gravity Waves as a Driving Force for the MJO Convective Initiation and Propagation

*Daisuke Takasuka[1,2], Masaki Satoh[1], Satoru Yokoi[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology

The Madden-Julian Oscillation (MJO) is known to be the most dominant intraseasonal variability in the tropics, which features large-scale convective envelopes emergening and propagating eastward slowly (~5 m s^{-1}) over the warm pool region. Since its discovery, there have been dedicated efforts to clarify mechanisms about MJO initiation and propagation in terms of large-scale low-frequency dynamics and thermodynamics and a multi-scale interaction with synoptic disturbances. As for the latter standpoint, although some recent observational and idealized numerical studies suggested that mixed Rossby-gravity waves (MRGs) can play a significant role in MJO mechanics, more detailed evidence is necessary because the realistic relationship between MJO and MRGs has had little recognition.

In this study, we examine the contributions of MRGs to the MJO convective initation and propagation in the Indian Ocean during the YMC-Sumatra 2017 field campaign (YMC: Years of the Maritime Continent). The intensive observation captured mid-tropospheric wind variations associated with MRGs, and those signals propagated westward over the Indian Ocean in the MJO suppressed phase. The transition to the MJO active phase follows tight MRG-convection coupling, which is enhanced when the wavelength becomes shorter due to weak mid-level convergence in the western Indian Ocean. Basin-scale anomalous mid-tropospheric moistening caused by MRG shallow circulations is also recognized. These processes lead to the lower-tropospheric MRG wave packet formation and successive triggering of MJO convection, with the eastward MRG group velocity corresponding to MJO propagation. This study suggests that it is worth reconsidering the MJO with a focus on MRG activities at least in the Indian Ocean.

Keywords: Madden-Julian Oscillation, equatorial waves, multi-scale interaction, the Years of the Maritime Continent

©2019. Japan Geoscience Union. All Right Reserved.

A characteristic of the MJO as a part of enhanced large-scale zonal circulation

*Tamaki Suematsu[1], Hiroaki Miura[2]

1. Atmosphere and Ocean Reaserch Institute, The University of Tokyo, 2. School of Science, The University of Tokyo

The Madden-Julian Oscillation (MJO) is known as the dominant mode of intraseasonal variability in the tropics, characterized a region of enhanced convective activities that propagate from the Indian Ocean (IO) to the Western Pacific(WP). However, our understanding of its fundamental role in the atmosphere, and explanation for why it exists is still limited. Taking this into consideration, this study examined how the MJO propagation speed and the intensity of their events were modulated by the background environment and sought for an intrinsic relationship of the MJO with the background atmospheric states. To build on our recent finding of MJO enhancement with background zonal sea surface temperature (SST) gradient, we examined how MJO propagation speed was influenced by the background SST. We constructed a tracking method of MJO convection and calculated the propagation speed of each event. We investigated how the characteristics of the MJO and the background SST states that they occur in varied depending on their propagation speed. The analysis revealed that the slower events were associated with a condition of low-frequency SST (> 60 days) distribution with a positive zonal gradient from the IO to WP. In contrast, high-frequency SST (20 –60 days) distributions associated with the MJO events were much the same between the fast and the slow groups with little zonal SST gradient across IO to WP. Furthermore, the extension of the analysis to rest of the events revealed that the relationship between zonal SST gradient and propagation speed was not a tendency restricted to the fastest and the slowest groups, but is an overall relationship that is displayed by all of the events. Taking note that the presence of zonal SST gradient in the low-frequency range has the potential to enhance large-scale zonal circulation, the component of the zonal wind associated with the background circulation was also analyzed. The analysis showed that there is a tendency for MJO to propagate slower when the background large-scale zonal circulation was stronger, implying that slower MJOs are embedded in enhanced large-scale zonal circulation.

Keywords: Madden-Julian Oscillation , Air-Sea Interaction, Large-Scale Circulation

©2019. Japan Geoscience Union. All Right Reserved.

The role of the moisture on the occurrences and distribution of the Amazonian mesoscale convective systems

*Amanda Rehbein[1,2], Masaki Satoh[2], Tercio Ambrizzi[1]

1. Univ. of Sao Paulo, 2. Univ. of Tokyo

The mesoscale convective systems (MCSs) are large and long-lived organized cloud systems, which have impacts on climate and weather. Studies on MCSs over the Amazon basin have been driven in recent years. They showed that MCSs occur spreadly during the Amazon’ s wet season (November to March) when the Intertropical Convergence Zone is toward northern South America. The MCSs occurrence during wet season months has variations very little known. For instance, during January and March, the MCSs occurrence is greater than in February, being March the month with most occurrences. A similar pattern occurs with the monthly precipitation. During the dry season (May to September), the number of MCSs decreases to a minimum in August, the same as precipitation. However, these MCSs are larger than those occurred in the wet season. Why these differences in the MCSs behavior and occurrence happens is an open question and very important for understanding and improving the MCSs simulations over the Amazon basin. Also, we know very few about the MCSs’ mechanism of genesis and maintenance over that region, mainly due to the lack of data on the Amazon capable of representing the convection time scale. Recently (Jan. 17th, 2019), the European Centre for Medium-Range Weather Forecasts (ECMWF) turn available the highest spatial and temporal reanalysis data (ERA5; hourly temporal and 0.5º spatial resolutions) for global range and long-term data (since 1979 to the present). Therefore, our objective is to use this dataset to investigate the moisture’ s role to the MCSs occurrences on the diurnal, seasonal and interannual scales. To achieve it, we will present temporal and spatial statistical analysis in the hourly, monthly, and annual scales, including vertical moisture profiles. The target period is 2000 to 2013 because of this is the same period of the available MCSs climatology by Rehbein et al. (2017). This investigation is complimentary for a major study where the Amazonian MCSs present and future climates are being investigated.

Keywords: Mesoscale convective systems, Moisture, Amazon basin

©2019. Japan Geoscience Union. All Right Reserved.

Interdecadal Change of the Impact of Eurasian Snow on Spring Precipitation Over Southern China

*Dingrui Cao[1]

1. Zhejiang University

In this study, the relationship between interdecadal and interannual changes of snow cover over Eurasia and precipitation over southern China are investigated. The results show that, the spring precipitation over southern China has experienced a change of positive to negative trend since the end of 1980s. The interannual change of spring precipitation over southern China has a significant positive correlation with the Eurasian snow cover (SCE) anomalies in northwest Lake Baikal. Baroclinic Atmosphere Model (LBM) was utilized in numerical simulation experiment. The results show that The SCE anomalies near northwest Lake Baikal can affect the spring precipitation over southern China by regulating the atmospheric circulation in East Asia and the Northwest Pacific. Further study indicates that the SCE anomalies near Lake Baikal have different contributions to the change of spring precipitation in south China around the end of 1980s. The whole dataset is divided into two periods, 1972-1987 (P1) and 1988-2009 (P2). During P1, the SCE anomalies around Lake Baikal contribute to the formation of regional mono-sign of spring precipitation over southern China. During P2, the SCE anomalies around Lake Baikal are conducive to the formation of north-south dipole modes of spring precipitation. Meanwhile, the SCE anomalies also have experienced an interdecadal change and contributes to precipitation mode over China. During P1, The SCE anomalies near Lake Baikal and its southeast side contribute to the formation of mono-sign of spring precipitation over southern China. During P2, the SCE anomalies near Lake Baikal and its northeast side are favorable for the south China spring precipitation to present the north-south dipole modes of spring precipitation.

Keywords: spring precipitation, snow cover, interdecadal changes

©2019. Japan Geoscience Union. All Right Reserved.

Atmospheric Rivers and related atmospheric circulations associated with Japanese disastrous precipitation in warm season

Naho Suetou[1], *Akiyo Yatagai[1], Yukari Takayabu[2]

1. Graduate School of Science and Technology/Hirosaki University, 2. Atmosphere and Ocean Research Institute/The University of Tokyo

Atmospheric Rivers (ARs) refer to the flow of moisture like an elongated river that reach the mid-troposphere, and water vapor evaporated in the tropics is transported rapidly by subtropical jet streams and extends to mid-latitudes. ARs play an important role in the meridional moisture (i.e. energy) transport in the mid-latitudes; besides bringing down heavy rain on the west coast of North America and the western coast of Europe. Recently, it was found that ARs could emerge around Japan, and the AR occurrence in Hiroshima in August 2014 was reported as one of the factors of heavy rain. However, there are few studies about a relation between heavy precipitation and ARs occurred in Japan. However, previous studies counted the AR occurrence among the heavy precipitation events in entire Japan (longitude 123˚-146˚ and latitude 24˚-46˚). The result during the warm season (April-October) was approximately 70%, which was a high value. It was considered that it included the location of heavy rain did not coincide with the occurrence spot of ARs, because the AR occurrence rate was calculated over a wide range. Therefore, this study analyzed it by dividing Japan into sub-regions, calculating the rate of ARs for heavy rain days that cause disasters in each region, and clarifying the atmospheric circulation field of the day when ARs occurred on heavy rain days.

The target period was 35 years from 1980 to 2014, and a year was divided into two seasons, the warm season (April-October) and the cold season (November-March). This study extracted heavy rain days and detected ARs in the warm season after defined conditions for extracting heavy rain days that cause disasters and conditions for detecting ARs that pass through around Japan. Then, Japan was divided into 13 regions, and it was sorted out the extraction of heavy rain days and AR detection in each region. At this time, AR detection in each area was the detection area up to 100 km in four directions of the area targeted, considering the remote influence of ARs. Only the AR occurrence rate of the warm season was targeted to be analyzed.

The AR occurrence rate in each area was lower than the value calculated in entire Japan. The area with the highest AR occurrence rate was 64.6 % in North Kyushu Region, and the areas with many heavy rain days but a low AR occurrence rate were in Shikoku-Kii Peninsula Region (44.1 %) and South Kyushu Region (45.8%).
This study compared Shikoku-Kii Peninsula Region and North Kyushu Region, and investigated the circulation field. First, the monthly value of AR occurrence rate was the highest in September (61.9 %) in Shikoku-Kii Peninsula Region and in June (83.3 %) in North Kyushu Region. Although the month that took the highest value was different, what common for these two regions were that it was relatively low in July and August and high in rainy seasons.

Regarding the circulation field, the moisture flux in both regions converged on the target areas; however, it diverged over water in the east in Shikoku-Kii Peninsula Region and over water in the south in North Kyushu Region. Both moisture flow comes along the western periphery of the Pacific high where moisture diverges. It is found that there is a trough near the Korean Peninsula in Shikoku-Kii Peninsula Region.

©2019. Japan Geoscience Union. All Right Reserved.

Next, looking into the vertical cross section of the relative humidity and the wind field, the area with high specific humidity anomaly in both regions extended to the mid-troposphere. Also, looking into the specific humidity anomaly and the wind anomaly at the 2 pressure altitudes (500 hPa and 700 hPa) of the mid-troposphere, the areas with high in the specific humidity anomaly existed roughly at the same position as the moisture flux convergence, and the wind anomaly was similar to the flow of the moisture flux in the both regions. The flow of this wind and the moisture flux flown from the southwest to the northeast passing through the sea near Taiwan in Shikoku-Kii Peninsula Region, and from the west-southwest to the east-northeast passing through the mainland of China in North Kyushu Region.

Lastly, from the vertical cross section of the Omega (vertical p-velocity) anomaly, it was seen a strong ascending flow area that was narrow in the east and west and long in the north and south in Shikoku-Kii Peninsula Region, and that was wide in the east and west and narrow in the north and south.

Keywords: AR, APHRO_JP, moisture transport

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 103 1F

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Isao Machida(Geological Survey of Japan, AIST)

We focus on various issues of water cycle and environment and aim to answer questions of hydrological and earth system sciences including 1) surface, subsurface and evapotranspiration processes of water cycle; 2) natural and anthropogenic hydrothermal systems, 3) environments issues and studies on a watershed or global scale, 4) water-related issues with ecological, environmental, and geochemical aspects, and 5) other issues in hydrological sciences. This session welcomes presentations regarding various kinds of approaches and techniques such as field survey, remote sensing, isotope tracers, numerical simulation, and theoretical analysis.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AHW23-01] Method for measuring the pore air pressure in the mountainous slope for rainfall-runoff processes research

★Invited Papers

*Sho Iwagami[1], Shoji Noguchi[1], Takanori Shimizu[1], Tayoko Kubota[1], Shin'ichi Iida[1], Makoto Araki[1] (1.Forestry and Forest Products Research Institute, Forest Research and Management Organization, National Research and Development Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AHW23-02] **A method to quantify the influence of total water storage change on climate elasticity of streamflow**

*Yin Tang[1] (1.Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AHW23-03] **Trade-off analysis of discharge-desiltation-turbidity and sediment simulation of a combined reservoir–river system under multi-phase and multi-layer conjunctive releasing operation**

*Chien-Lin Huang[1], Nien-Sheng Hsu[1], Gene Jiing-Yun You[1] (1.National Taiwan University, Taiwan)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AHW23-04] Gradient change of soil moisture effect on next-day precipitation identified via a Random Forest-Granger causality model

*Lu Li[1], Wei ShangGuan[1], Shu Peng Zhang[1], Jin Jing Pan[1], Nan Wei[1], Yong Jiu Dai[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AHW23-05] **Using data-driven methods to explore the predictability of surface soil moisture with FLUXNET site data**

*jinjing Pan[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AHW23-23] Global Analyis of the Hydrological Sensitivity to Climate Variability

*Marisol Dominguez[1], Hugo Alberto Gutierrez-Jurado[1] (1.University of Texas at El Paso)

Method for measuring the pore air pressure in the mountainous slope for rainfall-runoff processes research

*Sho Iwagami[1], Shoji Noguchi[1], Takanori Shimizu[1], Tayoko Kubota[1], Shin'ichi Iida[1], Makoto Araki[1]

1. Forestry and Forest Products Research Institute, Forest Research and Management Organization, National Research and Development Agency

Many researches have been conducted to clarify the mechanism of rainfall-runoff process in a forested catchment in humid warm-temperate regions. Some results obtained from hydrograph separation using isotopic tracer showed that stream discharge is mainly composed of pre-event old water rather than new water (rainwater). Since the 1980’s, the important issue in rainfall-runoff process studies has been solving how pre-event old water stored in the slope discharge in rapid response during rainstorm event. After 1990’s the role of bedrock groundwater contribution to rainfall-runoff process became to be illustrated. Iwagami et al. (2010) described the contribution of bedrock groundwater during rainfall events in a headwater catchment, however there were some large scale events which were not enough to be explain by the bedrock groundwater contribution. Further possible ideas to explain the rapid outflow of pre-event old water might be effect of pressure wave (Torres et al., 1998) and effect of entrapped air (Marui et al., 1993; Delfs et al., 2013).
Role of pore air effects (e.g., entrapped air and, pressure wave) on rainfall-runoff process are pointed out by previous studies however field evidence of pore air behavior or pore air pressure in the slope scale are still lacking. Also method for pore air pressure observation is not established and not discussed fully. In present study, in order to investigate the behavior of pore air under mountainous slopes, measurements of pore air pressure were conducted at two small headwater catchment in Hitachi Ohta Experimental Watershed and Tsukuba Experimental Watershed, Ibaraki Prefecture, Japan. We measured pore air pressure by detecting the inner pressure of borehole and piezometer. Focusing on the pressure difference between pore air and atmosphere (hereafter we call this as “pressure gap”), it is expected that during a dry period (not during rainfall and ground surface is unsaturated), shallow pore air pressure in the slope is almost at equilibrium state with the atmospheric pressure and the pressure gap might be zero. On the other hand, when the pressure gap was raised remarkably during the rainfall event, pore air is supposed to be entrapped and compressed by infiltrating rainwater (wetting front) and groundwater table (or underlying low permeability layer). During the observation from July 2018 to January 2019, pressure gap rising event have observed in both sites. Also negative pressure gap was observed after the pressure gap rising event. Further observation studies are needed for understanding the effect of entrapped air to rainfall-runoff process which could potentially contribute to the prediction of flash flood or corresponding slope instability.

Keywords: Rainfall-runoff processes, pore air, entrapped air, pressure gap

©2019. Japan Geoscience Union. All Right Reserved.

A method to quantify the influence of total water storage change on climate elasticity of streamflow

*Yin Tang[1]

1. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science

Numerous studies documented the climate elasticity of streamflow (i.e., precipitation elasticity and potential evapotranspiration elasticity) without considering the total water storage change (dS) based on long-term Budyko framework. However, the values of dS have been found to be a significant component of water balance at short time scales (e.g., annual) and some specific watersheds (e.g., arid regions). The purpose of this paper is to develop a new approach based on the extended Budyko framework to quantify the climate elasticity of streamflow with the influence of dS . The available water under the extended Budyko framework is the effective precipitation (Pe), i.e. the difference between precipitation and dS. The climate elasticity of streamflow with the influence of dS are derived from one recent proposed Budyko-type equation based on proportionality relationship under the extended Budyko framework. The performance of this new approach at annual scale as an example is evaluated for 273 MOPEX watersheds in the United States. Results show that climate elasticity of streamflow with the influence of dS are generally larger than that without considering the influence of dS for study watersheds. Results also indicates that the modeled proportional changes in annual streamflow are significantly biased by using the methods without considering the influence of dS, especially for peak values. This study highlights the needs to consider the influence of dS on climate elasticity of streamflow and provides a framework to quantify the climate elasticity of streamflow with the influence of dS.

Keywords: climate elasticity, total water storage change, MOPEX

©2019. Japan Geoscience Union. All Right Reserved.

Trade-off analysis of discharge-desiltation-turbidity and sediment simulation of a combined reservoir–river system under multi-phase and multi-layer conjunctive releasing operation

*Chien-Lin Huang[1], Nien-Sheng Hsu[1], Gene Jiing-Yun You[1]

1. National Taiwan University, Taiwan

Multi-objective reservoir operation considering the trade-off of discharge-desiltation-turbidity during typhoons and sediment concentration simulation modeling are the vital components for sustainable reservoir management. The purpose of this study is to analyze the multi-layer release trade-offs between reservoir desiltation and intake turbidity of downstream purification plants and thus propose a superior conjunctive operation strategy. To this end, this study proposed a methodology to develop (1) a series of multi-phase and multi-layer sediment-flood conjunctive release modes and (2) a specialized sediment concentration numerical model for a combined reservoir–river system. The conjunctive release modes involve (1) an optimization model where the decision variables are multi-phase reduction/scaling ratios and the timings to generate a superior total release hydrograph for flood control (Phase I: phase prior to flood arrival, Phase II/III: phase prior to/subsequent to peak flow) and (2) a combination method with physical limitations regarding separation of the singular hydrograph into multi-layer release hydrographs for sediment control. This study employed the featured signals obtained from statistical quartiles/sediment duration curve in mesh segmentation, and an iterative optimization model with a sediment unit response matrix and corresponding geophysical-based acceleration factors, for efficient parameter calibration. This study applied the developed methodology to the Shihmen Reservoir watershed in Taiwan. The trade-off analytical results using Typhoons Sinlaku and Jangmi as case examples revealed that owing to gravity current and re-suspension effects, Phase I+II can de-silt safely without violating the intake's turbidity limitation before reservoir discharge reaches 2238 m^3/s; however, Phase III can only de-silt after the release at spillway reaches 827 m^3/s, and before reservoir discharge reaches 1924 m^3/s, with corresponding maximum desiltation ratio being 0.221 and 0.323, respectively.

Keywords: Multi-phase sediment-flood management, Sediment concentration modeling, Sediment duration curve, Hydrological statistic, Multi-objective trade-off analysis, Multi-layer conjunctive releasing

©2019. Japan Geoscience Union. All Right Reserved.

Gradient change of soil moisture effect on next-day precipitation identified via a Random Forest-Granger causality model

*Lu Li[1], Wei ShangGuan[1], Shu Peng Zhang[1], Jin Jing Pan[1], Nan Wei[1], Yong Jiu Dai[1]

1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University

Surface soil moisture influences precipitation through its impact on water and energy cycles. Understanding of soil moisture-precipitation (SM-P) coupling on synoptic scale is important for improving short-term weather forecasting. However, the sign and pattern of SM-P feedback are still controversial, mainly caused by the difficulty to establish causal relationship. In this paper, we use empirical models to separate local land-atmosphere coupling effect from low frequency variation and persistence effects, and use Granger causality to identify the casual relationship between surface soil moisture and subsequent precipitation over China. Five experiments are designed to investigate the impact of the discrepancy of datasets and empirical models on SM-P feedback. Differences of SM-P feedback using different SM-P datasets are minor compared to those of empirical models. We improved the SM-P feedback model by using random forest to eliminate low frequency variation and persistence effects instead of generalized linear model. Moreover, we present a novel SM-P feedback framework by considering spatial impact of data, raising a new feature selection method and a new SM-P coupling index. The corresponding pattern of SM-P feedback shows that (1) positive SM-P feedback appears almost all over China. (2) The effect of surface soil moisture on next-day precipitation probability decreases from arid to humid regions over China. (3) The effect of low frequency variation and persistence on precipitation is larger than the effect of soil moisture, but we must emphasize that soil moisture also plays an important role in arid and semi-arid regions. Our finding statically supports the hypothesis that strong SM-P feedback locates in transition zones and SM-P coupling is higher during wet periods for dry regions.

Keywords: Soil moisture-precipitation feedback, random forest, granger causality

©2019. Japan Geoscience Union. All Right Reserved.

Using data-driven methods to explore the predictability of surface soil moisture with FLUXNET site data

*jinjing Pan[1]

1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University.

Soil moisture (SM) is a key variable of land surface-atmosphere interactions. Data-driven methods have been widely used to predict SM, but the predictability of SM has not been well evaluated. This study investigated what variables and methods can be used to better predict SM for leading times of 7 days or longer with a global coverage of FLUXNET site data for the first time. Three machine-learning models, i.e., Bayesian linear regression, random forest and gradient boosting regression tree, are used for the prediction. Variables including atmospheric forcing, surface soil temperature, time variables (year, day of year (DOY) and hour), the Fourier transformation of time variables and lagged SM (7-14 day lagged) were sequentially added into models. A framework with five experiments is designed for factorial exploration of SM predictability. A stepwise method was used to build the best models for each site. The performance of regression models became better when adding more explaining variables in most cases. The results showed that from 47 % to 95% of variation of the best models can be explained. The important explaining variables are lagged surface SM, followed by DOY, year, soil temperature and atmospheric forcing. The predictability of SM depends highly on SM memory characteristics and the persistence of seasonality. The effect of SM memory characteristics on SM prediction as an initial condition question has been widely discussed in this paper. Our results also provide an insight that mechanisms of seasonality effects on SM should be also paid more attention to.

Keywords: A framework with five contrasting experiments is designed to investigate the factors affecting the predictability of soil moisture, The best models can explain between 47% and 95% of variation with different explaining variable combinations at different sites, The most important explaining variable is lagged surface soil moisture, followed by time variables, soil temperature and atmospheric forcing, The predictability of soil moisture depends highly on soil moisture memory characteristics and the persistence of seasonality

©2019. Japan Geoscience Union. All Right Reserved.

Global Analyis of the Hydrological Sensitivity to Climate Variability

*Marisol Dominguez[1], Hugo Alberto Gutierrez-Jurado[1]

1. University of Texas at El Paso

Projected climate changes in the 21st century is expected to have a profound impact in the functioning of Earth's water cycle. Therefore, identifying the components contributing to the sensitivity and resilience of water resources constitutes a research priority of global relevance. Here we present a practical approach to globally assess the hydrologic sensitivity of regions to climate variability. The aim is to identify the regions most vulnerable to changes in their hydrologic functioning as they experience external climatic shifts. For this purpose we present a new metric, the Hydrologic Sensitivity Index (HSI). HSI is calculated for any given location within 50 degrees North and South of the equator using annual values of Potential and Actual Evapotranspiration (PET and AET) obtained from the Moderate Resolution Imaging Spectrometer (MODIS), and Precipitation (P) from the Tropical Rainfall Measuring Mission (TRMM) for all continents for the last 16 years (2001-2016). The HSI defines the hydrologic behavior under a given climatic condition by calculating the change in the Evaporative Index (DAET/P) against the change in the Dryness Index (DPET/P) between consecutive years. For HSI values >=1, regions are classified as Sensitive and for values of <1, Resilient. We calculated the mean, frequency and intensity of the HSI and analyzed the distribution of sensitive areas (HSI >=1) against changes in latitude, elevation, slope and aspect conditions using a 90m elevation dataset from the Shuttle Radar Topography Mission (STRM), as well as according to land cover properties defined by different biome types. Our analysis show the most hydrologically sensitive regions to climate variability occur in Temperate Grasslands along the Great Plains in North American and the Great Dividing Range in Australia, in parts of eastern Asia, in European Temperate Forests, parts of Tropical and Subtropical pampas east of the Amazonian forest and Tropical and Subtropical African Savannas. We also observe a combined latitudinal-elevation control on the HSI that is particularly noticeable along equatorial regions of the globe.

Keywords: Budyko Curve, Climate Variability , Hydrologic Sensitivity, Evapotranspiration, Global Analysis, Elevation and Aspect

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 103 1F

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Megumi Watanabe

We focus on various issues of water cycle and environment and aim to answer questions of hydrological and earth system sciences including 1) surface, subsurface and evapotranspiration processes of water cycle; 2) natural and anthropogenic hydrothermal systems, 3) environments issues and studies on a watershed or global scale, 4) water-related issues with ecological, environmental, and geochemical aspects, and 5) other issues in hydrological sciences. This session welcomes presentations regarding various kinds of approaches and techniques such as field survey, remote sensing, isotope tracers, numerical simulation, and theoretical analysis.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AHW23-06] A review on the global soil property maps for Earth system model

Yongjiu Dai[1], *Wei Shangguan[1], Dagang Wang[2], Nan Wei[1], Qinchuan Xin[2], Hua Yuan[1], Shupeng Zhang[1], Shaofeng Liu[1], Fapeng Yan[3], Xingji Lu[1] (1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University, 2.School of Geography and Planning, Sun Yat-sen University, 3.College of Global Change and Earth System Science, Beijing Normal University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AHW23-07] Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model

*Indishe Prabath Senanayake[1], In-Young Yeo[1,2], Natthachet Tangdamrongsub[3,4], Garry R Willgoose[1], Gregory R Hancock[5], Tony Wells[1], Bin Fang[6], Venkataraman Lakshmi[6], Jeffrey P Walker[7] (1.School of Engineering, Faculty of Engineering and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia., 2.Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA., 3.Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA., 4.Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA., 5.School of Environmental and Life Sciences, Faculty of Science, The University of Newcastle, Callaghan, NSW 2308, Australia., 6.School of Earth Ocean and Environment, University of South Carolina, Columbia, SC 29223, United States., 7.Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia.)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AHW23-08] Representation of dams in global flood inundation simulations by coupling the global hydrological model H08 and the global hydrodynamic model CaMa-Flood

*Julien Eric Boulange[1], Naota Hanasaki[1] (1.National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AHW23-09] An investigation into a potential long subglacial river beneath the Greenland ice sheet using SICOPOLIS simulations.

*Christopher Chambers[1], Ralf Greve[1], Bas Altena[2], Pierre-Marie Lefeuvre[2] (1.Hokkaido University, 2.University of Oslo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AHW23-10] Changes in Annual Rainfall patterns in the Democratic Republic of Congo: Congo river basin

*Chetan Sharma[1], Chandra Shekhar Prasad Ojha[1] (1.Indian Institute of Technology Roorkee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AHW23-11] Seasonality in the extreme precipitation events linked to temperature over Japan

*Sridhara Nayak[1], Tetsuya Takemi[1] (1.Disaster Prevention Research Institute, Kyoto University)

A review on the global soil property maps for Earth system model

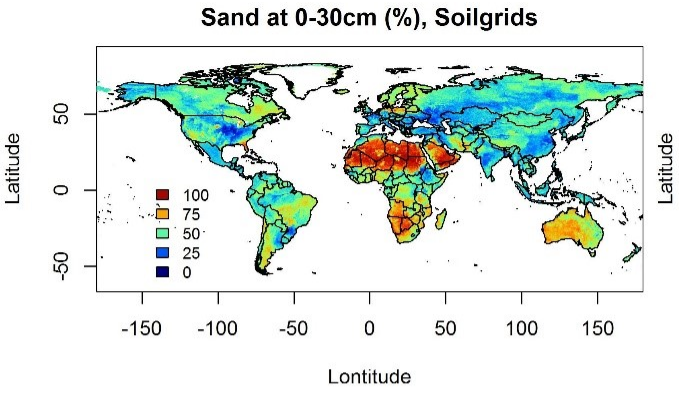
Yongjiu Dai[1], *Wei Shangguan[1], Dagang Wang[2], Nan Wei[1], Qinchuan Xin[2], Hua Yuan[1], Shupeng Zhang[1], Shaofeng Liu[1], Fapeng Yan[3], Xingji Lu[1]

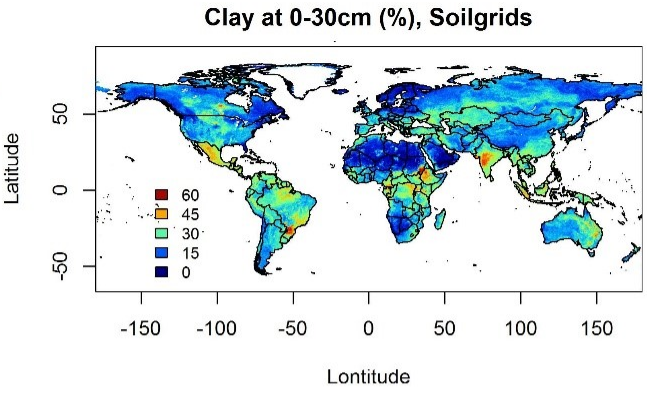
1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University, 2. School of Geography and Planning, Sun Yat-sen University, 3. College of Global Change and Earth System Science, Beijing Normal University

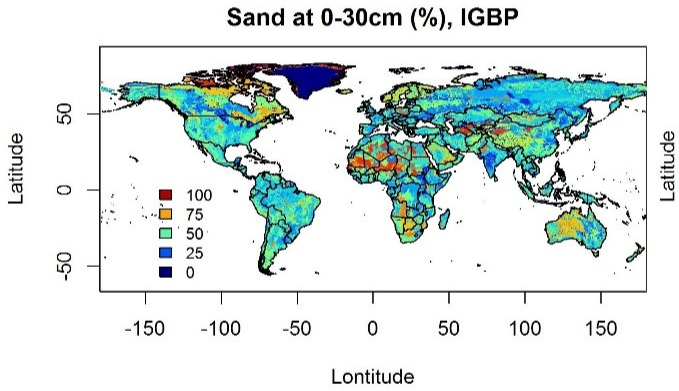
Soil is an important regulator of Earth system processes, but remains one of the least well-described data layers in Earth System Models (ESMs). We reviewed global soil property maps from the perspective of ESMs, including soil physical and, chemical and biological properties. These soil datasets provide model inputs, initial variables and benchmark datasets. For modeling use, the dataset should be geographically continuous, scalable and with uncertainty estimates. The popular soil datasets used in ESMs are often based on limited soil profiles and coarse resolution soil type maps. Updated and comprehensive soil information needs to be incorporated in ESMs. New generation soil datasets derived by digital soil mapping with abundant, harmonized and quality controlled soil observations and environmental covariates are preferred to those by the taxotransfer rule-based method for ESMs. Because there is no universal pedotransfer function, an ensemble of them may be more suitable to provide derived soil properties to ESMs. Aggregation and upscaling of soil data are needed for model use but can be avoid by taking a subgrid method in ESMs at the cost of increases in model complexity. Uncertainty of soil data needs to be incorporated in ESMs.

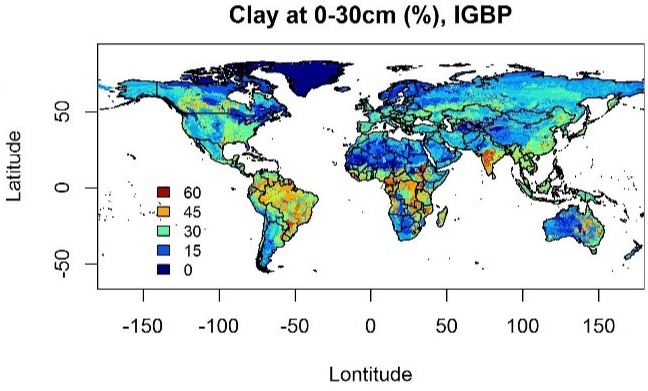
Keywords: Earth system model, soil hydrology, soil data, pedotransfer function

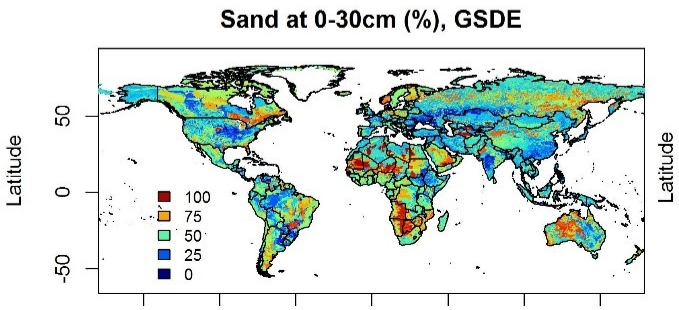
©2019. Japan Geoscience Union. All Right Reserved.

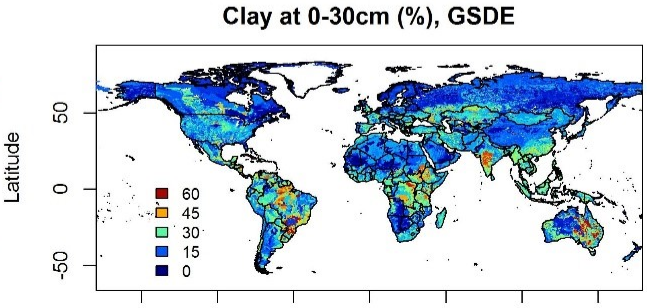












©2019. Japan Geoscience Union. All Right Reserved.

Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model

*Indishe Prabath Senanayake[1], In-Young Yeo[1,2], Natthachet Tangdamrongsub[3,4], Garry R Willgoose[1], Gregory R Hancock[5], Tony Wells[1], Bin Fang[6], Venkataraman Lakshmi[6], Jeffrey P Walker[7]

1. School of Engineering, Faculty of Engineering and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia., 2. Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA., 3. Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA., 4. Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA., 5. School of Environmental and Life Sciences, Faculty of Science, The University of Newcastle, Callaghan, NSW 2308, Australia., 6. School of Earth Ocean and Environment, University of South Carolina, Columbia, SC 29223, United States., 7. Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia.

Soil moisture is a key variable in the hydrologic cycle. Therefore, soil moisture information is important for hydrologic and climatic modelling, and for agricultural applications. However, the available point-scale in-situ observations and coarse resolution (10s of km) satellite soil moisture retrievals are unable to capture the spatial variability of soil moisture at high spatial resolutions as required by many of the local and regional scale applications. The lack of high resolution soil moisture data has resulted uncertainties in the model outcomes in these applications. Downscaling coarse spatial resolution L-band microwave satellite soil moisture products using high spatial resolution optical/thermal satellite data appears to be a feasible option to estimate near surface (~top 5 cm) soil moisture at a high spatial resolution. In this study a model was developed to estimate soil moisture at 1 km spatial resolution by downscaling coarse resolution satellite soil moisture products. This downscaling model was built by using in-situ observations from a long term monitoring network (2004-2015) over two sub-catchments, Krui and Merriwa River, located in the Upper Hunter Region of south-eastern Australia. The model was based on the soil thermal inertia relationship between the diurnal temperature difference (ΔT) and daily mean soil moisture (μSM). A regression tree (RT) was built between ΔT and μSM and classified based on the season, vegetation density and soil clay content. Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) and Normalized Difference Vegetation Index (NDVI) values at 1 km spatial resolution were input to the model to estimate soil moisture at 1 km resolution. Subsequently, SMAP-Enhanced 9 km (L3SMP-E) and SMOS 25 km grid (SMOS CATDS L3 SM 3-DAY) soil moisture products over the study area were downscaled and then compared against in-situ observations. Further, the downscaling algorithm was applied to aggregated soil moisture observations from National Airborne Field Experiment 2005 (NAFE’05) over a 40 x 40 km land area over Krui and Merriwa River catchments. The downscaled products were validated using 1 km airborne data. The SMAP L3SMP-E and SMOS CATDS L3 SM 3-DAY products show unbiased root mean square errors (ubRMSEs) of 0.068 and 0.051 cm^3/cm^3 (R^2 values of 0.40 and 0.61), respectively, against in-situ observations. The downscaled airborne soil moisture data shows an RMSE of 0.07 cm^3/cm^3 (with R value of 0.4). The model performed well in dry conditions compared to wet conditions. This method shows a good potential in developing a long time series of high spatial resolution soil moisture information over arid and semi-arid regions using SMOS and SMAP soil moisture products.

Keywords: Downscaling, remote sensing, SMAP, SMOS, soil moisture, thermal inertia

©2019. Japan Geoscience Union. All Right Reserved.

Representation of dams in global flood inundation simulations by coupling the global hydrological model H08 and the global hydrodynamic model CaMa-Flood

*Julien Eric Boulange[1], Naota Hanasaki[1]

1. National Institute for Environmental Studies

Dams and reservoirs regulate the flow of rivers, storing and releasing water to maximize its availability for human and environmental needs[1]. While regulating water flow is beneficial regarding human water security, it was reported to have rather dire consequences for the environment such as aquatic biota[2,3]. Nevertheless, currently about half of the major global river systems are affected by dams[4].
Global hydrodynamic models have greatly improved in terms of accuracy and computational efficiency in reproducing flood inundation extent[5]. However, to this day, still few such models successfully simulated flood inundation considering the influence of dams.
In this research, the global hydrological model H08[6,7] is coupled to the global hydrodynamic model CaMa-Flood[8] for representing dams in global flood inundation simulation. The input meteorological dataset used in this study were provided by the ISIMIP2b project[9] and consisted of 4 GCMs and 4 scenarios.

The coupled model simulates river discharge and inundation globally at a daily interval, at a spatial resolution of 0.5˚ ×0.5˚. Discharge predicted with the original CaMa-Flood model were compared to those obtained with the coupled model. The seasonal discharge in rivers heavily affected by reservoir operation were very different between the two simulations. Generally, annual minimum (maximum) 7-day discharge was significantly higher (lower) for the simulation explicitly representing dams. In addition, timings of the discharge peaks were also different between the 2 simulations. We deeply investigated the results in several selected river basins.

References:

1 Ehsani, N., Vörösmarty, C. J., Fekete, B. M. & Stakhiv, E. Z. *J. Hydrol.* (2017).
2 Pringle, C., Freeman, M. & Freeman, B. *Regional Effects of Hydrologic Alterations on Riverine Macrobiota in the New World: Tropical–Temperate Comparisons*. Vol. 50 (2000).
3 Kingsford, R. T. *Austral Ecology* (2000).
4 Dynesius, M. & Nilsson, C. *Science* (1994).
5 Teng, J. *et al. Environmental Modelling & Software* (2017).
6 Hanasaki, N. *et al. Hydrol. Earth Syst. Sci.* (2008).
7 Hanasaki, N. *et al. Hydrol. Earth Syst. Sci.* (2008).
8 Yamazaki, D., Kanae, S., Kim, H. & Oki, T. *Water Resour. Res.* (2011).
9 Frieler, K. *et al. Geosci. Model Dev. Discuss.* (2016).

Keywords: Global hydrology, Flood, H08 model, CaMa-Flood model

©2019. Japan Geoscience Union. All Right Reserved.

An investigation into a potential long subglacial river beneath the Greenland ice sheet using SICOPOLIS simulations.

*Christopher Chambers[1], Ralf Greve[1], Bas Altena[2], Pierre-Marie Lefeuvre[2]

1. Hokkaido University, 2. University of Oslo

The Greenland ice sheet appears to be hiding large geographical features at its base that have the potential to affect ice sheet simulations to an unknown degree. One feature is a broken valley extending from Petermann Fjord far into the center of Greenland revealed by the widely used BedMachine basal topographic dataset. The valley appears to be blocked by topographic rises at many points along its route, however it will be demonstrated that these blockages are entirely artificial consequences of data interpolation and that all available data indicate that the valley is not blocked. To test whether opening up this valley could affect ice sheet sliding, SImulation COde for POLythermal Ice Sheets (SICOPOLIS) simulations are used. The simulations show that opening up this valley creates an uninterrupted potential subglacial water pathway from central Greenland to Petermann Fjord (Figure 1) suggesting that water could flow along its length. The reason this is possible is because the valley tracks down a gentle ice thickness gradient as it roughly follows the ice divide. The redistribution of water towards Petermann Glacier focuses increased sliding there. There is also a small reduction of sliding in central west Greenland. Other effects of this valley on the ice-sheet hydrology and dynamics will be presented. If confirmed with further radar bed observations, this would be a great world river the runs under ice for its entire length, a distance that could be up to 1600 km.

Keywords: ice, glacier, river, Greenland, climate

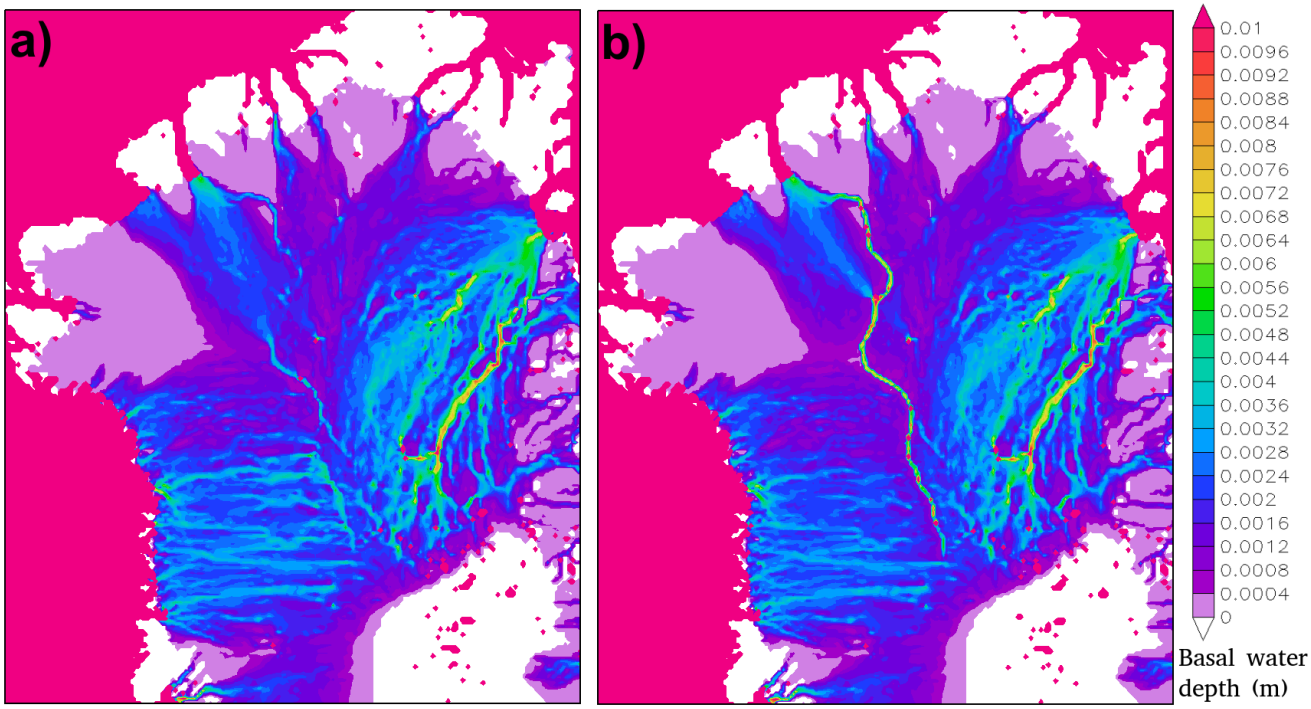


Figure 1: Basal water depth (m) for a) standard bed and b) valley inserted.

©2019. Japan Geoscience Union. All Right Reserved.

Changes in Annual Rainfall patterns in the Democratic Republic of Congo: Congo river basin

*Chetan Sharma[1], Chandra Shekhar Prasad Ojha[1]

1. Indian Institute of Technology Roorkee

This study focuses on the change detection in annual rainfall in the Democratic Republic of Congo (DRC) in the Congo river basin. High resolution gridded rainfall provided by Climate Research Unit (CRU) is used in this study. Trends in the annual rainfall patterns are calculated and the significance of the trends are found out using non-parametric Mann-Kendal test at 10% significance level. It is found that high negative trends are prevailing in Northern and Southern parts and high positive trends are in the Eastern and Western parts of the Congo river basin. Almost all of these locations show a significant trend. Central wetlands don’ t show a significant change in annual rainfall pattern. Change detection studies are carried out to detect year of change when annual rainfall starts showing deviation from its natural state. Mann-Whitney-Pettit method is used to detect year of change at 5% significance level in this study. Change is detected for almost all of the locations where the trend of annual rainfall is significant. Much earlier change is detected in the Eastern regions of the basin, i.e., the change year 1941-1960, while most of the Northern, Southern and Westerns shows change detection year from 1981-1995.
It is evident from this study that rainfall patterns in the Congo river basin are changing and the changes are non-uniform. There is no change detected in the central regions, while Northern and Southern areas show a significant decrease in rainfall and Eastern and Western regions are showing an increase in total annual rainfall. Change detection year also have non-uniform spatial patterns and Eastern regions are found to be affected much earlier by climate change.

Keywords: Change Detection, Congo river basin, Rainfall

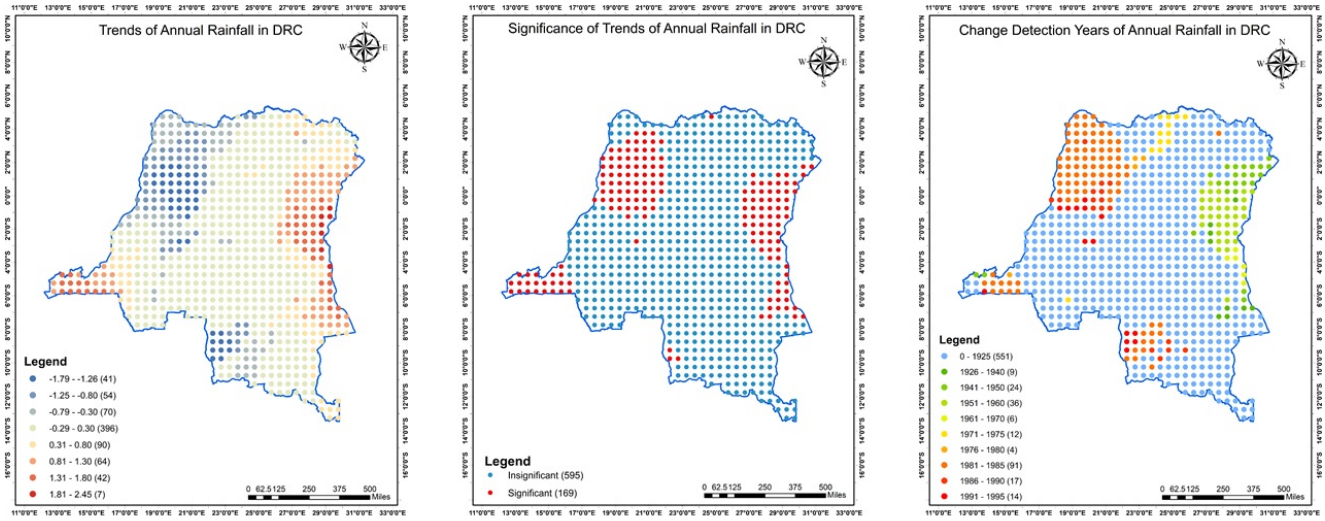


Fig-1. Annual Rainfall Patterns and Changes in Democratic Republic of Congo (DRC): Congo River basin (a) Trends (b) Significance of rends (c) Change Detection Year

©2019. Japan Geoscience Union. All Right Reserved.

Seasonality in the extreme precipitation events linked to temperature over Japan

*Sridhara Nayak[1], Tetsuya Takemi[1]

1. Disaster Prevention Research Institute, Kyoto University

The frequency of extreme precipitation events is expected to increase in future warmer climate according to the Clausius-Clapeyron (CC) equation which states that atmosphere can hold more moisture in warmer air temperature (about 7 percent per increase of 1ºC). In this study, the extreme precipitation intensities linked to temperature are investigated for different seasons over seven sub-regions of Japan by analyzing the d4PDF dataset at 20 km in present (1951-2010) and future climate (2051-2110). To do this we stratified the precipitation intensities of wet days (defined as excess of 1 mm per day) in different temperature bins at 1º intervals and computed the 99-percentile of the precipitation intensities from each temperature bin. We find that the extreme precipitation intensities linked to temperature is strongly influenced by the seasons and regions of Japan. The extreme precipitation intensities increase with temperature up to 21º over northern Japan, while the extreme precipitation intensities over Okinawa increase up to 24º. Intensities of extreme precipitation events over northern parts of Japan including Hokkaido and Tohoku regions are increased by about 10 mm per day in future warming climate, while over western regions of Japan it is increased by about 20 mm per day. Seasonal analysis indicates a super CC relationship in winter season and a sub CC relationship in summer. Overall results suggest that Japanese regions may experience more extreme precipitations in future warming climate.

Keywords: Extreme Precipitation Events, d4PDF, Clausius-Clapeyron Equation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

convener:Kazuhito Ichii(Chiba University), Prabir Patra(Research Institute for Global Change, JAMSTEC), Forrest M. Hoffman(Oak Ridge National Laboratory), Makoto Saito(National Institute of Environmental Studies), Chairperson:Kazuhito Ichii

The landmark Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) aims at reduction of greenhouse gases (GHGs) emission to keep the global warming below 2 degC. As per the agreement the nationally determined commitments (NDCs) and their progresses should be carefully monitored and verified by international bodies. The emission verification will be based on observation of the time evolution of greenhouse gases and model-based estimations of emissions from time to time.
In recent years, the number of observations and new techniques to monitor GHGs budget have been increasing. The improvements includes observational platforms for monitoring atmospheric GHGs, national or regional emission inventories, top-down models (e.g. atmospheric inverse models), and bottom-up models (e.g. process-based models). However, due to uncertainties in modeling and sparse observation network, high uncertainty exists in GHGs sources/sinks estimations at global and regional scales. These uncertainties lead to large variations in future projection of GHG budgets and climate changes.
The purpose of the session is to discuss state-of-the-art techniques for estimations of GHGs (e.g. CO2, CH4, N2O) budget at global and regional scales. The topic includes natural and anthropogenic processes, various methodologies (e.g. in-situ observation, aircraft monitoring, remote sensing, modeling), and various targets (e.g. atmosphere, terrestrial, and ocean), various spatial and temporal coverage (e.g. regional to global scales and past-present-future). Improved estimates of emissions from land use change, forest fires, and other anthropogenic sources (urban developments and thermal power station etc.) are also of interest. We also welcome discussions for designs and plans for future studies targeting city and country scale emission estimations using sophisticated modeling tools.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[ACG32-01] A high-resolution fossil fuel CO2 emission gridded dataset for tracer transport simulations and flux inversions: An overview, evaluations, applications and future perspectives

★Invited Papers

*Tomohiro Oda[1,2], Shamil Maksyutov [3], Miguel O. Roman [2,4], Zhousen Wang [4], Thomas Lauvaux[6,5], Sha Feng [5], Rostyslav Bun [7,8], James Wang [2,1], Randy Kawa [1], Lesley Ott[1], Steven Pawson[1] (1.NASA Goddard Space Flight Center, Greenbelt, MD, USA , 2.Universities Space Research Association, Columbia, MD, USA , 3.Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan , 4.Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA , 5.Department of Meteorology and Atmospheric Science, Penn. State University, State College, PA, USA , 6.Laboratoire des sciences du climat et de l'environnement, Gif sur Yvette, France, 7.Lviv Polytechnic National University, Lviv, Ukraine , 8.University of Dąbrowa Górnicza, Górnicza, Poland)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[ACG32-02] Towards Decreasing the Uncertainty in Global Carbon Dioxide Emission Inventory

*Richao Cong[1], Makoto Saito[1], Ryuichi Hirata[1], Akihiko Ito[1] (1.Center for Global Environmental Research, National Institute for Environmental Studies)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[ACG32-03] Evaluation of MIROC4-ACTM reanalysis of GHGs concentrations using aircraft

*Jagat Bisht[1], Prabir Patra[1], Naveen Chandra[1], Sergey Gromov[2], Taku Umezawa[3], Andreas Zahn[4], cARL A. M. Brenninkmeijer[5] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan, 2.Max Planck Institute for Chemistry, Mainz, Germany, 3.National Institute for Environmental Studies, Tsukuba, Japan, 4.Karlsruhe Institute of Technology (KIT), Institute for Meteorology and Climate

Research, Karlsruhe, Germany, 5.Max Planck Institute for Chemistry, Air Chemistry Division, Mainz, Germany)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[ACG32-04] **Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product**

*Tazu Saeki[1], Yosuke Niwa[1], Makoto Saito[1] (1.National Institute for Environmental Studies)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACG32-05] **Attribution of the ambiguity in methane's growth rate shifts during 1988-2016.**

*Naveen Chandra[1], Prabir Patra[1] (1.Japan Agency for Marine Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[ACG32-06] **Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño**

*Masayuki Kondo[1], Peter Landschützer[2], Yousuke Iida[3], Richard Houghton[4], Stephen Sitch[5] (1. Center for Environmental Remote Sensing, Chiba University, 2.Max Planck Institute for Meteorology, 3.Global Environment and Marine Department, Japan Meteorological Agency, 4.Woods Hole Research Center, 5.University of Exeter)

A high-resolution fossil fuel CO2 emission gridded dataset for tracer transport simulations and flux inversions: An overview, evaluations, applications and future perspectives

*Tomohiro Oda[1,2], Shamil Maksyutov [3], Miguel O. Roman [2,4], Zhousen Wang [4], Thomas Lauvaux[6,5], Sha Feng [5], Rostyslav Bun [7,8], James Wang [2,1], Randy Kawa [1], Lesley Ott[1], Steven Pawson[1]

1. NASA Goddard Space Flight Center, Greenbelt, MD, USA , 2. Universities Space Research Association, Columbia, MD, USA , 3. Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan , 4. Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA , 5. Department of Meteorology and Atmospheric Science, Penn. State University, State College, PA, USA , 6. Laboratoire des sciences du climat et de l'environnement, Gif sur Yvette, France, 7. Lviv Polytechnic National University, Lviv, Ukraine , 8. University of Dąbrowa Górnicza, Górnicza, Poland

Carbon dioxide (CO_2) emissions from fossil fuel combustion (Fossil fuel CO_2, FFCO2) is the largest input to the global carbon cycle over the decadal time scales. FFCO2 needs to be accurately quantified and monitored in order to deduce the carbon uptakes by natural sinks from atmospheric measurements as well as support the emission reduction and management. The Open-source Data Inventory for Anthropogenic CO_2 (ODIAC) is a global, high-spatial resolution (1x1km) gridded FFCO2 emission data product. We first pioneered the combined use of the point source information and satellite-observed nighttime lights data for emission downscaling in order to achieve global 1×1 km spatial resolution emission fields. The use of nightlight data allows us to observe dynamic changes in emissions spatial distributions in a timely manner and incorporate these into the emission field. Since its establishment in 2009, ODIAC has been extensively used in global and regional flux inversions especially with CO_2 data collected by carbon observing satellites, such as the Japanese Greenhouse gas Observing SATellite (GOSAT) and NASA’s Orbiting Carbon Observatory 2 (OCO-2). ODIAC has been also successfully applied to studies for localized emissions point sources such as power plants and cities. In order to further improve the accuracy of the emission downscaling, we have examined NASA’s new Visible Infrared Imaging Spectrometer Suite (VIIRS) Nighttime Environmental Product. An accurate global emission disaggregation is one of the key elements of future Monitoring and Verification Support (MVS) scientific systems that consist of the carbon modeling and data assimilation. Our advanced satellite-based emission downscaling model holds the promise of playing a critical role in such future systems.

Keywords: CO2, fossil fuel CO2 emissions, Carbon cycle, Remote sensing, GOSAT, OCO-2

©2019. Japan Geoscience Union. All Right Reserved.

Towards Decreasing the Uncertainty in Global Carbon Dioxide Emission Inventory

*Richao Cong[1], Makoto Saito[1], Ryuichi Hirata[1], Akihiko Ito[1]

1. Center for Global Environmental Research, National Institute for Environmental Studies

Global carbon dioxide (CO_2) emission inventory are considered as containing large uncertainty. To decrease the uncertainty, we corrected the emissions reported by some famous orgainzations to make a new global CO_2 emission map by top-down approach and to analyze the temporary variation of emissions at global, regional, and national scale. For that purpose, 133 nations across 10 databases which included the values from 2000 to 2010 were picked up for analysis. Then, the emissions are corrected by averaging of the values in the range of 25% to 75% quartile. To visualize the temporary variation for the emissions, we linked the emissions for 133 nations with global boundary map of nations by Geographic Information System (GIS). As our summarization, the total CO_2 emissions for 133 nations in 2010 are about 31,595 Tg CO_2 yr^{-1} which are inside the values reported by IEA (30,434 Tg only from fuel combustion) and CDIAC (33,469 Tg from fuel combustion, cement manufacture, and gas flaring), occupying about 94% of the emissions reported by EDGAR (33,588 Tg). In addition, we also combined the emissions with population, GDP, and area of each nation reported by world bank to summarize the emissions per capita and analyze the trends of them from 2000 to 2010.

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of MIROC4-ACTM reanalysis of GHGs concentrations using aircraft

*Jagat Bisht[1], Prabir Patra[1], Naveen Chandra[1], Sergey Gromov[2], Taku Umezawa[3], Andreas Zahn[4], cARL A. M. Brenninkmeijer[5]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan, 2. Max Planck Institute for Chemistry, Mainz, Germany, 3. National Institute for Environmental Studies, Tsukuba, Japan, 4. Karlsruhe Institute of Technology (KIT), Institute for Meteorology and Climate Research, Karlsruhe, Germany, 5. Max Planck Institute for Chemistry, Air Chemistry Division, Mainz, Germany

Using the “Atmospheric Chemistry Transport Model” being part of the “Model for Interdisciplinary Research On Climate Earth System Model, version 4” (MIROC4-ACTM), simulations of several important greenhouse gases, such as CH_4, CO_2, SF_6, and N_2O, have been conducted using optimized emissions by inverse modelling of surface measurements for the period 1996-2016 (referred to as “reanalysis data”). Aircraft observations, conducted on board passenger aircraft (projects: CARIBIC and CONTRAIL) over diverse latitude and longitude regions offer independent constraints for evaluating the quality of reanalysis data. MIROC4-ACTM captures the variations in CO_2 and SF_6 observed by CARIBIC and CONTRAIL very well, with a correlation coefficient of above 0.96 and a slope of 0.92 at all atmospheric conditions. However, for CH_4 and N_2O the agreement was worse, with correlation coefficients (slopes) between CONTRAIL observations and model simulations of 0.80(0.49)-0.87(0.66) and 0.74(0.55)-0.77(0.75), respectively, at 0-140°E and poleward of 40°N. Further south, that is between 30° S-40°N latitude (for the Tokyo-Australia flights), the correlation coefficients (slopes) was 0.76(0.83)-0.88(0.89) and 0.92(0.87)-0.98(1.05), respectively. Similarly, the agreement with the CARIBIC observations was moderate for CH_4 and N_2O, with correlation coefficients (slopes) of 0.81(0.55) and 0.88(0.65), respectively.

Keywords: MIROC4-ACTM, CONTRAIL, CARIBIC

©2019. Japan Geoscience Union. All Right Reserved.

Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product

*Tazu Saeki[1], Yosuke Niwa[1], Makoto Saito[1]

1. National Institute for Environmental Studies

Greenhouse gases (GHG) observations from satellites have contributed to expanding spatial coverage of observational networks for GHGs over the globe. Greenhouse gases Observing SATellite (GOSAT) has been monitoring the column-averaged dry-air mole fractions of atmospheric carbon dioxide (XCO_2) and methane (XCH_4) from space since its launch in January 2009. Its successor GOSAT-2 was successfully launched on 29 October 2018, and the observational data are being processed at GOSAT-2 ground systems. The GOSAT-2 mission aims to continue and enhance spaceborne measurement of GHGs started by GOSAT, and to monitor the impacts of climate change and human activities on the carbon cycle. Both satellites are jointly developed and operated by Ministry of the Environment, Japan Aerospace Exploration Agency (JAXA), and National Institute for Environmental Studies (NIES). NIES is responsible for producing and distributing higher level data products, such as Level 2 products (XCO_2 and XCH_4 etc.) and Level 4 products (surface fluxes of CO_2 and CH_4 and three-dimensional global distributions of CO_2 and CH_4 concentrations) (http://www.gosat-2.nies.go.jp).

We are currently developing an inversion system for operational use to produce GOSAT-2 L4 products. The Non-hydrostatic ICosahedral Atmospheric Model (NICAM)-based Transport Model (NICAM-TM; Niwa et al., 2011) is used for simulating atmospheric CO_2 and CH_4 concentrations, and an inversion system based on the four-dimensional variational (4D-Var) method with NICAM-TM (NICAM-TM 4D-Var; Niwa et al., 2017a,b) is adopted to estimate global surface CO_2 and CH_4 fluxes. In this presentation, we will present test results of CO_2 flux estimation with NICAM-TM 4D-Var using GOSAT data (not GOSAT-2 data), ground-based data, prior fluxes, and their error covariances. NICAM-TM is operated with a horizontal resolution of glevel-5 (an average grid resolution of 223 km) and 40 vertical layers, and its meteorological fields are nudged with JRA-55 data to simulate real atmospheric transport. NICAM-TM 4D-Var is run with stored meteorological data, which successfully reduces computational cost. CO_2 surface fluxes have been estimated at every 223 km grid resolution and at monthly time resolution. Preliminary test results with single-year GOSAT data showed that flux differences between the prior fluxes and estimated fluxes from the GOSAT data inversion appear over a broad area of land regions, even over Siberia and South America where ground sites are sparse, while the ocean regions showed relatively fewer flux changes after the inversion. Our ongoing work includes inversions with multi-year data, the inclusion of other data, and tuning model parameters. The details will be presented at the meeting.

Acknowledgments. The model simulations are performed with the NIES supercomputer system and the Research Computation Facility for GOSAT-2 (RCF2). This research is partly supported by the Environment Research and Technology Development Fund (2-1701) of the Environmental Restoration and Conservation Agency of Japan.

References

Niwa et al. (2011), Journal of the Meteorological Society of Japan. Ser. II, 89(3), 255–268.
Niwa et al. (2017a), Geoscientific Model Development, 10(3), 1157–1174.
Niwa et al. (2017b), Geoscientific Model Development, 10(6), 2201–2219.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Carbon budget, Flux estimations of greenhouse gases, Atmospheric inverse model, Top-down approach, Satellite remote sensing

©2019. Japan Geoscience Union. All Right Reserved.

Attribution of the ambiguity in methane’s growth rate shifts during 1988-2016.

*Naveen Chandra[1], Prabir Patra[1]

1. Japan Agency for Marine Earth Science and Technology

Atmospheric (CH_4) is an important greenhouse gas for mitigating climate change in the decadal scale due to its shorter atmospheric lifetime and about 30 times higher warming potential than carbon dioxide. The remarkable shift in CH_4 growth rate (decrease since early 1990s, quasi-stationary state during 1999-2005 and resume increase after 2006) has observed in past three decades (1990s-2010s). However, the attribution of these fluctuations remained highly conflicting. We have used a global inverse modeling system for constraining CH_4 emissions from 53 land regions for the period 1988–2016 using measurements from 19 sites and forward simulation by MIROC4-ACTM. The ACTM realistically represent inter-hemispheric transport and stratospheric age of air, and methyl chloroform concentration decay (proxy for loss OH concentration level) which are key elements for modelling CH4 in atmosphere. A set of 2 inversions is performed for different combinations of a priori emissions due to the wetlands and rice cultivation. We have shown that slowing down of emissions from oil and gas industry in the 1980s and Mt. Pinatubo volcanic eruption in 1991 led to a stabilization in emissions and thus the quasi-stationary state of CH4 concentration. The CH_4 growth after 2006 is attributed to increases in emissions mainly from coal industry and ruminant farming. The climatic variation due to ENSO caused significant interannual variation in the CH_4 growth rate. The role of CH_4 loss by hydroxyl (OH) reaction in CH4 growth rate variability is proposed to be not significant from inter-site differences.

©2019. Japan Geoscience Union. All Right Reserved.

Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño

*Masayuki Kondo[1], Peter Landschützer[2], Yousuke Iida[3], Richard Houghton[4], Stephen Sitch[5]

1. Center for Environmental Remote Sensing, Chiba University, 2. Max Planck Institute for Meteorology, 3. Global Environment and Marine Department, Japan Meteorological Agency, 4. Woods Hole Research Center, 5. University of Exeter

Large variability in El Niño-Southern Oscillation (ENSO) induces anomalous CO_2 fluxes both in biosphere and hydrosphere. In the negative phase of ENSO (i.e., El Niño), dryer climate over lower latitudes decreases productivity of land vegetation and increases vulnerability to biomass burning. At the same time, suppressed upwelling of carbon-rich water near the Pacific South America reduces outgassing of oceanic CO_2 to atmosphere. In years of a strong El Niño, anomalous land and ocean CO_2 fluxes account for a large part of interannual variability of the total net CO_2 flux of the Earth surface. Thus, anomalously large atmospheric CO_2 growth rates co-occur with periods of El Niño events.

Biomass burning is believed to be the dominant component of variability in atmospheric CO_2 growth rate during El Niño. The 1997/98 El Niño induced the most significant anomalous CO_2 release on record, largely due to forest and peat fires in Southeast Asia. Likewise, a massive fire haze over Southeast Asia was found during the recent 2015/16 El Niño. Despite the seemingly large impact of biomass burning in the two events, the 2015/16 El Niño accompanied substantially less atmospheric CO_2 growth compared with that in the 1997/98 El Niño. It turns out that CO_2 emission from biomass burning in 2015 was substantially less than that in 1997 because precipitation before the peak of fire emission (Sept-Oct) shortened the drought length of 2015.

However, it is still arguable that the insignificant biomass burning is the dominate cause behind no obvious signs of large CO_2 release in the 2015/16 El Niño. In the recent decades, both biospheric and hydrospheric CO_2 fluxes has shown trends towards a net sink of CO_2, which suggest a possibility of that increasing CO_2 uptake has suppressed the atmospheric CO_2 growth in the 2015/16 El Niño. To evaluate this possibility, a synthesis of land-ocean CO_2 flux over the period of the two El Niño events is necessary. Here, we explore mechanisms behind differences in the atmospheric CO_2 growth in the 1997/98 and 2015/16 El Niño. The aim of this study is to fully characterize the causes for insignificant atmospheric CO_2 growth in 2015/16 through analyzing types (anomaly/trend) of relative contributions of land-ocean fluxes to atmospheric CO_2 growth between the two El Niño events. Through the analysis, we discuss about components that would likely continue to mitigate atmospheric CO_2 growth in future El Niño.

Keywords: Carbon Cycle, El Nino, Attribution analysis

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

convener:Kazuhito Ichii(Chiba University), Prabir Patra(Research Institute for Global Change, JAMSTEC), Forrest M. Hoffman(Oak Ridge National Laboratory), Makoto Saito(National Institute of Environmental Studies), Chairperson:Prabir Patra

The landmark Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) aims at reduction of greenhouse gases (GHGs) emission to keep the global warming below 2 degC. As per the agreement the nationally determined commitments (NDCs) and their progresses should be carefully monitored and verified by international bodies. The emission verification will be based on observation of the time evolution of greenhouse gases and model-based estimations of emissions from time to time.

In recent years, the number of observations and new techniques to monitor GHGs budget have been increasing. The improvements includes observational platforms for monitoring atmospheric GHGs, national or regional emission inventories, top-down models (e.g. atmospheric inverse models), and bottom-up models (e.g. process-based models). However, due to uncertainties in modeling and sparse observation network, high uncertainty exists in GHGs sources/sinks estimations at global and regional scales. These uncertainties lead to large variations in future projection of GHG budgets and climate changes.

The purpose of the session is to discuss state-of-the-art techniques for estimations of GHGs (e.g. CO2, CH4, N2O) budget at global and regional scales. The topic includes natural and anthropogenic processes, various methodologies (e.g. in-situ observation, aircraft monitoring, remote sensing, modeling), and various targets (e.g. atmosphere, terrestrial, and ocean), various spatial and temporal coverage (e.g. regional to global scales and past-present-future). Improved estimates of emissions from land use change, forest fires, and other anthropogenic sources (urban developments and thermal power station etc.) are also of interest. We also welcome discussions for designs and plans for future studies targeting city and country scale emission estimations using sophisticated modeling tools.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG32-07] Observing vegetation seasonal dynamics in Japan with Himawari-8 hypertemporal data

*Tomoaki Miura[1,2], Shin Nagai[2], Kazuhito Ichii[3], Hiroki Yoshioka[4] (1.University of Hawaii at Manoa, 2.Japan Agency for Marine-Earth Science and Technology, 3.Center for Environmental Remote Sensing, Chiba University, 4.Aichi Prefectural University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG32-08] Carbon and Water Fluxes at High spatial Resolutions through Down-Scaling

*Jiquan Chen[1], Pietro Sciusco[1], Ranjeet John[1], Zutao Ouyang[1] (1.Michigan State University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG32-09] **Connecting Satellite Based Spectral Modelling Approach and Forest Inventory to Model Biomass and Carbon Stocks in Natural and Planted Forest over part of Semi-arid zone, India**

*SWATI UNIYAL[1], Siti Raju Rao (1.Andhra University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG32-10] **Allocation of forest net primary production varies by forest age and air temperature**

*Xiang Song[1], Xiaodong Zeng[1], Dongxiao Tian[2] (1.IAP, CAS, 2.Beijing Meteorological Information Center)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG32-11] Analyzing Model Biases in Terrestrial Carbon Cycle Submodels in Earth System Models and Offline Models

*Kazuhito Ichii[1], Kazutaka Murakami[2], Hiroaki Takayama[3], Tomohiro Hajima[3], Kaoru Tachiiri[3] (1.Chiba University, 2.National Institute for Environmental Studies, 3.Japan Agency for Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG32-12] Assessing terrestrial biogeochemical feedbacks in a strategically geoengineered climate

*Forrest M. Hoffman[1,2], Cheng-En Yang[2,1], Joshua S. Fu[2,1], Simone Tilmes[3], Lili Xia[4], Douglas G. MacMartin[5], Jadwiga H. Richter[3], Michael Mills[3], Ben Kravitz[6] (1.Oak Ridge National Laboratory, 2.University of Tennessee, 3.National Center for Atmospheric Research, 4.Rutgers University, 5.Cornell University, 6.Pacific Northwest National Laboratory)

Observing vegetation seasonal dynamics in Japan with Himawari-8 hypertemporal data

*Tomoaki Miura[1,2], Shin Nagai[2], Kazuhito Ichii[3], Hiroki Yoshioka[4]

1. University of Hawaii at Manoa, 2. Japan Agency for Marine-Earth Science and Technology, 3. Center for Environmental Remote Sensing, Chiba University, 4. Aichi Prefectural University

Spectral vegetation index (VI) time series data derived from moderate resolution, polar-orbiting satellite sensors, have been used to monitor and characterize the Earth’ s vegetative cover and its dynamics in regional to global scales. Unities of these VI time series data are, however, constrained by frequent cloud covers. That is, the derived VI products from these sensor data are at a weekly or bi-weekly temporal resolution due to the availability of cloud-free observations, resulting in relatively high uncertainties in their seasonal dynamics characterization. A new generation of geostationary satellite sensors equipped with spectral bands suitable for VIs, such as Himawari-8/9, have been launched during the last decade. As they are on geostationary orbit, they can image an Earth’ s hemisphere at 10-15 min intervals, potentially serving as another significant data source for the studies of vegetation dynamics.

In this study, we assessed the utilities of Himawari-8 “hypertemporal” NDVI data for characterizing seasonal dynamics of vegetation and land cover conditions. We compared Himawari NDVI temporal signatures to those derived from a new generation polar-orbiting satellite sensor, Visible Infrared Imaging Radiometer Suite (VIIRS), at select sites in Japan. Our analysis showed that cloud-free observations were available for ~24 days during the 45-day green-up period with Himawari, but ~12 days with VIIRS. In other words, the number of days with cloud-free observations could double with Himawari data compared to VIIRS data. These results indicate the potential of Himawari data for providing higher temporal resolution NDVI time series data and, thus, improved monitoring and characterization of vegetation dynamics in Japan compared to the current polar-orbiting satellite data. One potential drawback would be the fixed view zenith and azimuth angles which might become problematic when one is interested in analyzing vegetation dynamics across space. Validation of Himawari-observed NDVI temporal profiles with ground observational NDVI and carbon flux data will be one required step.

Keywords: Himawari, geostationary satellite, vegetation phenology, land surface phenology, NDVI

©2019. Japan Geoscience Union. All Right Reserved.

Carbon and Water Fluxes at High spatial Resolutions through Down-Scaling

*Jiquan Chen[1], Pietro Sciusco[1], Ranjeet John[1], Zutao Ouyang[1]

1. Michigan State University

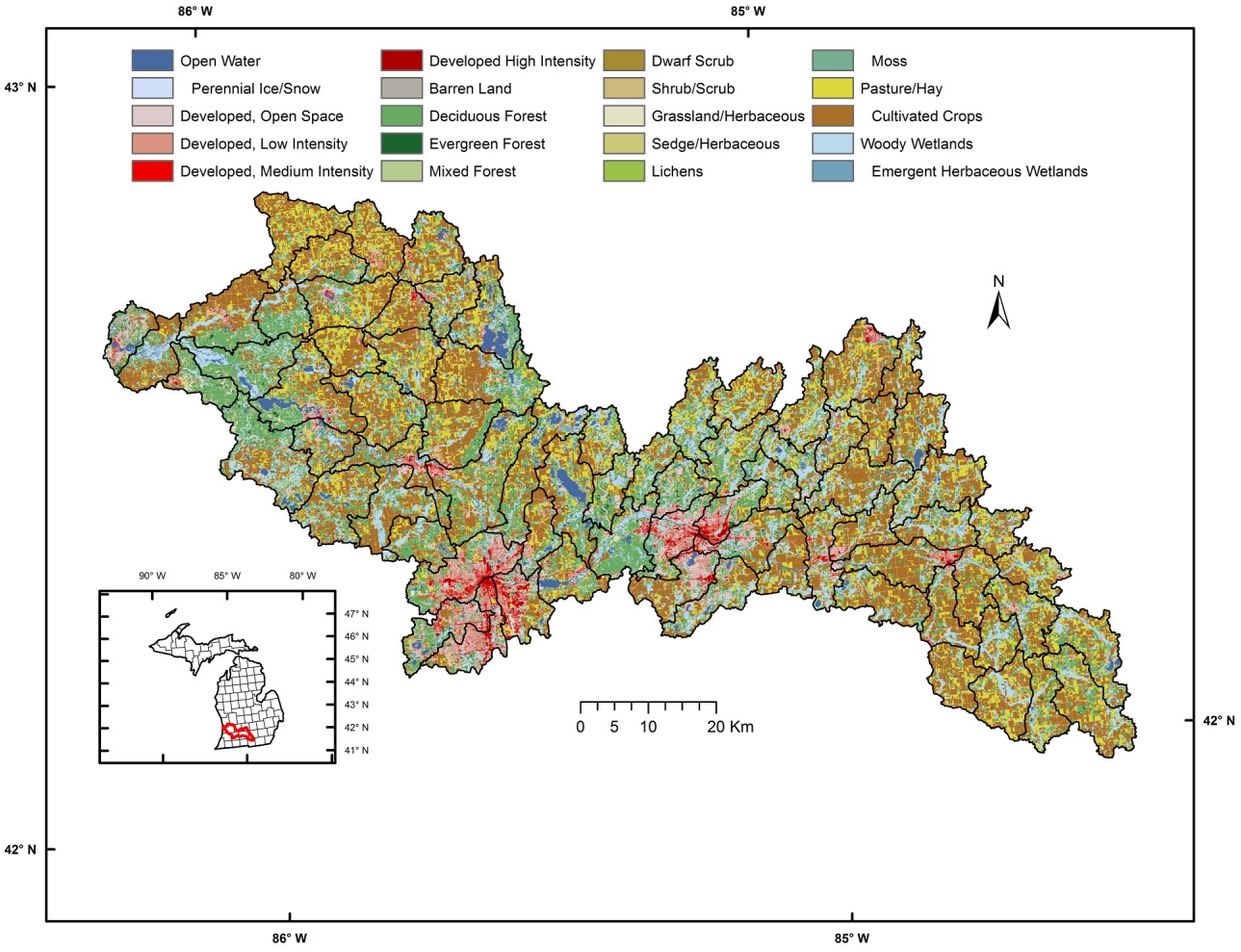
We propose an innovative top-down modeling approach to estimate high resolution (30 m) net primary production (NPP), evapotranspiration (ET) and *albedo* from MODIS products by integrating accurately classified land cover from Landsat/Sentinel and MODIS. Assuming that a measure of ecosystem ET in a landscape is a linear sum of ET of cover type (i), MODIS ET of a pixel can be expressed as:

$ET = sum(a_i * ET_i) + e$ [1]

where a_i is the compositional portion of cover type i within a MODIS pixel (where $sum(\alpha_i) = 1$) that can be calculated from classified land cover for the year; ET_i is the ET value of cover type i and can be estimated through multi-linear regression analysis with a zero intercept; and e is the residuals from the empirical model [1] and will be further examined for the potential influences of biophysical and socioeconomic driving forces. MODIS products of NPP, ET, and *albedo* of a landscape are estimated for their monthly and annual values by assuming that land cover during an individual year remains unchanged. This downscaling approach, currently tested for the Kalamazoo watershed in the southwestern Michigan, is only valid at a scale where similar climate, soil, and landforms exist (i.e. value of the same cover type in isolated patches are the same). To assure the validity of this approach, a multilinear regression analysis is performed with external factors such as soil type, climatic zone, and/or disturbance regime. Estimated ecosystem functions is then scaled up based on the 30 m resolution land cover of Landsat imagery for their high resolution spatiotemporal changes.

Keywords: carbon flux, down scaling, MODIS and Landsat

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Connecting Satellite Based Spectral Modelling Approach and Forest Inventory to Model Biomass and Carbon Stocks in Natural and Planted Forest over part of Semi-arid zone, India

*SWATI UNIYAL[1], Siti Raju Rao

1. Andhra University

Forests have been recognized as having important mitigation potential because of their critical role in the global carbon cycle and significant potential to capture and hold carbon. Biomass is an important parameter to assess the atmospheric carbon that is harvested by trees.

This study describes an effort to estimate regional level Above Ground Biomass (AGB) and carbon from plot to point from multi-season MODIS data for a part of semi-arid zone i.e. Madhya Pradesh state by establishing a correlation with field observed data. Using clustered sampling approach a total number of 1200 plots were laid on ground for natural forests and planted forests/tress. Stand biomass for each plot was computed from ground inventory using diameter, height, generalized species and interspecies allometric equations.

Spectral modelling was done with red, infra-red and NDVI of different seasons with observed AGB using statistical functions like linear, logarithmic, power and exponential. Various linear and multiple regression models were tested among all seasons and bands, and the best fit model from those was used for predicting biomass and carbon at regional level.

Red band and NDVI spectral reflectance combined with logarithmic function in multiple regression was found to be the best model (r^2=0.5784) for model Y= a +b1* ln (NDVI) + b2 *1/x*(Red) +b3 *sqrt (NDVI) for predicting biomass and Carbon. Predicted biomass value is in the range of 0-134.836t/ha, while total biomass of the area is 5950Tg. Similarly Predicted Carbon content is in the range of 0-64.04tC/ha and total carbon content in the range of 2690TgC.

Results were validated using 50 random points. The observed ABG of these 50 points validated with predicted AGB, a correlation R^2= 0.6003 was obtained indicating biomass and carbon obtained through spectral modelling has given good estimation at regional level.

Comparing biomass and carbon value for natural forest and plantation study explicitly noted that planted forest/trees sequester more carbon because results from a combination of site factors and adaptation of good silvicultural practices, while for natural forest wide variation in stand structure, tree growth, different stages of forest growth cycle, and varying tree density resulted in lower carbon content.

Keywords: Biomass, Spectral Modelling, Carbon Cycle, MODIS

©2019. Japan Geoscience Union. All Right Reserved.

Allocation of forest net primary production varies by forest age and air temperature

*Xiang Song[1], Xiaodong Zeng[1], Dongxiao Tian[2]

1. IAP, CAS, 2. Beijing Meteorological Information Center

Carbon partition among plant parts has a vital influence not only on the growth of individual plants but also on decomposition, carbon and nitrogen sequestration, and plant-atmosphere water exchange. Although many studies have tried to reveal plant growth mechanisms using observational living biomass or the biomass ratio among different organs, knowledge and understanding about carbon partition is still scarce and exists much uncertainty. In this work, a dataset from the Chinese Ecosystem Research Network (CERN) was used to explore the dependences of net primary production (NPP) partition among foliage, stem and branch, and root on forest age, and mean annual temperature (MAT). The results found that (1) younger plants usually allocated a higher proportion of the NPP to stems, branches, and roots; (2) MAT was negatively correlated with the proportions of the NPP allocated to foliage (F_{leaf}; %) and roots (F_{root}; %), while proportions of the NPP allocated to stems and branches (F_{stbr}; %) were positively dependent on MAT; (3) forest age had a larger direct influence on F_{leaf} and F_{root}, while MAT was relatively important for F_{stbr}. This work not only is important for understanding the contribution of climatic factor and forest age on forest NPP partition, but also provides valuable ideas for developing ecological models.

Keywords: net primary production partition, forest age, climate, China’s forest

©2019. Japan Geoscience Union. All Right Reserved.

Analyzing Model Biases in Terrestrial Carbon Cycle Submodels in Earth System Models and Offline Models

*Kazuhito Ichii[1], Kazutaka Murakami[2], Hiroaki Takayama[3], Tomohiro Hajima[3], Kaoru Tachiiri[3]

1. Chiba University, 2. National Institute for Environmental Studies, 3. Japan Agency for Marine-Earth Science and Technology

Improvement of terrestrial models in earth system models (ESMs) is important to reduce uncertainties in future projections of global carbon cycle and climate. Toward an improvement of ESMs, we need to evaluate current performance of terrestrial components in current ESMs and analyze their causes of biases. Therefore, using available observation based products (e.g. satellite-based products), offline ecosystem model outputs, and CMIP-5 ESM outputs, we attempted to characterize causes of biases of modeled terrestrial carbon flux and pools. We found that key climate variables, such as precipitation, is one of the causes of biases in ESM-based carbon fluxes. For example, positive precipitation biases in Africa and Oceania results in positive biases of gross primary productivity (GPP), biomass, and net biome productivity (NBP). Negative precipitation bias in tropical South America leads to negative GPP, biomass and NBP biases. Therefore, improvement of spatial patterns are one of the important next step toward ESM, in particular toward realistic simulations of sub-continental scale terrestrial variations.

Keywords: Terrestrial Carbon Cycle, Remote Sensing, Model, Data-driven estimation

©2019. Japan Geoscience Union. All Right Reserved.

Assessing terrestrial biogeochemical feedbacks in a strategically geoengineered climate

*Forrest M. Hoffman[1,2], Cheng-En Yang[2,1], Joshua S. Fu[2,1], Simone Tilmes[3], Lili Xia[4], Douglas G. MacMartin[5], Jadwiga H. Richter[3], Michael Mills[3], Ben Kravitz[6]

1. Oak Ridge National Laboratory, 2. University of Tennessee, 3. National Center for Atmospheric Research, 4. Rutgers University, 5. Cornell University, 6. Pacific Northwest National Laboratory

Stratospheric geoengineering by injecting sulfur dioxide into the lower stratosphere has been suggested as a possible means of reducing anthropogenic warming. While the impacts of stratospheric aerosol geoengineering on climate change have been investigated in the past few decades, only a few studies have considered the terrestrial biogeochemical feedbacks resulting from such treatment. These feedbacks can alter the atmospheric carbon dioxide concentration by storing or releasing additional carbon in terrestrial and marine ecosystems, thus, changing the climate trajectory and aerosol injection strategy for geoengineering. In this study, we analyzed model output from the recent Stratospheric Aerosol Geoengineering Large Ensemble project to assess the changes in terrestrial biogeochemical feedbacks on climate, particularly the carbon sink strength (CSS), in response to stratospheric aerosol geoengineering. Our results showed that the terrestrial CSS increased globally by 5.2 Pg C during 2070–2089 compared to that during the first twenty years of geoengineering starting from 2020, *i.e.*, an additional 11 ppm CO_2 -equivalent amount of carbon in the atmosphere would be stored on land. Among seven latitude bands, the midlatitudes in the Northern Hemisphere (35˚N–60˚N) had the largest CSS increase (+8.0 Pg C) whereas the Tropics (23.5˚S–23.5˚N) released carbon back to the atmosphere (–2.9 Pg C). Hypotheses regarding the causes of the variations in the differences in regional responses will be presented.

Keywords: geoengineering, biogeochemistry-Earth system interactions, carbon sink strength

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 304 3F

[H-DS09] Landslides and related phenomena

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Gonghui Wang(Disaster Prevention Research Institute, Kyoto University), Fumitoshi Imaizumi(Faculty of Agriculture, Shizuoka University), Chairperson:Fumitoshi Imaizumi

Mass movements, such as landslides, rockfalls, and debris flows, have been occurring extensively in a large number of countries, causing heavy damage. In order to understand them and mitigate induced disasters, we invite contributions that report and discuss on mass movements and related phenomena, focusing on improved understanding of their characteristics; new insights into landslide mechanisms; the development of new approaches to monitoring; novel approaches to behavior forecasting and prediction; studies of successful landslide management; and the development of methods for hazard and risk evaluation. In particular, papers about recent landslide hazards, induced by 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 western Japan rainstorm, and 2018 Hokkaido earthquake are welcome.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HDS09-01] Mechanical behavior modulated by shear surface morphology of simulated shear zone

*Yao Jiang[1], Gonghui Wang[2], Toshitaka Kamai[2] (1.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 2.Research Center on Landslide, Disaster Prevention Research Institute, Kyoto University, Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HDS09-02] On the Pre-failure Shear Behavior of Clayey Soil

*Chengrui Chang[1], Gonghui Wang[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HDS09-03] GeoGuard: low-cost GNSS sensors for the continuous monitoring of landslides and structures

*Andrea Gatti[1], Giulio Tagliaferro[1], Eugenio Realini[1], Stefano Caldera[1] (1.Geomatics Research & Development srl)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HDS09-04] Landslide Susceptibility Analysis in the Chenyulan River Watershed, Taiwan

*Po-Tsun Yeh[1], Kuang-Tsung Chang[1] (1.National Chung Hsing University, Taiwan)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HDS09-05] Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

*Jamie Rhys Evans[1], Fumitoshi Imaizumi [1] (1.Faculty of Agriculture, Shizuoka University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HDS09-06] Landslides induced by the knickpoint migration in the southern and the eastern margins of the Tibetan Plateau.

*Masahiro Chigira[1], Ching-Ying Tsou[2], Siyuan Zhao[4], Xiong Wu[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Hirosaki University, 3.Souithwest Jiaotong University, 4.Graduate School of Science, Kyoto University)

Mechanical behavior modulated by shear surface morphology of simulated shear zone

*Yao Jiang[1], Gonghui Wang[2], Toshitaka Kamai[2]

1. Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 2. Research Center on Landslide, Disaster Prevention Research Institute, Kyoto University, Japan

Mechanical behaviors of geologic granular materials in shear provide fundamental insights into the mobility mechanisms related to the dynamics of landslides and tectonic faults. Some previous experimental studies have shown that the mineralogy of constituent materials plays a first-order control on the transitions of mechanical behaviors, including sliding stability or instability. Moreover, other laboratory investigations have demonstrated the importance of shear rate as a primary control on the strength properties, leading to rate-strengthening or rate-weakening. Despite these efforts, however, neither the knowledge of general relationships between material properties and failure modes nor the underlying processes are well understood. Here we report on a series of ring-shear friction experiments designed to investigate the shear surface morphology on the mechanical behaviors along pre-existing granular shear zones. Two kinds of commercial granular materials were used in our experiments, say, halite and silica. Results directly show that only inclusion a low proportion of granular halite can produce the transition from stable sliding to stick-slip instability. The visual observations of shear surfaces further indicate that the variations with halite content form different morphologies. By analyzing the shear displacement and acoustic emission data, the microslip precursors were identified to stick-slip instability. It is expected that the mechanical behavior transition may constrain the evolution of asperity mechanism in nucleating rupture instability along heterogeneous shear surfaces owing to breakage of grain interfaces.

Keywords: granular materials, mechanical behavior, shear surface, acoustic emission, ring shear apparatus

©2019. Japan Geoscience Union. All Right Reserved.

On the Pre-failure Shear Behavior of Clayey Soil

*Chengrui Chang[1], Gonghui Wang[1]

1. Disaster Prevention Research Institute, Kyoto University

Introduction

Landslides are significant natural hazard that cause substantial economic loss and extensive loss of life. Triggering in landslides occurs as a result of highly dynamic processes and the hydrological state has a profound influence on the stability of the slopes. For rainfall-induced landslides, the increase of pore water pressure as a result of rainfall infiltration progressively reduces the normal effective stress of the slope materials acting on a potential shear surface and the shear resistance decreases as the inter-particle friction is reduced by the buoyancy force. Saito (1965) first proposed a linear trend when the inverse velocity before failure is plotted against time which has made a significant contribution to the understanding and monitoring of landslides (Voight, 1988, 1989; Fukozono, 1990). Many studies focusing on the deformation and pore water pressure noted that the rate of strain was initially small but showed a very rapid increase towards failure (Anderson & Sitar, 1995; Zhu & Anderson, 1998; Dai et al, 1999; Ng & Petley,

Methods

The aim of this study is to investigate experimentally the nature of the interactions between the pore pressure variation and the development of the displacement in the pre-failure stage. All the soil samples were taken from the Nishiwaki landslide, which was induced by the heavy rainfall accompanying the No. 21 Typhoon on Oct. 22rd, 2017 in Wakayama Prefecture. Subsequently, two different series of tests were undertaken under the combined condition of predefined normal stress and shear stress simulating consolidated nature slope in the ring shear apparatus. One series of test is the pore-pressure-controlled test, which uses a serially connected air tank and water tank to increase the pore water pressure (PWP) in the shear box of ring shear apparatus. This series of tests aims at simulating the effect of decreasing the effective stress state whilst holding constant shear stress to reproduce a slope undergoing heavy rainfall. The pore water pressure was increased deliberately and then hold or decrease the pore water pressure as a short-term movement was detected. Such a procedure has been repeated until the shear resistance dropped, which indicates the shear failure. The shear-stress-controlled series is aiming to investigate the shear displacement pattern with a gently cumulative increase in shear stress under undrained condition, which involves an increase of the shear stress in a flattened gradient after consolidation. Both series of tests are conducted in three kinds of consolidated conditions to examine the correlation between velocity and acceleration.

Results and discussions

In pore-pressure-controlled tests, the displacement shows a creep-like pattern before failure. During the whole test, several periods of constant velocity had been identified. We also found that shear swelling occurred in the drained shear test, therefore, we inferred that the possible infiltration of water into the shear zone may enable the continuous increase of pore water pressure so that the shear resistance will be lowered to initiate the accelerating movement. We also found that “stick-slip” behavior (short-term movements) occurred in the shear tests. We inferred that the increment of the PWP initiates the shear displacement rather than the amount of the PWP.

The results indicate that the increment of PWP can initiate larger and more rapid shear displacement when the level of the PWP is higher. A series of creep-like movements leads to final failure. The role of increasing pore water pressure in the initiation of the tertiary acceleration will be key for us to understand the creep behavior, and further tests and detailed examination on this issue will be continued.

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

GeoGuard: low-cost GNSS sensors for the continuous monitoring of landslides and structures

*Andrea Gatti[1], Giulio Tagliaferro[1], Eugenio Realini[1], Stefano Caldera[1]

1. Geomatics Research & Development srl

The United Nation Office for Disaster Risk Reduction warned that economic losses from landslides, floods, earthquakes, and drought will continue to escalate unless businesses take action to reduce their exposure to disaster risks. Structures can suffer structural deterioration due to aging, misuse or lack of proper maintenance. In addition, they are subject to exposure to natural hazards such as landslides, floods, and earthquakes. Traditional visual inspection techniques are both time consuming and expensive. They are also qualitative and can only assess outward appearance. Structures and natural hazard control and management are becoming one of the key issues in the approach to sustainable development of modern countries. In this framework, structural health monitoring is representing one of the most valuable approaches for the decision-making process. Global Navigation Satellite System (GNSS) technology can provide position information with accuracy to a few millimeters in near real-time. However, the widespread adoption of GNSS monitoring is hindered by the high cost of dual-/multi-frequency geodetic GNSS receivers.

In 2015, through a partnership with the Italian company Softeco, GReD started GeoGuard, an innovative end-to-end service for the continuous monitoring of landslides and structures by means of single-frequency GNSS low-cost receivers and antennas. GeoGuard provides accurate positioning with centimeter-level accuracy in near real-time, or millimeter-level accuracy for daily/sub-daily solutions. The GNSS network observations are processed by means of both Bernese software, and an ad-hoc evolution of goGPS, a free and open source positioning software package developed by the GReD team. A software platform was developed for the management of a GNSS positioning service, and for the visualization and delivery of results. Currently, GeoGuard uses GPS L1 observations for its operational activities; however, promising results are being obtained with the addition of Galileo E1 observations, especially for sites with limited sky visibility, and to improve the accuracy of sub-daily (e.g. hourly) solutions. Currently, the GeoGuard service is operational on two landslides, a highway bridge, a dam, and two penstocks.

Keywords: Monitoring, GNSS, GPS, Landslide, Structures, low-cost

©2019. Japan Geoscience Union. All Right Reserved.

Landslide Susceptibility Analysis in the Chenyulan River Watershed, Taiwan

*Po-Tsun Yeh[1], Kuang-Tsung Chang[1]

1. National Chung Hsing University, Taiwan

Many rainfall-triggered landslides occurred in the Chenyulan river watershed of central Taiwan during typhoon Morakot. In order to prevent rainfall-triggered landslide disasters, it is important to understand the relation of the disasters and the factors of rainfall, geology, and topography. In this study, the landslide susceptibility model of the Chenyulan river watershed was built and evaluated under the multiple logistic regression analysis based on slope units. These units were delineated by topography and 249 units out of them were chosen because orientation data of weak planes were included. The detection of the binary dependent variables (landslide and non-landslide samples) were based on the geomorphic change using satellite imageries before and after typhoon Morakot. Then the independent variables include geological, topographic and rainfall factors. Especially, we considered the orientation of weak planes and the spatial and temporal variability of rainfall. The result showed that the p-value of Hosmer-Lemeshow test and the Area Under the Curve of ROC are over 0.1 and 0.75, respectively. As the result, the chosen factors in the model could predict landslides in the Chenyulan river watershed effectively. It could be reference for follow-up research.

Keywords: Landslide susceptibility, Spatial and temporal variability of rainfall, Multiple logistic regression, Orientation of weak plane, Slope unit

©2019. Japan Geoscience Union. All Right Reserved.

Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

*Jamie Rhys Evans[1], Fumitoshi Imaizumi [1]

1. Faculty of Agriculture, Shizuoka University

The occurrence of landslides in forested terrain can have large impacts on the future productivity of soil and the quality of water that drains from a catchment, as well as damaging a valuable asset in the forest itself. The relationship between tree height and landslide occurrence in the Ikawa catchment, Northern Shizuoka prefecture, is investigated to gain a better insight into the distribution of landslides. Root depth profile, measured for trees of various height via trenches, is used in conjunction with tree height when assessing the distribution of landslides. Root tensile strength for unit areas of soil is calculated from individual root diameters to better understand the effect of the root network on slope stability. Landslide ratios in the Ikawa catchment show that landslides occur more frequently in shorter forests, with occurrence decreasing as tree height increases. This is likely due to stabilizing features of trees being accentuated as they grow, which is supported by both total root area and total root tensile strength data showing a significant increase between that of the 6.5m Kumashide, 8m Momi, and 12m Kumashide. The random distribution of results when comparing landslide depth to tree height suggests that while tree height, and hence total root tensile strength, has an impact upon whether a landslide is to occur or not, the depth of the landslides that do occur are independent of the height of trees. This suggests that slope stability increases alongside tree height and that landslide depth is not controlled by tree height so is therefore controlled by other factors. While there is no relationship between tree height and landslide depth, both Kumashide trees surveyed show decreases in total root tensile strength around the average depth of landslides in the Ikawa catchment of 0.46m.

Keywords: Landslide depth, Tree height, Root tensile strength, LiDAR

©2019. Japan Geoscience Union. All Right Reserved.

Landslides induced by the knickpoint migration in the southern and the eastern margins of the Tibetan Plateau.

*Masahiro Chigira[1], Ching-Ying Tsou[2], Siyuan Zhao[4], Xiong Wu[3]

1. Disaster Prevention Research Institute, Kyoto University, 2. Hirosaki University, 3. Souithwest Jiaotong University, 4. Graduate School of Science, Kyoto University

Because of the collision of Indian plate to Eurasian continent, Himalaya, which is the southern margin of the Tibetan Plateau, is uplifting very rapidly and also the eastern margin of the Tibetan Plateau is uplifting. Those mountains are the sites of uplift and also the sites of rapid erosion and mass movements. We made field survey, using PRISM image with a resolution of 5 m and 5-m ALOS AW3D in both areas. We studied gravitational slope deformation and landslide, which are the response of mountain slopes to river incision, along the Kaligandaki River in Nepal Himalaya and the Minjiang River in Sichuan and found that gigantic landslides have occurred due to the slope instability made by the upstream migration of knickpoints and undercutting of the nearby slopes.

Along the Kaligandaki River, there are two outstanding knickpoints at Kalopani and Talbagar, respectively. The knickpoint at Kalopani is located at the largest landslide dam, which is called Kalopani landslide or Lete landslide. This landslide is inferred to be preceded by buckling deformation of calc gneiss. It is located near the lower margin of the glaciated area, and the slope could have been eroded by a glacier at the foot of the slope. Downstream of the Lete landslide are aligned 4 gigantic landslides, of which the most upstream one is the Talbagar landslide. It occurred on the left bank just downstream of an outstanding knickpoint of the Kali Gandaki River. This knickpoint propagated from downstream forming a slope break 200-400 m high from the riverbed. Talbagar landslide is a rock compound slide and the other three gigantic landslides were of two mica gneiss and occurred on slopes that had been toppled above the slope break.

There are two significant knickpoints along the Minjian River upstream of the Longmenshan fault. The effects of the knickpoint propagation and inner gorge formation on slope stability are dependent on the geometrical relationships between the river and geological structures. When the geological trend is normal or highly oblique to the river axis, landslides generally do not occur, but gigantic catastrophic landslides have occurred on one side of the Minjiang valley, which can be attributed to a wedge structure consisting of bedding planes and joints with intersections dipping valleyward and tight folds with hinges plunging valleyward. Diexi landslide, the largest landslide along the Minjian River was a wedge failure induced by this knickpoint migration.

Keywords: Landslide, Tibetan Plateau, Himalaya, Minjan, Knickpoint

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 304 3F

[H-DS09] Landslides and related phenomena

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Gonghui Wang(Disaster Prevention Research Institute, Kyoto University), Fumitoshi Imaizumi(Faculty of Agriculture, Shizuoka University), Chairperson:Wang Gonghui, Issei Doi

Mass movements, such as landslides, rockfalls, and debris flows, have been occurring extensively in a large number of countries, causing heavy damage. In order to understand them and mitigate induced disasters, we invite contributions that report and discuss on mass movements and related phenomena, focusing on improved understanding of their characteristics; new insights into landslide mechanisms; the development of new approaches to monitoring; novel approaches to behavior forecasting and prediction; studies of successful landslide management; and the development of methods for hazard and risk evaluation. In particular, papers about recent landslide hazards, induced by 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 western Japan rainstorm, and 2018 Hokkaido earthquake are welcome.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[HDS09-07] Landslides caused by the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*Shin-ichiro Hayashi[1], Nobutomo Osanai[1], Takashi Yamada[1], Shin'ya Katsura[1], Takahisa Furuichi[1], Seiji Yanai[2], Yasuharo Murakami[3], Tomoyoshi Miyazaki[4], Yuichiro Tanioka[1], Shigetaka Takiguchi[5], Mayumi Miyazaki[6] (1.Hokkaido University, 2.Ishikawa Prefectural University, 3.Civil Engineering Research Institute for Cold Region, PWRI, 4.Shin Engineering Consultant, Co., Ltd., 5.Ministry of Land, Infrastructure, Transport and Tourism, 6.Pasco Corporation)

11:15 AM - 11:45 AM JST | 2:15 AM - 2:45 AM UTC

[HDS09-08] On the coseismic landslides occurring on tephra slopes during the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*Gonghui Wang[1], Gen Furuya[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Toyama Prefectural University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HDS09-09] Seismological and geotechnical surveys on the landslides induced by the 2018 Hokkaido Eastern Iburi earthquake

*Issei Doi[1], Hikaru Osawa[2], Sumio Matsuura[1] (1.Disaster Prevention Research Institute, Kyoto University, 2.Mountain Science Center, University of Tsukuba)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Landslides caused by the 2018 Hokkaido Eastern Iburi Earthquake

*Shin-ichiro Hayashi[1], Nobutomo Osanai[1], Takashi Yamada[1], Shin'ya Katsura[1], Takahisa Furuichi[1], Seiji Yanai[2], Yasuharo Murakami[3], Tomoyoshi Miyazaki[4], Yuichiro Tanioka[1], Shigetaka Takiguchi[5], Mayumi Miyazaki[6]

1. Hokkaido University, 2. Ishikawa Prefectural University, 3. Civil Engineering Research Institute for Cold Region, PWRI, 4. Shin Engineering Consultant, Co., Ltd., 5. Ministry of Land, Infrastructure, Transport and Tourism, 6. Pasco Corporation

The 2018 Hokkaido Eastern Iburi Earthquake struck the eastern Iburi region (epicenter: 42.691˚N, 142.007˚E, depth: 37.0km) of Hokkaido, Japan, at 3:07.59 JST, September 6, 2018 (18:07.59, September 5, 2018 UTC). Many shallow landslides and several large-scale deep-seated landslides, generating a landslide dam in the Hidaka-horonai River, were triggered by this magnitude 6.6 M_w (6.7 M_j) earthquake. The sedimentary rock in the affected area was covered by thick pyroclastic fall deposits derived from the Tarumae Volcano etc.. Landslides were densely distributed over hilly regions (elevation: 200–400 m) within an area of approximately 400 km^2 in Atsuma, causing 36 deaths, Abira and Mukawa, and representing the largest total area of earthquake-related landslides in Japan since the Meiji Era (1868–1912). The shallow landslides were characterized as follows: 1) pyroclastic fall deposits on sedimentary rock (basement complex) were moved by the strong seismic shock, 2) slip surface types included weathered tephra, weathered bedrock, and buried humus layers, 3) many occurred at relatively gentle slopes (< 30˚), 4) shallow landslides moving along valley type topography tended to travel longer than those moving along planar slope topography, and 5) concentrated shallow landslides occurred in tributary catchments of the Atsuma and Abira Rivers. Large-scale deep-seated landslides were characterized as follows: 1) rare occurrence and 2) slip surface within sedimentary rock.

Keywords: 2018 Hokkaido Eastern Iburi Earthquake, pyroclastic fall deposits, shallow landslide, landslide dam

©2019. Japan Geoscience Union. All Right Reserved.

On the coseismic landslides occurring on tephra slopes during the 2018 Hokkaido Eastern Iburi Earthquake

*Gonghui Wang[1], Gen Furuya[2]

1. Disaster Prevention Research Institute, Kyoto University, 2. Toyama Prefectural University

Numerous landslides were triggered by 2018 Hokkaido Eastern Iburi Earthquake on the tephra slopes, resulting in 36 casualties. Although one large landslide was initiated with its sliding surface being in the bedrock of sandstone and siltstone, most of them occurred on the tephra slope. To understand the initiation and movement mechanisms of these landslides occurring on tephra slopes, we performed field investigation (including geophysical survey, penetration test and field director shear box tests), and also conducted dynamic shear tests on the tephra samples taken from the sliding surface. The results will be presented in this report.

Keywords: Coseismic landslide, 2018 Hokkaido Eastern Iburi Earthquake, Tephra slope, Initiation mechanism, Movement mechanism

©2019. Japan Geoscience Union. All Right Reserved.

Seismological and geotechnical surveys on the landslides induced by the 2018 Hokkaido Eastern Iburi earthquake

*Issei Doi[1], Hikaru Osawa[2], Sumio Matsuura[1]

1. Disaster Prevention Research Institute, Kyoto University, 2. Mountain Science Center, University of Tsukuba

Atsuma Town, central part of Hokkaido, Japan, suffered from numerous landslides induced by the 2018 Hokkaido Eastern Iburi earthquake (Mw 6.7). We had a seismological and geotechnical surveys on some of the landslides. We selected a shallow landslide within tephra layers and a huge landslide of rockslide. Aftershock observation was conducted to grasp the vibration characteristics of the large landslide. Frequency components of ~2 Hz were dominant for S- and coda parts, with long durations of monochroic vibrations. Surface wave surveys, in both active and passive ways, were deployed to understand the vertical profile of the shallow landslide area. Very low (~ 50 m/s) Vs layers with the thickness ~ 1 m, which were consistent to the landslide depth, were detected along the survey line beside the landslide area, while such layers did not exist inside the landslide.

Acknowlegement: Hirokazu Fukui, a graduate student in Kyoto University, helped us for conducting the surveys.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 304 3F

[H-DS09] Landslides and related phenomena

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Gonghui Wang(Disaster Prevention Research Institute, Kyoto University), Fumitoshi Imaizumi(Faculty of Agriculture, Shizuoka University), Chairperson:Fumitoshi Imaizumi, Chigira Masahiro

Mass movements, such as landslides, rockfalls, and debris flows, have been occurring extensively in a large number of countries, causing heavy damage. In order to understand them and mitigate induced disasters, we invite contributions that report and discuss on mass movements and related phenomena, focusing on improved understanding of their characteristics; new insights into landslide mechanisms; the development of new approaches to monitoring; novel approaches to behavior forecasting and prediction; studies of successful landslide management; and the development of methods for hazard and risk evaluation. In particular, papers about recent landslide hazards, induced by 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 western Japan rainstorm, and 2018 Hokkaido earthquake are welcome.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[HDS09-10] Initiation conditions of debris flows in Ohsawa landslide, Mt. Fuji

★Invited Papers

*Fumitoshi Imaizumi[1], Kazuki Yamamoto[1], Atsushi Ikeda[4], Okihiro Ohsaka[1], Hiroyuki Sugimoto[2], Satoru Suzuki[2], Shinichi Sato[2], Yoshiaki Kashiwabara[3], Naoki Nishimura[3] (1.Faculty of Agriculture, Shizuoka University, 2.Fuji Sabo Office, Ministry of Land, Infrastructure and Transport, 3.Asia Air Survey Co., Ltd., 4.Faculty of Life and Environmental Sciences, Tsukuba University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HDS09-11] The role of thrust faults with incohesive clayey fault materials to generate deep-seated gravitational slope deformations and catastrophic landslides in the Shimanto accretionary complex

*Noriyuki Arai[1], Masahiro Chigira[1] (1.Disaster Prevention Research Institute,Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HDS09-12] Control effect of huge faults on the structure of surrounding regional rock mass in the whole mountain: implications for the distribution pattern of coseismic landslides

*Chao HUANG[1,2], Yusheng LI[1], Chunhao WU[3], Shujian YI[1,3], Kai LIU[1,4], Gonghui WANG[2] (1.State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, China, 2.Disaster Prevention Research Institute, Kyoto University, Japan, 3.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 4.China Railway Eryuan Engineering Group CO. LTD, China)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

Discussion

Initiation conditions of debris flows in Ohsawa landslide, Mt. Fuji

*Fumitoshi Imaizumi[1], Kazuki Yamamoto[1], Atsushi Ikeda[4], Okihiro Ohsaka[1], Hiroyuki Sugimoto[2], Satoru Suzuki[2], Shinichi Sato[2], Yoshiaki Kashiwabara[3], Naoki Nishimura[3]

1. Faculty of Agriculture, Shizuoka University, 2. Fuji Sabo Office, Ministry of Land, Infrastructure and Transport, 3. Asia Air Survey Co., Ltd., 4. Faculty of Life and Environmental Sciences, Tsukuba University

Initiation condition of the debris flow is generally explained only using rainfall threshold. However, the rainfall threshold possibly changes in cold seasons because of decreasing in the infiltration rate by freezing of the ground water. Snow cover and volume of unstable sediment in the debris flow torrent are also potential factor affecting the rainfall threshold. We have studied initiation condition of debris flow in Ohsawa landslide, Mt. Fuji, where the ground freezes for a long period due to high elevation. Snow cover period was estimated by the degree-day method. Progress of the freezing and melting of the groundwater toward deeper part of the ground was estimated using freezing degree days and degree days, respectively. In addition, effect of the freezing, snow cover, and volume of storage was studied by analyzing the rainfall and debris flow records over fifty years. Rainfall intensity and total rainfall needed for occurrence of debris flows in freezing periods is lower than that in the non-freezing periods. Rainfall threshold in the non-freezing periods with small volume of storage is lower than that in the non-freezing periods with large volume of storage. Influence of snow cover on the occurrence of debris flow and slash avalanche was not clear.

Keywords: Debris flow, Landslide, Mt. Fuji, Frozen soil

©2019. Japan Geoscience Union. All Right Reserved.

The role of thrust faults with incohesive clayey fault materials to generate deep-seated gravitational slope deformations and catastrophic landslides in the Shimanto accretionary complex

*Noriyuki Arai[1], Masahiro Chigira[1]

1. Disaster Prevention Research Institute,Kyoto University

The purpose of this study is to clarify the geological and geomorphological background of deep-seated catastrophic landslides (DCLs) and related gravitational slope deformations (DGSDs) that occur in mountain areas of accretionary complexes. We performed the detailed geological survey for the area of 25 km^2 in the Shimanto accretionary complex in the middle of the Kii Mountains, Japan. In this area, six DCLs were induced by the heavy rain of Typhoon Talas in 2011. Using the 1-m DTMs made from LiDAR data taken before and after the landslides by the Kinki Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, and Nara Prefecture, we investigated the distribution of the thrust faults with the incohesive clayey fault materials in the mountain slopes and the inner structures of these thrusts. Mineralogy, permeability and shear strength were measured for the fault gouge.
As a result, we obtained the following results and conclusions.
1. Low-angle thrust faults with incohesive fault rocks thicker than approximately 1 m were newly found to develop at intervals of a few km in the study area.
2. Many of these thrust faults were different from previously reported thrust faults. The thrust faults with incohesive fault rocks include clayey crush materials that form a weak and impermeable layer, which becomes the base of a DGSD and would accommodate a sliding surface of a DCL.
3. The DGSDs and rain-induced DCLs in the study area preferentially occur in the hanging walls of those thrust faults and their areal alignments are controlled by the thrust faults.
4. Thrust faults commonly extend for kilometers as planar features but are sometimes locally folded with their nearby rocks. When a syncline involving thrust faults plunges valleyward, this structure also facilitates DGSDs.

Keywords: deep-seated catastrophic landslide, gravitational slope deformation, incohesive clayey fault material, accretionary complex

©2019. Japan Geoscience Union. All Right Reserved.

Control effect of huge faults on the structure of surrounding regional rock mass in the whole mountain: implications for the distribution pattern of coseismic landslides

*Chao HUANG[1,2], Yusheng LI[1], Chunhao WU[3], Shujian YI[1,3], Kai LIU[1,4], Gonghui WANG[2]

1. State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, China, 2. Disaster Prevention Research Institute, Kyoto University, Japan, 3. Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 4. China Railway Eryuan Engineering Group CO. LTD, China

Introduction

Earthquakes and earthquake induced landslides are the most threatening geological disasters in nature. Coseismic landslide, as a surface catastrophic effect induced by earthquakes, has drawn much scientific attention. The fact that seismic faults play a control role in the occurrence of landslide has been generally recognized. Many relating researches focused on the relationship between landslide distribution patterns and the distance to the co-seismic fault, peak ground acceleration (PGA) of the earthquake, and types of faults based on remote sensing interpretation and GIS method. Many statistical methods including fuzzy analytic hierarchy process, principal component analysis, and logistic regression, were used to evaluate landslide susceptibility in an earthquake event considering the main role of faults. However, how the faults affect the distribution patterns of coseismic landslides has not been clearly understood.Therefore, in this study we examined this issue based on a case study on the landslides triggered by the 2008 Wenchuan earthquake, in China.

Method

We selected Qingping part of Longmenshan faults generating the Ms 8.0 earthquake as a target region. First, measurements of rock mass structure were conduceted. In-situ field rock mass structure investigations, 2m*2m measurement network was used, in laboratory, fractures that were visible to the naked eye in the field were sketched and counted using a square frame (0.3 *0.3 m) along profiles oriented across the faults. Then fracture density was calculated to determine the characteristics of fractured system of the crustal rock mass in the fault zone area. Finally, Wenchuan earthquake landslides distribution patterns was combined to deeply discuss the effects of faults on landslides.

Result

The results of spatial variations in fracture density with increasing distance from the Jiangyou-Dujiangyan fault were shown in Fig 1. As can be seen in Fig. 1, fracture density is much higher in the faults zone than other areas and sharply decreases with further increase after it exceeds a certain distance (CD) from the main fault. In Yingxiu-Beichuan fault, this CD is 3030 m in hanging wall and 1170 m in footwall, while in Jiangyou-Dujiangyan fault, this CD is 1350m in the hanging wall. Fracture density also increases when subsidiary faults across. The results showed that occurrences of fractures are strongly concentrated around the faults zone, such as Yingxiu-Beichuan fault and Jiangyou-Dujiangyan fault, presence of secondary faults also has a strong relation with fracture density distribution. Most co-seismic landslides for wenchuan earthquake in the research area distributed on the concentration part of rockmass factures.

Discussion

In this study, we found that there are control effects confined to a certain range of huge faults on the surrounding regional rock mass structure, showing a great impact on rock mass structure in a large scale. A concept named “fracture zone” was defined to express this phenomenon.

The results suggest the existence of remarkable hanging wall effect of rock mass structure, since the width of fracture zone in the hanging wall is greater than that in the foot wall. The fracture zone of Yingxiu-beichuan fault hanging wall is much wider than that of Jiangyou-dujaingyan fault, indicating that

©2019. Japan Geoscience Union. All Right Reserved.

there is a stronger control effect on rockmass structure of Yingxiu-beichuan fault compared with Jiangyou-dujaingyan fault.

Most co-seismic landslides for wenchuan earthquake distributed on the concentration part of rockmass factures, namely fracture zone. Distinct “hanging wall” effect of rockmass structure is consistent with the distribution pattern of coseismic landslides in the research area. Results indicate that the control effect has directly impacts on the distribution pattern of Wenchuan coseismic landslides

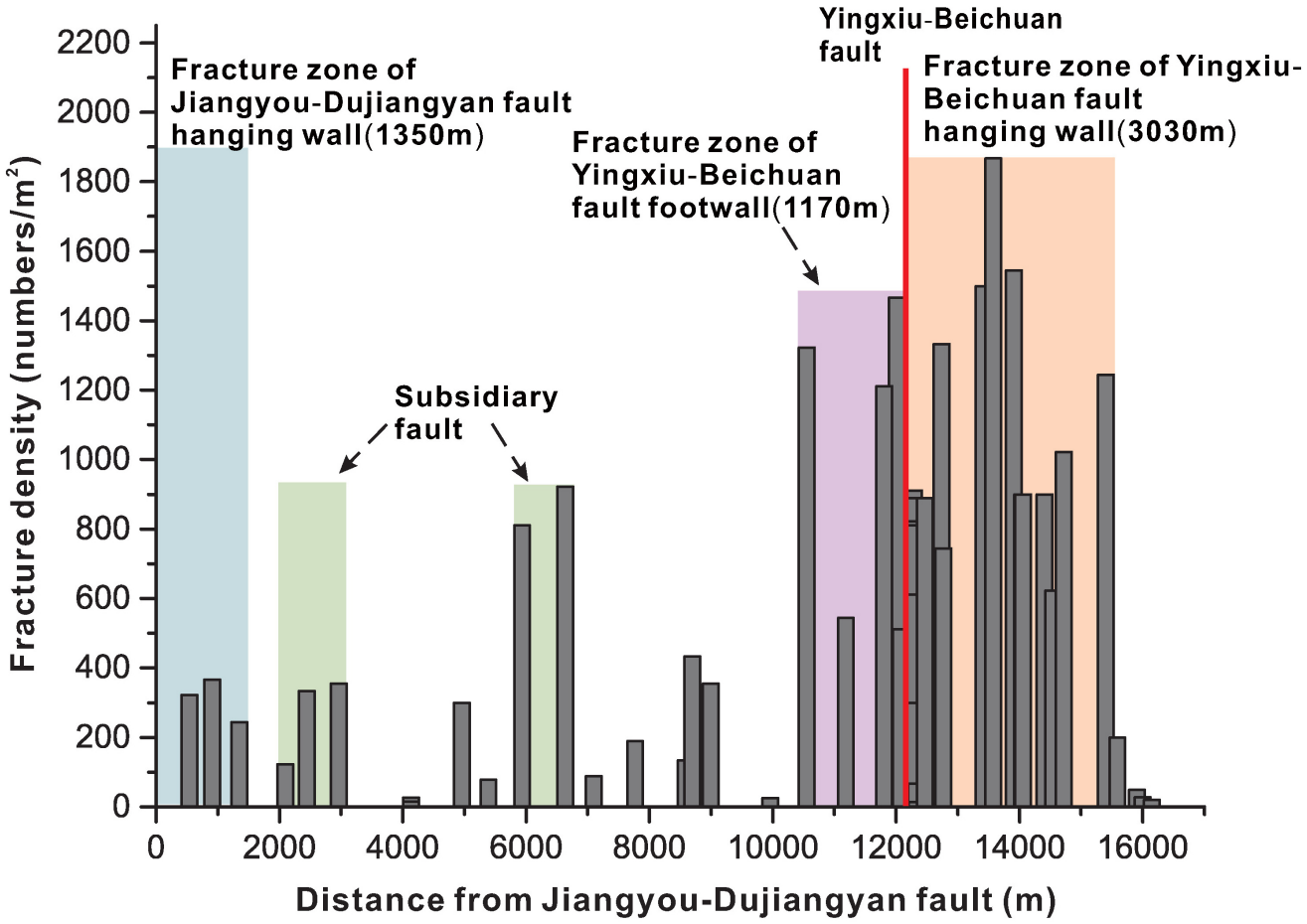
Conclusion

1. A control effect confined to a certain range of huge faults on the structure of surrounding regional rock mass in the whole mountain by using fracture density method, this effect was defined as “fracture zone” effect, which has directly impacts on the distribution pattern of Wenchuan earthquake induced landslides.
2. The control effect on surrounding regional rock mass structure were also founded in other huge faults, we argue that this effect is universal, which could be also suitable for other huge faults. The control effect marks long-term dangerous zones, since fragmented rock mass is vulnerable to subjected to failure, which has implications for disaster prevention in mountainous areas where faults are active.

Reference

Keefer, D. K. (1984). Landslides caused by earthquakes. GSA Bulletin 95(4): 406-42

Keywords: Huge fault, Rock mass structure, Coseismic landslide



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 302 3F

[H-TT18] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Nobuhito Ohte(Department of Social Informatics, Graduate School of Informatics, Kyoto University), Gabriel J Bowen(University of Utah), Chairperson:Nobuhito Ohte(Kyoto University)

Modern society uses almost all the elements present in the natural world. Although there have long been calls for the sustainable use of the resources that provide these elements and the building of human societies that are in harmony with the environment, the survival of the human race is increasingly at risk as a result of qualitative changes to the environment as a whole. Implementation by the society of methodologies for diagnosing and tracking these various elements of the natural environment and their relationships with humans are now required.
Elements cycle within and among the Earth system spheres, human society and the human body. Information on the concentrations and stable isotopes of elements is powerful tool for tracing this cycling and has been applied in studies of atmosphere-hydrosphere circulation, ecological systems, and the life, health and history of humans. We propose a session to discuss development and applications of environmental traceability methods toward the goal of establishing traceability in natural and human systems.
We encourage the presentation of research integrating isotopic information in various disciplines, such as geochemistry, hydrology, ecology, geology, mineralogy, anthropology, food science, and forensics. Studies applying "Isoscapes", maps of spatial isotopic variation, in addition to traditional database-based approaches, are strongly encouraged.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HTT18-01] Environmental traceability methodology by multi-isoscapes

*Ichiro Tayasu[1], Lei Fujiyoshi[1], Shiho Yabusaki[1], Ki-Cheol Shin[1], Takanori Nakano[1], Makoto Taniguchi[1] (1.Research Institute for Humanity and Nature)

9:15 AM - 9:45 AM JST | 12:15 AM - 12:45 AM UTC

[HTT18-02] Exploring physical and biological connections using isoscapes

★Invited Papers

*Gabriel J Bowen[1] (1.University of Utah)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HTT18-03] Spatial and temporal variations in stable isotopes and soluble ions on high mountain snow surface of Mt. Tateyama, Toyama Prefecture, Japan

*Nozomu Takeuchi[1], Ryo Sugiyama[1] (1.Chiba University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HTT18-04] Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters in a chert watershed.

*Masami Koshikawa[1], Mirai Watanabe[1], Tomoyoshi Murata[1], Takejiro Takamatsu[1], Shingo Miura[1], Ki-Cheol Shin[2], Takanori Nakano[2] (1.National Institute for Environmental Studies, 2.Research Institute for Humanity and Nature)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HTT18-05] Influences of soil dust, sea salt and anthropogenic activities on ionic and Sr isotopic compositions of wet deposition in Iran

*Yoriko Yokoo[1], Kosuke Asai[1], Sae Horii[1], Ryo Anma[2], Shiva Mehrabani[3], KiCheol Shin[4] (1.Faculty of Science and Engineering, Doshisha University, 2.Tokushima University, 3.Kurdistan University, 4.RIHN)

Environmental traceability methodology by multi-isoscapes

*Ichiro Tayasu[1], Lei Fujiyoshi[1], Shiho Yabusaki[1], Ki-Cheol Shin[1], Takanori Nakano[1], Makoto Taniguchi[1]

1. Research Institute for Humanity and Nature

Stable isotope ratios of elements, together with the concentrations of elements, can trace a matter flow, the environmental condition of sites, ecosystem structure and food products. Spatio-temporal variation of multiple isotope ratios can be used for studying the earth systems from local to global point of view. By using the traceability function of the multiple isotope ratios, we can conduct research that contributes to solving global environmental problems covering various regions and time scales. Spatio-temporal variation of multiple isotope ratios can be used for studying earth systems, ranging from local to global scales. The information may serve as a key decision- making factor for local people to consider water, food and environmental security, all of which are fundamental for the sustainability of human society.

We are conducting a research for establishing a methodology for how to use the concept of environmental traceability. A combination of quantitative and qualitative tools, including “Multi-Isoscapes” (use of multiple elements and multiple isotope ratios, together with GIS-based mapping technique), social surveys, and workshops, are deployed to investigate the role of environmental traceability in confronting environmental issues. We hypothesize that the role and perception of traceability methods in transdisciplinary processes will differ among stakeholders and that the co-production of “Multi-Isoscapes” can act as an effective “bridging tool” for understanding and explaining variation in local environments. The ultimate objective of this research is to demonstrate the effectiveness of multi-isotopic information in solving global environmental issues. Research is taking place at sites in Ono City, Fukui; Otsuchi Town, Iwate; Saijo City, Ehime; Oshino Village, Yamanashi; the Chikusa river watershed, Hyogo; Lake Biwa and Yasu river watershed in Shiga; and Silang-Santa Rosa sub-watershed in the Philippines.

Keywords: Stable isotopes, Milti-isoscapes, Environmental traceability

©2019. Japan Geoscience Union. All Right Reserved.

Exploring physical and biological connections using isoscapes

*Gabriel J Bowen[1]

1. University of Utah

Environmental chemistry data provide a wealth of information on Earth system processes, but perhaps one of the most general and widely useful applications of such data is in to identify within- and between-system connectivity. Chemical signatures have been used to establish hydrological connectivity, identify the provenance of geological materials, artefacts and forensic evidence, and trace the migration of humans and other animals. Particularly useful are spatial and temporal patterns of environmental isotope variation, which are often predictable based on large-scale databases and/or fundamental physio-chemical theory. I will review case studies demonstrating how the resulting quantitative data products, called isoscapes, have led to new advances and applications in fields as diverse as forensic science, water resources research, and aquatic ecology. I will also discuss how community data and computational infrastructure, including the Waterisotopes Database (wiDB; http://waterisotopes.org) and Isoscape Modeling, Analysis and Prediction tool (http://isomap.org) are facilitating and promoting the use of geochemical data in connectivity research and related outreach and education.

Keywords: stable isotopes, traceability, connectivity, water resources, forensics, hydrology

©2019. Japan Geoscience Union. All Right Reserved.

Spatial and temporal variations in stable isotopes and soluble ions on high mountain snow surface of Mt. Tateyama, Toyama Prefecture, Japan

*Nozomu Takeuchi[1], Ryo Sugiyama[1]

1. Chiba University

A great amount of snow accumulates during winter in mountain regions in Japan due to strong westerly of the Asian monsoon. Snow can preserve various aerosols in the atmosphere, such as sea spay, anthropogenic pollutants, mineral dust, and volcanic substances. Thus, studies of snow chemistry provide a means to understand spatial and seasonal variabilities of aerosols. Furthermore, soluble chemists in snow affect alpine vegetations and also affect microbes growing on snow surface during snow melting season. In this study, we investigated spatial variations in water stable isotopes and major soluble ions on snow surface of high alpine area of Mt. Tateyama (2300 - 2700 m a.s.l.) from spring to summer to understand sources and transportation of aerosols affecting the surface snow chemistry. The soluble ion concentrations in the surface snow are generally higher in April, when the surface snow did not melt yet, than those in May to August, when the snow melted significantly. We found high anomaly in Cl and stable isotope in the area along a small valley, called Raicho-zawa throughout the seasons. They are likely to originate from an active volcanic fumarole, called Jigokudani, located in this area. Results shows that the chemical conditions of the snow surface in this mountain area are mostly influenced by sea spay and anthropogenic pollutants supplied by westerly before melting season, and are also partially influenced by the volcanic fumarole of the mountain throughout the melting seasons.

Keywords: snow, stable isotope, soluble ion

©2019. Japan Geoscience Union. All Right Reserved.

Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters in a chert watershed.

*Masami Koshikawa[1], Mirai Watanabe[1], Tomoyoshi Murata[1], Takejiro Takamatsu[1], Shingo Miura[1], Ki-Cheol Shin[2], Takanori Nakano[2]

1. National Institute for Environmental Studies, 2. Research Institute for Humanity and Nature

The sources of Ca in forest ecosystems in Japan have been considered to be sea salt, weathering product of bedrock, and weak-acid soluble minerals in Kosa (Asian dust). However, we believe that volcanic ash in soil also plays an important contributor of Ca in areas with volcanic ash soil (e.g., Andosols), especially in the regions where the Ca supply from bedrock is anticipated to be low. We reported the significant contribution of volcanic ash in soil to Ca in stream waters and plants in a granite watershed of Tsukuba area, using stable isotope of Sr, a good proxy of Ca (Koshikawa et al. 2016). To evaluate the contribution of volcanic substances to soil-vegetation-stream systems, we conducted a similar study at the forest on Mount Amamaki where volcanic ash in soil would be more abundant than Tsukuba area and chert with high resistance to chemical weathering are widely distributed. In this presentation, we report the concentrations of Sr and Ca and the isotope ratio of Sr in the 42 stream waters, and those of precipitation, bedrock and volcanic ash which are considered to be the end component, and estimate the contribution of volcanic ash to Sr and Ca in stream waters.

Keywords: Volcanic ash, Sr isotopes, Stream water, Ca sources, Chert

©2019. Japan Geoscience Union. All Right Reserved.

Influences of soil dust, sea salt and anthropogenic activities on ionic and Sr isotopic compositions of wet deposition in Iran

*Yoriko Yokoo[1], Kosuke Asai[1], Sae Horii[1], Ryo Anma[2], Shiva Mehrabani[3], KiCheol Shin[4]

1. Faculty of Science and Engineering, Doshisha University, 2. Tokushima University, 3. Kurdistan University, 4. RIHN

We collected monthly wet deposition in four western cities (Hamedan, Ilam, Shiraz and Ahvaz) from January 2014 to May 2017 and in three eastern cities (Mashhad, Birjand and Zahedan) from January 2016 to May 2017 and in Rezvanshahr from May 2016 to May 2017 in Iran, and determined their pH values, electrical conductivity (EC), major ionic concentration (Na^+, Mg^{2+}, K^+, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-} and HCO_3^-) and Sr isotope ratios ($^{87}Sr/^{86}Sr$) in order to elucidate the influences of soil dust, sea salt and anthropogenic activities on wet deposition chemistry. In no-rainfall months, we rinsed the sampler with ultrapure water and collected it to understand the influence of aerosols. The climate in Iran is semiarid, and the dry and wet seasons are from June to September and from October to May, respectively.
The wet deposition and rinsed water samples in western and eastern Iran were neutral to slightly alkaline ranging from 6.26 to 9.04 and from 6.71 to 11.08 in pH, respectively. Those in Rezvanshahr were neutral to acidic ranging from 3.88 to 7.48 in pH. The ionic compositions of most precipitation samples were enriched in $Ca^{2+}$and HCO_3^-. Although the pH of natural rain in equilibrium state with atmospheric CO_2 is typically 5.6, precipitation in western Iran is not acidic because of neutralization by aeolian minerals such as calcite originating from arid areas. The $^{87}Sr/^{86}Sr$ of samples fell in a narrow range of 0.708±0.001. These values were most likely due to the dissolution of calcite. Small, but detectable seasonal variation was found in the $^{87}Sr/^{86}Sr$ ratio that suggests different provenances of calcite/gypsum controlled by changing wind direction.
The ionic compositions of several samples were abundant in NO_3^- and SO_4^{2-} in Hamedan, Ilam, Shiraz and Mashhad. These samples were collected during dry season and wet season immediately after the dry season. These results suggest that the samples dissolved NO_3^- and SO_4^{2-} derived from anthropogenic activities and/or soil dust such as sulfate minerals concentrated in atmosphere during the dry season. The ionic compositions of samples in Ahvaz, Rezvanshahr, Birjand and Zahedan were relatively enriched in Na^+ and Cl^-. Ahvaz and Rezvanshahr are closer to the Persian Gulf and the Caspian Sea, respectively. These indicate that the wet deposition samples in Ahvaz and Rezvanshahr are subject to salt from sea and salt lake.

Keywords: wet deposition, ionic composition, Sr isotope ratio, West Asia

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 302 3F

[H-TT18] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Nobuhito Ohte(Department of Social Informatics, Graduate School of Informatics, Kyoto University), Gabriel J Bowen(University of Utah), Chairperson:Gabriel Bowen(The University of Utah)

Modern society uses almost all the elements present in the natural world. Although there have long been calls for the sustainable use of the resources that provide these elements and the building of human societies that are in harmony with the environment, the survival of the human race is increasingly at risk as a result of qualitative changes to the environment as a whole. Implementation by the society of methodologies for diagnosing and tracking these various elements of the natural environment and their relationships with humans are now required.
Elements cycle within and among the Earth system spheres, human society and the human body. Information on the concentrations and stable isotopes of elements is powerful tool for tracing this cycling and has been applied in studies of atmosphere-hydrosphere circulation, ecological systems, and the life, health and history of humans. We propose a session to discuss development and applications of environmental traceability methods toward the goal of establishing traceability in natural and human systems.
We encourage the presentation of research integrating isotopic information in various disciplines, such as geochemistry, hydrology, ecology, geology, mineralogy, anthropology, food science, and forensics. Studies applying "Isoscapes", maps of spatial isotopic variation, in addition to traditional database-based approaches, are strongly encouraged.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HTT18-06] Long-term increasing trend of line-conditioned excess in groundwater

*Masanori Katsuyama[1] (1.Graduate School of Agriculture, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HTT18-07] Geochemistry of river water in the Okayama and Tottori Prefectures, Japan

*Katsuyuki Yamashita[1], Takahiro Kamei[1], Yuga Kishimoto[1], Masahiko Mori[1], Aya Ooi[2], Ayaka Onishi[2], Yoko Kurihara[2], Hitoshi CHIBA[1], Takanori Nakano[3], Ki-Cheol Shin[4] (1.Graduate School of Natural Science and Technology, Okayama University, 2.Faculty of Science, Okayama University, 3.Ono City, 4.Research Institute for Humanity and Nature)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HTT18-08] Study on groundwater flow system at Oshino Village in Yamanashi Prefecture – Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

*Shiho Yabusaki[1], Makoto Taniguchi[1], Ichiro Tayasu[1], Tomoya Akimichi[1], Noboru Ohomori[2], Ken Gotou[2], Souichirou Watanabe[2], Hitoshi Watanabe[2] (1.Research Institute for Humanity and Nature, 2.Oshino Village)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HTT18-09] The hydrogen and oxygen isotopic compositions of water in the Chikusa River

*Ken'ichi Ohkushi[1], Shiho Yabusaki[2], Ichiro Tayasu[2], Lei Fujiyoshi[2], Takanori Nakano[2], Ki-Cheol Shin[2], Tadashi Yokoyama[3], Hiromune Mitsuhashi[4], Masayuki Itoh[1], Kazuki Yasugi[1] (1.Kobe University, 2.The Research Institute for Humanity and Nature, 3.Ako School for Students with Special Ne, 4.University of Hyogo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HTT18-10] Dynamics of sulfate and nitrate inferred from stable isotope techniques in Chikusa river watershed, Hyogo Prefecture

*Lei Fujiyoshi[1], Ichiro Tayasu[1], Shiho Yabusaki[1], Takashi F Haraguchi[1], Chikage Yoshimizu[1], Ken'ichi Ohkushi[2], Fumiko Furukawa[2], Masayuki Itoh[2], Yudai Yamamoto[3], Tadashi Yokoyama[4], Hiromune

Mitsuhashi[5] (1.The Research Institute for Humanity and Nature, 2.Kobe University, 3.Nagoya University, 4.Hyogo prefectural Ako School for Students with Special Needs, 5.University of Hyogo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HTT18-11] Chemistry and sulfur and oxygen isotope ratios of sulfate ion of water soluble component of suspended particulate matter at Okayama city.

*Hitoshi CHIBA[1], Tsubasa Yamamoto[1] (1.Graduate School of Natural Science and Technology, Okayama University)

Long-term increasing trend of line-conditioned excess in groundwater

*Masanori Katsuyama[1]

1. Graduate School of Agriculture, Kyoto University

The isotope composition in water is commonly used for the analysis of hydrological processes. According to the recently proposed two water world hypothesis, precipitation will separated into two water pools such as the stored portion in soil pore which is much evaporated and used by vegetation, and the rapidly infiltrated portion which is less affected by evaporation and recharge the stored ground- and stream water. The line-conditioned excess (or lc-excess) is an appropriate indicator to find these separation. This method defines the offset between a meteoric water line and each water samples, with a negative value indicate the effect of evaporation. The long-term observation of isotope composition is ongoing at the Kiryu Experimental Watershed (KEW). The isotope composition in the rain water does not have a clear increasing or decreasing trends for the observation period. The long-term trend of the lc-excess was also not found in soil water and shallow groundwater. On the other hand, the increasing trend of the lc-excess was found in deeper groundwater. This fact means that the effects of evaporation on the infiltrating water are decreasing. The d18O in the groundwater was slightly decreasing. If the global warming directly effects on the isotope composition in the groundwater, the d18O may increase. Thus, the decreasing d18O and the increasing lc-excess may be the results of the change of local hydrological processes. Recently, it is reported that the extreme rainfall events are increasing in Japan, including in KEW. Therefore, the trend of lc-excess in groundwater suggest that change of rainfall patterns cause the increase of rapid infiltration and recharge of groundwater body. Moreover, the long-term trend of groundwater isotope composition was observed at five locations, Hokkaido, Toyama, Yamanashi, Tottori, and Miyazaki prefectures in Japan and one location in California, USA using commercially available bottled waters. Within these locations, similar trend as KEW was found at Tottori and California. Although the depth and size of groundwater body and their residence time may effect on the patterns and trends of isotope composition, the results shown here suggest that the importance of the long-term monitoring of the groundwater. The effects of extreme rainfall events and vulnerability of each region should be evaluated based on the intensive observations at highly installed watersheds, as well as the utilization of easily available samples such as bottled waters.

Keywords: Groundwater, Stable isotope in water, local meteoric water line, line-conditioned excess, two water world hypothesis, extreme events

©2019. Japan Geoscience Union. All Right Reserved.

Geochemistry of river water in the Okayama and Tottori Prefectures, Japan

*Katsuyuki Yamashita[1], Takahiro Kamei[1], Yuga Kishimoto[1], Masahiko Mori[1], Aya Ooi[2], Ayaka Onishi[2], Yoko Kurihara[2], Hitoshi CHIBA[1], Takanori Nakano[3], Ki-Cheol Shin[4]

1. Graduate School of Natural Science and Technology, Okayama University, 2. Faculty of Science, Okayama University, 3. Ono City, 4. Research Institute for Humanity and Nature

In order to evaluate the effect of water-soil (rock) interaction, as well as human impact on the geochemical nature of river water, we have collected 695 river water samples from 454 locations in the Okayama and Tottori Prefectures, Japan. The area is ideal for such study because (1) the geology of the area is well studied, (2) there is a sharp contrast in the amount of precipitation between the southern Okayama and northern Okayama to Tottori, and (3) the population density is highly variable. We have measured the major dissolved components, trace element concentrations, and O-H isotope ratios for all of the samples, along with Sr and S isotope ratios of the selected samples. Using these data, the high-resolution geochemical maps of the two prefectures were constructed.
Both the oxygen and hydrogen isotope ratios display a clear altitude effect. The d-excess, on the other hand, is high in the northern Okayama and Tottori Prefectures (>20), and gradually decreases towards the southern Okayama (5~15). This pattern can be explained by considering the O-H isotopic signatures of the precipitation (e.g Mao 2017), as well as the difference in the amount of precipitation in the two areas. The concentration of some elements seems to correlate well with the type of rocks exposed in the area. For example, Ca and Sr concentrations are high in the areas where limestones are exposed, whereas Cr and Ni concentrations are generally high in the areas dominated by ultra-mafic rocks. In the Mt. Daisen area of the western Tottori Prefecture where dacitic volcanic rocks are common, the concentration of Si, V, Rb, Cs is high. These observations suggest that the concentration of some elements in the river water is strongly controlled by the geochemistry of rocks exposed in the area. The concentration of some dissolved constituents such as SO_4 and NO_3, on the other hand, seem to correlate well with the population density. This may imply that human activity (industrial and agricultural) is responsible for the elevation of SO_4 and NO_3 concentrations in the river water.

Keywords: River water, Okayama Prefecture, Tottori Prefecture

©2019. Japan Geoscience Union. All Right Reserved.

Study on groundwater flow system at Oshino Village in Yamanashi Prefecture –Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

*Shiho Yabusaki[1], Makoto Taniguchi[1], Ichiro Tayasu[1], Tomoya Akimichi[1], Noboru Ohomori[2], Ken Gotou[2], Souichirou Watanabe[2], Hitoshi Watanabe[2]

1. Research Institute for Humanity and Nature, 2. Oshino Village

Oshino Village is located in southern part of Yamanashi Prefecture, Japan. The elevation is 936 m a.s.l. and the area of village is about 8 km from east to west and about 4 km from north to south. The Oshino Hakkai springs that is registered as World Cultural Heritage Site are located in Oshino Village. It is suggested that the Oshino Hakkai springs are recharged at Mt. Fuji as a result of field observation. The objective in this study to clarify the detailed groundwater flow and residence time of spring water and groundwater in Oshino Village. In this presentation, the authors will report about average residence time of groundwater and spring water.

The water samples for estimating the residence time by using the CFCs and SF_6 have been collected at 2 spring water sites, 1 shallow groundwater site and 11 deep groundwater sites. For ^{3}H analysis, water samples have been collected at 4 spring water sites and 4 deep groundwater sites. In this study, “shallow groundwater” is defined as several meters to some dozen meters depth, and “deep groundwater” is defined as about 100 m to 400 m depth.

As a result of analysis, the average residence time of spring water is about 10 to 26 years, shallow groundwater is about 30 to 40 years and deep groundwater is about 40 to 60 years. In addition, it is estimated that the average residence time of spring water which show the specific water quality (Na-SO_4 type, $\delta^{18}O$ and δD is relatively low) is more than 70 years. We will consider the relation between average residence time and water quality/ stable isotopes in future.

The continuous observation of water temperature and EC at 2 sites of Oshino Hakkai has been implemented since August, 2018. We will continue the field observation of Oshino village at 2019, and estimate the groundwater flow system and residence time more clearly.

Keywords: Oshino Village, groundwater, water quality, stable isotopes, groundwater flow, residence time

©2019. Japan Geoscience Union. All Right Reserved.

The hydrogen and oxygen isotopic compositions of water in the Chikusa River

*Ken'ichi Ohkushi[1], Shiho Yabusaki[2], Ichiro Tayasu[2], Lei Fujiyoshi[2], Takanori Nakano[2], Ki-Cheol Shin[2], Tadashi Yokoyama[3], Hiromune Mitsuhashi[4], Masayuki Itoh[1], Kazuki Yasugi[1]

1. Kobe University, 2. The Research Institute for Humanity and Nature, 3. Ako School for Students with Special Ne, 4. University of Hyogo

Chikusa River is the class B river facing the Seto Inland Sea in southwest Japan. Because of heavy rain, this river sometimes flows over and its basin is damaged, so Hyogo prefecture has carried out river reforming works to improve the capacity of flow until May, 2016. But the works changed the environment of this river, the impact on the quality of river water and the river ecosystem is concerned and we need the basic data of this river to measure this impact scientifically. In this study, we analyzed concentrations of dissolved ion and trace elements, stable isotopic ratio of water (δ 2H, δ 18O). In addition, we plotted the result of analysis on a basin map with a geographical information system so that the result could be seen easily and we aimed to offer the basic data which was easy to use. Furthermore, we estimated the formation factor of dissolved ion, trace elements and stable isotopic ratio of the river water through a comparison between the result of analysis and the land use, geological features and topography of the basin.

In Chikusa River, Chikusa River Conservation Committee has been holding “The simultaneous survey of water temperature all around Chikusa River” in every August since 2002. In this survey, the committee and many local residents measure water temperature at 94 sites, from headwaters to river-mouth and some tributaries. From 2015, Research Institute for Humanity and Nature, Kobe University and University of Hyogo has joined in this survey and started collecting water samples. In the survey of 2018 (held in August 5, 13:00~16:00), we received the water samples from local residents and we filtered them at once, with cellulose acetate filters whose diameters of holds are 0.2 μm. After filtering, we subdivided the samples into some polyethylene bottles and a glass vial and stored them at 20℃ or -30℃. We analyzed stable isotopic compositions of water. Stable isotopic composition of water was lower in the upstream and higher from the middle reaches to the downstream. From the upstream toward the middle reaches, the ratio became lower as the altitude became higher because of the precipitation affected by the altitude effects. On the other hand, the ratio was higher from the middle reaches to the downstream in spite of the altitude. These areas’ river became shallower and wider in the river reforming works, so the effects of sunlight on the river became big and the evaporation from the surface of river became more active.

©2019. Japan Geoscience Union. All Right Reserved.

Dynamics of sulfate and nitrate inferred from stable isotope techniques in Chikusa river watershed, Hyogo Prefecture

*Lei Fujiyoshi[1], Ichiro Tayasu[1], Shiho Yabusaki[1], Takashi F Haraguchi[1], Chikage Yoshimizu[1], Ken'ichi Ohkushi[2], Fumiko Furukawa[2], Masayuki Itoh[2], Yudai Yamamoto[3], Tadashi Yokoyama[4], Hiromune Mitsuhashi[5]

1. The Research Institute for Humanity and Nature, 2. Kobe University, 3. Nagoya University, 4. Hyogo prefectural Ako School for Students with Special Needs, 5. University of Hyogo

The Chikusa river watershed is located in the southwestern part of Hyogo prefecture. Recent river improvement in the watershed has posed concerns about changes in water quality and river ecosystem. This study aims to clarify the dynamics of dissolved ions especially sulfate and nitrate using stable isotope techniques, and to contribute to the evaluation of water environment in the watershed.

Water samples were collected from headwaters to the river mouth in August (2015, 2016, and 2017) and in February (2018), and measured ion concentrations, sulfur (δ^{34}S) and oxygen (δ^{18}O) stable isotope ratios of sulfate, and nitrogen (δ^{15}N) and oxygen (δ^{18}O) stable isotope ratios of nitrate.

Sulfate concentration was lower upstream and higher downstream in all periods, and the nearest point to the river mouth showed topically high concentration (1156 mgl^{-1}). The δ^{34}S and δ^{18}O values of sulfate suggested that the sulfate was mainly derived from soil sulfate, and the sulfate near the river mouth was derived from the seawater. In contrast, nitrate concentration was higher upstream and lower downstream in August, however the trend reversed in February. The δ^{15}N and δ^{18}O values of nitrate imply that the contribution of primary production and/or denitrification in water caused the reversed trend of nitrate concentration. The spatial distribution of δ^{15}N of nitrate showed a significant correlation with the proportion of fertilized land use (paddy field, farmland, and golf course) in all periods, suggesting an influence of fertilization.

Keywords: sulfate, nitrate, sulfur stable isotope, nitrogen isotope, oxygen stable isotope, Chikusa River watershed in Hyogo

©2019. Japan Geoscience Union. All Right Reserved.

Chemistry and sulfur and oxygen isotope ratios of sulfate ion of water soluble component of suspended particulate matter at Okayama city.

*Hitoshi CHIBA[1], Tsubasa Yamamoto[1]

1. Graduate School of Natural Science and Technology, Okayama University

Suspended particulate matters (SPM and PM2.5) have been collected at Okayama University, Okayama city in order to elucidate their chemical nature, origin and relationship with sulfate ion in precipitation. SPM and PM2.5 were sampled once a month and duration of the sampling is 96 hours. Water soluble components of SPM and PM2.5 were extracted ultrasonically. Their chemical compositions were analyzed by ion chromatography and sulfur and oxygen isotope ratios were analyzed by EA-IRMS and TC/EA-IRMS, respectively.

Soluble components of PM and PM2.5 are overwhelmingly composed NH_4^+ and SO_4^{2-}, thus seems to be mainly $(NH_4)_2SO_4$. There is no significant compositional difference in SPM and PM2.5.

Sulfur isotopic ratio of sulfate in water soluble components in SPM and PM2.5 at Okayama city is high in winter and low in other seasons, similar to nss-sulfate in precipitation. However, their sulfur isotope ratios in autumn and winter are 1 to 2‰ higher than those of nss-sulfate in precipitation. High sulfur isotope ratios in winter seem to be affected by sulfur compounds originated from coal combustion in China. However, they are clearly lower than those of sulfate in total suspended particulate matter in Beijing (Han et al., 2016) and indicate that, even in winter, contribution of sulfur originated from coal-combustion in China seems to be small at Okayama city and local source may mainly contribute to sulfate of suspended particulate matter. Furthermore, sulfur isotope ratios of nss-sulfate in PM2.5 at Niigata city (Inomata et al., 2016) agree generally with our data at Okayama city.

Oxygen isotope ratios of soluble components in SPM and PM2.5 seem to be high in winter. Oxygen isotope ratios of nss-sulfate of precipitation is also high in spring. However, the cause of this phenomena is not clear now.

Present data suggests that the direct contribution of trans-border transport of SPM and PM2.5 from China is limited at Okayama city and/or that sulfur and oxygen isotope signatures of sulfate in water soluble components of SPM and PM2.5 are greatly altered during transport from China to Okayama.

Keywords: Water soluble components of suspended particulate matter, Okayama, Sulfur isotope ratio of sulfate, Oxygen isotope ratio of sulfate

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 302 3F

[H-TT18] Development and application of environmental traceability methods

convener:Ichiro Tayasu(Research Institute for Humanity and Nature), Nobuhito Ohte(Department of Social Informatics, Graduate School of Informatics, Kyoto University), Gabriel J Bowen(University of Utah), Chairperson:Ichiro Tayasu(Research Institute for Humanity and Nature)

Modern society uses almost all the elements present in the natural world. Although there have long been calls for the sustainable use of the resources that provide these elements and the building of human societies that are in harmony with the environment, the survival of the human race is increasingly at risk as a result of qualitative changes to the environment as a whole. Implementation by the society of methodologies for diagnosing and tracking these various elements of the natural environment and their relationships with humans are now required.
Elements cycle within and among the Earth system spheres, human society and the human body. Information on the concentrations and stable isotopes of elements is powerful tool for tracing this cycling and has been applied in studies of atmosphere-hydrosphere circulation, ecological systems, and the life, health and history of humans. We propose a session to discuss development and applications of environmental traceability methods toward the goal of establishing traceability in natural and human systems.
We encourage the presentation of research integrating isotopic information in various disciplines, such as geochemistry, hydrology, ecology, geology, mineralogy, anthropology, food science, and forensics. Studies applying "Isoscapes", maps of spatial isotopic variation, in addition to traditional database-based approaches, are strongly encouraged.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HTT18-12] **Do mountain-climbing mammals protect plants from global warming by their vertical seed dispersal?**

*Shoji NAOE[1], Ichiro Tayasu[2] (1.Forestry and Forest Products Research Institute, Forest Research and Management Organization, 2.Research Institute for Humanity and Nature)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HTT18-13] Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

*Takashi F Haraguchi[1], Ryosuke Koda[2], Ichiro Tayasu[1] (1.Research Institute for Humanity and Nature, 2.RIEAF, Osaka)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HTT18-14] Nutrient supply from forest to river in eastern Toyama: carbon and nitrogen isotopic composition of Epilithic Organic Matter

*JING ZHANG[1], Ryosuke Masuda[1], SAKI KATAZAKAI[1], Tamihisa Ohta[1], OSAMU INAMURA[2], Fumiko Nakagawa[3] (1.University of Toyama, 2.Uozu Aquarium, 3.Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HTT18-15] Investigation on the possibility of the identification of air pollutant sources using stable isotope ratios of lead and strontium

*Shinji Sakurai[1], Takao Nakagiri[1], Kosuke Tanaka[1], Haruhiko Horino[1], Ki-Cheol Shin[2], Ichiro Tayasu[2], Shiho Yabusaki[2] (1.Osaka Prefecture University, 2.Research Institute for Humanity and Nature)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HTT18-16] **Magnesium and zinc stable isotopes in stream ecology**

*Kai Nils Nitzsche[1], Yoshikazu Kato[1], Ki-Cheol Shin[1], Hiromitsu Kamauchi[1], Ichiro Tayasu[1] (1.Research Institute for Humanity and Nature)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HTT18-17] A mechanitic metabolic model of nitrogen stable isotope dynamics in trophic processes

*Reiichiro Ishii[1], Maki Noguchi Aita[2], Eitaro Wada (1.Research Institute for Humanity and Nature, 2.Japan Agency for Marine-Earth Science and Technology)

Do mountain-climbing mammals protect plants from global warming by their vertical seed dispersal?

*Shoji NAOE[1], Ichiro Tayasu[2]

1. Forestry and Forest Products Research Institute, Forest Research and Management Organization, 2. Research Institute for Humanity and Nature

Today, global warming is progressing rapidly, and attention is focused on how trees that make up the forest respond. The easiest and most powerful means for trees to escape from global warming is to move to colder areas, that is, higher altitude or latitude, by seed dispersal. Considering that the temperature drop with increasing altitude is one hundred to a thousand times larger than that of the equivalent latitudinal distance, vertical seed dispersal seems a key process for plant escape from warming temperatures. However, no study has evaluated vertical seed dispersal itself due to technical difficulty or high cost. By using negative correlation between altitudes and oxygen isotope ratio of seeds, we evaluated the vertical seed dispersal of summer-fruiting wild cherry and autumn-fruiting wild kiwi by mammals in central Japan. The results were contrasting: while seeds of cherry were dispersed toward mountain tops (by bear; mean +307.2, marten; +193.0 m), seeds of kiwifruit were dispersed toward the foot of mountains (by bear; -393.1, monkey; -98.5, raccoon dog; +4.5, marten; -226.9 m). These were probably because mammals followed plant phenology in temperate zone which proceeds from the foot to the top of mountains in spring to summer and from the top to the foot in autumn to winter. Downhill seed dispersal will likely lead to a serious population decrease of plants under global warming, because their performance is strongly reduced by novel competitive plants in the lower altitude environment. Considering that many of trees depend on animals and fruit in autumn to winter, forest composition in temperate zone might dramatically change under global warming due to biased vertical seed dispersal by animal.

Keywords: seed dispersal, global warming, temperate forest, mammal, cherry, kiwi

©2019. Japan Geoscience Union. All Right Reserved.

Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

*Takashi F Haraguchi[1], Ryosuke Koda[2], Ichiro Tayasu[1]

1. Research Institute for Humanity and Nature, 2. RIEAF, Osaka

A rapid increase in the number of sika deer (*Cervus nippon*) in the last decades aroused needs for quantitatively estimating crop herbivory by them, in order to evaluate how much damage they cause to agriculture. Analysis of ingredients in deer feces using observation under microscopes or molecular techniques is useful to reveal whether they consumed crops. Nevertheless, these techniques in common tend to underestimate crop herbivory, because crops are usually digested more easily than wild plants and less likely to remain in the feces. Measurement of fecal nitrogen stable isotope ratio (fecal δ^{15}N) can be a complement to the molecular technique, considering that application of fertilizer leads to distinctively higher δ^{15}N values of crops than the adjacent wild plants. In our previous study using captive deer individuals, we estimated the fecal δ^{15}N values are 2.0 to 3.5‰ lower than those of deer diets. Based on the test using captive individuals, the uncertainties of the fecal δ^{15}N values associated with the variations in isotopic fractionation were far less than the difference of δ^{15}N values between fertilized crops and wild plants. In this study, for a field validation of the fecal δ^{15}N measurements as an indicator of crop consumption, we examined the spatial distribution of the fecal δ^{15}N, assuming the crop consumption should occur in the individuals of sika deer inhabiting close to cropland.

Deer feces were collected in 80 forested sites in the northern part of Osaka prefecture in the 2014 to 2015 winter period. The fecal samples, which were dried at 60℃, ground, and homogenized for each of the fecal mass, were used for δ^{15}N measurements. Based on GPS telemetry of sika deer in the region (Ishizuka et al., 2007), we assumed that short-time moving range of sika deer is around 500 m in radius and the accessibility of crops for the deer is reflected by surrounding land use within the distance from sampling points. Land use surrounding sampling points were categorized into four components; forest, crop field, herbal vegetation, residential area and area of each component were calculated. Land use data are obtained from MoE National Surveys on the Natural Environment and area (m^2) of the surrounding sampling points. We conducted Spatial AutoRegressive model (SAR) and PCNM-RDA analyses to analyze the effects of surrounding areas of these landscape components on the fecal δ^{15}N values and concentrations of nitrogen in the feces.

The surrounding area of crop field was selected as a single variable to explain the fecal δ^{15}N values, and the positive correlation between the fecal δ^{15}N values and crop field area indicated the availability of crop to deer was a factor of the increase in the fecal δ^{15}N values. Based on the result, this study supported our hypothesis that fecal δ^{15}N values are an effective indicator of crop consumption by sika deer. In our presentation, we will further discuss about the relationships among concentration of nitrogen in the feces, which is known as an indicator of nutritional status of the defecated individual, estimated deer population density, and land use to elucidate factors inducing crop consuming behavior of sika deer.

Keywords: wildlife control, spatial analysis, biologging

©2019. Japan Geoscience Union. All Right Reserved.

Nutrient supply from forest to river in eastern Toyama: carbon and nitrogen isotopic composition of Epilithic Organic Matter

*JING ZHANG[1], Ryosuke Masuda[1], SAKI KATAZAKAI[1], Tamihisa Ohta[1], OSAMU INAMURA[2], Fumiko Nakagawa[3]

1. University of Toyama, 2. Uozu Aquarium, 3. Nagoya University

River water has higher concentrations of dissolved components than precipitation because dissolved components are added when precipitation passes through forest areas interacting with rocks and vegetation. To clarify the supply of nutrients from the forest area to the river, in this study we focused on catchment areas and conducted research at river upstream areas in eastern Toyama prefecture where there is with very little human influence. River waters and Epilithic Organic Matter (EOM) were collected from 2016 to 2018. We measured the concentration of major chemical components, stable isotope composition of oxygen and hydrogen (d18O, dD) in water samples, and stable carbon and nitrogen isotopic ratios of EOM. Analysis results are discussed together with topographical data and the vegetation map obtained by GIS. The results are as follows.

1) Judging from d18O values and dD values, river waters were formed by a mixture of precipitation in summer and in winter in an altitude range of 300 ~ 2000 m.

2) There was a correlation between d13C values of EOM and both Calcium and bicarbonate concentration. This suggests that Ca in river water is supplied by carbonate (CaCO3) weathering of rock and soil in the catchment area. Ca, Na, K and Mg concentrations showed a significant positive correlation with the coniferous proportion, it suggests that these chemicals are added into river water when passing through the forest area. Compared to rain water, chemical components were higher in rivers, about 200 times for Ca, 6 times for Na, 8 times for K and 10 times for Mg respectively.

3) A negative correlation exists between riverine nitrate concentration and evergreen percentage of vegetation in the catchment, and more than 90% of nitrate in river water is derived from the forest using oxygen isotopic ratio Δ17O of nitrate. It means the amount of nitrate in precipitation is trapped in the forest and then the forest originated nitrogen discharges into the rivers.

4) Δ15N in EOM, which possibility “records" the nitrogen supply information for several days to weeks when using nitrate from river water, is bounded at the altitude of 1500 m and reflects the vegetation within the catchment areas. In addition, the δ15N value showed a positive correlation with the evergreen percentage in the Catchment area, suggesting that vegetation affects nitrate outflow to rivers.

Keywords: Epilithic Organic Matter, carbon and nitrogen isotopic composition, nutrient supply, forest area, eastern Toyama

©2019. Japan Geoscience Union. All Right Reserved.

Investigation on the possibility of the identification of air pollutant sources using stable isotope ratios of lead and strontium

*Shinji Sakurai[1], Takao Nakagiri[1], Kosuke Tanaka[1], Haruhiko Horino[1], Ki-Cheol Shin[2], Ichiro Tayasu[2], Shiho Yabusaki[2]

1. Osaka Prefecture University, 2. Research Institute for Humanity and Nature

In Japan, transboundary air pollution coming from neighboring countries is concerned as one of the serious threads on the health. However, it is not easy to assess the actual impact because of difficulty to identifying the detailed transport path and the source of pollutants. Although it is expected that stable isotope ratios (hereafter, isotope ratios) of lead (Pb) and strontium (Sr) can be used as environment tracers to identify the pollutant source, even the basic information on their characteristics such as chronological and/or seasonal variations at resolution of rainfall event as well as the relationship between the ratios and other water quality parameters is still not enough to consider the possibility.
In our study, rainwater was collected in a polyethylene bottle, on the top of which a polypropylene funnel was set, separately in every rainfall event from June 2016 to August 2018 at the campus of Osaka Prefecture University in Sakai, Osaka, Japan. The isotope ratios of Pb and Sr ($^{207}Pb/^{206}Pb$, $^{208}Pb/^{206}Pb$, and $^{87}Sr/^{86}Sr$) in the rainwater samples were measured using a multi-collector inductively coupled plasma mass spectrometer. Concentrations of heavy metals (Fe, Mn, Cd, Cu, Ni, and Pb), inorganic ions, pH, EC, TOC, COD, T-N, and T-P were measured as water quality parameters. Rainfall amount was measured with a rain gauge set near the rainwater sampling point. Other meteorological data needed to investigate and estimate the pollutant sources, such as air temperature, wind direction, and duration of drought, were obtained from the Japan Meteorological Agency.
There was no obvious trend either chronologically or seasonally for $^{207}Pb/^{206}Pb$ or $^{87}Sr/^{86}Sr$. The values of the $^{207}Pb/^{206}Pb$ ratio declined slightly during the observation period, but the $^{87}Sr/^{86}Sr$ ratio did not show this chronological variation.
There was no obvious correspondence between most of water quality parameters and each isotope ratio. The $^{207}Pb/^{206}Pb$ varied widely during events in which Cr and Fe concentrations were low, but was close to 0.871 as the concentrations of these metals were getting higher. There is similar tendency in $^{87}Sr/^{86}Sr$ for Fe and Cr. It was suggested that these metals might be derived from the same source.
For correspondence with meteorological factors, the monthly rainfall amount weighted average of $^{207}Pb/^{206}Pb$ fluctuated when the wind from the west or the west-southwest was dominant, while it took almost a unique value for the south-southwest. It was suggested that Pb was originated from various sources with the west wind.
Plots of the obtained data on the $^{207}Pb/^{206}Pb$ vs. $^{208}Pb/^{206}Pb$ were distributed upside and parallel to the lead isotope growth curve. When comparing our plots with the previous global studies, we found that ours were distributed in a manner similar to those from China and Russia. It was indicated that it is difficult to identify pollutant sources from these countries, which are thought to cause transboundary pollution in Japan.
Further research, including the collection of data on isotope ratios as environmental tracers, is necessary to identify pollutant sources using isotope ratio of Pb and/or Sr.

Keywords: stable isotope ratio, air pollution, heavy metal, lead, strontium, rainwater

©2019. Japan Geoscience Union. All Right Reserved.

Magnesium and zinc stable isotopes in stream ecology

*Kai Nils Nitzsche[1], Yoshikazu Kato[1], Ki-Cheol Shin[1], Hiromitsu Kamauchi[1], Ichiro Tayasu[1]

1. Research Institute for Humanity and Nature

Magnesium (Mg) and zinc (Zn) play important roles in biological production in stream ecosystems. Aquatic organisms take up metals from the diet and the water; however, relative contributions are largely unknown, which is assumed to depend on feeding habits. We determined Mg and Zn stable isotope ratios (δ^{26}Mg, δ^{66}Zn) of aquatic macroinvertebrates and of small goby, and their potential Mg and Zn sources (periphyton, plant litter, stream water) from upper and lower reaches of two temperate streams in the Lake Biwa catchment. Our goal was to understand Mg and Zn sources to aquatic organisms, and to explore δ^{26}Mg and δ^{66}Zn variations across feeding habits. δ^{26}Mg and δ^{66}Zn did not correlate with each other indicating that Mg and Zn sources differ across functional feeding groups and/or different degrees of isotopic fractionation during Mg and Zn uptake. Grazers, shredders and predators showed offsets to higher δ^{26}Mg values compared to metal sources indicating isotope fractionation during Mg accumulation, while stream water was the main Mg source to filter-feeders. In contrast, δ^{66}Zn of grazers and filter-feeders indicated Zn was often a mixture between periphyton and stream water, while δ^{66}Zn of shredders and predators gave evidence for Zn isotopic fractionation. Our results demonstrate the usefulness of applying non-traditional isotopes to understand metal sources to aquatic organisms, which could be used to trace the ultimate origin of metals from the catchment.

Keywords: Aquatic animals, Stream food web, Magnesium, Zinc, Non-traditional isotopes

©2019. Japan Geoscience Union. All Right Reserved.

A mechanitic metabolic model of nitrogen stable isotope dynamics in trophic processes

*Reiichiro Ishii[1], Maki Noguchi Aita[2], Eitaro Wada

1. Research Institute for Humanity and Nature, 2. Japan Agency for Marine-Earth Science and Technology

Stable isotope analysis of nitrogen and carbon have been a powerful tool used for identifying trophic structure of ecosystems. Our previous studies suggested that the ratios of trophic fractionation of carbon and nitrogen isotopes ($Dd^{15}N/Dd^{13}C$) throughout food chain are similar in various ecosystems (Aita et al. 2011, Wada et al. 2013), although the general mechanisms determining isotopic incorporation rates and discrimination factors are not understood mechanistically yet. On the other hand, recent studies revealed the 15N enrichment factor for trophic processes varies among amino acids from which new method of estimation of the trophic level of animal samples (e.g., Chikaraishi et al. 2009).
Based on these observations, we developed a simple dynamic model of the isotopic fractionation in nitrogen metabolic processes that are common to animals composing most grazing food chains. Particularly, we focused on and incorporated the transamination and deamination processes of two classes of amino acid, essential and non-essential, respectively into the model. With this model we investigated how d15N signatures of the two amino acid classes and whole-body change. Preliminary result suggests that the instant isotopic composition of animals are sensitive to the change of their diet composition and growth rate, but on the other hand, the isotopic composition converges as the integrating period becomes long. Based on this model we will discuss possible negative feedback processes in isotopic enrichment for nitrogen to explain the commonly observed trophic-step 15N-enrichment factor through many food chains.

Keywords: metabolic model, nitrogen stable isotope, ecological conditions

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-CG Complex & General

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 302 3F

[H-CG28] Implementing Integrated Research for Sustainable Future

convener:Yukio Himiyama(Emeritus Professor, Hokkaido University of Education), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), Takeshi Sakurai(Graduate School of Agricultural and Life Sciences, The University of Tokyo), Kenichi Abe(Research Institute for Humanity and Nature), Chairperson:Ernan Rustiadi(Bogor Agricultural University), Qinxue Wang(National Institute for environmental Studies), takeshi sakurai

The world global environmental studies are being re-organized in the framework of Future Earth, which is considered to be an important driver to achieve the Sustainable Development Goals (SDGs) set by UN in 2015. Geoscience, which has traditionally been concerned about the dynamic nature and phenomena of the Earth, including lithosphere, hydrosphere, atmosphere and biosphere, is now increasingly committed to human sphere and human dimensions of global change, assuming unique roles in Future Earth and the SDGs. The session is intended to discuss the crucial issues related with them, particularly in reference to such SDGs as good health and well-being, quality education, clean water and sanitation, sustainable cities and communities, climate action, life below water and life on land. Those interested in Future Earth, SDGs, and ESD (Education for Sustainable Development) particularly those who have already started or are about to start related projects, or are interested in Future Earth Knowledge-Action Networks (KANs), such as Ocean, Food-Water-Energy Nexus, Health, Disasters, Cities, Natural Assets, will find this Session an ideal place to present his/her research results, to exchange information and ideas, and to seek new collaborative relations with other research groups and even with partners in the society.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG28-01] Implementing Integrated Research for Sustainable Future - a human geoscience perspective

*Yukio Himiyama[1] (1.Emeritus Professor, Hokkaido University of Education)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG28-02] Application of environmental carrying capacity analysis and land cover change scenarios in collaborative spatial planning process: The Jakarta Megacity Case

★Invited Papers

*ERNAN RUSTIADI[1], Andrea Emma Pravitasari[2], Diar Shiddiq[1], Laode Syamsul Iman[1], Setyardi Pratika Mulya[2], Mia Ermyanila[1], Nur Etika Karyati[1] (1.Center for Regional System Analysis, Planning and Development, Bogor Agricultural University , 2.Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG28-03] Does the Market Economy Save the Local Natural Resources While Improving Human Welfare? The Case of 101 Natural Forests in the Middle Hills of Nepal

*Takeshi Sakurai[1], Towa Tachibana[2], Santosh Rayamajhi [3] (1.The University of Tokyo, 2.Chiba University , 3.Tribhuvan University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG28-04] Academic-public-private partnerships for sustainable herding under increasing frequency of climate hazards

*Masato Shinoda[1] (1.Graduate School of Environmental Studies Nagoya University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG28-05] Land use after death and funeral of citizen mainly based on public cemeteries in modern Beijing city

*Haruhiro Doi[1], Yanwei Chai[2], Peiwei Xu[3] (1.Faculty of Education, Oita University, 2.Peking University, 3.Beijing Normal University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HCG28-06] Restoration and sustainable land management of degraded landscapes in Asia and Africa

★Invited Papers

*OKURO TOSHIYA[1] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

Implementing Integrated Research for Sustainable Future - a human geoscience perspective

*Yukio Himiyama[1]

1. Emeritus Professor, Hokkaido University of Education

Global environmental programmes are re-organized under the framework of Future Earth, which is intend to play a leading role in guiding or coordinating world research communities for sustainability. Human geoscience, which has been built on geoscience which studies dynamic nature and phenomena of the Earth including its resources, geo-hazards and environmental changes, is uniquely committed to human sphere, where human, the environment, environmental problems and disasters are, and to the world sustainability. It hence has strong human/social scientific, as well as physical scientific, viewpoint, and assumes important roles in Future Earth, SDGs (Sustainable Development Goals), and other programmes for global sustainability or disaster risk reduction. This session is intended to discuss crucial issues related with them, and to seek right ways to implement needed integrated research for sustainable future in human geoscience perspective.

Keywords: Future Earth, SDGs, sustainability, human geoscience, disaster, environmental problem

©2019. Japan Geoscience Union. All Right Reserved.

Application of environmental carrying capacity analysis and land cover change scenarios in collaborative spatial planning process: The Jakarta Megacity Case

*ERNAN RUSTIADI[1], Andrea Emma Pravitasari[2], Diar Shiddiq[1], Laode Syamsul Iman[1], Setyardi Pratika Mulya[2], Mia Ermyanila[1], Nur Etika Karyati[1]

1. Center for Regional System Analysis, Planning and Development, Bogor Agricultural University , 2. Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University

In the National Spatial Plan, the Jabodetabekpunjur area (Jakarta Megacity) is designated as a national strategic area. Due to the increasing environmental problems, the Indonesian government carried out a revision process of spatial plan based on an environmental carrying capacity assessment. This research is intended to explain how the study of land-based carrying capacity assessment was applied to the spatial planning process. First, this research is carried out by developing scenarios for land cover changes. Projections of land use change are carried out by extrapolating 20-year time series data on land cover change backward to forecast 20 years of future land use. The study of environmental carrying capacity against current and future conditions is based on the concept of land capability, land suitability, and multi-criteria analysis. The results of the study of carrying capacity were then used to revise existing spatial plans. The decision-making process on revising spatial plan was carried out by a collaborative process involving relevant stakeholders in serial workshop processes by considering the results of the carrying capacity study.

Keywords: urban sprawl, land capability, land use cover changes, regional planning

©2019. Japan Geoscience Union. All Right Reserved.

Does the Market Economy Save the Local Natural Resources While Improving Human Welfare? The Case of 101 Natural Forests in the Middle Hills of Nepal

*Takeshi Sakurai[1], Towa Tachibana[2], Santosh Rayamajhi [3]

1. The University of Tokyo, 2. Chiba University , 3. Tribhuvan University

To pursue a sustainable human development, while expanding human frontiers into space, we need to conserve the natural environment of our mother planet. In low-income countries, deterioration of local natural resources such as forests for firewood, inshore fishery for home and local consumption has been the most urgent environment issue. Various measures have been taken to stem excessive harvesting of local natural resources in the course of the population increase: e.g., community management. Little attention has been paid, however, to the seemingly most powerful lifesaver for the overuse of local natural resources: the market economy. Out-migration from the marginally productive rural areas along with the investments in urban areas would attain both the conservation of natural resources and improvements in human welfare. With 101 randomly-sampled natural forests in the Middle Hills of Nepal, we compare the impacts of community management and those of out-migration on forest conditions. Forest condition was evaluated by forest inventory conducted in 1997-1999 and 2014-2016.

©2019. Japan Geoscience Union. All Right Reserved.

Academic-public-private partnerships for sustainable herding under increasing frequency of climate hazards

*Masato Shinoda[1]

1. Graduate School of Environmental Studies Nagoya University

Socio-ecological damage from climate-related disasters has increased worldwide, including a slow-onset cold-season disaster that is unique to Mongolia, known as *dzud*. *Dzuds* are defined, bio-geophysically, as anomalous climatic and/or land-surface (i.e. snow) conditions that lead to reduced accessibility and/or availability of pastures, and ultimately to significant livestock mortality during winter–spring. Our studies showed that recent *dzuds* were caused by a half-to-half combination of multi-climate hazards and man-made vulnerability, including inadequate pasture management, poverty, and insufficient winter preparedness. With this background, for the first time, our academia produced a new *dzud* risk map to predict risky areas at the national level for the 2015/2016 winter. Subsequently, the early warning system developed together with the risk map has been implemented and successfully applied for sustainable herding under the framework of partnerships among universities/research institutes, Mongolian government, international aid organizations, and herders. This action was supported by the Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science ‘Integrating Dryland Disaster Science’ and nominated as a top case study of early warning early action at the Asian Ministerial Conference on Disaster Risk Reduction in July 2018.

Keywords: Transdisciplinary approach, Disaster risk map, Climate disaster, Livestock mortality, Mongolia

©2019. Japan Geoscience Union. All Right Reserved.

Land use after death and funeral of citizen mainly based on public cemeteries in modern Beijing city

*Haruhiro Doi[1], Yanwei Chai[2], Peiwei Xu[3]

1. Faculty of Education, Oita University, 2. Peking University, 3. Beijing Normal University

After death, a person builds a graveyard by occupying a certain land, such as by relatives left behind. Therefore, in urban areas of China where economic growth and population growth continue, the demand for the land used for the deceased is large, so controlling the cemetery area as part of the management of land resources is an important policy task.
In modern Beijing City, large-scale public cemeteries have been developed throughout the city over the last few decades in order to cope with the increasing demand for land use after death. These public cemeteries are mainly located in rural areas that are relatively adjacent to built-up areas and suitable fountains on Feng shui in suburban areas (Doi and Chai, 2017).
The present report intends to examine the history of maintenance of these public cemeteries and its relations with neighboring rural communities and to consider the relationship between the funeral of the ethnic minorities other than the Han tribe in modern Beijing.

Keywords: Urban policy, suburban rural areas, ethnic group

©2019. Japan Geoscience Union. All Right Reserved.

Restoration and sustainable land management of degraded landscapes in Asia and Africa

*OKURO TOSHIYA[1]

1. Graduate School of Agricultural and Life Sciences, The University of Tokyo

Land degradation causes reduction or loss of the biological or economic productivity and complexity, resulting from land uses or from processes arising from human activities and habitation patterns. As land degradation is also defined as “the processes of landscape changes caused by miss-match between natural land conditions and land use by human”, it is necessary to reconstruct new land use systems based on new human-environment relations which can realize sustainable use of ecosystem services. This paper introduces case studies on the sustainable land management (SLM) approaches, focusing on human-environment relations, or social-ecological systems in rangelands of Asia and Africa. Firstly, I show a modelling of trade-offs in ecosystem services and assessment of effectiveness of countermeasures on land restoration. Secondly, I show a concept and methodology of grassland management systems in consideration of biodiversity-ecosystem functioning relationships. Finally I propose future perspectives, possible research topics which should be further developed, and implication to SDGs.

Keywords: social-ecological system, threshold, biodiversity, ecosystem functioning, sustainable land management, non-equilibrium

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[S-SS06] Nankai Trough Seismogenic Zone Experiment: Logging and sampling the seismogenic megathrust

convener:Kyuichi Kanagawa(Graduate School of Science, Chiba University), Demian M Saffer(Pennsylvania State University), Masataka Kinoshita(Earthquake Research Institute, University of Tokyo), Chairperson:Kyuichi Kanagawa(Graduate School of Science, Chiba University), Demian Saffer(Department of Geosciences, Pennsylvania State University), Masataka Kinoshita(Earthquake Research Institute, the University of Tokyo)

The Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) is a multidisciplinary investigation of fault mechanics and seismogenesis along the megathrust at the Nankai Trough subduction zone, and includes reflection and refraction seismic imaging, direct sampling by drilling, in situ measurements, and long-term monitoring in conjunction with laboratory and numerical modeling studies. During the past 12 IODP expeditions off Kii Peninsula since 2007, 15 sites have been drilled by D/V "Chikyu" down to depths from 100s of meters to more than 3000 meters below seafloor, where the inner and outer wedge of the Nankai margin has been logged and sampled extensively, and three state-of-the-art real-time downhole observatories are now in operation. The final NanTroSEIZE expedition aiming to log and sample the seismogenic megathrust at ~5200 meters below seafloor is now ongoing from October, 2018 to March, 2019.
In this session, we expect presentations not only on scientific outcomes from the past NanTroSEIZE expeditions, but also on the exciting preliminary results of the final NanTroSEIZE expedition. We welcome presentations on, but are not limited to, seismic imaging, borehole logging and monitoring, chemical analyses of pore water and mud gas, lithology, structures, physical properties and laboratory experiments of cuttings and core samples, and theoretical and numerical modeling.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS06-01] Geoscientific information about plate boundary along the Nankai Trough provided by the GNSS-A

★Invited Papers

*Yusuke Yokota[1], Tadashi Ishikawa[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic department, Japan Coast Guard)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS06-02] Deep Drilling at the Nankai Trough: IODP NanTroSEIZE Expedition 358 Summary and First Results

★Invited Papers

*Harold Tobin[1], Takehiro Hirose[7], Matt Ikari[5], Kyuichi Kanagawa[10], Gaku Kimura[3], Masataka Kinoshita[8], Hiroko Kitajima[6], Demian M Saffer[4], Asuka Yamaguchi[9], Lena Maeda[2], Nobu Eguchi[2], Sean Toczko[2] (1.Department of Earth and Space Sciences, University of Washington, 2.JAMSTEC-CDEX, 3.Tokyo Un. of Marine Science-Technology, 4.Penn State University, 5.MARUM Un. of Bremen, 6.Texas A&M University, 7.JAMSTEC-KCC, 8.Un. of Tokyo Earthquake Research Institute, 9.Un. of Tokyo AORI, 10.Chiba University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS06-03] Coexistence of soft and hard sediments at deep Nankai accretionary prism, NanTro SEIZE Project, IODP Exp.358

*Arito Sakaguchi[1,2], Michael Strasser[3], Mari Hamahashi[4,5], Takehiro Hirose[2], Hiroko Kitajima[6], Expedition 358 Scientists IODP (1.Yamaguchi Univ., 2.JAMSTEC, 3.University of Innsbruck, 4.University of Tokyo, 5.Nanyang Technological University, 6.Texas A&M University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS06-04] Active and passive seismic experiment during the IODP Exp. 358 deep riser drilling in the Nankai Trough, Japan

*Toshinori Kimura[1], Takashi Tonegawa[1], Kazuya Shiraishi[1], Eiichiro Araki[1], Yasuyuki Nakamura[1], Yuka Kaiho[1], Gou Fujie[1], Seiichi Miura[1], Shuichi Kodaira[1], Noriaki Sakurai[1], Yoshinori Sanada[1], Yukari Kido[1], Masataka Kinoshita[2], Narumi Takahashi[3,1], Yuya Machida[1], Shuhei Nishida[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS06-05] Microfabric analysis of damaged zone of principal shear zone in the frontal megathrust in the Nankai Trough

*Gaku Kimura[1], Asuka Yamaguchi[2], Yohei Hamada[3], Suguru Yabe[4] (1.Tokyo University of Marine Science and Technology, 2.Atomosphere and Ocean Research Institute, The University of Tokyo, 3.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 4.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS06-06] Seismic Imaging of Mud Diapirs in Northern Kumano Basin, Nankai Trough

*Gregory F Moore[1], Miho Asada[2], Shuichi Kodaira[2], Achim Kopf[3] (1.University of Hawaii at Manoa, 2.JAMSTEC, 3.MARUM)

Geoscientific information about plate boundary along the Nankai Trough provided by the GNSS-A

*Yusuke Yokota[1], Tadashi Ishikawa[2]

1. Institute of Industrial Science, The University of Tokyo, 2. Hydrographic and Oceanographic department, Japan Coast Guard

In the last decade, many geophysical implications were provided by the GNSS-A seafloor geodetic network. Along the Japan Trench, coseismic and postseismic deformations following the 2011 Tohoku-oki earthquake were detected [Sato et al., 2011, Science; Watanabe et al., 2014, GRL; Tomita et al., 2017, Sci. Adv.]. Coseismic monitoring result was applied for many seismological research [e.g., Ozawa et al., 2012, JGR] and geological research and monitoring plan. Postseismic viscoelastic behavior and afterslip event [Sun et al., 2016, Nature; Iinuma et al., 2016, Nature Comm.] could not be identified without our monitoring results.

After 2015, more important geoscientific suggestions were obtained from monitoring in the Nankai Trough. Yokota et al. [2016, Nature] showed undersea interseismic coupling condition. This observation result has been broadly applied to various geophysical studies while being modified [e.g., Nishimura et al., 2018, Gesphere; Noda et al., 2018, JGR] and constrains earthquake prediction research including numerical simulation and submarine drilling research.

In addition, recently, we improved the GNSS-A technology and upgraded observation frequency and precision [Yokota et al., 2017, Rep. Hydro. Ocean. Res; Yokota et al., 2018, MGR]. With the present observation ability, yearly time change of the amount of undersea crustal deformation was newly unclosed. This new version data suggests that there were longer-term sequences of slow slip events (SSEs) around strong coupling regions [Yokota and Ishikawa, this JpGU meeting].

These results provide several suggestions about property and condition on the plate boundary. The simple and biggest question is what is the reason for separating strong coupling and SSE conditions. Since the difference between the generation patterns of SSE and other slow earthquakes is also considered to be due to physical properties, some dominant factor can be assumed. Differences and similarities between deep and shallow SSEs are also important. What physical properties control the behaviors of deep and shallow SSEs?

For answering these questions, additional experiments and observations from many different viewpoints will be necessary. At the same time, continuous GNSS-A monitoring and upgrading its density and accuracy are required for understanding shallow coupling conditions and SSEs.

Keywords: GNSS-A, Nankai Trough, SSE, plate boundary, coupling condition

©2019. Japan Geoscience Union. All Right Reserved.

Deep Drilling at the Nankai Trough: IODP NanTroSEIZE Expedition 358 Summary and First Results

*Harold Tobin[1], Takehiro Hirose[7], Matt Ikari[5], Kyuichi Kanagawa[10], Gaku Kimura[3], Masataka Kinoshita[8], Hiroko Kitajima[6], Demian M Saffer[4], Asuka Yamaguchi[9], Lena Maeda[2], Nobu Eguchi[2], Sean Toczko[2]

1. Department of Earth and Space Sciences, University of Washington, 2. JAMSTEC-CDEX, 3. Tokyo Un. of Marine Science-Technology, 4. Penn State University, 5. MARUM Un. of Bremen, 6. Texas A&M University, 7. JAMSTEC-KCC, 8. Un. of Tokyo Earthquake Research Institute, 9. Un. of Tokyo AORI, 10. Chiba University

IODP Expedition 358 was carried out beginning October 10, 2018 and scheduled to continue until March 31, 2019. The primary objective was to sample and make geophysical measurements in and around the megasplay fault/plate boundary fault at Site C0002, by extending the riser borehole (Hole C0002P) established during previous Integrated Ocean Drilling Program NanTroSEIZE expeditions. After Expedition 348 in 2014, Hole C0002P was left suspended, with steel casing in pace holding the borehole open to 2922 meters below the sea floor (mbsf). The primary seismic reflector target interpreted as the main plate boundary fault zone was estimated to lie at a little more than 5000 mbsf, necessitating a plan to re-enter that hole and then add about 2000 meters of new depth drilling to reach and cross it.

Drilling commenced with a sidetracking operation to establish Hole C0002Q, which was advanced to 3263 mbsf, but operational difficulties precluded going any deeper. Two more attempts were made to advance the riser hole over many weeks, but ultimately did not result in further progress toward the objective. At the time of this writing, coring operations are ongoing at the site at a depth of about 2900 mbsf, in deformed and steeply-dipping mid-Miocene age inner accretionary wedge rocks. There are plans to end riser operations at Site C0002 at the end of February 2019 despite not reaching the primary target, and instead commence drilling at a new site to target the frontal thrust portion of the plate boundary near previous IODP Site C0006. First results from the expedition will be reviewed in this presentation, and a preliminary assessment of the scientific outcomes will be made.

Keywords: Nankai Trough, IODP , megathrust

©2019. Japan Geoscience Union. All Right Reserved.

Coexistence of soft and hard sediments at deep Nankai accretionary prism, NanTro SEIZE Project, IODP Exp.358

*Arito Sakaguchi[1,2], Michael Strasser[3], Mari Hamahashi[4,5], Takehiro Hirose[2], Hiroko Kitajima[6], Expedition 358 Scientists IODP

1. Yamaguchi Univ., 2. JAMSTEC, 3. University of Innsbruck, 4. University of Tokyo, 5. Nanyang Technological University, 6. Texas A&M University

It was believed that sediment strengthened irreversibly with depth, and same lithology has same strength in same depth. It was found that quite soft portions were developed within hard sedimentary rock at deep Nankai accretionary prism, southwest Japan, during the NanTro Seize Project, IODP Expedition 348 and 358.

The site C0002 is located at the Tonankai Earthquake (1944 M=8.0) area and penetrates 3262 m below sea floor (mbsf) through the Kumano basin and Nankai accretionary prism. The porosity decreases, and hardness increases with depth gradually. Deeper than approximately 2000 mbsf, the Silty claystone of dark gray lithified hard rock with low porosity less than 20% is occurred for main lithology. Interleaved between this hard rock, the Fine silty claystone with high porosity upper than 30% was observed deeper than 2360 mbsf (Tobin et al., 2015). This soft sediment is similar with the Silty claystone in grain size and mineral assemblages, but strength is totally difference. Such soft stuffs are commonly generated during drilling. In this site, various types of drill tools of bit and reamers were operated due to unstable hole condition. However, no relationship was found between drilling tool and occurrence of the Fine silty claystone. Optical microscope and micro X-CT observations revealed that some sedimentary laminations and burrows of benthos were preserved within the Fine silty claystone. These show that the fine silty claystone is natural sediment, but not drilling induced artifact.

The reason for coexistence of soft and hard sediments in same depth can be explained by conceptual idea as below. In initial state of diagenesis, some crystals will grow larger having smaller surface energy than the other. This surface energy difference in same solution causes that smaller crystal dissolution and larger crystal grow further. Resulting of this process, well crystalline and less crystalline parts probably have marked contrast in strength. This implies that present of heterogeneous strength distribution around the initiation depth of diagenesis.

Keywords: Nankai trough, IODP Exp.358, CHIKYU, Diagenesis

©2019. Japan Geoscience Union. All Right Reserved.

Active and passive seismic experiment during the IODP Exp. 358 deep riser drilling in the Nankai Trough, Japan

*Toshinori Kimura[1], Takashi Tonegawa[1], Kazuya Shiraishi[1], Eiichiro Araki[1], Yasuyuki Nakamura[1], Yuka Kaiho[1], Gou Fujie[1], Seiichi Miura[1], Shuichi Kodaira[1], Noriaki Sakurai[1], Yoshinori Sanada[1], Yukari Kido[1], Masataka Kinoshita[2], Narumi Takahashi[3,1], Yuya Machida[1], Shuhei Nishida[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, The University of Tokyo, 3. National Research Institute for Earth Science and Disaster Resilience

Stress and strain should be crucial parameter to understand preparation/generation cycle of mega-thrust earthquakes which repeatedly occur along subduction zone. Recent studies suggest that seismic approach (c.f. seismic anisotropy analysis and seismic velocity monitoring) could be alternative tool to monitor stress/strain field in the seismogenic zone. The IODP Exp. 358, which includes deep riser drilling by D/V Chikyu around the IODP C0002 hole in the Nankai Trough region, is a great opportunity to observe the seismic dataset, which would be used to discuss the relationship between seismic parameters and stress field before, after and while the deep borehole drilling.

We performed a series of seismic experiments including passive and active surveys. The experiments include: 1) Seismic velocity monitoring near the C0002 hole by seismic interferometry using drilling/vessel noise. 2) Seismic anisotropy survey around the C0002 hole by air-gun circular shooting. 3) Microearthquakes and tremors monitoring to identify stress condition around the borehole. In this region, real-time borehole seismic observatory and seafloor seismic observatory, named LTBMS (Long-Term Borehole Monitoring System) and DONET (Dense Oceanfloor Network system for Earthqukae and Tsunamis), have been already installed and operated. These observatories can be used as seismic receivers for this experiment. 10 OBSs (Ocean Bottom Seismicmeter) were additionally deployed near the C0002 hole for dense seismic observation within 10 km from the C0002 hole. 6 OBSs were deployed by R/V Yokosuka during the YK18-14 cruise. Another 4 OBSs were deployed by Chikyu’s ROV (Remotely Operated Vehicle) with distances of 90 m to 300 m from the C0002 hole. These OBSs will be recovered from May to Oct. 2019. As active seismic survey, R/V Kaimei fired circular shooting line around the C0002 hole during the KM18-10 cruise. The air-gun signals were clearly observed by LTBMS seismometer and seafloor DONET seismometers. The observed data show clear seismic events which should be caused by seismic anisotropy. Since 2013 to 2016, we have performed the same survey around the C0002 hole by R/V Kairei in every year. Therefore, time-lapse discussion on seismic anisotropy should be possible by using the newly and existing dataset.

Phase analysis and beam-forming processing would be possible by using the OBS array dataset to discuss distributions of microearthquake and tremors. OBS array data can be also used for seismic interferometry analysis to discuss velocity structure monitoring during the drilling. In this presentation, we will show initial data observed by OBS if the data were available after the recovery. Also, we will show initial results of active seismic survey observed by LTBMS and DONET seismometers including time-lapse discussion on seismic anisotropy.

Keywords: Nankai Trough, Seismic experiment, Deep drilling, Monitoring

©2019. Japan Geoscience Union. All Right Reserved.

Microfabric analysis of damaged zone of principal shear zone in the frontal megathrust in the Nankai Trough

*Gaku Kimura[1], Asuka Yamaguchi[2], Yohei Hamada[3], Suguru Yabe[4]

1. Tokyo University of Marine Science and Technology, 2. Atomosphere and Ocean Research Institute, The University of Tokyo, 3. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 4. Japan Agency for Marine-Earth Science and Technology

The outer wedge of the Nankai forearc is located to the south of the splay fault, which is the traditional southern margin of the seismogenic rupture zone. The evidence for seismo-tsunamigenic slip was, however, recognized on the basis of a thermal anomaly along ~2 mm thick fault gouge indicative of frictional heating at the frontal thrust. This fact suggested a rupture propagation to the Nankai Trough in the past. Recently, slow slips along the megathrust beneath the outer wedge were observed and an intimate relationship between the coseismo-tsunamigenic large and fast slip and interseismic slow slips is a matter of great concern.

The underlying micro-mechanical processes responsible for the fast or slow slips are, however, poorly known.

We revisited the recovered core sample of the frontal thrust and added further micro-textural observations for damaged zone to already reported principal shear zone. The detailed mineralogical, chemical and micro fabric analysis for a principal shear zone presents the nearly complete transformation from smectite to illite, which is consistent with frictional heating. The observed micro-texture of the gouge and its surroundings of damaged zone is characteristic of experimentally-produced brittle textures for slow slip. This suggests an overprint of slow slip on the previous seismo-tsunamigenic fast slip. This micro-tectonic based interpretation is consistent with the recent observation of inter-sesimic slow slip beneath the outer wedge and around the frontal megathrust. We suggest that the illite-smectite lithology of gouge and surrounding is conditionally stable, allowing it to transition from co-seismic rapid slip to inter-seismic slow slip at different times.

Keywords: Nankai trough, frontal thrust, principal shear zone, slow slip, fault fabric, tsunamigenic fault

©2019. Japan Geoscience Union. All Right Reserved.

Seismic Imaging of Mud Diapirs in Northern Kumano Basin, Nankai Trough

*Gregory F Moore[1], Miho Asada[2], Shuichi Kodaira[2], Achim Kopf[3]

1. University of Hawaii at Manoa, 2. JAMSTEC, 3. MARUM

Mud volcanoes (MV), the surface expression of deeper-seated diapirs are now well known in Kumano Basin. Fifteen years ago, Morita et al. (2004) published a seismic line across the basin showing mud diapirs sourcing the MVs, but the extent of these diapirs has remained underappreciated. We present JAMSTEC 2D seismic lines across and along the basin axis showing that significant deformation of the shallow sedimentary section in the northern part of the basin is caused by mud diapirs. The diapirs feed at least 11 MVs in the northern part of the basin, all of which have been surveyed with multibeam bathymetry, high-resolution sonar and sampling. The diapirs range in diameter from 4-6 km and have seismic expression to at least 2-3 km below the seafloor. Older sedimentary layers are tilted upward adjacent to the diapirs and have internal onlap features that indicate several stages of uplift. Bottom simulating reflections (BSRs) that cross-cut the sediment and diapirs are locally disrupted under the MVs, indicating upward migration of fluids through the methane hydrate layers to the surface. Morita et al. (2004) report that mudstone fragments carried to the surface by the MVs range in age from 18.2-13.6 Ma (late Early Miocene –early Middle Miocene), indicating that the mud diapirs, which probably originate within the underlying accretionary prism, passed through the older layers of the forearc basin.

Reference: Morita, S., Ashi, J., Aoike, K., and Kuramoto, S. (2004), Evolution of Kumano basin and sources of clastic ejecta and pore fluid in Kumano mud volcanoes, Eastern Nanaki Trough, In: Proceedings of the International Symposium on Methane Hydrates and Fluid Flow in Upper Accretionary Prisms, Engineering Geology Laboratory, Department of Civil & Earth Resources Engineering, Kyoto University, Kyoto, pp. 92–99.

Keywords: Nankai Trough, Mud diapir, Accretionary prism

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Kenji Kawai, Sebastian Ritterbex

Recent observational and experimental investigations have significantly advanced our understanding of the structure and constituent materials of the deep Earth. Yet, even fundamental properties intimately linked with formation and evolution of the planet, such as details of the chemical heterogeneity in the mantle and light elements dissolved in the core, remained unclear. Seismological evidence has suggested a vigorous convection in the lower mantle, whereas geochemistry has suggested the presence of stable regions there that hold ancient chemical signatures. The amounts of radioactive isotopes that act as heat sources and drive dynamic behaviors of the deep Earth are also still largely unknown. We provide an opportunity to exchange the achievements and ideas, and encourage persons who try to elucidate these unsolved issues of the core-mantle evolution using various methods, including high-pressure and high-temperature experiments, high-precision geochemical and paleomagnetic analyses, high-resolution geophysical observations, geo-neutrino observations, and large-scale numerical simulations. Papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community are also welcomed.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT21-19] Seismological Explorations of Earth's Outer Core: Normal Mode and Body Wave Analyses

★Invited Papers

*Jessica C E Irving[1], Sanne Cottaar[2], Vedran Lekic[3], Wenbo Wu[4] (1.Princeton University, 2.University of Cambridge, 3.University of Maryland, College Park, 4.California Institute of Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT21-20] Discussion

*Kenji Kawai[1] (1.University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT21-21] On the 1-D radial convective structure of the Earth’s core inferred from a coupled core-mantle evolution model

*Takashi Nakagawa[1] (1.Department of Earth Sciences, The University of Hong Kong)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT21-22] Structural and transport properties of liquid iron-light-element mixtures under outer core conditions

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Inst. of Tech., 2.Ehime Univ.)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT21-23] Development of New Technology for Geoneutrino Directional Measurement

*Hiroko Watanabe[1] (1.Research Center for Neutrino Science, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SIT21-24] Investigation of multi light elements in iron-silicate-water system using high pressure and temperature neutron experiments: Implications for the Earth's evolution

★Invited Papers

*Riko Iizuka-Oku[1], Hirotada Gotou[2], Ko Fukuyama[1], Hiroyuki Kagi[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.The Institute for Solid State Physics, The

University of Tokyo)

Seismological Explorations of Earth's Outer Core: Normal Mode and Body Wave Analyses

*Jessica C E Irving[1], Sanne Cottaar[2], Vedran Lekic[3], Wenbo Wu[4]

1. Princeton University, 2. University of Cambridge, 3. University of Maryland, College Park, 4. California Institute of Technology

Earth's outer core is a source of both the geodynamo and heat for mantle convection. However, we still do not fully understand its chemical composition, and there is debate about whether the uppermost outer core may contain a stratified layer enriched in light elements. We present low frequency normal mode and high frequency body wave investigations of the outer core's properties.

Normal mode oscillations of the whole Earth, excited by large earthquakes, are sensitive to the large-scale variations in velocity and density. We use reported centre frequencies of hundreds of normal mode oscillations to investigate the bulk properties of the outer core. We carry out a Bayesian inversion using a mineralogical Equation-of-State framework to infer the outer core's velocity, density and mineralogical properties, under the assumption that the outer core is well mixed and adiabatic. The model we produce, EPOC, describes the Elastic Parameters of the Outer Core. EPOC predicts seismic velocities at the top of the outer core which are closer to some existing body-wave models than to PREM, resolving a long-standing discrepancy. EPOC also fits normal-mode data better than the Preliminary Reference Earth Model. We also consider the effects of relaxing our assumptions that (i) there is no stratified layer at the top of the outer core, and (ii) that PREM is correct outside the outer core.

To better assess the uppermost outer core, often referred to as the E' layer, we use a novel, iterative technique to measure SmKS differential travel times. SmKS waves are particularly sensitive to the E' layer, and reflect (m-1) times from the underside of the core-mantle boundary. We find that the SmKS differential travel times are better described by models with seismic velocities in the E' layer slower than PREM, such as EPOC or body-wave derived KHOMC (Kaneshima and Helffrich, 2013).

Keywords: Outer Core, Normal Modes, Body waves

©2019. Japan Geoscience Union. All Right Reserved.

Discussion

*Kenji Kawai[1]

1. University of Tokyo

Discussion

©2019. Japan Geoscience Union. All Right Reserved.

On the 1-D radial convective structure of the Earth’s core inferred from a coupled core-mantle evolution model

*Takashi Nakagawa[1]

1. Department of Earth Sciences, The University of Hong Kong

A coupled core-mantle evolution model in the global heat and mass balance of the Earth’s mantle and core is to reveal the 1-D radial convective structure of the Earth’s core over the geologic time-scale. Since tracking the convective structure of the Earth’s core over the geologic time-scale is not still available for numerical geodynamo simulations, the assessment with the global heat and mass balance model of Earth’s core and mantle is quite powerful. Regarding the global heat balance of the Earth’s mantle, the global heat balance approach incorporating with the heat transport by the partial melting is assumed, which is the parameterized mantle convection based on the modified version of Driscoll and Bercovici (2014). The heat flow across the core-mantle boundary computed from this parameterized convection model is used to compute the thermal and chemical structure of the Earth’s core based on the global heat balance of the Earth’s core with the realistic material properties of the Earth’s core provided from Labrosse (2003; 2015) However, on the assessment of convective structure, the effects of compositional convection caused by releasing the light elements associated with inner core growth and/or the metal-silicate partitioning are included (e.g. Takehiro and Sasaki, 2018). As indicated in Takehiro and Sasaki (2018), the effects of compositional convection are essential for understanding the convective structure of the Earth’s core even if the realistic density structure of the Earth’s core is included in the energy flux computations. On the magnetic field generation caused by geodynamo actions, again, the compositional convection plays a significant role under the high thermal conductivity expected from the high-pressure physics. In the presentation, I will indicate the evolution of the convective structure described as the entropy flux of the Earth’s outer core over 4 billion years as a function of the evolution of the heat flows across the core-mantle boundary and oceanic lithosphere.

Keywords: Earth's core, Evolution, Convective structure

©2019. Japan Geoscience Union. All Right Reserved.

Structural and transport properties of liquid iron-light-element mixtures under outer core conditions

*Satoshi Ohmura[1], Taku Tsuchiya[2]

1. Hiroshima Inst. of Tech., 2. Ehime Univ.

It is widely believed that Earth’ s outer core consists of liquid iron (or liquid-nickel alloy) with light element (LE) impurities. For understanding magnetic and thermal behaviors of the Earth, it is required to explore electrical and thermal conductivities of liquid iron and influence of the light elements on these properties.

For this reason, we have investigated influences of light elements on transport properties of liquid iron under high pressure by using ab initio molecular dynamics simulations. We reported the structural and transport properties of liquid Fe-LE binary systems in connection with a microscopic structural properties. This times, in addition to binary systems, we have investigated transport properties of Fe-LE ternary systems. To provide further details of the effects of light-element, we discuss structural and transport properties of liquid Fe alloys in terms of the type and amount of light elements.

Keywords: liquid iron alloy, ab initio molecular dynamics simulation, transport properties, high pressure properties

©2019. Japan Geoscience Union. All Right Reserved.

Development of New Technology for Geoneutrino Directional Measurement

*Hiroko Watanabe[1]

1. Research Center for Neutrino Science, Tohoku University

Neutrino is an elusive particle and it can penetrate even astronomical objects. While neutrino experiments continue to explore the neutrino propertied, e.g. oscillation nature of neutrino flavor transformation, mass-square differences and mixing angles, we have began to utilize neutrino as a tool to look into the Earth. Anti-neutrinos emitted from radioactive isotopes, geo-neutrinos, bring unique and direct information of the Earth's interior and thermal dynamics.

KamLAND, Kamioka Liquid-scintillator Anti-neutrino Detector, has 1 kton ultra pure liquid scintillator. They reported the first experimental study of geo-neutrino in 2005. Later the geo-neutrino signals were used to estimate the Earth's radiogenic heat production and constrain the composition models of the bulk silicate Earth. Following the Fukusima reactor accident in March 2011, the entire Japanese nuclear reactor industry has been subjected to a protected shutdown. This unexpected situation allows us to improve the sensitivity for geo-neutrinos.

The liquid scintillator detectors have the sensitivity for measuring total amount of geo-neutrinos from the Earth's crust and mantle. However, we do not have the technology to track the direction of incoming geo-neutrinos at present due to the high miss-identification in a neutrino's track reconstruction. The direction-sensitive detector can map out the U and Th distribution inside the Earth and this technic is also applicable to resolving crust versus mantle contributions. Recent progress in studying this this new technology confirmed that a signify improvement is possible in neutrino tracking identification with a combination of ^{6}Li-loaded liquid scintillator and imaging detector. We developed prototype detector to measure 3D image of scintillation light and study the methodology for the image reconstruction. We will present recent status of our prototype detector and achievement of dark noise reduction of pixelated detector.

Keywords: geoneutrino, radiogenic power

©2019. Japan Geoscience Union. All Right Reserved.

Investigation of multi light elements in iron-silicate-water system using high pressure and temperature neutron experiments: Implications for the Earth's evolution

*Riko Iizuka-Oku[1], Hirotada Gotou[2], Ko Fukuyama[1], Hiroyuki Kagi[1]

1. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2. The Institute for Solid State Physics, The University of Tokyo

Introduction:

The Earth’s core is considered to consist of Fe alloy and some light elements (O, S, Si, H, C). Hydrogen (H) is the most abundant element in the universe and one of the promising candidates existing in the Earth’s core. However, its amount dissolved in the core and its process are still unknown because H cannot be detected by X-ray diffraction (XRD) and it easily escapes from iron by the release of pressure. Recently, H content in *fcc*-Fe at high pressure and high temperature (high-PT) has been determined using in-situ neutron diffraction measurements at J-PARC [1], suggesting that H had preferentially dissolved into iron before any other light elements have dissolved in the very early stage of Earth’s evolution. It is important to further study the partitioning of the other light elements between iron hydride (not pure iron) and silicates. To clarify the effects of multi light elements on the core-mantle segregation in the Earth’s formation, we have focused on sulfur (S) and investigated its effect on hydrogenation of iron.

Experimental:

Iron fine powder was pelletized with/without S powder and placed at the center of the graphite sample capsule. Powder mixture of quartz (SiO_2), brucite $Mg(OD)_2$ (or MgO for comparison of the water existence) surrounds the Fe pellet. Sample composition of Fe:$Mg(OD)_2$:SiO_2=2:1:1 of molar ratio with 5wt.% of S simulates an ideal condition of the primitive Earth.

In-situ high-PT neutron experiments were carried out using a six-axis multi-anvil press “Atsuhime” installed at MLF, PLANET (BL11), J-PARC. An originally improved multi-anvil 6-6 type assembly was applied. Three samples were pressurized up to 6–7 GPa and then heated up to 700 ˚C step by step. The reaction processes (dehydration of $Mg(OD)_2$, phase transformations of Fe (*bcc*-*fcc*) and FeS, formation of silicates) were carefully checked in real time. The diffraction patterns of *fcc*-Fe were measured at 550 ˚C and 700 ˚C for long time and analyzed using the Rietveld refinement method to determine structural and atomic parameters of *fcc*-Fe and sub-products. The recovered samples were examined by XRD and SEM-EDS to more precisely identify the products, their compositions, and the elements partition.

Results and Discussion:

The cell volume changes in *fcc*-Fe and sub-phase of FeS-V were investigated for every hour during the long-time measurements at 700 ˚C. For the sample including water, the volume of *fcc*-Fe was significantly increased with time, while the sample without water showed no change regardless of temperatures. The cell volume of FeS-V did not increase, suggesting that the formation of FeS was promoted in the existence of water, but its hydrogenation was negligible. Fe gradually incorporated D in the existence of water and FeD_x formed (x~0.10 at a maximum). From the results of SEM, the inhibition of deuterization might be due to the formation of FeS layer surrounding Fe pellet, whereas such a thick layer was not observed when using the Fe+S pellet. The sample without water did not include FeS layer nor Fe-bearing silicates.

It is suggested that both S and Fe were not mobile and could not react with each other without the existence of water. H and S can be preferentially incorporated into solid Fe at lower-T (~700 ˚C) before melting. The other light elements (C, O, Si) could have dissolved into molten iron hydride and/or FeS in the later process of Earth’s core-mantle differentiation at much higher-PT condition.

©2019. Japan Geoscience Union. All Right Reserved.

Reference:
[1] R. Iizuka-Oku, T. Yagi, H. Gotou, T. Okuchi, T. Hattori, A. Sano-Furukawa, Nature Commun. 8, 14096 (2017).

Keywords: Hydrogen, Sulfur, In situ high pressure and high temperature observation, Core-mantle formation, light elements

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-IT21] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener:Kenji Kawai(Department of Earth and Planetary Science, School of Science, University of Tokyo), Tsuyoshi Iizuka(University of Tokyo), Kenji Ohta(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Taku Tsuchiya(Geodynamics Research Center, Ehime University), Chairperson:Noriyoshi Tsujino, Kenta Ueki

Recent observational and experimental investigations have significantly advanced our understanding of the structure and constituent materials of the deep Earth. Yet, even fundamental properties intimately linked with formation and evolution of the planet, such as details of the chemical heterogeneity in the mantle and light elements dissolved in the core, remained unclear. Seismological evidence has suggested a vigorous convection in the lower mantle, whereas geochemistry has suggested the presence of stable regions there that hold ancient chemical signatures. The amounts of radioactive isotopes that act as heat sources and drive dynamic behaviors of the deep Earth are also still largely unknown. We provide an opportunity to exchange the achievements and ideas, and encourage persons who try to elucidate these unsolved issues of the core-mantle evolution using various methods, including high-pressure and high-temperature experiments, high-precision geochemical and paleomagnetic analyses, high-resolution geophysical observations, geo-neutrino observations, and large-scale numerical simulations. Papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community are also welcomed.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SIT21-25] Low hydrogen contents in the cores of terrestrial planets

★Invited Papers

*Vincent Clesi[1], Mohamed Ali Bouhifd[2], Nathalie Bolfan-Casanova[2], Geeth Manthilake[2], Federica Schiavi[2], Caroline Raepsaet[3], Hélène Bureau[4], Hicham Khodja[3], Denis Andrault[2] (1.Laboratoire de Geologie de Lyon - Terre, Planètes, Environnement, Université Claude Bernard Lyon 1, CNRS, ENS-Lyon, 69622 Villeurbanne, France., 2.Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS UMR 6524, OPGC–IRD, Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France., 3.Laboratoire d'Etude des Eléments Légers, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif sur Yvette Cedex, France., 4.Institut de Minéralogie et de Physique de la Matière et de Cosmochimie, Sorbonne Universités, UMR CNRS-UPMC 7590, 4 place Jussieu, 75252 Paris, France.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SIT21-26] Discussion

*Taku Tsuchiya[1] (1.Geodynamics Research Center, Ehime University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT21-27] Fe_2S: the most iron-rich Fe-S compound at pressures of the inner core

*Shigehiko Tateno[1,2], Haruka Ozawa[2,3], Kei Hirose[1,4], Toshihiro Suzuki[5] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Institute for Planetary Materials, Okayama University, 3.Nuclear Science and Engineering Center, Japan Atomic Energy Agency, 4.Department of Earth and Planetart Science, The University of Tokyo, 5.Geochemical Research Center, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SIT21-28] First-principles Investigation of Iron Diffusion Properties with Implications to Inner Core Plasticity

★Invited Papers

*Sebastian Ritterbex[1], Taku Tsuchiya[1] (1.GRC Ehime University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SIT21-29] Dependence of the dipole component dominancy on the Rayleigh number and inner core size in geodynamo simulations

*Yuki Nishida[1], Yuto Katoh[1], Hiroaki Matsui[2], Masaki Matsushima[3], 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)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SIT21-30] Elasticity of Fe-Si Alloy

*Taku Tsuchiya[1], Yu Fukunaga[1] (1.Geodynamics Research Center, Ehime University)

Low hydrogen contents in the cores of terrestrial planets

*Vincent Clesi[1], Mohamed Ali Bouhifd[2], Nathalie Bolfan-Casanova[2], Geeth Manthilake[2], Federica Schiavi[2], Caroline Raepsaet[3], Hélène Bureau[4], Hicham Khodja[3], Denis Andrault[2]

1. Laboratoire de Geologie de Lyon - Terre, Planètes, Environnement, Université Claude Bernard Lyon 1, CNRS, ENS-Lyon, 69622 Villeurbanne, France., 2. Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS UMR 6524, OPGC–IRD, Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France., 3. Laboratoire d’ Etude des Eléments Légers, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif sur Yvette Cedex, France., 4. Institut de Minéralogie et de Physique de la Matière et de Cosmochimie, Sorbonne Universités, UMR CNRS-UPMC 7590, 4 place Jussieu, 75252 Paris, France.

The accretion of planets from primordial materials and their subsequent differentiation to form a core and a mantle are fundamental questions in terrestrial and solar system. Many of the questions about the processes are still open and much debated. For example, could the presenceof water during the metallic phase segregation affect the planet-accretion models? The existing studies on the elemental metal-silicate partitioning under hydrous conditions were extended recently to a range of P, T, f_{O2} and water content (5 - 20 GPa, 2000 - 2500 K, from 1 to 5 log units below the iron-wüstite buffer, and for X_{H2O} varying from 500 ppm to 1.5 wt%) [1]. These experimental results show that except for Fe, there is no effect of water on the partitioning of moderately siderophile elements. It allowed us to build consistent models of planetary accretion from reducing to oxidized conditions. Furthermore, for the range of water concentrations studied, there is no evidence of important hydrogen incorporation into planetary cores, thus making unlikely for hydrogen to be a major light element of the core as previsously assumed [2]. We report H metal-silicate partition coefficients of about 0.2, up to two orders of magnitude lower than reported previously, and indicative of lithophile behavior. Our results imply H content of ~60 ppm in the Earth and Martian cores [3].

[1] Clesi et al. (2016) Geochim. Cosmochim. Acta 192, 97-121.

[2] Okuchi, T. (1997) Science 278, 1781-1784.

[3] Clesi et al. (2018) Science Advances 4: e1701876

Keywords: Hydrogen, Core formation, Primitive Earth, Experimental Petrology

©2019. Japan Geoscience Union. All Right Reserved.

Discussion

*Taku Tsuchiya[1]

1. Geodynamics Research Center, Ehime University

Discussion

©2019. Japan Geoscience Union. All Right Reserved.

Fe_2S: the most iron-rich Fe-S compound at pressures of the inner core

*Shigehiko Tateno[1,2], Haruka Ozawa[2,3], Kei Hirose[1,4], Toshihiro Suzuki[5]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Institute for Planetary Materials, Okayama University, 3. Nuclear Science and Engineering Center, Japan Atomic Energy Agency, 4. Department of Earth and Planetart Science, The University of Tokyo, 5. Geochemical Research Center, The University of Tokyo

Sulfur is considered to be one of the light elements in the Earth’s core as iron sulfides are universally found in iron meteorites. The phase diagram of the Fe–FeS system at the high-pressure and high-temperature (P-T) conditions of the core has particular importance to understand the composition and state of the Earth’s core. Because Fe3S is known as the most iron-rich Fe–S compound at > 20 GPa, the iron–sulfur core model has been discussed considering Fe and Fe_3S in the solid core. However, our previous experiment reveals that Fe_3S decomposes into S-bearing hcp-Fe and CsCl (B2)-type phase above ~250 GPa from X-ray diffraction measurements (XRD) (Ozawa et al., 2013 GRL). Furthermore, TEM analysis on the recovered sample exhibits that S-poor phase, likely to be a former hcp-Fe, coexisted with S-rich phase with >33.5 atm% S. Hence, the S-rich end-member compound has not been constrained under pressure more than 250 GPa. In order to re-investigated the phase relations in Fe-FeS system, we studied phase relations in Fe_2S at multi-megabar pressure range.

High P-T conditions were generated in a laser-heated diamond-anvil cell (DAC) using double-beveled diamond anvils with 40 or 60 μm culets. We used the Fe_2S phase as the starting material, which was synthesized beforehand at high pressures in a multianvil apparatus and confirmed by microprobe analysis. SiO_2 glass and MgO were used for thermal insulation and pressure calibration. We loaded such sample assembly as MgO/SiO_2-glass/Fe_2S/SiO_2-glass so that MgO was detached from an iron sample, in order to avoid possible chemical reaction at high temperature. Angle-dispersive XRD measurements were conducted at BL10XU, SPring-8. Heating was performed from both sides of the sample by employing a pair of 100 W Yb fiber lasers.

We performed three separate sets of experiments at pressures between from 120-310 GPa and temperature up to 3000 K. When we heated the Fe_2S sample being mostly amorphous by compression to 300 GPa at 300 K, the 20 new peaks appeared in a few minutes and became spotty with further heating. All peaks are assigned to the orthorhombic structure, which agrees well with Pnma symmetry phase proposed by the theoretical prediction (Bazhanova et al., 2017). This observation indicates that Fe_2S composition crystallizes as a single phase. In the following decompression and re-heating the sample, its stability was confirmed to be 150-310 GPa.

Our previous study (Mori et al., 2017 EPSL) reported that hcp-Fe and B2 phase crystallizes in Fe-6wt% S bulk composition at 270 GPa and 2400 K. Then, the peaks from the B2 phase become weak at further hearting. We re-analyzed the series of XRD datum, and found that such apparent weakening was caused due to the appearance of Fe_2S phase. Indeed, in the XRD patten collected at 3500 K, we confirmed that additional weak peaks from Pnma-Fe_2S were clearly visible and the reflection from the coexisting hcp-Fe phase became intense simultaneously. This indicates that stable phase assemblage in Fe-6wt% S bulk composition changes from hcp-Fe + B2-FeS into hcp-Fe + Pnma-Fe_2S. Hence, Fe_2S is the sulfur-rich end-member compound after the decomposition of Fe_3S at 250 GPa. The slope of eutectic melting curve should have kink at the decomposition of Fe_3S. Also, pressure evolution of the eutectic composition should change as well. Since the extrapolation from lower pressure data <250 GPa is not available, higher P-T experiments are necessary to establish the phase diagram at the pressure of inner core boundary.

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

First-principles Investigation of Iron Diffusion Properties with Implications to Inner Core Plasticity

*Sebastian Ritterbex[1], Taku Tsuchiya[1]

1. GRC Ehime University

The mechanical properties of Earth’ s inner core are key for understanding the evolution and dynamics of the core. However, little is known about the mechanical properties of iron (alloys) at inner core conditions. Therefore, long-standing questions remain open about the viscous strength of the inner core (Yoshida et al., 1996; Karato, 1999), about the origin of its seismic anisotropy (Deuss, 2014) and about its rotational dynamics (Buffett, 1997). All these issues rely on plastic deformation of the inner core, which is barely constrained.

Under extreme conditions of the Earth’ s deep interior, plasticity is expected to be rate limited by atomic diffusion. Experimental studies of diffusion in iron-nickel alloys at elevated P,T conditions finally rely on extrapolation to inner core conditions (Yunker and Van Orman, 2007; Reaman et al., 2012). Here, we investigate vacancy diffusion in iron at the appropriate inner core conditions. We use a density functional approach to calculate all quantities entering the diffusion coefficient, including the role of pressure and temperature, and quantify the self-diffusion coefficient of hcp iron according to transition state theory (TST).

Vacancy diffusion controls many deformation mechanisms such as dislocation creep, an effective strain producing mechanism in metals. We derived a creep model (based on Weertman, 1955 and Nabarro, 1967) to quantify the rate limiting bounds of climb-controlled dislocation creep in hcp iron to provide the first theoretical estimates of the inner core viscosity. Our results suggest an inner core viscosity that is significantly lower than that of Earth’ s mantle.

Keywords: Inner Core, Self-diffusion, Plasticity

©2019. Japan Geoscience Union. All Right Reserved.

Dependence of the dipole component dominancy on the Rayleigh number and inner core size in geodynamo simulations

*Yuki Nishida[1], Yuto Katoh[1], Hiroaki Matsui[2], Masaki Matsushima[3], 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

Geomagnetic field is generated by a dynamo action in the fluid outer core. Studies of the thermochemical evolutions of the Earth's core suggest that the solid inner core has been growing up for approximately one billion years [e.g., O'Rourke and Stevenson, 2016]. Results of numerical dynamo simulations with various aspect ratios (ratios of inner to outer core radii) indicates that the sustained magnetic field is categorized into dipolar-dominated or non-dipolar-dominated regime [e.g., Hori et al., 2010; Driscoll, 2016]. However, any dominant factors controlling the regime have not been fully understood. In the present study, we perform dynamo simulations with various inner core radii using a geodynamo code Calypso to investigate the characteristics of the generated magnetic field. 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 and the aspect ratio to be $r_i/r_o = 0.15$, 0.25, and 0.35. Then we examine the dominancy of the dipole component in two approaches; one is calculating the dipolarity, f_{dip}, which is the ratio of the amplitude of the axial dipole magnetic field to the total amplitude, and the other is comparing magnetic energy for the dipole component with extrapolated magnetic energy for $l = 1$ using an exponential function for odd degree components from $l = 3$ to $l = 19$. The magnetic energy for the dipole component is compared with that extrapolated from the fitting curve.

In $r_i/r_o = 0.25$ and 0.35 cases, f_{dip} is approximately 0.8 at $Ra/Ra_{crit} \fallingdotseq 2.0$ and gradually decreases to approximately 0.45 with increase of Ra/Ra_{crit} up to around 6.0, where Ra_{crit} is the critical Rayleigh number. By referring to the obtained fitting curve, we find that the magnetic energy for the dipole component is more than 5 times larger than the extrapolated value for $l = 1$ at $Ra/Ra_{crit} \fallingdotseq 2.0$ and decreases with increase of Ra/Ra_{crit} in both aspect ratios. The dependency of the dipole component dominancy on the Rayleigh number is similar in both aspect ratio cases. However, in the $r_i/r_o = 0.15$ case, f_{dip} is approximately 0.4 at $Ra/Ra_{crit} \fallingdotseq 8.0$ and decreases to approximately 0.1 with increase of Ra/Ra_{crit} up to around 15.6. At $Ra/Ra_{crit} = 8.1$ and 9.0, the amplitude of the dipole component is comparable to extrapolated value from the fitting curves. At $Ra/Ra_{crit} > 10.1$, the magnetic energy for $l = 1$ component is smaller than that for the $l = 2$ component. Consequently, the magnetic field obtained in the simulation results is non-dipolar. To summarize above, we categorize the present dynamo simulations as shown in Figure 1. Here we define strong/weak dipolar dynamo by a condition that the magnetic energy is larger/smaller than the kinetic energy. The axial dipolar component becomes small in all three ratio cases for larger Rayleigh numbers. Non-dipolar components become larger for the smaller inner core. In other words, for $r_i/r_o < 0.35$, it is likely that the dipolar magnetic field is dominant for larger inner core.

Keywords: Geodynamo, Inner core size, Rayleigh number, Dipole component dominancy

©2019. Japan Geoscience Union. All Right Reserved.

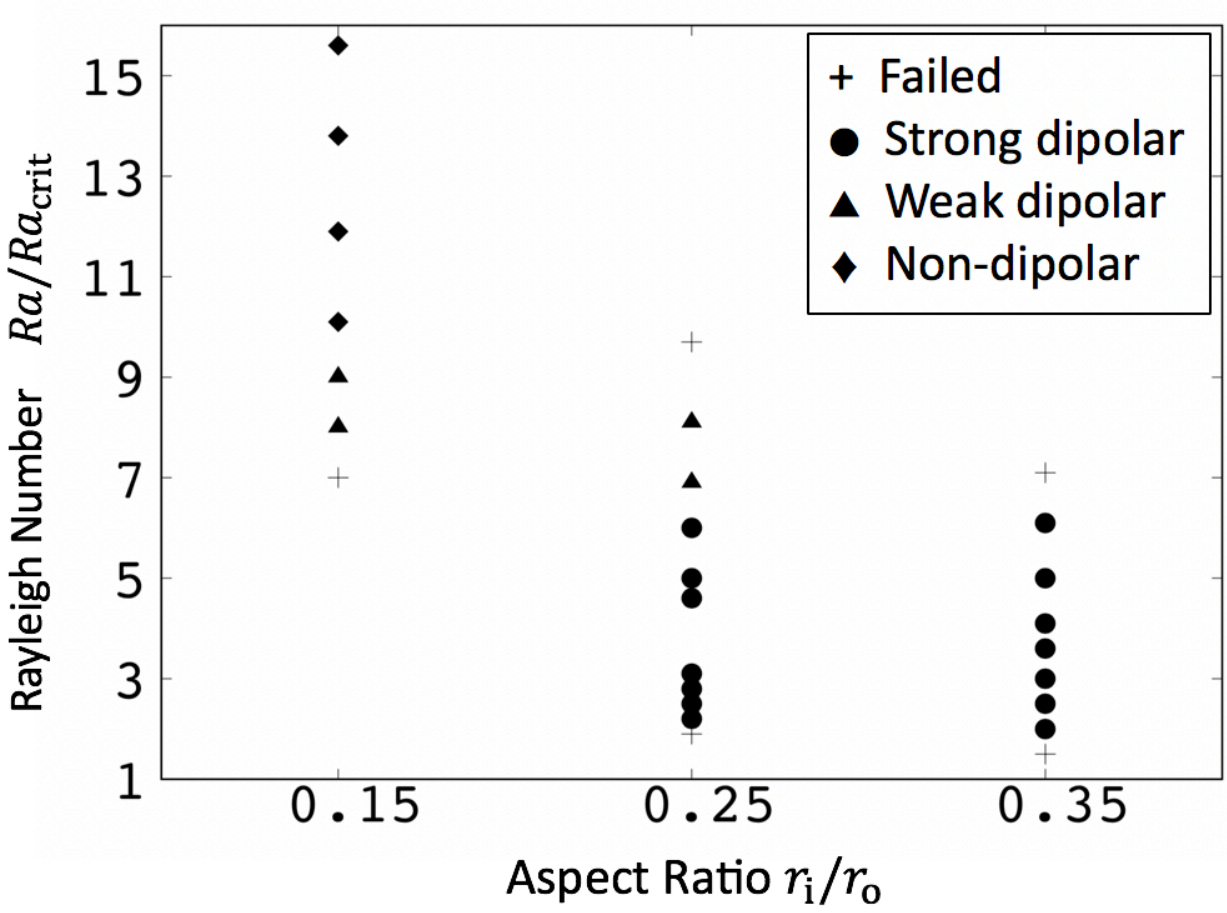


Figure 1 Dynamo regime in various aspect ratios. Cross, circle, triangle, and diamond symbols represent failed, strong dipolar, weak dipolar, and non-dipolar dynamo cases, respectively.

©2019. Japan Geoscience Union. All Right Reserved.

Elasticity of Fe-Si Alloy

*Taku Tsuchiya[1], Yu Fukunaga[1]

1. Geodynamics Research Center, Ehime University

Earth’ s inner core (329~364 GPa and 5000~6000 K) is thought to be composed of solid Fe-Ni alloy with some unknown light elements (e.g., Mao et al., 1998). Thermoelasticity of iron alloys is therefore a key to interpreting seismological information of the inner core: density, seismic wave velocities, and their anisotropy. So far, several studies reported that pure hcp iron has a shear modulus distinctly larger than that of the inner core and a small P-wave anisotropy (e.g., Mao et al., 1998; Vocadlo et al., 2009). This large V_P/V_S ratio of the inner core is one of the remaining inexplicable features of the deep Earth, and it suggests the presence of mechanisms to lower the S-wave velocity in the inner core, such as a low-velocity component (Prescher et al., 2015), pre-melting effect (Martorell et al., 2013), anelasticity, and so on.

In this study, we perform ab initio molecular dynamics simulations on the thermoelasticity of alloy compositions including potential light element candidate of Si. Computations are conducted at the inner core P,T conditions. The obtained velocities, density and aggregate anisotropies are compared against seismological constraints, and we show the first evidential result on the suitable compositions to the inner core constituents, which can reproduce all of V_P, V_S, V_Φ, and ρ of the inner core simultaneously. We also report why Fe-Si alloy can have a large V_P/V_S ratio.

Research supported by KAKENHI .JPN15H05834.

Keywords: Ab initio density functional computation, High-P,T elasticity, Inner core

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP29] Oceanic and Continental Subduction Processes

convener:REHMAN Ur Hafiz(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University), Tatsuki Tsujimori(Tohoku University), Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University), Kazuaki Okamoto(Faculty of Education, Saitama University), Chairperson:Hafiz REHMAN(Kagoshima University), Tatsuki Tsujimori

This JpGU-AGU joint session aims at bringing earth scientists from Japan and overseas to present their research related to the processes of oceanic and continent subduction, continent-continent collisions, metamorphism of crustal rocks, formation of the oceanic/continental arcs, and accretion/ tectonic erosion of material along subduction boundaries.

Topics such as role of the fore- and back-arcs in the subduction zones, process of accretion of volcaniclastic and terrigenous sediments along the subduction/collision boundaries, deformation and metamorphism of subducted crust, and exhumation will be the main focus of the session.

In addition to the above mentioned topics, our focus for the10th anniversary of this international session will be towards our understanding and progress on the ultrahigh-pressure/temperature metamorphic terranes in the world.

Exchange of ideas among geoscientists applying different approaches on problems related to the theme of the session are most welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SMP29-01] Pb-isotope of Fe-Ni alloy associated with serpentinite: Geochemical constraints on the fluid-mediated hyper-reducing environment in mantle wedge

★Invited Papers

*Mayu Kakefuda[1], Tatsuki Tsujimori[1], Katsuyuki Yamashita[2], Yoshiyuki Iizuka[3] (1.Tohoku University, 2.Graduate School of Natural Science and Technology, Okayama University, 3.Institute of Earth Sciences, Academia Sinica)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SMP29-02] PETROCHEMISTRY AND AGE DETERMINATION OF THE NEWLY DISCOVERED ECLOGITE IN THE WESTERN MONGOLIA

*Kosuke Naemura[1], Erdenjargal Choindonjamts[4], Takenori Kato[5], Otgonkhuu Javkhlan[3], Katsuyoshi Michibayashi[2] (1.Nagoya University Museum, 2.Nagoya University Graduate school of environmental studies, 3.Chinese Academy of Geological Sciences, 4.Mongolian Academy of Sciences, 5.Nagoya University Space-Earth Environmental Research)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[SMP29-03] Continental subduction, "*Intraslab UHP Metasomatism*", and the formation of metamorphic diamond

★Invited Papers

*Yoshihide Ogasawara[1] (1.Department of Earth Sciences, Waseda University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SMP29-04] Ultrahigh-pressure pseudotachylyte in a marble

★Invited Papers

*Tadao Nishiyama[1], Tomoya Fujimoto[1] (1.Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SMP29-05] Dehydration and Deformation process of subducted large Oceanic Pleateau -case study of the Mikabu blueschist-

*Kazuaki Okamoto[1] (1.Faculty of Education, Saitama University)

Pb-isotope of Fe-Ni alloy associated with serpentinite: Geochemical constraints on the fluid-mediated hyper-reducing environment in mantle wedge

*Mayu Kakefuda[1], Tatsuki Tsujimori[1], Katsuyuki Yamashita[2], Yoshiyuki Iizuka[3]

1. Tohoku University, 2. Graduate School of Natural Science and Technology, Okayama University, 3. Institute of Earth Sciences, Academia Sinica

Although the occurrence of Fe-Ni alloy is very limited in the vicinity of modern Earth’s surface due to the highly oxidized state, serpentinization in the forearc mantle wedge can rarely provide extraordinary reducing environments that stabilizes the Fe-Ni alloy.

In order to understand those fluid-mediated hyper-reducing environments in serpentinizing mantle wedge of an active convergent plate margin, we revisited so-called ‘josephinite' —an unusual ‘metallic rock' composed mainly of Fe-Ni alloy (awaruite)— found in the Josephine Ophiolite, by engaging in microtextural and geochemical analyses.

Microtextural analyses using high-resolution FE-SEM and FE-EPMA found the presence of Ni-As mineral within aggregates of Fe-Ni alloy; the Ni-As mineral also occurs as discrete grains in ‘josephinite'-hosting serpentinite, suggesting that Ni-As mineral acted as a precursor seed before the crystallization of Fe-Ni alloy.

Since each leachate obtained by stepwise leaching of a ‘josephinite' pebble confirmed compositional homogeneity, this allows to calculate weighted mean values that give much precise Pb isotope compositions of aliquots of seventeen leaching steps determined by ID-TIMS; the values yielded $^{207}Pb/^{204}Pb$ = 18.3378 ±0.0016, $^{206}Pb/^{204}Pb$ = 15.5693 ±0.0015, and $^{208}Pb/^{204}Pb$ = 38.0879 ± 0.0044. These newly obtained high precision Pb isotope compositions revealed that the ‘josephinite'-forming fluids have a minor GLOSS-like sedimentary component. The presence of Ni arsenide also supports the infiltration of arsenic-bearing external fluids derived from sedimentary rocks.

Considering the geological context of the Josephine Ophiolite, the ‘josephinite’-forming fluids might have been derived from the top layer of subducting sediments. The lack of high-pressure metamorphic rocks such as blueschist in ‘josephinite'-hosted serpentinite implies that the ‘josephinite' formation might have occurred at a relatively shallow level of serpentinizing mantle wedge.
The absence of carbonate minerals further postulates that redox agent of the ‘josephinite' forming hyper-reducing environment was H_2 evolved by the serpentinization rather than CH_4 that is commonly preserved in blueschist and eclogites. This fact would speculate a widespread hyper-reducing environment caused by H_2 fluids in a shallow level of serpentinizing mantle wedge.

Keywords: Fe-Ni alloy, serpentinization, Pb isotope composition, reducing fluid, mantle wedge

©2019. Japan Geoscience Union. All Right Reserved.

PETROCHEMISTRY AND AGE DETERMINATION OF THE NEWLY DISCOVERED ECLOGITE IN THE WESTERN MONGOLIA

*Kosuke Naemura[1], Erdenjargal Choindonjamts[4], Takenori Kato[5], Otgonkhuu Javkhlan[3], Katsuyoshi Michibayashi[2]

1. Nagoya University Museum, 2. Nagoya University Graduate school of environmental studies, 3. Chinese Academy of Geological Sciences, 4. Mongolian Academy of Sciences, 5. Nagoya University Space-Earth Environmental Research

This study report on newly discovered eclogite from the Western Mongolia in the Central Asian Orogenic Belt. Lenticular eclogite bodies with several meters in length are enclosed in quartzite of the Shubun/Urgamal formation in the southernmost part of the Zavkhan block which forms a part of the Neoproterozoic Tuva-Mongolian arc. Trace element patterns of eclogites are like those of OIB. We used relatively fresh eclogite sample and amphibolite sample to reconstruct the pressure-temperature history. Fresh eclogite preserves omphacite (with jadeite 38 mole%) coexisting with garnet ($Alm_{56}Gros_{35}Pyr_{8}$), barroisite, phengite (Si=3.36 apfu, O=11), quartz, epidote, rutile with accessory apatite, calcite, and hematite (assemblage 1). Garnet-core includes paragonite and kyanite coexisting with titanite, quartz, barroisite, which represents prograde stage mineral assemblage (Stage 0). The eclogite assemblages are variably retrogressed into amphibolite assemblage of hornblende, plagioclase, quartz, biotite, Mg-rich garnet-rim ($Alm_{61}Gros_{29}Pyr_{9}$), epidote and titanite (assemblage-2). In amphibolite sample, atoll-shaped garnet is ubiquitously observed. The atoll-shaped garnet consists of the eclogite facies core, Ca-rich mantle ($Alm_{53}Gros_{44}Pyr_{3}$) probably formed during the amphibolite facies stage 2, and a Ca-poor Mg-rich rim (or shell) ($Alm_{64}Gros_{25}Pyr_{10}$). The last Ca-poor garnet rim coexists with plagioclase, hornblende, epidote, quartz, titanite (assemblage-3). The earliest stage of metamorphism might happen in the "lawsonite stability field" if we interpret kyanite formed from paragonite. Subsequent Stage 1 P-T condition was determined at about 2 GPa and 480 ºC by garnet-clinopyroxene-phengite geothermobarometry. The eclogite once experienced decompression to the epidote-amphibolite assembalge equilibrated at ca. 0.8 GPa and 400 ºC during the Stage 2, determined by garnet-hornblende-plagioclase geothermobarometry. After the initial exhumation, the eclogite experienced heating to the high-pressure amphibolite stage 3 formed at ca. 600 ºC and 1.2 GPa. Such multiple P-T paths have been reported from eclogites from collision zones such as Sesia Alps and W.Tianshan. Additionally, we determined U-Pb age of zircon by CHIME method. Zircon typically exhibit oscillatory zoning and are sometimes included at the garnet core. Most zircons are severely altered, with rare fresh core only in large zircon grains (>0.1 mm). We obtained three populations of age at 1170 Ma, 680 Ma and 340 Ma for such zircon fresh cores. If we interpret these ages as igeneous protolith ages, the eclogite-facies metamorphism should have taken place after 340 Ma. Combining the metamorphic history and U-Pb zircon ages, we speculated that the eclogite primarily formed at the ocean island on the Mongol-Okhotsk (MO) ocean. If so, eclogite-facies metamorphism (assemblage 0→1) should have taken place when the MO plate subducted beneath the Siberian craton. Subsequently the eclogite probably separated from the subducting plate and come up to the crustal depth through the subduction channel, and was transformed into epidote-amphibolite assemblage (assemblage 2). Finally, continental collision took place when the N. China craton collide with the Siberian craton to close the MO ocean at 140 Ma, which transformed the rock to high-pressure amphibolite (assemblage 3).

Keywords: Eclogite, Central Asian Orogenic Belt, Mongol-Okhotsk Ocean

©2019. Japan Geoscience Union. All Right Reserved.

Continental subduction, “*Intraslab UHP Metasomatism*”, and the formation of metamorphic diamond

*Yoshihide Ogasawara[1]

1. Department of Earth Sciences, Waseda University

Deep continental subduction is the process carrying supracrustal materials into deep mantle, and UHP metamorphic rocks are the direct evidence for this process as the materials having the information of P-T and the chemical environments during subduction, escaped from the homogenization with mantle rocks. Usually, UHPM silicate rocks have been strongly retrograded during exhumation, and the preservation of UHPM information is limited excepting inclusions in refractory minerals; decoding the chemical processes in subducted materials is difficult. In carbonate and calc-silicate rocks, UHPM information has been well preserved and can be decoded even in the matrix because the chemical reactions in these rocks make distinct changes from the protolith chemistries, not erased during exhumation.

Carbonate-bearing assemblages have large P-T stabilities at HP/UHP and low H_2O activity, and this indicates high possibility of survival of carbonates and transportation of carbon into deep mantle. H_2O-fluid supply is necessary for metamorphic reactions in these rocks because H_2O-fluid lowers temperatures of decarbonations. As a model showing the processes in deeply subducting continental materials, *Intraslab UHP Metasomatism* (metasomatism within subducting continental materials at UHP mantle depths) will be introduced on the basis of our last 20 years research on the Kokchetav UHPM rocks. In this model, key materials are H_2O and CO_2 in the subducting continental slab, and a key process is H_2O-fluid infiltration within the slab. The outline of this model is as follows. 1) In the subducting slab, silicate rocks (gneisses and eclogite) were a H_2O reservoir, and carbonate and calc-silicate rocks were a CO_2 reservoir. 2) During subduction, H_2O-fluid with several components (e.g. C, K, Ti) occurred by dehydrations of silicate rocks. 3) Dehydrations in silicate rocks preceded decarbonation reactions in carbonate and calc-silicate rocks. 4) Infiltration of H_2O-fluid into carbonate and calc-silicate rocks was a trigger for decarbonations. 5) H_2O-fluid infiltration was controlled by the timing of dehydrations in silicate rocks and vaired in mm to cm scales to form or to characterize the mineral assemblages in carbonate and calc-silicate rocks. 6) H_2O-fluid (with C-bearing species) contributed to the formation of diamond in some carbonate calc-silicate rocks. 7) Modal compositions of carbonates in the protoliths controlled the survival of carbonate depending on the intensity of fluid infiltration.

The following subjects from the Kokchetav UHPM rocks support this model. A) Dolomite marble contains abundant diamond formed at two stages; 2nd stage diamond ($\delta^{13}C$: -17 to -27 ‰) from H_2O-fluid. Dol + Di is not the highest-T assemblage and was controlled by fluid composition, XCO_2 as 0.1, which was suitable for diamond formation. B) Dolomitic marble has the highest-T assemblages, Arg-Fo, Arg-Ti-Chum, but diamond was unstable because of low XCO_2 as 0.01. C) Calcite (after Arg) marble with Coe exsolution in Ttn contains diamond only in Di layer, and other parts do not; this indicates short-term stability of diamond in this rock depending on changing XCO_2. The later fluid was low XCO_2 as 0.02; too low for diamond formation. D) Two types of Grt-Cpx rocks occur; diamond-bearing and diamond-free. Their protoliths are a mixture of silicates and carbonates. Minor diamond occurs as two modes in diamond-bearing Grt-Cpx rock; one is fine-grained (several μm) and the other is cubic (max. 200 μm). A cubic diamond has fine core and crystallized slowly from H_2O-fluid on a fine grain as a seed crystal. E) In gneisses, diamond occurrence is diverse; several morphologies with different colors were observed. Two-stage growth was not confirmed. Dissolution of carbon from diamond in gneisses could be possible,

©2019. Japan Geoscience Union. All Right Reserved.

and carbon was carried into dolomite marble by H_2O-fluid to crystallize 2^{nd} stage diamond.

Many of the subjects being still unclear will be mentioned as the targets of future research.

Keywords: intraslab UHP metasomatism, UHP metamorphism, diamond, carbonate, fluid, Kokchetav Massif

©2019. Japan Geoscience Union. All Right Reserved.

Ultrahigh-pressure pseudotachylyte in a marble

*Tadao Nishiyama[1], Tomoya Fujimoto[1]

1. Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University

A black vein in a marble from the Higo metamorphic rock in central Kyushu, Japan, represents a signature of dolomite growth from a carbonate melt and also evidence of liquid immiscibility between carbonate and silicate melts. The formation condition is estimated to be 3.5 GPa and 1280 C by the dolomite composition based on the phase diagram in the system CaCO3– MgCO3. This is a peculiar example of pseudotachylyte formed under ultrahigh-pressure condition.

The Higo metamorphic rock is Cretaceous low P/T metamorphic rock, however, some authors have suggested the existence of high to ultrahigh-pressure metamorphism prior to the low P/T metamorphism. In the south of Mt. Kousadake, Tomochi Town, Kumamoto Prefecture, marble occurs as several layers intercalated with pelitic and siliceous gneisses. The thickness of the marble layer is variable from several meters to several tens of meters. In one of the marble layers, near the contact with the surrounding pelitic gneiss, we found a black vein 10 cm thick and 1 m long, of which strike crosscuts that of the boundary between the marble and gneiss. It shows a branching texture, extending perpendicular to the vein strike from the vein towards the country rock (marble). The branching is a signature typical to the pseudotachylyte.
The marble consists of pure calcite, whereas the black vein consists of dolomite domain and silicate domain. The dolomite domain is composed of aggregates of anhedral to subhedral dolomite grains of 10 micrometers in size with oscillatory or complex zoning in terms of Ca, Mg and Fe. The dolomite grains do not show any deformation texture. The dolomite domain occasionally includes fractured quartz clasts, of which fractures are filled with dolomite. The silicate domain occurs as rounded or irregular-shaped aggregates of several hundred micrometres in size. It consists of rounded quartz grains, fibrous aggregates of hydrous alumino-silicate (unknown clay mineral) and minor dolomite grains. The silicate domains occur sporadically in the dolomite domains, and some silicate domains are connected with each other by network veins of silicates of the same material as the silicate domain. Rounded zircon rarely occurs in the silicate domain. In some parts of the vein, thin marble layers several millimeters thick occur, showing a flow folding.
Subhedral shape, oscillatory zoning and non-deformed texture of dolomite in the dolomite domain indicates the origin of dolomite either as precipitates from the fluid or as growth in the melt. If dolomite precipitated from the C-O-H fluid, the assemblage of dolomite + quartz, which occurs both in the dolomite and silicate domains, is stable at relatively low T, high P and high XCO2 region. Outside the stability field, it will react to form diopside. Diopside is common in calc-silicate gneisses in this region, therefore, the assemblage of dolomite + quartz + C-O-H fluid would imply temperature condition lower than that of the regional metamorphic condition. This observation leads to a conclusion that the dolomite grew from the melt, because fault rocks should show temperature condition higher than that of the country rock owing to frictional heating. The silicate domain may represent recrystallized silicate melt, and the coexistence of carbonate and silicate domains implies the liquid immiscibility between carbonate and silicate melts. In such a case, dolomite should represent a minimum melt composition in the system CaCO3 –MgCO3. The minimum melt composition and its temperature depends strongly on pressure (Irvine and Wyllie, 1975 and Buob et al., 2006), therefore, we can estimate the melting temperature and pressure from the dolomite composition. The effect of FeCO3 component is evaluated to be small based

©2019. Japan Geoscience Union. All Right Reserved.

on the experiment of Shatsky et al. (2014). The estimated pressure and temperature conditions are 3.5 GPa and 1280 C. Thus, we interpret that the black vein is a pseudotachylyte formed under ultrahigh-pressure condition, indicating that the Higo metamorphic rock has experienced the ultrahigh-pressure.

References: Buob, A., et al. (2006) Amer. Mineral., 91, 435-440; Irvine, A.J. and Wyllie, P.J. (1975) GCA, 39, 35-53; Shatsky, A. et al. (2014) Amer. Mineral., 99, 773-785.

Keywords: Ultrahigh-pressure metamorphism, pseudotachylyte, Higo metamorphic rock

©2019. Japan Geoscience Union. All Right Reserved.

Dehydration and Deformation process of subducted large Oceanic Pleateau -case study of the Mikabu blueschist-

*Kazuaki Okamoto[1]

1. Faculty of Education, Saitama University

In order to know an origin of mega-earthquake related to subducted large seamount, observation of deformation process recorded in the blueschist (high P/T metamorphic rock) is the best method. Mikabu blueschist is considered as accreted large oceanic plateau and suffered blueschist facies metamorphism at Jurassic time. It extends approximately 1000 km in EW direction from the Kanto Mountain to Kyushu Island. In north-south direction, succession of ocean plateau stratigraphy can be reconstructed although accretion thrusts duplicate them. We have done detailed field observation along the N-S route and collected the rock sample systematically. In the outcrop, the Mikabu blueschist is well foliated with mineral lineation. However, we have identified massive, cataclastic samples in the structural middle in the NS section. Under the microscope, glassy parts suffered brittle and ductile deformation. Origin of the most glass part can be ascribed as igneous product. However, some glass layers along the deformation band in stilpnomelane aggregates might be formed as melt due to shear heating. If this zone is related to earthquake fault zone, it indicates that a huge earthquake has occurred. Metamorphic petrology based on mineral assemblage devides the Mikabu belt as three zones; the North, Mid, and the South zone, respectively. Psseudo-section analysis concludes that the North zone suffered relatively higher T metamorphism compated to the South zone. In the Mid zone, local temperature increase stabilized stilpnomelane after chlorite.

Keywords: subducted large-ocean plateau, blue schist metamorphism, deformation and metamorphic process

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP29] Oceanic and Continental Subduction Processes

convener:REHMAN Ur Hafiz(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University), Tatsuki Tsujimori(Tohoku University), Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University), Kazuaki Okamoto(Faculty of Education, Saitama University), Chairperson:Tsai Chin-HO(National Dong Hwa University), Hafiz REHMAN(Kagoshima University)

This JpGU-AGU joint session aims at bringing earth scientists from Japan and overseas to present their research related to the processes of oceanic and continent subduction, continent-continent collisions, metamorphism of crustal rocks, formation of the oceanic/continental arcs, and accretion/ tectonic erosion of material along subduction boundaries.

Topics such as role of the fore- and back-arcs in the subduction zones, process of accretion of volcaniclastic and terrigenous sediments along the subduction/collision boundaries, deformation and metamorphism of subducted crust, and exhumation will be the main focus of the session.

In addition to the above mentioned topics, our focus for the10th anniversary of this international session will be towards our understanding and progress on the ultrahigh-pressure/temperature metamorphic terranes in the world.

Exchange of ideas among geoscientists applying different approaches on problems related to the theme of the session are most welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SMP29-06] Unusually high Nb/Ta ratio of fluid-precipitated jadeites from New Idria serpentinite body, California: Implications for extreme fractionation in slab fluids

*Naoko Takahashi[1], Tatsuki Tsujimori[2], Qing Chang[3], Jun-Ichi Kimura[3] (1.Graduate School of Science, Tohoku Univ., 2.CNEAS, Tohoku Univ., 3.Department of Solid Earth Geochemistry, JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SMP29-07] The collision process interpreted using the systematic change of metamorphic pattern along theQinling–Dabie–Odesan collisional belt between the North and South Korea-China Cratons

★Invited Papers

*Chang Whan Oh[1,2] (1.Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea, 2.Environmental Science System Research Center, Chonbuk National University,Jeonju, Republic of Korea)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SMP29-08] Contrasting collision processes between northwest and central Himalaya: examination from the "Lesser Himalayan granites” in Pakistan

*Masatsugu Ogasawara[1], Mayuko Fukuyama[2], Rehanul H Siddiqui[3] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Graduate School of Engineering Science, Akita University, 3.Balochistan University of Information Technology, Engineering and Management Sciences)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SMP29-09] New petrologic indications of subduction metamorphism in the Yuli belt, eastern Taiwan

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Dominikus Deka Dewangga[1], Yui Kouketsu[2], Masaki Enami[3] (1.Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2.Department of Earth & Planetary Sciences, Nagoya Univ., 3.Institute for Space-Earth Environmental Research, Nagoya Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SMP29-10] **The importance of Mn-nodules on the sea floor during subduction for the formation of ophiolitic diamond**

*Richard Wirth[1] (1.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences 3.5 Surface Geochemistry)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SMP29-11] **Along-strike variability of primitive magmas inferred from olivine-hosted melt inclusions, southernmost Andean Southern Volcanic Zone, Chile**

*Derek Weller[1,2], Charles R Stern[2] (1.Earthquake Research Institute, 2.University of Colorado)

Unusually high Nb/Ta ratio of fluid-precipitated jadeites from New Idria serpentinite body, California: Implications for extreme fractionation in slab fluids

*Naoko Takahashi[1], Tatsuki Tsujimori[2], Qing Chang[3], Jun-Ichi Kimura[3]

1. Graduate School of Science, Tohoku Univ., 2. CNEAS, Tohoku Univ., 3. Department of Solid Earth Geochemistry, JAMSTEC

Fractionation of Nb and Ta, which are conventionally thought as geochemical twins, is a key to understanding the evolution of the silicate Earth. The subchondritic Nb/Ta ratio of the continental crust (12-13; Barth et al., 2000), which is a long-standing problem, has been explained by Nb/Ta fractionation during subduction processes such as slab melting and/or dehydration. However, recent studies have revealed that extreme Nb/Ta fractionation of subduction-zone fluids from minerals in eclogite (up to 87; Xiao et al., 2006; Liang et al., 2009) and metagranite (up to 239; Chen and Zheng, 2015). In order to decipher Nb-Ta (and Zr-Hf) behavior of slab-derived fluids in shallower levels, we investigated a veined jadeitite from the New Idria serpentinite body, which is regarded as direct precipitates from slab-derived fluids at forearc depth. We applied *in-situ* measurements of trace element abundance of jadeites using a LA-ICP-QMS. The New Idria jadeites is characterized by remarkably high Nb concentration but depleted in Ta. Consequently Nb/Ta ratio varies from 10 to 115; Zr/Hf ratio also shows a wide range of 38–164. Nb–Ta and Zr–Hf correlations suggest coupling behaviors of those elemental pairs in fluids during the jadeitite vein formation. A simple Rayleigh fractional crystallization model for jadeite growth using partitioning coefficient D_{Nb} and D_{Ta} between clinopyroxene-aqueous fluid (Stalder et al., 1998) is also unlikely to explain the data. Although the extreme Nb/Ta and Zr/Hf fractionation can occur in seawater (Firdaus et al., 2011), oxygen isotope composition of New Idria jadeites ($\delta^{18}O$ = +8.4 to +9.9‰; Sorensen et al., 2006) eliminates a possibility that jadeitite-forming fluid source was originated from pore fluids derived from seawater. Alternatively, the Nb-Ta behavior might be explained by breakdown of hydrous minerals with high Nb/Ta ratio such as phengitic mica and/or consequences of high degree of fluid-rock interaction in a case of $D_{Nb}/D_{Ta} > \sim 10$ for fluid-rock system. New Idria jadeitite veins would provide an evidence for the presence of highly Nb/Ta fractionated fluids in serpentinized mantle wedge beneath forearc, supporting the idea that Nb and Ta are highly mobile and fractionate during the early stage of oceanic plate subduction before the appearance of rutile.

Keywords: Nb/Ta fractionation, subduction, fluid, water-rock interaction, jadeite

©2019. Japan Geoscience Union. All Right Reserved.

The collision process interpreted using the systematic change of metamorphic pattern along theQinling–Dabie–Odesan collisional belt between the North and South Korea-China Cratons

*Chang Whan Oh[1,2]

1. Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea, 2. Environmental Science System Research Center, Chonbuk National University,Jeonju, Republic of Korea

Along the Qinling–Dabie–Odesan collisional belt between the North Korea-China and South Korea-China Cratons, the peak metamorphic conditions reflect systematically changing metamorphic regimes from east to west: ultra-high temperature (UHT) granulite-facies metamorphism in the Odesan area (905–1160˚C, 9-10.6 kbar) at 247-245 Ma; high pressure (HP) eclogite-facies metamorphism in the Hongseong area (819–835˚C, 23-25 kbar) at 250 Ma; ultra-high pressure (UHP) eclogite-facies metamorphism in the Sulu, Dabie and Hong’ an areas (620–880˚C, 26–43 kbar) at 220-240 Ma; HP eclogite facies metamorphism in the Tonbai area (530–610˚C, 17–20 kbar) at 216 Ma; epidote–amphibolite and blueschist facies metamorphism in the Wudang area (505–550˚C, 10–13 kbar) at 216 Ma ; and HP granulite-facies metamorphism in the western Qinling area (657–772˚C, 9.7–13.2 kbar) at 214 Ma. Additionally, the Triassic post-collisional igneous rocks regionally intruded at both ends of the collision belt, in the Hongseong–Odesan areas at 230 Ma and in the west Qinling at 210 Ma. These observations indicate that the following collisional processes occurred along the Qinling–Dabie–Odesan collisional belt. The collision between the North Korea-China Craton and South Korea-China Craton first occurred in the eastern margin of the collision belt (the Odesan area) with an angle of approximately 60˚ between their long axes of two Cratons and propagated towards west. The amount of oceanic slab subducted before the collision increased from the Odesan area to the Sulu area due to westwards increase in the width of the ocean between the North Korea-China and South Korea-China Cratons, resulting an increase in the depth of slab break-off. After slab break-off occurred in the Sulu area, the lateral tearing force strengthened, resulting a decrease in the depth of slab break-off from the Sulu area to the western Qinling area as collision propagated westward. At both ends of the collision belt, post collisional igneous activities occurred with metamorphism higher than granulite facies relating to high heat supply from upwelling mantle due to shallow depth of slab break-off.

Keywords: Qinling-Dabie-Odesan collision belt, The depth of slab break-off, Peak metamorphism, Post collisional igneous activity, Collisional process

©2019. Japan Geoscience Union. All Right Reserved.

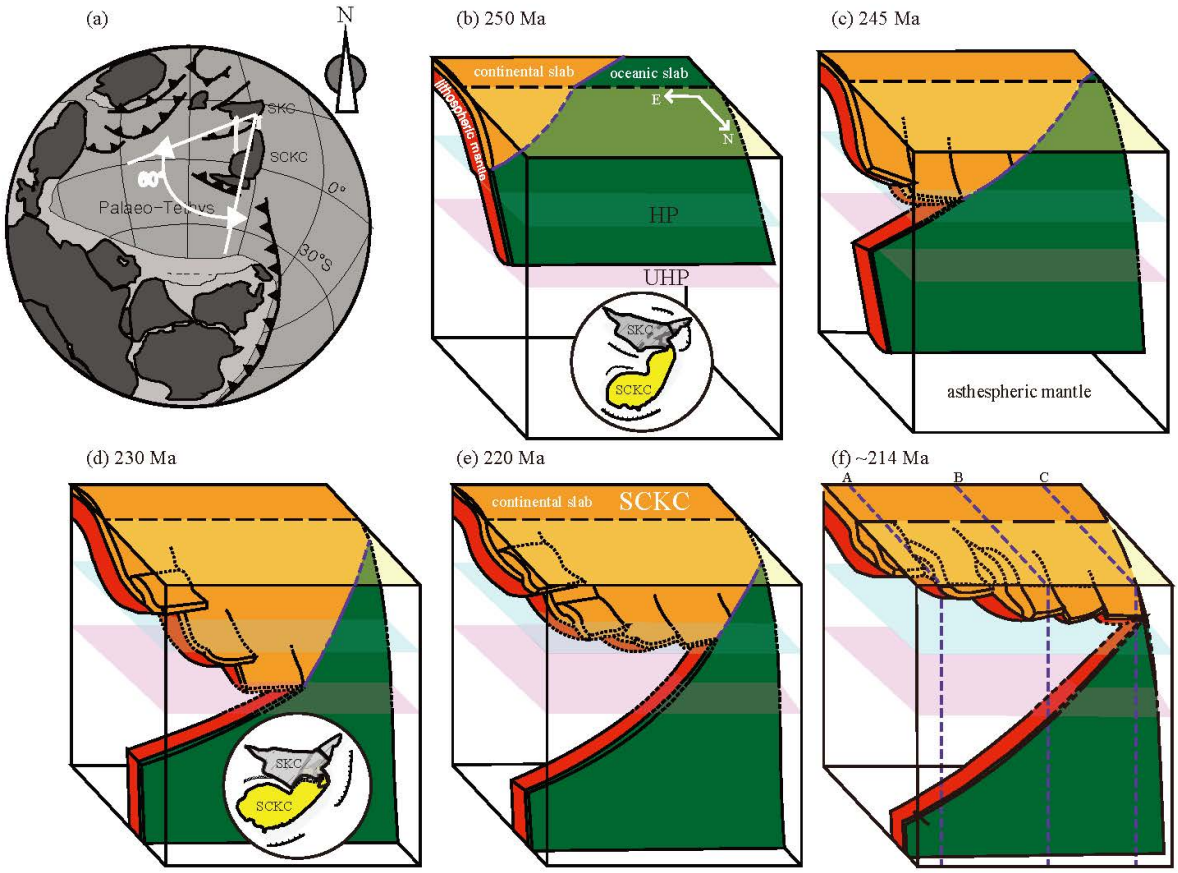


Fig. 16 Oh and Lee,

©2019. Japan Geoscience Union. All Right Reserved.

Contrasting collision processes between northwest and central Himalaya: examination from the "Lesser Himalayan granites" in Pakistan

*Masatsugu Ogasawara[1], Mayuko Fukuyama[2], Rehanul H Siddiqui[3]

1. Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. Graduate School of Engineering Science, Akita University, 3. Balochistan University of Information Technology, Engineering and Management Sciences

The Himalayan orogenic belt was formed by the Cenozoic collision of Indian and Eurasian plates. In the eastern and central part of the Himalaya, four main tectonostratigraphic zones have been recognized, such as from south to north, Sub-Himalaya, Lesser Himalaya, Greater Himalaya and Tethys Himalaya. However, the northwest Himalaya in Pakistan and northwest India shows some distinct features differ from the main part of the Himalaya, i.e., (1) Presence of the Cretaceous island arc blocks between the Indian and the Eurasian blocks: (2) Boundary between the Lesser Himalaya and Greater Himalaya is not well defined: (3) Presence of UHP eclogites: (4) Extensive exposure of "Lesser Himalayan granites" represented by the Mansehra granite in Pakistan. As granite and granitic gneiss are major components of the Himalayan orogenic belt, we have examined geochemical and isotopic characteristics of the Mansehra granite and compared those with "Lesser Himalaya granites" and granite gneisses of the Greater Himalaya in the central part of the Himalaya. Before the collision of the India to the Eurasian, granites similar to the Mansehra granite were present along the northern margin of the India continent. The collision of India continent with the Tibet of the Eurasia plate formed two separate zones of granites, the "Lesser Himalayan granites" and extensively deformed granite gneiss in the Greater Himalaya. In the collision of India to the Cretaceous island arc blocks in northwest Himalaya did not disturbed distribution of the granite, resulting large exposure of the Mansehra granite. The southern extension of the Karakoram Fault which is a dextral strike-slip fault separating the Tibet and the Karakoram/Pamir block, approximates a boundary between the northwest Himalaya and the eastern and central Himalaya.

Keywords: collision, Himalaya, granite

©2019. Japan Geoscience Union. All Right Reserved.

New petrologic indications of subduction metamorphism in the Yuli belt, eastern Taiwan

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Dominikus Deka Dewangga[1], Yui Kouketsu[2], Masaki Enami[3]

1. Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2. Department of Earth & Planetary Sciences, Nagoya Univ., 3. Institute for Space-Earth Environmental Research, Nagoya Univ.

Previous reports of high-pressure (HP) metamorphism in the Yuli belt are mainly from meta-igneous and meta-volcaniclastic rocks, which are minor constituents within allochthonous metabasite-serpentinite blocks embedded in the dominant metasedimentary schists. By contrast, no HP minerals have yet been found in the metasedimentary rocks, whereas serpentinite is not suitable for pressure constraint. Thus skepticism on whether the Yuli belt is truly a HP metamorphic belt still exists. To solve this problem, we have investigated garnet-bearing pelitic schists using quartz-inclusion Raman spectroscopy barometry and surveyed the metasomatic zones around the Tsunkuanshan serpentinite body. Our Raman spectroscopic analyses on quartz inclusions in garnet from three metapelitic samples yielded residual (entrapment) pressures of 11-15 kbar at temperatures of 420-620˚C (constrained by Raman spectra of carbonaceous material thermometry). These results are essentially consistent with those of HP metabasites, glaucophane schists, and metaplagiogranites in the Yuli belt by recent pseudosection modeling. In the Tsunkuanshan area, meter-scale metasomatic zones crop out at the contact between serpentinite and surrounding pelitic schists. We discovered rare early-stage glaucophane (crossite) in an intermediate amphibole-albite rich rock in the metasomatic zones. This new occurrence indicates that serpentinite bodies might have been incorporated into a (paleo) subduction channel and subsequently recrystallized together with the host metasediments in HP conditions. Both the new pressure-temperature constraints from metasedimentary rocks and the finding of blue amphibole in metasomatic zones around serpentinite bodies indicate that the Yuli belt was subject to ‘warm’ subduction metamorphism.

Keywords: glaucophane, metasomatic zone, serpentinite, garnet, quartz-inclusion Raman barometry

©2019. Japan Geoscience Union. All Right Reserved.

The importance of Mn-nodules on the sea floor during subduction for the formation of ophiolitic diamond

*Richard Wirth[1]

1. Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences 3.5 Surface Geochemistry

Diamonds, native elements and unusual metal alloys from chromitites in ophiolites have been reported already almost 20 years ago (Bai et al., 2000). However, the genesis of these diamonds enclosed in chromite is still challenged. A major question is the origin of all the unusual elements and alloys recorded so far such as W, Co, Ta, CrFe, NiCu, AgAu, CoFeNi and most important Mn-Ni-Co alloys. Meanwhile, diamonds in chromite in ophiolites have been reported from several different locations on the planet (Tibet, Mongolia, Polar Urals, Turkey, Albania), which are separated from each other by long distances (Yang et al., 2014). There is one common feature observed in these diamonds, they usually contain small inclusions (from nanometre up to a few micrometre in size) of a Mn-Ni-Co alloy. The composition of the alloy is varying in diamond from different locations. These diamonds are natural diamonds that is demonstrated by the presence or coexistence of several additional nanoinclusions in diamond such as oxides, silicates and sulphides and selenides. Thinking about the genesis of these ophiolitic diamonds the question arises where all these strange elements and alloys come from? They are not typical Upper Mantle components. However, it is well known that Mn-nodules from the sea floor contain all these rare and unusual elements (Wegorzweski et al., 2015 and ref. therein). Subduction of the sea floor transports the nodules to a depth where melting of the nodules finally occurs. Depending on the Co-concentration melting of a Mn-Ni-Co ally will start at temperatures < 900˚C with increasing Co-concentration at much lower temperature. Under local reducing conditions such Mn-Ni-Co alloy melt pools might exist in the subducted slab. The sea floor also contains plenty of organic material that could potentially supply the carbon necessary for the formation of diamond. Carbon rich fluids might react with the Mn-Ni-Co alloy melt, the melt acting as a catalyst to reduce the C-rich fluid to C. Carbon is dissolved in the alloy melt to a high amount depending on pressure and temperature. A change in PT during uplift then will result in the precipitation of solid carbon from the melt. If that happens in the diamond stability field diamond will precipitate. That process would explain the presence of such kind of Mn-Ni-Co alloy inclusions in diamond. Mn-nodules with their content of a wide variety of elements from the periodic system cannot only explain the unusual occurrence of diamond in chromitite in ophiolites but also the presence of other unusual elements and compounds. The details of the processes involved are not fully understood and they are subject of future investigations.

Bai, W.J., Robinson, P.T., Fang, Q., Hu, X-F., Zhou, M., (2000) Origin of PGE and base metal allloysin podifoem chromitites of he Luobusa ophiolite, southern Tiet. Canadian Mineralogist, 38, 585-598.

Wegorzewski, A.V., Kuhn, T., Dohrmann, R., Wirth, R., Grangeon, S. (2015) Mineralogical characterization of individual growth structures of Mn-nodules with different Ni+Cu content from the central Pacific Ocean. Amer. Min., 100, 2497-2508.

©2019. Japan Geoscience Union. All Right Reserved.

Yang, J., Meng, F., Xu.X, Robinson, P.T., Dilek, Y., Makeyev, A.B., Wirth, R., Wiedenbeck, M., Griffin, W.L., Cliff, J. (2014) Diamonds, native elements and metal alloys from chromitites of the Ray-Iz ophiolite of the Polar Urals. Gondwana Research, http://dx.doi.org/10.1016/j.gr.2014.07.004.

Keywords: Subduction, Mn-nodules, ophiolitic diamond

©2019. Japan Geoscience Union. All Right Reserved.

Along-strike variability of primitive magmas inferred from olivine-hosted melt inclusions, southernmost Andean Southern Volcanic Zone, Chile

*Derek Weller[1,2], Charles R Stern[2]

1. Earthquake Research Institute, 2. University of Colorado

Glass compositions of melt inclusions in olivine phenocrysts found in tephras derived from explosive eruptions of the four volcanoes along the volcanic front of the southernmost Andean Southern Volcanic Zone (SSVZ) are used to constrain primitive magma compositions and melt generation parameters. Primitive magmas from Hudson, Macá, and Melimoyu have similar compositions and are formed by low degrees (8-18 %) of partial melting. Compared to these other three centers, primitive magmas from Mentolat have higher Al_2O_3 and lower MgO, TiO_2 and other incompatible minor elements, and are generated by somewhat higher degrees (12-20%) of partial melting. The differences in the estimated primitive parental magma compositions between Mentolat and the other three volcanic centers are consistent with difference in the more evolved magmas erupted from these centers, Mentolat magmas having higher Al_2O_3 and lower MgO, TiO_2 and other incompatible minor element contents, suggesting that these differences are controlled by melting processes in the mantle source region above the subducted oceanic plate. The observed along-arc changes in parental magma chemistry may be due to the close proximity below Mentolat of the subducted Guamblin Fracture Zone that could efficiently transport hydrous mineral phases, seawater, and sediment into the mantle, driving enhanced volatile fluxed melting beneath this center compared to the others.

Keywords: Andean volcanism, tephra, olivine melt inclusions, primitive magma

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP30] Crust-Mantle Connections

convener:Yoshihiko Tamura(Research Institute for Marine Geodynamics, Japan Agency for Maine-Earth Science and Technology), Osamu Ishizuka(Geological Survey of Japan, AIST), Chris Conway(Geological Survey of Japan), Chairperson:Yoshihiko Tamura(JAMSTEC), Chris Conway, Tomoaki Morishita(Kanazawa University)

A paradigm of the solid Earth geochemical cycles is that the Earth's crust forms by melting of the Earth's upper peridotitic mantle. How divers is the spectrum of primary melts and which factors may contribute to its variations? What is the influence of crustal processing vs. primary magma diversity in creating the diversity of the Earth's crust? The session seeks to explore the crust-mantle connections at divergent and convergent plate boundaries, and oceanic island settings based on volcanology, petrology, geochemistry, geophysics, geochronology, and geodynamics studies.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SMP30-01] **Noble gas and carbon isotopic compositions of petit-spot lavas from southeast of Marcus Island**

★Invited Papers

*Junji Yamamoto[1], Tetsuma Kawano[2], Naoto Takahata[3], Yuji Sano[3] (1.Hokkaido University Museum, 2.Graduate School of Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SMP30-02] A series of cummingtonite-bearing rhyolites in Niijima, Izu-Bonin arc, Japan: petrological and geochemical constraints

★Invited Papers

*Yoji Arakawa[1], Daisuke Endo[2], Junya Oshika[3], Taro Shinmura[4], Kei Ikehata[1] (1.Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Shimane Prefectural Sanbe Nature Museum Sahimeru (Shimane) , 3.Earth Resoueces Faculty, China University of Geosciences, 4.Faculty of Economics, Kumanoto-Gakuen University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SMP30-03] **Generation of primary andesitic magma in oceanic arcs: Evidence from Kibblewhite Volcano, Kermadec Arc**

★Invited Papers

*Yasuhiro Hirai[1,2], Yoshihiko Tamura[2], Kaj Hoernle[3], Christian Timm[4], Folkmar Hauff[3], Reinhard Werner[3], Bogdan Vaglarov[2], Qing Chang[2], Takashi Miyazaki[2], Jun-Ichi Kimura[2] (1.Graduate School of Natural Science and Technology, Kanazawa University, Japan, 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Kanagawa, Japan, 3.GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany, 4.GNS Science, Lower Hutt, New Zealand)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SMP30-04] Petrogenesis of high-Mg# andesite lavas from Ruapehu volcano, New Zealand

*Chris Conway[1], Katy Chamberlain[2], Yumiko Harigane[1], Daniel Morgan[3] (1.Geological Survey of Japan, 2.Univ. Derby, 3.Univ. Leeds)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SMP30-05] Hydrous felsic magma generated by unmixing of slab-derived supercritical liquid: evidence from Rishiri Volcano, Kuril Arc

★Invited Papers

*Hajime Taniuchi[1], Takeshi Kuritani[2,3], Tetsuya Yokoyama[4,3], Eizo Nakamura[3], Mitsuhiro Nakagawa[2] (1.Department of Natural History Science, Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Science, Faculty of Science, Hokkaido University, 3.Institute for

Planetary Materials, Okayama University, 4.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SMP30-06] Genesis of recent mafic volcanism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of cataclysmic caldera-forming systems?

*Georg F Zellmer[1], Jun-Ichi Kimura[2], Claudine Stirling[3], Gert Lube[1], Phil A Shane[4] (1.Volcanic Risk Solutions, Massey University, Tennent Drive, Palmerston North 4410, New Zealand, 2.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology [JAMSTEC], Natsushima-cho 2-15, Yokosuka 237-0061, Japan, 3.Department of Chemistry, University of Otago, Dunedin 9054, New Zealand, 4.School of Environment, University of Auckland, Auckland 1142, New Zealand)

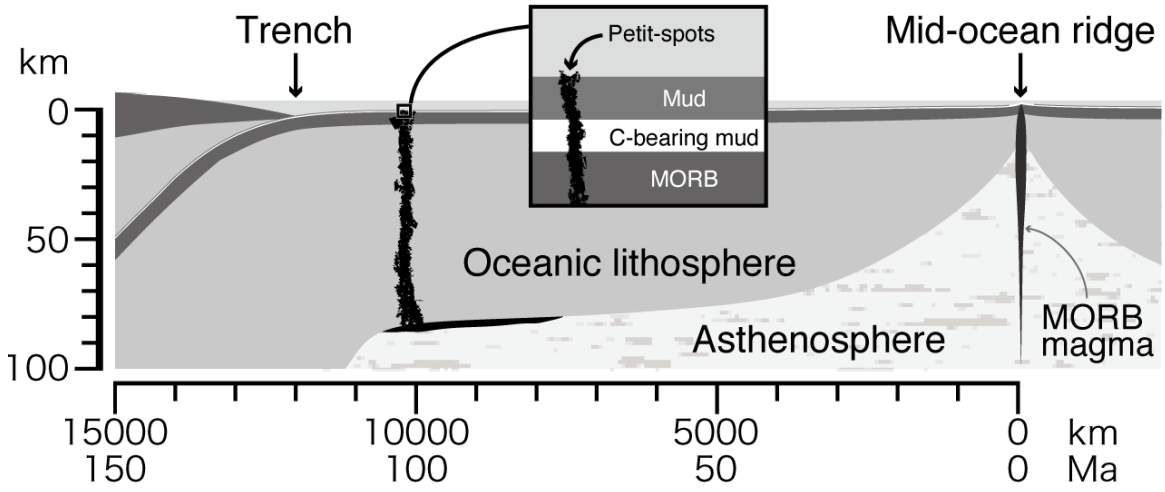
Noble gas and carbon isotopic compositions of petit-spot lavas from southeast of Marcus Island

*Junji Yamamoto[1], Tetsuma Kawano[2], Naoto Takahata[3], Yuji Sano[3]

1. Hokkaido University Museum, 2. Graduate School of Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute

We measured noble gas isotopic compositions of quenched lavas sampled from seamounts, so-called petit-spot volcanoes, on the 160-million-year-old northwestern Pacific Plate. The samples $^{3}He/^{4}He$ and $^{40}Ar/^{36}Ar$ ratios were, respectively, 2.5–8.3 Ra and up to 1735, where Ra stands for atmospheric $^{3}He/^{4}He$, which are analogous to or lower than those of MORB. Considering narrow sampling regions, a secondary effect might be responsible for variation of the data.
During ascent and subsequent cooling of magma in the oceanic lithosphere, chemical components in the magma will be assimilated with those in the lithosphere. Correlation between $CO_2/^{3}He$ ratios and carbon isotopic ratios suggests that carbon was affected by the incorporation of seafloor carbonate. The same would be true of noble gases. The mixing of noble gases among a mantle source, an atmospheric component dissolved in seawater and a radiogenic component can explain the data distribution. There is no $^{3}He/^{4}He$ ratio exceeding MORB-like value. The mantle source of the petit-spot magma was likely to have had a MORB-like $^{3}He/^{4}He$ ratio originally. The eruption of petit-spot magma shows a close relation with the bending of subducting oceanic plates. The MORB-like $^{3}He/^{4}He$ ratio supports the hypothesis that the petit-spot magma is derived from the lithosphere–asthenosphere boundary.

Keywords: noble gases, carbon isotope, petit-spot, lithosphere-asthenosphere boundary, crustal assimilation



©2019. Japan Geoscience Union. All Right Reserved.

A series of cummingtonite-bearing rhyolites in Niijima, Izu-Bonin arc, Japan: petrological and geochemical constraints

*Yoji Arakawa[1], Daisuke Endo[2], Junya Oshika[3], Taro Shinmura[4], Kei Ikehata[1]

1. Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba, 2. Shimane Prefectural Sanbe Nature Museum Sahimeru (Shimane) , 3. Earth Resoueces Faculty, China University of Geosciences, 4. Faculty of Economics, Kumanoto-Gakuen University

Niijima volcano in the northern part of the Quaternary Izu–Bonin volcanic arc, Japan, consists predominantly of rhyolitic volcanic units and minor basaltic and andesitic units. Most of the rhyolites are characterized by a phenocryst assemblage of orthopyroxene (Opx), cummingtonite (Cum), biotite (Bt), and hornblende, and a lack of clinopyroxene (Cpx). These rocks can be classified into four types: Opx–Cum, Cum, Cum–Bt, and Bt according to their eruption sequence (e.g., Isshiki, 1987; Endo et al., 2010). Cummingtonite is a common phenocryst phase and is present in most of the rhyolitic units. This sequence of cummingtonite-bearing rhyolites is a unique feature amongst the silicic volcanoes of the northern Izu–Bonin volcanic arc, most of which have an Opx–Cpx phenocryst assemblage (Shukono et al., 2006; Tamura et al., 2009; Haraguchi et al., 2017).

The decreasing anorthite contents (An mol.%) of plagioclase and Mg values (Mg#) of cummingtonite and biotite with time possibly indicate a gradual decrease in the temperature (and pressure) of the magmas. The rhyolites have high whole-rock SiO_2 (73–78 wt.%) and K_2O (1.5–3.3 wt.%) contents, and their trace element contents and patterns differ slightly amongst and within the four types. Highly differentiated rare earth element (REE) patterns characterize most of the rhyolites from Niijima volcano. All rock types from Niijima volcano have limited ranges of isotope values ($^{87}Sr/^{86}Sr$ = 0.70317–0.70339; $^{143}Nd/^{144}Nd$ = 0.51303–0.51308). The phenocryst assemblages and mineral chemistries of the rhyolitic volcanic rocks suggest that these magmas were produced under low temperatures (<800˚C) and low pressures (<3 kbar), and possibly water-saturated conditions, which is consistent with the experimental results for similar dacites and rhyolites from other volcanic arcs (Geschwind and Rutherford, 1992; Nicholls et al., 1992). Major and trace element variations indicate that fractionation of mostly plagioclase and amphibole was the dominant process during evolution of the rhyolitic magma, as supported by the presence of tonalite–granite xenoliths with cumulate textures and chemistries.

The coeval basaltic and andesitic volcanic units and mafic–intermediate inclusions (or enclaves) indicate that these magmas played an important role in the generation and evolution of the dominant rhyolitic magmas. The parental rhyolitic magmas are likely to have been generated by partial melting of lower to middle crust as a result of basaltic underplating, after which the magmas ascended and fractionated into more silicic magmas, producing more than 13 magma units at shallow crustal levels. At deeper crustal levels, basaltic and rhyolitic (or dacitic) parental magmas were mixed to produce andesitic to dacitic magmas, and these magmas ascended and mingled with the shallow rhyolitic magmas before eruption. The complex magmatic system beneath Niijima volcano was developed within a relatively thick crustal sequence on the rear-arc side of the Izu–Bonin volcanic arc.

Keywords: Niijima volcano, Cummingtonite, High-silica rhyolite, Izu-Bonin arc, basaltic-andesitic inclusions

©2019. Japan Geoscience Union. All Right Reserved.

Generation of primary andesitic magma in oceanic arcs: Evidence from Kibblewhite Volcano, Kermadec Arc

*Yasuhiro Hirai[1,2], Yoshihiko Tamura[2], Kaj Hoernle[3], Christian Timm[4], Folkmar Hauff[3], Reinhard Werner[3], Bogdan Vaglarov[2], Qing Chang[2], Takashi Miyazaki[2], Jun-Ichi Kimura[2]

1. Graduate School of Natural Science and Technology, Kanazawa University, Japan, 2. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Kanagawa, Japan, 3. GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany, 4. GNS Science, Lower Hutt, New Zealand

Melting of hydrous subarc mantle at low pressure (<1 GPa) may produce primary andesitic melts, suggesting that primary andesitic lavas can be expected in oceanic arcs where the crust is thin (Tamura et al., 2016). Beneath thick crust, melting of hydrous mantle at higher pressures will occur at higher pressures below the thick crust, generating basaltic primary melts. Recently, Tamura et al. (2018) discovered olivine-bearing andesites derived from primary andesitic melts at the Nishinoshima volcano in the Ogasawara Arc, Japan, where the crustal thickness is 21 km. Here, we will present another example for generation of primary andesitic melts in the southern Kermadec arc.

During R/V SONNE expedition in 2017 (SO-255), phenocryst-poor andesites (57.5–57.6 wt.% SiO_2) were recovered from Kibblewhite volcanic complex, southern Kermadec Arc. These andesites contain skeletal olivine and clinopyroxene microphenocrysts with similar and restricted Mg-numbers (Mg/[Mg+Fe] = 0.84–0.85) and a few euhedral olivine xenocrysts with a magnesian cores (Mg/[Mg+Fe] = ~0.92). The magnesian andesites (5.5–5.6 wt.% MgO; Mg# = 56.8–57.3) have relatively high Ni (~50 ppm) and Cr (~180 ppm) contents. These lavas have depleted high-field strength element and enriched large-ion lithophile element compositions (e.g., Nb/Yb = 0.75–0.80; Ba/Nb = 148–175), similar to the coeval Kibblewhite basalts and typical for other southern Kermadec Arc lavas. Sr-Nd-Hf-Pb isotope compositions for the andesites and basalts of the Kibblewhite Volcano also cannot be distinguished from each other and are consistent with the range of published data for the southern Kermadec Arc (Todd et al., 2011; Timm et al., 2014).

Calculation of equilibrium olivine compositions and olivine fractionation trends (Tamura et al., 2000) indicate that olivine microphenocrysts in the andesites are in equilibrium with host rocks and that the andesites have experienced 10% olivine fractionation from mantle-derived primary melts. Primary melt compositions for the andesites (estimated by addition of 10 wt.% equilibrium olivines) are still andesitic (55.9–56.0 wt.% SiO_2; 9.58–9.68 wt.% MgO) in composition and similar to the estimated primary andesite melt of the Nishinoshima volcano. According to thermo-barometric modelling of Lee et al. (2009) the primary melts for the andesites are segregated from mantle peridotite at temperatures of 1190–1220℃ and pressures of 0.45–0.55 GPa assuming primary H_2O contents to be 1.0–3.0 wt.%. The low primary magma segregation pressures, corresponding to 15–18 km depths, are consistent with thin (9–12 km; Bassett et al., 2016) crust beneath the southern Kermadec Arc.

Keywords: Subduction zone, Kermadec Arc, Kibblewhite Volcano, SO-255

©2019. Japan Geoscience Union. All Right Reserved.

Petrogenesis of high-Mg# andesite lavas from Ruapehu volcano, New Zealand

*Chris Conway[1], Katy Chamberlain[2], Yumiko Harigane[1], Daniel Morgan[3]

1. Geological Survey of Japan, 2. Univ. Derby, 3. Univ. Leeds

The eruption of high-magnesium andesites (HMA) with Mg# values >60 at continental arc volcanoes conflicts with the expectation that mantle-equilibrated primitive magmas produced at subduction zones are basaltic. Studies of the origins of HMA lavas provide details on how primitive magmas transit through arc lithosphere, which has implications for constraints on crust-mantle connections as well as volcanic hazards.

Here we report on the occurrence and origin of a sequence of HMA lavas erupted at ~45 ka from Ruapehu volcano, which is a frequently active andesite-dacite stratovolcano in the Taupo Volcanic Zone (TVZ). The suite of lavas forms linear trends on bivariate whole-rock major and trace element plots that are distinctly elevated for MgO, Ni and Cr compared with all other lavas of Ruapehu and most other calk-alkaline andesites of the TVZ. The relatively primitive whole-rock geochemical characteristics are attributed to the involvement of mafic sources during magma genesis, as revealed by the presence of sharply reverse-zoned pyroxene phenocrysts with rims of $Mg\#_{85-89}$ and olivine xenocrysts with cores of Fo_{88-93} and Cr-spinel inclusions. The contribution of felsic end-members to the genesis of Ruapehu HMA magmas is recorded by the presence of rhyolitic glass within partially fused metasedimentary xenoliths and the low Mg# cores for pyroxenes within crystal clots that also preserve rhyolitic interstitial glass and melt inclusions.

The petrological and geochemical features of the samples indicate that the assembly of HMA magmas involved influxes of mafic magmas from the mantle that entrained olivine xenocrysts into mush zones of bulk (rhyo-) dacitic composition, which had evolved via preceding assimilation, fractionation and mixing processes in the crust. Timescale results from Fe-Mg interdiffusion modelling of orthopyroxene indicate that eruptions occurred within days to weeks of magma mixing events. Ruapehu HMA lavas are valuable samples of high-Mg# magmas collected from the global subduction zone system that were formed by crustal level magma hybridization processes (cf. Streck and Leeman, 2018) rather than directly by mantle melting processes (cf. Mitchell and Grove et al. 2016).

Keywords: andesite, magma mixing, active volcano

©2019. Japan Geoscience Union. All Right Reserved.

Hydrous felsic magma generated by unmixing of slab-derived supercritical liquid: evidence from Rishiri Volcano, Kuril Arc

*Hajime Taniuchi[1], Takeshi Kuritani[2,3], Tetsuya Yokoyama[4,3], Eizo Nakamura[3], Mitsuhiro Nakagawa[2]

1. Department of Natural History Science, Graduate School of Science, Hokkaido University, 2. Department of Earth and Planetary Science, Faculty of Science, Hokkaido University, 3. Institute for Planetary Materials, Okayama University, 4. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Introduction

Water-rich components released from the subducting slab play important roles in the generation of subduction-zone magmas in the mantle wedge (e.g. Elliott, 2003). With increasing fluid releasing depths, the slab-derived water-rich materials would become supercritical liquid (e.g. Bureau and Keppler, 1999).Experimental studies have suggested that slab-derived supercritical liquid is separated into hydrous silicate melt and aqueous fluid during the ascent in the mantle wedge (e.g. Kawamoto et al., 2012). However, the occurrence of magmas corresponding to this hydrous melt has not been reported so far. In this context, we have carried out a detailed petrological, geochemical, and chronological study on calc-alkaline andesite and dacite at Rishiri Volcano.

Results

Rishiri Volcano is a Quaternary stratovolcano in southern Kuril arc, and is 300 km above the Wadati-Benioff Zone. The volcanic activity started at ~0.2 Ma, which is characterized by coexistence of alkali basalt, tholeiitic andesite to dacite, and calc-alkaline andesite to dacite. The calc-alkaline andesitic products and the following dacitic lavas, investigated in this study, comprise Middle stage of the volcanic activity (Ishizuka, 1999). Our new $^{40}Ar/^{39}Ar$ age data for the dacitic and andesitic lavas are 35.5 ±1.4 ka and 34.6 ±3.0 ka, respectively.

The phenocryst assemblage of the dacitic lavas is Cpx + Opx + Pl, and that of the andesitic lavas is Ol + Cpx + Opx + Pl. All phenocrysts in the dacite have homogeneous compositions or show normal zonation with limited variations. In contrast, those in the andesite occasionally show reverse zonation. Some olivine and plagioclase phenocrysts have core compositions with up to Mg#89 and An#88, respectively. The dacitic lavas are characterized by high Sr/Y and La/Yb ratios (adakitic signature), no Eu anomaly, homogeneous Sr, Nd, and Pb isotopic ratios, and ^{230}Th-excesses. On the other hand, the andesitic lavas are heterogeneous in whole-rock major, trace, and isotopic compositions.

Discussion

The petrological and geochemical features of the andesitic products suggest that they were produced by mixing between felsic magma and primitive mafic magma. On the other hand, the dacitic lavas do not show any evidence of magma mixing. The absence of Eu anomaly negates a primary role of fractional crystallization in the magma genesis. In addition, the adakitic signature cannot be produced by crustal melting, because the underlying crust is too thin (Niu et al., 2016) for garnet to be stable (e.g. Rapp and Watson, 1995). Therefore, it is suggested that the dacitic magma was derived from the upper mantle, most plausibly, from the subducting slab. The slab origin of the magma is consistent with the ^{230}Th-excess

©2019. Japan Geoscience Union. All Right Reserved.

signature and the Pb isotopic compositions, which can be explained by mixing of a sediment component and an altered oceanic crust component of the slab.

One possible origin of the dacitic magma would be direct partial melting of the subducted slab (e.g. Defant and Drummont, 1990). However, extremely high temperatures with >1300ºC (Mibe et al., 2011) is required to melt the slab at ~300 km depth, which is highly unlikely. The andesitic and dacitic lavas erupted almost contemporaneously (~35 ka), with the former preceding the latter. The primitive mafic magma, involved in the generation of the andesitic magma, is considered to have been generated through fluid-fluxed melting of the mantle. These observations suggest that slab-derived aqueous fluid and slab-derived hydrous melt, corresponding to the dacitic magma, were almost simultaneously present in the upper mantle beneath the Rishiri Volcano at ~35 ka. Therefore, it is suggested that the dacitic magma may represent hydrous melt, which was separated from the ascending slab-derived supercritical liquid at the depth corresponding to the critical end point, leaving behind aqueous fluid (e.g. Kawamoto et al., 2012) that induced the generation of the primitive basaltic magma.

Keywords: Supercritical liquid, Unmixing, Subduction zone magmatism

©2019. Japan Geoscience Union. All Right Reserved.

Genesis of recent mafic volcanism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of cataclysmic caldera-forming systems?

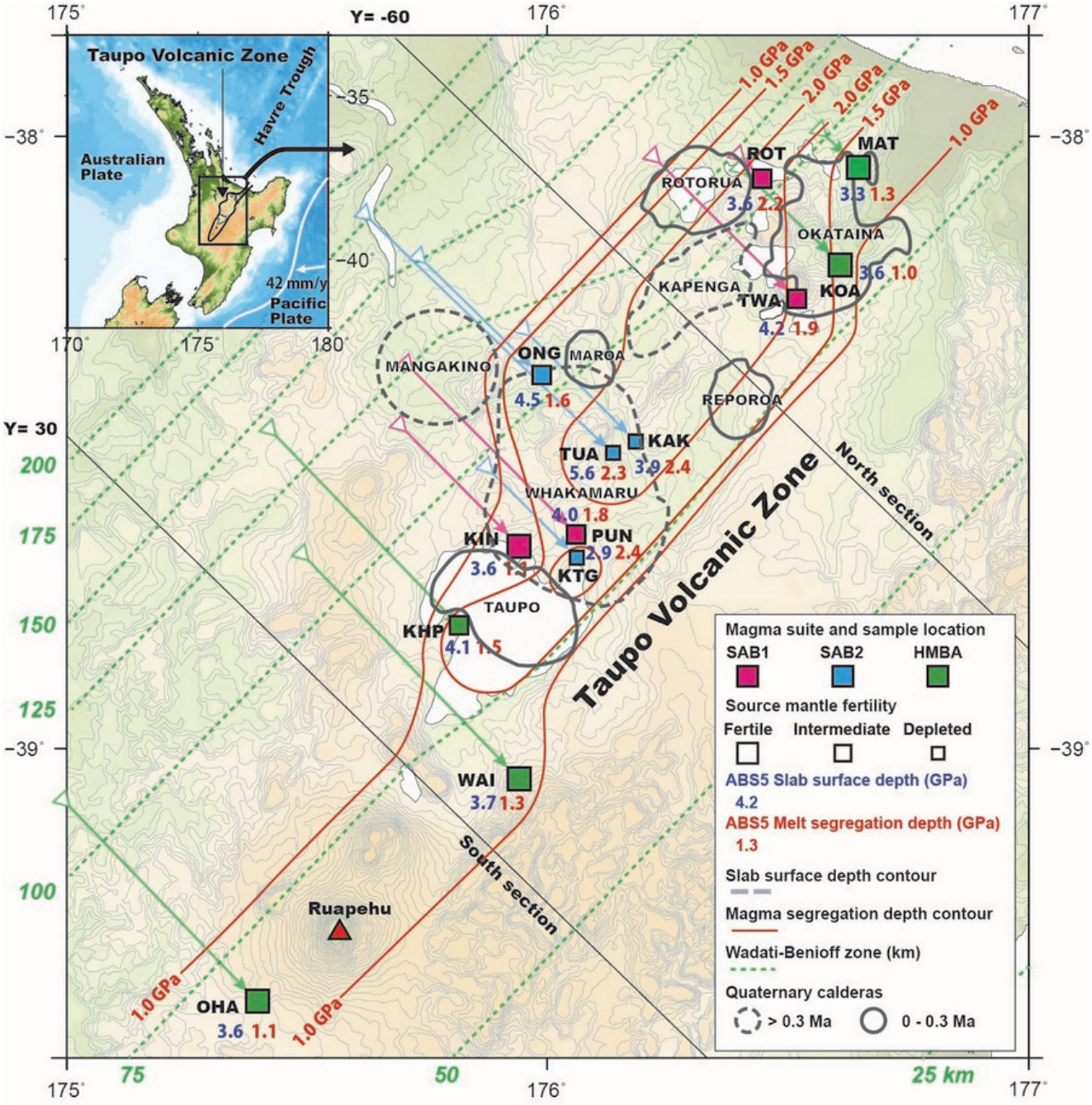
*Georg F Zellmer[1], Jun-Ichi Kimura[2], Claudine Stirling[3], Gert Lube[1], Phil A Shane[4]

1. Volcanic Risk Solutions, Massey University, Tennent Drive, Palmerston North 4410, New Zealand, 2. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology [JAMSTEC], Natsushima-cho 2-15, Yokosuka 237-0061, Japan, 3. Department of Chemistry, University of Otago, Dunedin 9054, New Zealand, 4. School of Environment, University of Auckland, Auckland 1142, New Zealand

Mafic magmatism of the actively extending Taupo Volcanic Zone (TVZ) of the North Island, New Zealand, is volumetrically minor, but thought to tap the material that provides the heat source for voluminous rhyolite production through partial melting of the crust, which ultimately results in cataclysmic caldera-forming eruptions. We have studied the major and trace element chemistry 14 mafic samples from across the entire TVZ, and the uranium isotopic composition of whole rocks, groundmasses and separates of mafic mineral phases from a selection of 9 samples (with the remaining 5 too sparsely phyric for mineral separation). Some minerals yield significant ^{234}U enrichments despite groundmass and whole rock close to ^{238}U-^{234}U secular equilibrium, pointing to uptake of variably hydrothermally altered antecrystic minerals prior to the eruption of originally sparsely pyric to aphyric mafic magmas. However, incompatible trace element pattern indicate that there are three chemically distinct groups of samples, and that all but one sample may be used to derive primary melt compositions. We employ the latest version of the Arc Basalt Simulator (ABS5) to forward model these compositions, deriving mantle source parameters including mantle fertility, slab liquid flux, mantle volatile content, degree of melting, and P-T conditions of melt segregation. We show that mafic rocks erupted in areas of old, now inactive calderas constitute low-degree, deep melts, while those in areas of active caldera-volcanism are high-degree partial melts segregated from a less depleted source at an intermediate depth. Finally high-Mg basaltic andesites erupted in the southwest and the northeast of the TVZ point to a fertile, shallow mantle source. Our data are consistent with a petrogenetic model where mantle melting is dominated by decompression, rather than fluid fluxing, and progresses from shallow to deeper levels with time. Melt volumes initially increase to a tipping point, at which large scale crustal melting and caldera volcanism become prominent, and then decrease due to progressive depletion of the mantle wedge by melting, resulting in the dearth of heat provided and eventual cessation of rhyolitic cataclysim. For the first time, a direct link becomes apparent between the chemistry of recently erupted mafic magmas and the long-term activity and evolution of caldera volcanism in the TVZ.

Keywords: Arc Basalt Simulator, uranium isotopes, basaltic magmatism, rhyolitic magmatism, subduction zone processes

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP30] Crust-Mantle Connections

convener:Yoshihiko Tamura(Research Institute for Marine Geodynamics, Japan Agency for Maine-Earth Science and Technology), Osamu Ishizuka(Geological Survey of Japan, AIST), Chris Conway(Geological Survey of Japan), Chairperson:Chris Conway, Yoshihiko Tamura(JAMSTEC)

A paradigm of the solid Earth geochemical cycles is that the Earth's crust forms by melting of the Earth's upper peridotitic mantle. How divers is the spectrum of primary melts and which factors may contribute to its variations? What is the influence of crustal processing vs. primary magma diversity in creating the diversity of the Earth's crust? The session seeks to explore the crust-mantle connections at divergent and convergent plate boundaries, and oceanic island settings based on volcanology, petrology, geochemistry, geophysics, geochronology, and geodynamics studies.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SMP30-07] Introducing an oceanic core complex in the Shikoku Basin: Mado Megamullion

★Invited Papers

*Yasuhiko Ohara[1,2], Kyoko Okino[3], Norikatsu Akizawa[3], Masakazu Fujii[4], Yumiko Harigane[5], Naoto Hirano[6], Ken-ichi Hirauchi[7], Osamu Ishizuka[5], Shiki Machida[8], Katsuyoshi Michibayashi[9], Alessio Sanfilippo[10], Jonathan E. Snow[11], Hiroyuki Yamashita[12] (1.Hydrographic and Oceanographic Department of Japan, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmosphere and Ocean Research Institute, University of Tokyo, 4.National Institute of Polar Research, 5.Geological Survey of Japan/AIST, 6.Tohoku University, 7.Shizuoka University, 8.Chiba Institute of Technology, 9.Nagoya University, 10.University of Pavia, 11.University of Houston, 12.Kanagawa Prefectural Museum of Natural History)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SMP30-08] Spatial variation of petrological and geochemical characteristics of mantle peridotites in Mado Megamullion, Shikoku Basin

*Norikatsu Akizawa[1], Shiki Machida[2], Kyoko Okino[1], Yasuhiko Ohara[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Hydrographic and Oceanographic Department of Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SMP30-09] Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres

★Invited Papers

*Mathieu Rospabe[1,2], Mathieu Benoit[1], Georges Ceuleneer[1] (1.GET, OMP, Univ. of Toulouse, CNRS, IRD, F-31400 Toulouse, France, 2.JAMSTEC, Yokosuka 237-0061, Japan.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SMP30-10] Serpentinization and carbonation of dunites in the western part of the Isua Supracrustal Belt, Southwestern Greenland

*Juan Miguel Ramirez Guotana[1], Tomoaki Morishita[1], Akihiro Tamura[1], Ikuya Nishio[1], Kenichiro Tani[2], Yumiko Harigane[3], Kristoffer Szilas[4], D. Graham Pearson[5] (1.Kanazawa University, 2.National Museum of Nature and Science, Japan, 3.Institute of Geology and Geoinformation Geological Survey of Japan/AIST, 4.University of Copenhagen, 5.University of Alberta)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SMP30-11] Petrogenesis of fertile abyssal peridotites of the Pujada Ophiolite, SE Mindanao, Philippines

*Valerie Shayne Vargas Olfindo[1], Betchaida Duetes Payot[1], Gabriel Theophilus Valera[1], Shoji Arai[2], Tomoyuki Shibata[4], Masako Yoshikawa[3] (1.Rushurgent Working Group, National Institute of Geological

Sciences, University of the Philippines, 2.Department of Earth Sciences, Kanazawa University, Kakuma, Kanazawa, Ishikawa 920-1192, Japan, 3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, Beppu 874-0903, Japan, 4.Department of Earth and Planetary Systems Science, Hiroshima University, Hiroshima 739-8526, Japan)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SMP30-12] Ultramafic rock in the Hida metamorphic belt: an example of arc plutons

Yohei Ogusu[1], *Tomoaki Morishita[1], Akihiro Tamura[1] (1.Kanazawa University)

Introducing an oceanic core complex in the Shikoku Basin: Mado Megamullion

*Yasuhiko Ohara[1,2], Kyoko Okino[3], Norikatsu Akizawa[3], Masakazu Fujii[4], Yumiko Harigane[5], Naoto Hirano[6], Ken-ichi Hirauchi[7], Osamu Ishizuka[5], Shiki Machida[8], Katsuyoshi Michibayashi[9], Alessio Sanfilippo[10], Jonathan E. Snow[11], Hiroyuki Yamashita[12]

1. Hydrographic and Oceanographic Department of Japan, 2. Japan Agency for Marine-Earth Science and Technology, 3. Atmosphere and Ocean Research Institute, University of Tokyo, 4. National Institute of Polar Research, 5. Geological Survey of Japan/AIST, 6. Tohoku University, 7. Shizuoka University, 8. Chiba Institute of Technology, 9. Nagoya University, 10. University of Pavia, 11. University of Houston, 12. Kanagawa Prefectural Museum of Natural History

Oceanic core complexes (OCCs) are domal bathymetric highs with axis-normal corrugations, and with exposure of serpentinized peridotite and gabbroic rocks, interpreted as exhumed footwalls of low-angle detachment faults. OCCs provide a valuable opportunity to directly study the architecture of oceanic lithosphere, together with the tectono-magmatic processes associated with its formation and evolution.

A significant fraction of the ocean floor is created in backarc basins where water plays a major role in generating backarc basin basalts, strikingly contrasting to magmatic process at mid-ocean ridges. The opportunity to explore the recent formation of backarc basin lower crust and upper mantle is, therefore, an important contribution to understanding the ocean basins. The extensive multi-beam bathymetric mapping by Japan’ s continental shelf survey has revealed the presence of potential OCCs in the multiple portions of the Philippine Sea Plate, such as in the Parece Vela Basin, Shikoku Basin, Kita-Daito Basin and West Philippine Basin. Among these, Godzilla Megamullion in the Parece Vela Basin is the largest known OCC on the Earth, and is one of the well-studied OCCs in the world.

In order to advance our understanding of the lithospheric composition of the Philippine Sea Plate, we need to utilize the potential Philippine Sea OCCs as tectonic windows to sample the lower crust and upper mantle materials. However, these potential OCCs have been remained largely unsampled and unstudied except only a few locations. We thus have started a new project focusing on the Shikoku Basin OCCs. Two cruises in the 2018 summer (YK18-07 and KH-18-2) collected peridotites and gabbros from the main Shikoku Basin OCC, here we named “Mado Megamullion”. The scheduled YK19-04S cruise in 2019 April will collect more datasets on this OCC.

In this contribution, we will show the general tectono-magmatic characteristics of Mado Megamullion. The OCC provides the information on the Shikoku Basin lower crust and upper mantle for the first time. Mado Megamullion is an ~20 km square OCC, the areal size is comparable to Kane Magamullion in the Mid-Atlantic Ridge. Thus it should be easier for us to make a comparative study between the two OCCs, providing useful information to understand the difference of the lithospheric characteristics between the two major ocean environments.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Mado Megamullion, Shikoku Basin, Oceanic Core Complex

©2019. Japan Geoscience Union. All Right Reserved.

Spatial variation of petrological and geochemical characteristics of mantle peridotites in Mado Megamullion, Shikoku Basin

*Norikatsu Akizawa[1], Shiki Machida[2], Kyoko Okino[1], Yasuhiko Ohara[3]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3. Hydrographic and Oceanographic Department of Japan

Oceanic core complex is one of the tectonic windows, where mantle peridotites are exposed directly to the ocean floor. The mantle peridotites can provide petrological and geochemical information of the inaccessible oceanic mantle. However, the mantle peridotites from the oceanic core complex bear a possibility that their petrological and geochemical characteristics were modified during exhumation to the ocean floor via detachment faulting. Thus, formation process of the oceanic core complex must be elucidated in order to better presume the pristine oceanic mantle materials therein. Here, we present petrological and geochemical characteristics of mantle peridotites collected from a newly termed backarc oceanic core complex, “Mado (window in Japanese)” Megamullion in the Shikoku Basin, Philippine Sea. The samples were collected through a series of scientific cruises, YK18-07 by R/V Yokosuka with DSV Shinkai 6500, and KH-18-2 by R/V Hakuho. A total of 16 samples is used here: 13 peridotites and 3 dunites. Vein-like oxide gabbros are included in some peridotite samples from a region close to the ridge axis (proximal region), whereas none of the peridotites showing such lithological characteristics were found from a region far from the ridge axis (distal region). In contrast, the dunite samples were found only from the distal region. Since dunites are commonly interpreted as fossil channels for primitive (silica-depleted) melts beneath mid-ocean ridges, they likely transported parental melts of mid-ocean ridge basalt (MORB) beneath paleo-ridge axis. With regards to the spatial variation of petrological and geochemical characteristics of the mantle peridotites, we delineate a scenario of Mado Megamullion formation, where the exhumed mantle materials were getting modified by evolved magmas with time proceeding, indicating magma stagnation due probably to time-dependent cooling of the ridge spreading system. Therefore, the mantle peridotites in the distal region might show relatively pristine geochemical compositions in comparison with those in the proximal region.

Keywords: Oceanic core complex, Peridotite, Dunite, MORB, Whole-rock chemical composition, Mineral chemical composition

©2019. Japan Geoscience Union. All Right Reserved.

Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres

*Mathieu Rospabe[1,2], Mathieu Benoit[1], Georges Ceuleneer[1]

1. GET, OMP, Univ. of Toulouse, CNRS, IRD, F-31400 Toulouse, France, 2. JAMSTEC, Yokosuka 237-0061, Japan.

Beneath oceanic spreading centres, the transition from the upwelling and partially molten peridotitic mantle and the accreting gabbroic lower crust appears as a major chemical, thermal and rheological interface. In most ophiolites worldwide, it is underlined by a dunitic horizon whatever the paleo-tectonic setting (mid-ocean ridges vs. supra-subduction zone). Since dunite is observed in present-day oceans in different geodynamic environments, in association with mantle harzburgite and with troctolitic-gabbroic veins and sills, it is reasonable to suppose that ophiolitic dunitic transition zone (DTZ) formed prior to the intra-oceanic thrusting leading to obduction.

As a matter of fact, the understanding of the petrological processes occurring in the mantle-crust transition zone beneath oceanic ridges can be studied in the Oman ophiolite. Particularly, the Maqsad area (Sumail massif) evolved in a MORB-like magmatic environment and presently exposes a >300 m thick DTZ above a paleo-mantle diapiric structure. It has been attributed to peridotite reactional melting or to the accumulation of olivine from Mg-rich melts, whether a combined origin is more likely. Following the reactional origin, a partially molten harzburgite reacts with interstitial melts, enhancing the orthopyroxene dissolution and the crystallization of secondary olivine, resulting in a rock essentially made of olivine. Interstitial mineral fractionation during melt migration between olivine grains (or melt-rock reaction) is partly responsible of the extensive petrological and geochemical variability observed at Moho level.

Recent studies evidenced a large interstitial mineral variety in dunites from the DTZ with, in addition to plagioclase and clinopyroxene expected in a MORB magmatic environment, the presence of orthopyroxene and amphibole among others. These minerals are also observed, together with mica, as silicate inclusions in chromite grains scattered in the dunite. This calls for the early involvement of hydrated, Si- and alkali-rich melts in the formation of dunite and chromitite ore bodies at Moho level beneath oceanic ridges. Since the presence of this peculiar mineralogy is ubiquitous within the DTZ and absent in mantle harzburgite, this distribution supports that the hydrated component originated from above, probably seawater in origin. These fluids interacted with surrounding rocks and with the variably evolved MORB issued from the Maqsad diapir, allowing to generate the hybrid melts, i.e. a blend between supercritical hydrothermal fluids rich in silica or trondhjemitic melts issued from hydrous melting of the country rocks.

The chemical variations observed along the Maqsad DTZ define trends with a characteristic vertical scale of few tens of meters. The chemical variation patterns are spatially correlated to the distribution of ridge-related faults or fracture zones (i.e. active at an early, high temperature magmatic stage), not only for fluid-mobile elements but also for immobile elements (e.g. REE, HFSE). These faults seem to have

©2019. Japan Geoscience Union. All Right Reserved.

enhanced (i) melt migration and extraction, from the mantle to the crust, and (ii) deep hydrothermal fluids introduction down to the Moho level. In other words, they are the main vectors for upwelling melt modification by hybridization, with hydrothermal fluids and/or silicic hydrous melts, and crystallization. In this context, the DTZ appears as a reactive interface that developed by the combination of three primary processes: tectonics, magmatism and deep, high temperature hydrothermal circulations. Fluid-melt-rocks reactions occurring at Moho level may have a significant impact on the MORB variability surveyed along present-day mid-ocean ridges and may contribute to part of the signatures observed at hydrothermal vents.

Keywords: Oman ophiolite, dunitic transition zone, melt-rock reactions

©2019. Japan Geoscience Union. All Right Reserved.

Serpentinization and carbonation of dunites in the western part of the Isua Supracrustal Belt, Southwestern Greenland

*Juan Miguel Ramirez Guotana[1], Tomoaki Morishita[1], Akihiro Tamura[1], Ikuya Nishio[1], Kenichiro Tani[2], Yumiko Harigane[3], Kristoffer Szilas[4], D. Graham Pearson[5]

1. Kanazawa University, 2. National Museum of Nature and Science, Japan, 3. Institute of Geology and Geoinformation Geological Survey of Japan/AIST, 4. University of Copenhagen, 5. University of Alberta

The 3.7 Ga Isua supracrustal belt (ISB) hosted in Itsaq Gneiss Complex in southwestern Greenland preserves one of the oldest metamorphosed mafic-ultramafic complex in the world which provides opportunity to study early petrological processes on Earth. Ultramafic bodies are common throughout the Isua supracrustal belt. These ultramafic rocks are interpreted to be possible mantle residues while other studies consider a cumulate origin. In the western limb of the ISB, less altered dunitic bodies enveloped by metasomatized dunites and amphibolites are exposed. The studied dunite lens is also referred as Lens B by previous studies. The northern part of Lens B dunites are highly deformed, highly serpentinized and carbonatized. The central and lower Lens B are less deformed and composed of olivine, serpentine, magnesite, magnetite, stichtite and Ti-rich humites. Ti-chondrodite (Ti-Chn) and Ti-clinohumite (Ti-Chu) are present in the central and southern part of Lens B. Ti-Chn and Ti-Chu occur commonly as irregular patches in olivine. In some portions, intergrowths of Ti-Chn and Ti-Chu are present. The F contents of the the Ti-Chn and Ti-Chu are also very low. Olivine grains are highly forsteritic and are comparable to those derived by deserpentinization process. The major serpentine phase is antigorite which occur as platy grains and minor amounts as inclusion in olivine. Stichtite, a magnesium-chromium hydroxycarbonate mineral, also includes clinohumite minerals. The clinohumite intergrowth in ISB dunites can be associated to the breakdown of Ti-Chn to Ti-Chu (Ti-Chn+Atg+Ol=Ti-Chu+H2O). The clinohumites are also almost F-free which suggests a lower temperature within the antigorite stability field compared to F-bearing clinohumites. Petrographic and geochemical results suggest that the dunites reached P-T conditions within the Ti-Ch and Atg stability field and retrogressed and carbonated (stichtite and magnesite) at lower pressure and temperature where Ti-Chu is stable.

Keywords: Isua Supracrustal Belt, archaean, peridotites

©2019. Japan Geoscience Union. All Right Reserved.

Petrogenesis of fertile abyssal peridotites of the Pujada Ophiolite, SE Mindanao, Philippines

*Valerie Shayne Vargas Olfindo[1], Betchaida Duetes Payot[1], Gabriel Theophilus Valera[1], Shoji Arai[2], Tomoyuki Shibata[4], Masako Yoshikawa[3]

1. Rushurgent Working Group, National Institute of Geological Sciences, University of the Philippines, 2. Department of Earth Sciences, Kanazawa University, Kakuma, Kanazawa, Ishikawa 920-1192, Japan, 3. Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, Beppu 874-0903, Japan, 4. Department of Earth and Planetary Systems Science, Hiroshima University, Hiroshima 739-8526, Japan

Fresh mantle peridotites of the Pujada Ophiolite are extensively exposed in southeast Mindanao, Philippines. Despite its good preservation, its origin and formation is not constrained due to lacking geologic data. In this study, petrographic and geochemical characteristics of the mantle section of the Pujada Ophiolite are investigated to determine its tectonic setting and the magmatic processes operating during its formation.

The mantle section of the Pujada Ophiolite is composed of massive and pyroxene-rich lherzolites and harzburgites and interlayers of variably serpentinized lherzolites, harzburgites and dunites. Mineral chemistry of the spinel peridotites reveal spinel Cr# =0.10-0.50 and olivine Fo =89-91 typical of abyssal peridotites. The mantle peridotites are classified into three based on their field occurrence and spinel Cr#: Group I - massive lherzolites and harzburgites with Cr# =0.10-0.40, Group II - interlayered lherzolites and harzburgites with Cr# =0.10-0.40, and Group III - interlayered harzburgites and dunites with Cr# >0.4. The Group I peridotites are protogranular with minor vermicular spinel. The Group II peridotites are highly serpentinized. Preserved portions show porphyroclastic texture with vermicular to subhedral spinel. The Group III peridotites are also highly serpentinized but porphyroclastic texture in the harzburgites can be observed. Clinopyroxene and orthopyroxene compositions of the peridotites reveal an increasing depletion in Al_2O_3 from Group I to Group II and III with increasing Mg#. Groups I and II show lower Mg# =0.90-0.93 and 0.92-0.93, respectively. The Group III peridotites have the highest Mg# =0.925-0.935. The clinopyroxene Na_2O and TiO_2 of the three groups are within the same range of 0.10-0.40 and 0.10-0.25, respectively. The orthopyroxenes also show the same range of Na_2O and TiO_2 of 0.01-0.10 and 0.01-0.20, respectively. In general, rare earth element composition shows depletion of light rare earth element (LREE) and relatively flat heavy rare earth element (HREE) which further suggest an abyssal origin. Trace element compositions of the peridotites are indicative of low degrees of partial melting within 6%-14%. A few peridotite samples also show LREE enrichment suggesting that metasomatism may have affected these rocks.

Keywords: Pujada Ophiolite, peridotites, mid-oceanic ridge, LREE enrichment

©2019. Japan Geoscience Union. All Right Reserved.

Ultramafic rock in the Hida metamorphic belt: an example of arc plutons

Yohei Ogusu[1], *Tomoaki Morishita[1], Akihiro Tamura[1]

1. Kanazawa University

We report petrology and mineral compositions of ultramafic rocks in the Hida metamorphic belt, which was metamorphosed at around 235-250 Ma (Takahashi et al., 2018, Island Arc). It was pointed out in a graduation thesis of Kanazawa University that a small ultramafic body exists in the Hida metamorphic blet of Ozoe area, Hakusan City (Nagaoka, 1970). A preliminary result revealed that this ultramafic rock of the Hakusan City is mainly composed of large poikilitic amphibole grains enclosing many olivine grains, which are traditionally called as cortlandite (Williams, 1893 Jour. Geol.). These amphibole-rich plutonic rocks are expected in deeper part of island arc (e.g., Davidson et al., 2007 Geology). In fact, cortlandite and/or amphibole-rich plutonic rocks in granitic rocks/felsic metamorphic rocks were reported from all over the world (e.g., Tiepolo et al., 2011 Jour. Petrol.). Although these formation ages are different, it is noticed that they formed at convergent plate boundaries (Tiepolo et al., 2011). Cortlandite is minor but is reported from the Ryoke metamorphic belt, Japan (e.g., Kutsukake, 1978, Memoir. Kyoto Univ. Ser. Geol. Mineral.). Cortlandite and related amphibole-rich rocks would shed light on magmatic processes occurred beneath island arcs.

Ultramafic rocks of the Hakusan city (simply call Hakusan Ultramafic rock hereafter) is mainly composed of large poikilitic amphibole and orthopyroxene enclosing olivine grains. These olivine grains contain chromian spinels. Olivine with spinel existed phases before amphibole and orthopyroxene were crystallized. Orthopyroxene are sometimes included in amphibole and amphibole shows euhedral shape against the next orthopyroxene grain indicating amphibole is an early crystallization phase. The Fo content of olivine is around 84 and XMg of amphibole is around 90. High XMg of mafic minerals indicate that the Hakusan Ultramafic rock was formed from a relatively primitive melt. Poikilitic amphibole is pargasitic in composition. Calculated melt compositions from trace element compositions of the poikilitic amphibole are characterized by high in LILEs with negative anomalies of HFSEs, and are similar to arc magmas. We concluded that the Hokuriku Ultramafic rocks are formed from arc-related magma. It is important to study the origin of cortlandite and related amphibole-rich plutons from other metamorphic belts with different ages to understand the differences in mode and conditions of arc formation.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP31] Supercontinents and Crustal Evolution

convener:Madhusoodhan Satish-Kumar(Department of Geology, Faculty of Science, Niigata University), Tomokazu Hokada(National Institute of Polar Research), Krishnan Sajeev(Centre for Earth Sciences, Indian Institute of Science), Yasuhito Osanai(Division of Evolution of Earth Environments, Faculty of Social and Cultural Studies, Kyushu University), Chairperson:M. Satish-Kumar(Niigata University), Tomokazu Hokada(National Institute of Polar Research)

Supercontinent formation and dispersion has been enigmatic in the Earth's history. Eurasia is one such current supercontinent and incredible progress in the understanding of its geological evolution has been achieved in the past decade. Earlier supercontinents in the Earth's history such as Gondwana (0.5 Ga), Rodinia (1.0 Ga), Columbia/Nuna (2.0 Ga), Kenorland (2.5 Ga) and Vaalbara (3.1 Ga), have been the focus of several studies, however limited information on older supercontinents has restricted an understanding of their tectonic evolution. In this session, we invite authors around the world to present new data as well as review existing results on the continental scale crustal processes and tectonic evolution that are associated with supercontinent formation and breakup events in the Earth's history. The well-studied Eurasia and Gondwana supercontinents are of particular focus. Topics of interest include, but not restricted to, extremes in metamorphism, P-T-d-t evolution, magmatism, and the role of fluids. We hope to provide a platform for scientific discussions that will enlighten our understanding of the physical and chemical processes in the continental crust that records episodes of orogenesis that contributed to the formation and evolution of supercontinents.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SMP31-01] Tectonic development of the East Indian cratonic margin and its status in Columbia Supercontinent

★Invited Papers

*Kaushik Das[1] (1.Hiroshima University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SMP31-02] **Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India**

★Invited Papers

*VINOD O SAMUEL[1] (1.Yonsei University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SMP31-03] Preliminary paleomagnetic studies on the mafic dykes in Western Dharwar craton, South India.

*Silpa Ammini Sasidharan[1], Madhusoodhan Satish-Kumar[2], Naoto Ishikawa[3], Krishnan Sajeev[4] (1.Graduate School of Science and Technology, Niigata University, 2.Department of Geology, Faculty of Science, Niigata University, 3.Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan, 4.Centre for Earth Sciences, Indian Institute of Science, Bangalore, India)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SMP31-04] Syn-metamorphic boron-bearing fluid infiltrations deduced from tourmaline in the Main Central Thrust zone, eastern Nepal Himalayas

★Invited Papers

*Tetsuo Kawakami[1], Harutaka Sakai[1], Katsushi Sato[1] (1.Graduate School of Science, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SMP31-05] **Geochemical characteristics of mafic and felsic igneous rocks (1.9-1.75 Ga) in the Lesser Himalaya: Regional variation and its implications for tectonic setting**

*Ryuichi Shinjo[1], Tomoki Amuro[1], Kohei Oura[1], Kazuya Oshiro[1], Shiro Tahara[1], Harutaka Sakai[2] (1.Department of Physics and Earth Sciences, University of the Ryukyus, 2.Faculty of Science, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SMP31-06] Petrogenesis and tectonic implications of orbicular granodiorite from Yangtze cratonic nucleus

*Yihe Li[1] (1.China University of Geosciences Wuhan)

Tectonic development of the East Indian cratonic margin and its status in Columbia Supercontinent

*Kaushik Das[1]

1. Hiroshima University

The East Indian cratonic margin is an important geological area towards understanding the tectonic development of the Precambrian India co-evolving with its erstwhile continental neighbors, including Antarctica. It, at present spreads out several linearly arranged Mesoproterozoic sedimentary basins (Chhattisgarh Basin and its satelite basins) unconformably lying on the Archean Bastar cratonic basement rocks and also juxtaposed on its east by a Proterozoic orogenic belt (Eastern Ghats Belt, EGB). While the basement rocks reveal the origin and evolution of the Archean craton and later tectonics affecting it, the sedimentary basins preserve the history of basin tectonics and fluctuation of different geological and geochemical proxies indicating the fluctuation of paleoenvironment, and also the tectonics of surrounding areas. The adjacent orogenic belt also has a variegated history of its developement and final cratonization, at least the tectonic history of the southern part was older while major part of the northern part was younger than the formation of those sedimenatry basins.
Our group in recent years have carried out detailed sedimentological, geochemical, and geochronological studies of the early sediment fills of these Mesoproterozoic basins (Chakraborty et al., 2012, Precam. Res., 200-203, 129-148; Das et al., 2015, Geol. Soc. London, Memoirs, 43, 207–221; Saha et al., 2016, Precam. Res., 281, 363-383) In this presentation, the collated data on the paleo-environmental facies analysis, variation in Nd-isotope geochemistry and U-Pb detrital zircon geochronology will be presented for the sediments of Singhora Basin, Khariar Basin and Ampani Basin, and also the geochemical character with tectonic affinity of the ca. 1450 Ma felsic porcellanitic tuff layer in all these basins. This will help to have an integrated understanding of the evolution of deep- to shallow continental crust in the East Indian Craton margin, as well as the connection between its neighbors in the supercontinent, "Columbia".

Keywords: East Indian Craton margin, Mesoproterozoic Chhattisgarh Basin, Felsic volcanism, Columbia Supercontinent

©2019. Japan Geoscience Union. All Right Reserved.

Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India

*VINOD O SAMUEL[1]

1. Yonsei University

Earth is a unique planetary body with an evolved felsic continental crust on its surface. Had this continental crust not evolved, Earth’ s crust would have been basaltic/gabbroic in composition, and covered almost completely by water. It is important to understand how the mafic crust, which formed after the differentiation of Planet Earth transformed to one that is felsic in composition. Presently active processes capable of transforming crust from mafic to felsic composition, on a large scale, are subduction and subsequent arc magmatism. However, whether such processes were active during the Hadean–Archean eon is highly debated. Field evidence from major cratons show that partial melting of the earlier formed mafic crust (e.g., processes like sagduction) formed felsic continental crust. Thus, understanding when subduction-related process started on the planet is important. Here we present evidence from metamorphosed magmatic rocks such as pyroxenite, metagabbro, two-pyroxene granulite, charnockite, hornblende-biotite gneiss and rhyolite from the Nilgiri Block, southern India. U-Pb zircon age data shows that all these rocks formed during the late Neoarchean (core ages between 2600–2500Ma) and that they underwent subsequent metamorphism during the early Paleoproterozoic (rim ages between 2500–2450Ma). If felsic rocks formed from the partial melting of earlier formed mafic rocks, the mafic rocks should be older. Since all these rocks were formed and metamorphosed simultaneously, it is possible that protoliths of these rocks formed through melt differentiation followed by partial melting in the mantle wedge during the subduction-related arc magmatic process. An enrichment in light field strength elements and REE compared to heavy ones, and Nb-Ta depletion are common signatures in rocks formed through the arc magmatic process, where fluids or melts formed from subducted basaltic crust and the overlying sediments enrich the mantle wedge in lighter elements. Further, during metamorphism, these rocks could partially melt and form granitic melts. However there is no field evidence that suggests partial melting during metamorphism in these rocks. Textural relations and vein networks of silicate-oxide-sulfide-phosphate minerals in these rocks suggest that they could have possibly metasomatized in the presence of saline fluids during the early Paleoproterozoic. Such saline fluids could have been released during the waning stages of the magmatic process, probably due to the collapse and mixing of the accretionary wedge to the mantle wedge.

Keywords: Arc Magmatism, Metamorphism, southern India

©2019. Japan Geoscience Union. All Right Reserved.

Preliminary paleomagnetic studies on the mafic dykes in Western Dharwar craton, South India.

*Silpa Ammini Sasidharan[1], Madhusoodhan Satish-Kumar[2], Naoto Ishikawa[3], Krishnan Sajeev[4]

1. Graduate School of Science and Technology, Niigata University, 2. Department of Geology, Faculty of Science, Niigata University, 3. Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan, 4. Centre for Earth Sciences, Indian Institute of Science, Bangalore, India

Mafic dykes of varying dimensions and ages are well exposed all along the Archean Dharwar craton of south India. The mafic dykes in the Eastern Dharwar craton (EDC) have been studied in detail by several researchers previously (French and Heaman, 2010; Kumar et al., 2012, Srivastava et al., 2014). However, limited information is available for the dyke in Western Dharwar craton (WDC) and is considered in the present study. Representative samples were collected from dykes in the WDC and detailed petrography and geochemistry were carried out. The thin section observation revealed two different types of dykes based on the mineral assemblage, texture and the degree of alteration. First category of dykes is dolerites with typical ophitic texture and lath-shaped plagioclase. The other group of dyke samples showed high degree of alteration and remnant ophitic textures with the preservation of very less plagioclase laths as well as original mineralogy. This group termed as meta-dolerites, because of the prominent metamorphism. The dolerites and meta-dolerites are found to exhibit different distribution of major oxides as well as distinct trace and rare-earth element concentrations (Silpa and Satish-Kumar, 2018). The difference in petrography and geochemistry between the dolerites and meta-dolerites can lead to a preliminary inference that these two suits of rocks might not be co-genetic.

Understanding paleo- positions in which the dykes were emplaced is key while correlating the present, spatially distant cratons. Paleomagnetic studies will help to understand the paleo-position of the cratons and mafic dykes are expected to provide excellent records of the earth’s magnetic field as they cool rapidly when emplaced (Belica et al., 2014). For the preliminary paleomagnetic analyses, 86 core specimens were prepared from 33 sites including both dolerite and meta-dolerites and progressive demagnetization experiment has been conducted to assess the stability of natural remanent magnetization (NRM). Pilot specimens were subjected to alternating-field or thermal demagnetization and the NRMs were measured with a spinner magnetometer. Dolerite specimens yielded better magnetic behaviors with stable magnetic components. On the other hand, meta-dolerites show magnetic components probably carried by pyrrhotite and the magnetic behaviors were very unstable. Fig. 1 shows demagnetization behaviors of dolerite sample plotted on orthogonal vector-endpoint diagrams and equal area stereonets.

Studying the dykes in the Dharwar craton is key to understanding the evolution of the mantle during the Precambrian, especially in the Archean to Proterozoic transitional period. Dykes are emplaced after the period of major continental crust formation at around 2.7 Ga and hence the variation in mantle composition through time can be constrained. The dykes can be a result of a plume activity or an indicator of large igneous province and hence the study of which will give valuable information about the mantle source, the degree of melting and the source regions where melting occurred. Dyke swarms and LIPs are the products of major magmatic events in the Earth’s history that probably was the driving force in the breaking up of supercontinents, and they provide clues regarding the cratonic evolution through time. Due to their wide distribution, geochemically coherent dykes can be found in many cratons, thus providing key information on the close proximity of now separated supercontinents.

©2019. Japan Geoscience Union. All Right Reserved.

References

Belica, M.E., Piispa, E.J., Meert, J.G., Pesonen, L. J., Plado, J., Pandit, M.K., Celestino, M. Precambr. Res. 244, 100–122 (2014).

French, J. E., Heaman, L. M. Precambrian Res. 183, 416–441 (2010).

Kumar, A., Nagaraju, E., Besse, J.,. Rao ,Y. J. J. B. Precambrian Res. 220-221, 123–138 (2012).

Silpa, A. S., Satish-Kumar, M. J. Indian Inst. Sci. 98: 4, 365-378 (2018).

Srivastava, R. K.,Samal, A. K., Gautam, G. C. Int. Geol. Rev. 57, 11-12(2014).

Keywords: Mafic dykes, Precambrian, Paleomagetism, Geochemistry

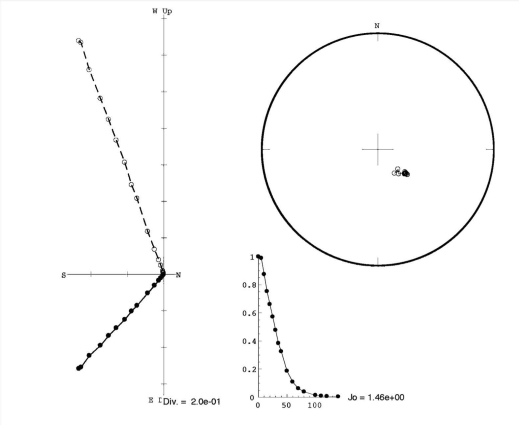


Fig. 1. Orthogonal vector plot, equal area stereonet and alternating-field demagnetization behavior for the dolerite showing typical characteristic remanent magnetization directions.

©2019. Japan Geoscience Union. All Right Reserved.

Syn-metamorphic boron-bearing fluid infiltrations deduced from tourmaline in the Main Central Thrust zone, eastern Nepal Himalayas

*Tetsuo Kawakami[1], Harutaka Sakai[1], Katsushi Sato[1]

1. Graduate School of Science, Kyoto University

Mode of occurrence and chemical composition of tourmaline in pelitic schists from the Main Central Thrust (MCT) zone of the Lesser Himalayan Sequences (LHS) are described in detail to deduce the chemical characteristics of tourmaline formed through boron-bearing fluid infiltration, and to estimate the syn-metamorphic fluid compositions.

Metasomatic tourmaline from the tourmalinized wall rocks of tourmaline-quartz veins and a plagioclase-quartz vein shows significant increase in X_{Ca} [=Ca/(Ca+Na)] at almost constant X_{Mg} [=Mg/(Mg+Fe_{total})]. Plagioclase present in such veins are anorthite-rich, and is not in equilibrium with tourmaline. These chemical characteristics of tourmaline are also confirmed in some of the tourmaline-rich pelitic schists that contain more than 1.0 vol% tourmaline. The tourmaline-rich pelitic schists, therefore, are considered to have formed through boron-bearing fluid infiltration. Ca-metasomatism observed in the pelitic schists adjacent to the metadolostone layers points to Ca-enrichment of the fluid composition when passing through the metadolostone layers. Episodic infiltration of such fluids into pelitic schists resulted in production of abundant tourmaline with increasing X_{Ca} trend at almost constant X_{Mg}. Most of the tourmaline in tourmaline-rich pelitic schists are in equilibrium with plagioclase, suggesting rock-buffered environment during the fluid infiltration. The pelitic schists without tourmaline enrichment mostly show increase in X_{Ca} at broad X_{Mg} values, reflecting its growth during longer range of metamorphism.

The fluid compositions that coexisted with tourmaline were estimated by applying experimentally-determined fluid/tourmaline chemical relationships to the vein, tourmaline-rich pelitic schist and tourmaline-poor pelitic schist samples. Assuming coexisting anion to be Cl, they all gave salinity similar to the sea water (~0.6 mol/l NaCl) and slightly above it (~0.4-0.9 mol/l NaCl+$CaCl_2$). The tourmaline-bearing veins and tourmaline-rich pelitic schists indicative of syn-metamorphic boron-bearing fluid infiltrations are widely distributed in the MCT zone of the LHS.

This observation supports that such fluid infiltrations into the High Himalayan Crystallines (HHC), contemporaneous with the inverted metamorphism of the MCT zone, caused vapor-saturated partial melting of the HHC and formed tourmaline leucogranite melts.

Keywords: metamorphic fluid , boron, tourmaline, inverted metamorphism

©2019. Japan Geoscience Union. All Right Reserved.

Geochemical characteristics of mafic and felsic igneous rocks (1.9-1.75 Ga) in the Lesser Himalaya: Regional variation and its implications for tectonic setting

*Ryuichi Shinjo[1], Tomoki Amuro[1], Kohei Oura[1], Kazuya Oshiro[1], Shiro Tahara[1], Harutaka Sakai[2]

1. Department of Physics and Earth Sciences, University of the Ryukyus, 2. Faculty of Science, Kyoto University

We present geochemical characteristics of mafic and felsic intrusive rocks (1.9-1.75 Ga) in the Lesser Himalaya and discuss about its tectonic setting. Rocks are taken from wide range of the Lesser Himalaya.

Models of tectonic setting for these rocks are controversial, which include subduction-zone setting (Kohn et al., 2010) and continental rift setting (Sakai et al., 2013).

Analyses of immobile trace element compositions suggest that mafic rocks (metagabbro) from the eastern Nepal have within-plate (or OIB) type composition, while the rocks from central and western Nepal have chemical compositions similar to subduction-related (active continental margin) basalt. It is noted that both types occur in the western Nepal. Based on these results, we suggest that plume-related rift system is more likely tectonic setting for these mafic magmatism than arc setting. Arc-like signature in western Nepal rocks may be derived from sub-continental lithospheric mantle.

Similar regional variation in trace element compositions for felsic rocks was observed. Initial 143Nd/144Nd and 176Hf/177Hf of felsic rocks are lower than those of mafic rocks; thus crustal component might involved significantly in generation of felsic magmas.

Keywords: Nepal, Lesser Himalaya, tectonic setting

©2019. Japan Geoscience Union. All Right Reserved.

Petrogenesis and tectonic implications of orbicular granodiorite from Yangtze cratonic nucleus

*Yihe Li[1]

1. China University of Geosciences Wuhan

Orbicular granodiorite outcropped in the Yangtze cratonic nucleus (Huangling Dome), where at least six Precambrian (3.4-0.8 Ga) tectonic events have been recorded. Hence, Huangling Orbicluar Granodiorite (HOG) could help us to investigate both petrogenesis and tectonic implications.

The HOG exposed in the northern margin of Neoproterozoic (~0.8 Ga) Huangling batholith, merely 30 meters long and 5 meters wide. They are composed of obicules (5-12 centimeters in diameter) and matrix. The obicules have different structure as no shell, one-layer shell and multiple-layer shells. In detail, one-layer shell are formed by dark color minerals such as amphibole and biotite; multiple-layer shells are made up of dark layers (dominated by amphibole) and light layers (dominated by plagioclase) at random intervals (0.2-4.3 millimeters). Their inner parts (core) are major plagioclase with minor amphiboles.

Mineral chemistry data are obtained by Electron Probe Micro Analyzer (EPMA) from two profiles crossing obicules. The An (An=100 Ca/(Ca+Na+K)) of plagioclase in matrix, shell and core from one-layer obicule are 26-30, 30-35 and 35-40, indicating the crystallization sequence is from core to shell and then matrix. The An of plagioclase in matrix, shell and core from multiple-layer obicule are more complicate, as 33, 36-46 and 42-45. The data suggest that the obicule crystallized before matrix, without distinct sequence between core and shells.

P-T conditions are calculated by Hb-Pl thermobarometry (Holland and Blundy, 1994; Bhadra and Bhattacharya, 2007). 0.63 GPa and 728℃ are obtained from core of one-layer obicule, while 0.49 GPa and 706℃ are gained from core of multiple-layer obicule. Moreover, P-T condition of multiple-layer shells vary from 0.50-0.80 Gpa and 669-713 ℃, showing pressure decrease towards core with few sharp increasing. The average P-T condition of shells are 0.60 Gpa and 700 ℃, whose pressure is higher than the core. As a result, the multiple-layer obicules may form during decompression. Besides, the sharp increase of An and P-T condition suggest that more basic (Ca-rich) composition may be added into shells during formation.

Chemical distribution patterns of shells and *in-situ* zircon structure have been examined by field emission scanning electron microscopy (FESEM). Energy-dispersive X-ray spectrometers (EDS) mapping shows that no obvious chemical differentiation have been observed in the rhythm shells. Core-mantle-rim structure zircons have been found in the matrix near the shells of obicules. Short columnar zircons with oscillatory bands have been found in amphiboles, while long columnar zircons with wide bands and overgrowth rims/patches have been found in plagioclase.

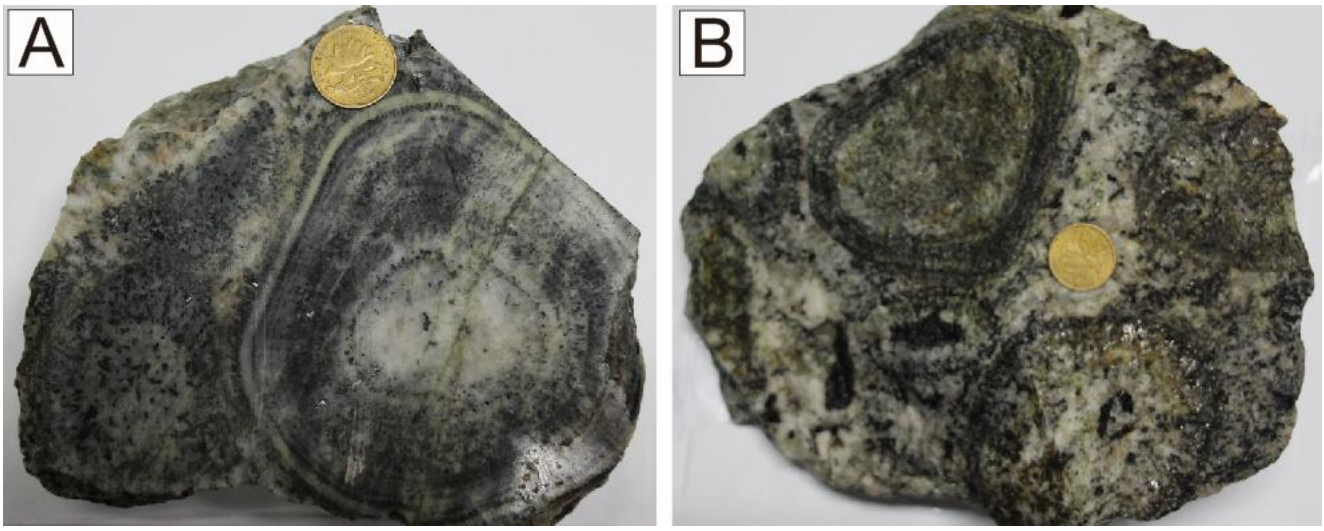
Zircons with Core-mantle-rim structure present concordant U-Pb ages as 1.95 Ga, 1.85 Ga and 0.88 Ga, with corresponding Epsilon Hf(t) values of -17.2 to -4.6, -10.8 to 0.36 and -23.6 to -21.5. Both short and long columnar zircons present concordant U-Pb ages of 0.88 Ga with Epsilon Hf(t) values of -23.7 to -19.85.

Based on new data and geological background, a model for generation of the HOG has been proposed as:

©2019. Japan Geoscience Union. All Right Reserved.

1) sediments metamorphosed at 1.95 Ga during continent-continent collision (Yin et al., 2013); 2) A-type granitic magma intruded the metasediments at 1.85 Ga (Xiong et al., 2009); 3) dioritic magma intruded the metasediments via the A-type granitic channel at 0.88 Ga; 4) water-rich superheating caused by dehydration of metasediments; 5) rapid crystallzation caused by undercooling while pressure decreasing.

Keywords: Huangling Orbicluar Granodiorite, Cratonic nucleus, Petrogenesis, Tectonic implications



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-CG49] Hard-Rock Drilling Science: From Continental to Deep Sea Drilling, and Oman Project

convener:Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Eiichi TAKAZAWA(Department of Geology, Faculty of Science, Niigata University), Norikatsu Akizawa(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Eiichi Takazawa(Niigata University), Norikatsu Akizawa(AORI The University of Tokyo)

The Oman Drilling Project (OmDP) has completed to drill numerous hard-rock cores within ancient oceanic lithosphere and the underlying subduction zone of the Samail ophiolite in Oman, with support from ICDP, IODP, Japan Society for the Promotion of Science, the Sloan Foundation's Deep Carbon Observatory, US, and European research agencies. Moreover, a number of IODP expeditions have focused on hard-rock drilling over the last several years including Expedition 352 in 2014, which drilled the volcanic sequence associated with subduction initiation in the Bonin fore-arc, Expedition 357, which drilled the Lost City hydrothermal field, Expedition 360, which drilled the lithosphere associated with ultraslow-spreading at the Southwest Indian Ridge in 2016, and Expedition 366, which drilled the serpentinite seamounts in the Mariana fore-arc. In this session, we invite presentations on the scientific results of hard-rock drilling at these and other sites. We also invite related presentations on oceanic lithosphere, island arc formation, and any other significant issue that could be addressed by future hard-rock drilling. This includes marine studies of oceanic lithosphere and on-land geological investigations of ophiolites, accreted arcs, and subduction complexes. The session is intended to be interdisciplinary, including the fields of geophysics, geochemistry, petrology, engineering, and biology.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG49-06] Melt transport and compositional heterogeneity of the mantle: a case study of peridotite, dunite, and wehrlite from Atlantis Massif

*Norikatsu Akizawa[1], Gretchen L. Früh-Green[2], Akihiro Tamura[3], Chiori Tamura[1], Tomoaki Morishita[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth Sciences, Eidgenössische Technische Hochschule-Zürich, 3.Institute of Science and Engineering, Kanazawa University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG49-07] Lower crustal accretion processes revealed from the study of gabbroic cores in Holes GT1A and GT2A, the ICDP Oman Drilling Project

*Sayantani Chatterjee[1], Eiichi TAKAZAWA[1], Katsuyoshi Michibayashi[2], Peter B Kelemen[3], Damon A.H. Teagle[4], Oman Drilling Project Phase I Science Party (1.Department of Geology, Faculty of Sciences, Niigata University, Japan, 2.Department of Earth and Environmental Sciences, Nagoya University, Japan, 3.Lamont Doherty Earth Observatory, Columbia University, USA, 4.Southampton Marine and Maritime Institute, University of Southampton, United Kingdom)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG49-08] Petrology of Oman listvenite : Implications for carbon cycle in the subduction zone

*Toma Takahashi[1], Tomoaki Morishita[2], Hiroki Sato[3], Juan Miguel Guotana[2], Tatsuhiko Kawamoto[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 science Party (1.Faculty of Geosciences and Civil Engineering, Kanazawa university, 2.Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa university, 3.Faculty of Science, Kyoto university, 4.Department of Geoscience, Faculty of Science, Shizuoka university, 5.Lamont-Doherty Earth Observatory, Columbia university, 6.School of Ocean and Earth Science, National Oceanography Center Southampton, University of Southampton, 7.School of Geography, Earth and Environmental Sciences,

Plymouth University, 8.Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya university, 9.Institute of Science and Technology, Niigata university)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG49-09] PGE and Os isotope variation in the gabbros and peridotites from the Oman DP drilling cores in the Samail ophiolite, Oman

*Ryoko Senda[1,2], Katsuhiko Suzuki[2], Tomoaki Morishita[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Damon AH Teagle[7], Jude Ann Coggon[7], Marguerite Godard[8], The Oman DP Science Party (1.Faculty of Social and Cultural Studies, Kyushu University, 2.Research and Development Center for Submarine Resources, JAMSTEC, 3.School of Natural System, Colleage of Science and Technology, Kanazawa University, 4.SDepartment of Geology, Faculty of Science, Niigata University, 5.Department of Earth and Planetary Sciences, Nagoya University, 6.Columbia University, 7.University of Southampton, 8.Géosciences Montpellier)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG49-10] Overview of drilling of crust-mantle boundary at CM1&2 sites of Wadi Tayin massif of Oman ophiolite: the ICDP Oman Drilling Project

*Eiichi TAKAZAWA[1], Damon A H Teagle[2], Katsuyoshi Michibayashi[3], Yoshihiko Tamura[4], Jude Ann Coggon[2], Juerg Matter[2], Peter B Kelemen[5], Oman Drilling Project Phase 2 Science Party (1.Department of Geology, Faculty of Science, Niigata University, 2.University of Southampton, 3.Nagoya University, 4.JAMSTEC, 5.Columbia University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG49-11] Petrological observation of core samples drilled from a mantle section of the Oman ophiolite: A preliminary report of the Oman Drilling Project Phase 2

*Yuji Ichiyama[1], Oman Drilling Project Phase 2 Scientific Party (1.Chiba University)

Melt transport and compositional heterogeneity of the mantle: a case study of peridotite, dunite, and wehrlite from Atlantis Massif

*Norikatsu Akizawa[1], Gretchen L. Früh-Green[2], Akihiro Tamura[3], Chiori Tamura[1], Tomoaki Morishita[3]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Department of Earth Sciences, Eidgenö ssische Technische Hochschule-Zürich, 3. Institute of Science and Engineering, Kanazawa University

Harzburgitic, dunitic, and wehrlitic rocks drilled at Atlantis Massif (Mid-Atlantic Ridge, 30˚N), where mantle-derived rocks were exhumed to the sea floor via detachment faulting, were investigated employing *in situ* geochemical analyses. Since dunitic and wehrlitic rocks are commonly interpreted as fossil melt channels, they likely represent transported parental melts of mid-ocean ridge basalt (MORB) beneath the paleo-ridge axis. Although the rocks are severely serpentinized, primary olivines, chromian spinels, orthopyroxenes, and clinopyroxenes were found in several samples. The Cr/(Cr + Al) ratios (Cr#) of the chromian spinel show a bimodal distribution, where one group records higher Cr# (0.35–0.5) and the other group is represented by lower Cr# (0.2–0.3). The extent of mantle melting is strongly correlated to the Cr# of the chromian spinel, thus the mantle-derived lithologies of the Atlantis Massif record at least two end-members with regards to the extent of melting: refractory mantle material with higher Cr#, and enriched mantle material with lower Cr#. To quantitatively evaluate mantle melting and melt transport mechanisms in the suboceanic mantle beneath this section of the Mid-Atlantic Ridge, a one-dimensional, steady-state decompositional mantle melting model was carried out based on rare-earth element concentrations of clinopyroxene. Our modelling results demonstrate that the melting region of the mantle extends unevenly across the ridge axis, with deeper melting occurring on-axis from the garnet-stability field, and shallower melting occurring off-axis from the spinel-stability field. We propose that depleted melts generated at depths in the absence of garnet within the off-axis region were possibly focused to the ridge axis via fracture-induced melt channels and produced wehrlite. It is likely that fracture-induced melt migration was dominantly a response to a decrease of temperature as the mantle was exhumed during detachment faulting.

Keywords: IODP Exp 357, Mid-Atlantic Ridge, Harzburgite, Melt transport, MORB, ultra-depleted melt

©2019. Japan Geoscience Union. All Right Reserved.

Lower crustal accretion processes revealed from the study of gabbroic cores in Holes GT1A and GT2A, the ICDP Oman Drilling Project

*Sayantani Chatterjee[1], Eiichi TAKAZAWA[1], Katsuyoshi Michibayashi[2], Peter B Kelemen[3], Damon A.H. Teagle[4], Oman Drilling Project Phase I Science Party

1. Department of Geology, Faculty of Sciences, Niigata University, Japan, 2. Department of Earth and Environmental Sciences, Nagoya University, Japan, 3. Lamont Doherty Earth Observatory, Columbia University, USA, 4. Southampton Marine and Maritime Institute, University of Southampton, United Kingdom

Transition between middle crustal foliated and to lower crustal layered gabbros of Oman ophiolite was drilled at Hole GT2A and GT1A in Wadi Gideah of Wadi Tayin massif (22˚51.793'E/58˚31.198'N and 22˚53.535'/58˚30.904' respectively) during Phase 1 of Oman drilling project. With total depth of 406.77m long Hole GT2A core samples the middle foliated to layered gabbro. Hole GT1A drilled the lower crustal section in the southern Oman ophiolite and recovered 401.52 m of total cores (99.6% recovery). Petrographic observation of representative samples from GT2A and GT1A, we found two dominant rock types: gabbbro and olivine gabbro, where later dominates the lower part of the drill hole.

The layered structure is mainly controlled by the variable grain size and modal composition of minerals. Gabbros contain plagioclase and clinopyroxene (showing poikilitic texture) as primary minerals associated with few amounts of oxides. Clinopyroxenes are often replaced by brown amphibole along cleavages or at the rim. Olivine gabbros are constituted of plagioclase, clinopyroxene, olivine, some orthopyroxene and oxide minerals. Texturally, olivine grains are present as subhedral to skeletal in nature. Magmatic foliation is often demarcated by laths of plagioclase followed by elongated clinopyroxene. The contact between olivine and plagioclase frequently marked by presence of symplectitic intergrowth between spinel and orthopyroxenewhich suggests, olivine was reacting with late stage liquid and produce simultaneous coprecipitation of magnetite and orthopyroxene. Downhole evolution present from bottom to top for both in gabbro and olivine gabbro samples in terms of Mg#,TiO2, and Cr2O3 in clinopyroxene, olivine and plagioclase, particularly at 270mt and 130mt Mg# increase (influx of primitive melts at several intervals). TiO2 and Cr2O3 correspond with Mg#, and eventually follow fractionation trend. Data from rare earth elements implies that ol-gabbros are crystallized from different parent melts (at least two types) supported by the evidence from evolution with depth profile.

Gabbroic lithologies in GT1A represented by anhedral olivine with tabular to elongate shape. Plagioclase are partly or totally enclosed by large clinopyroxene. Clinopyroxenes are tabular to subequant in habit. Some thin films of orthopyroxene present as corona around olivine. Most of the samples have undergone alteration and obscured the igneous origin. In case of Hole GT2A, gabbros are much less affected by alteration compared to GT1A. Downhole variation in mineral composition (in-situ composition) can be correlated with several cycles of crystallization history. Detailed petrographic, microstructural and geochemical study of all the representative samples will be presented. We have also attempted to determine the oxygen fugacity, where (fO2 vs.T plot) oxide pairs are plotted within FMQ field (fO2 vs. T plot). Temperature estimation ranges from 600-800˚C (shallow level gabbro to deeper gabbro) cover total range of temperature from high to low and also have a clue to determine the thermal evolution by rate of cooling.

Keywords: Oman Drilling Project, Lower crust, Gabbro

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Petrology of Oman listvenite : Implications for carbon cycle in the subduction zone

*Toma Takahashi[1], Tomoaki Morishita[2], Hiroki Sato[3], Juan Miguel Guotana[2], Tatsuhiko Kawamoto[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 science Party

1. Faculty of Geosciences and Civil Engineering, Kanazawa university, 2. Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa university, 3. Faculty of Science, Kyoto university, 4. Department of Geoscience, Faculty of Science, Shizuoka university, 5. Lamont-Doherty Earth Observatory, Columbia university, 6. School of Ocean and Earth Science, National Oceanography Center Southampton, University of Southampton, 7. School of Geography, Earth and Environmental Sciences, Plymouth University, 8. Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya university, 9. Institute of Science and Technology, Niigata university

Listvenites obtained during the Phase 1 of the Oman Drilling Project can be generally divided into two main groups based on color: red series and green-white series. Although there is a clear color difference, the mineral assemblage is mainly composed of magnesite and quartz. Dolomite occurs as late veins and/or small patches. Opaque minerals are abundant in the red series which occur either as veins or disseminated grains which are commonly enveloped by carbonate minerals and quartz. The opaque minerals are hematite based on Raman spectrometry analysis. In the green-white listvenite series, opaque minerals are very scarce. Greenish portions in both listvenites were observed on a hand sample scale. In the green-white series, dark green and light green portions are present while only light green portions are observed in the red listvenites. These greenish features are interpreted as mainly polymineralic pseudomorphic replacement of orthopyroxene. In the same hole, pyroxene relics in serpentinites exhibit the same shape as with the previously described greenish pseudomorphs. The dark green portions in the green-white listevenites contain fuchsite (Cr-mica) around spinel relics. Silicified relic pyroxenes with fuchsite along relic cleavages are also present in the light green portions. On the other hand, the greenish portions in the red listvenite series are characterized by magnesite with intergranular fuchsite (?). Hematites in the red listvenites have similarities in form with the opaque minerals occurring as discontinuous veinlets in the serpentinite. The combined similarities in the petrographic features suggest that some listvenites were formed from serpentitnites. Quartz veins with Ni-bearing magnesite were observed in the red series and were formed in the last stage.

Keywords: Listvenite, Oman drilling project, Oman ophiolite, elements mobility, Carbonation

©2019. Japan Geoscience Union. All Right Reserved.

PGE and Os isotope variation in the gabbros and peridotites from the Oman DP drilling cores in the Samail ophiolite, Oman

*Ryoko Senda[1,2], Katsuhiko Suzuki[2], Tomoaki Morishita[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Damon AH Teagle[7], Jude Ann Coggon[7], Marguerite Godard[8], The Oman DP Science Party

1. Faculty of Social and Cultural Studies, Kyushu University, 2. Research and Development Center for Submarine Resources, JAMSTEC, 3. School of Natural System, Colleage of Science and Technology, Kanazawa University, 4. SDepartment of Geology, Faculty of Science, Niigata University, 5. Department of Earth and Planetary Sciences, Nagoya University, 6. Columbia University, 7. University of Southampton, 8. Géosciences Montpellier

It is well known that oceanic crust covers almost 70 % of Earth’ s surface. It is formed at mid-ocean ridge and is subducted into mantle at convergent plate margin. This plate motion is pull many kinds of surface materials in inside the mantle and contributed to a global recycling system. However the details of the oceanic crusts and underlain upper mantle are still poor understanding. The construction of the oceanic crusts is defined by constructions of ophiolites which were the ancient oceanic plates exposed onto land.

To have better understandings of the oceanic crust, underlain upper-most mantle and related other things, the Oman Drilling Project by ICDP was done the drilling from 2016 to 2018 in Samail ophiolite, Oman. The Samail ophiolite in the northern part of Oman is the largest and having better exposed section of the oceanic lithosphere in the world.

We will report the preliminary results of the PGE abundances and Os isotope ratios in the whole-rock gabbros and mantle related peridotites from the drilling cores and compering to the data from the Oman surface data. These data will be help us to better understanding of the relationships between the oceanic crust and underlying upper mantle, mechanisms of making oceanic crust, and planning the future Mohole projects.

Keywords: Oman DP, gabbro, peridotite, Os isotope ratio, PGE abundance

©2019. Japan Geoscience Union. All Right Reserved.

Overview of drilling of crust-mantle boundary at CM1&2 sites of Wadi Tayin massif of Oman ophiolite: the ICDP Oman Drilling Project

*Eiichi TAKAZAWA[1], Damon A H Teagle[2], Katsuyoshi Michibayashi[3], Yoshihiko Tamura[4], Jude Ann Coggon[2], Juerg Matter[2], Peter B Kelemen[5], Oman Drilling Project Phase 2 Science Party

1. Department of Geology, Faculty of Science, Niigata University, 2. University of Southampton, 3. Nagoya University, 4. JAMSTEC, 5. Columbia University

At the boundary between the crustal section and the mantle section of the Oman ophiolite there are several tens to hundreds of meters thick, mainly composed of dunite called the crust-mantle transition zone (MTZ) [1]. Since it often accompanies thin veins or clots of plagioclase and clinopyroxene and several centimeters to meters thick gabbro sills, it leaves traces of magma activity right under the ridge. The origin of dunite in MTZ is still under debate: the accumulation of olivine crystallized from melt [2], or the reaction of harzburgite with pyroxene-undersatulated melt [3], or both [4]. Recently, the presence of water at the time of formation has also been pointed out [5]. To clarify the origin of MTZ, more detailed research by continuous core through MTZ is necessary.

From November 2017 to January 2018 MTZ of Wadi Zeeb (CM1&2 sites) in Wadi Tayin massif was drilled by the International Continental Scientific Drilling ProgramOman Drilling Project [6]. Geological mapping on ground associated with information from the recovered cores the thickness of the MTZ is estimated as about 150 m. The upper and lower boundaries of the MTZ has a strike in the east-west direction, and it is inclined about 30 degrees south. In the summer of 2018, the drilled cores were carefully described by scientists on the deep-sea drilling vessel "CHIKYU". The stratigraphy has been divided into four igneous sequences based on the abundance of different lithologies: Layered Gabbro Sequence, Dunite Sequence, Dunite with Gabbro Sequence, and Mantle Sequence. Dunite Sequence and Dunite with Gabbro Sequence are summarized as Crust - Mantle Transition.

Hole CM1A is inclined 60˚ northward. The upper 160 m of the core is the Layered Gabbro Sequence, mostly composed of olivine gabbro, interlayered with gabbro and a small amount of wehrlite, dunite, anorthosite and troctolite. From 160 to 310 m the Crust-Mantle Transition is divided into an upper 90 m Dunite Sequence and a lower 60 m Dunite with Gabbro Sequence containing small lenses of gabbro, troctolite and wehrlite. The dunites are highly serpentinized, and rodingite and diopsidite commonly replace minor gabbroic rocks in these sequences. The lower 80 m of the hole is the Mantle Sequence, with alternating layers of dunite and increasingly abundant, residual mantle harzburgite.

Hole CM2B is a vertical hole located 400 m north of CM1A, and samples the Crust-Mantle Transition and the Mantle Sequence. As in CM1A, the transition is divided into an upper Dunite Sequence and a lower Dunite with Gabbro Sequence. In contrast to Hole CM1A, a small amount of olivine has escaped complete serpentinization in the lower portions of the CM2B transition zone. In the Mantle Sequence, harzburgite is dominant. Dunite accounts for about 25% of this Sequence, less than in CM1A. The lowermost peridoties in Hole CM2B are strongly altered to talc+carbonate.

[1] Boudier and Nicolas, 1995, J. Petrol., 36, 777-796, [2] Pallister and Hopson, 1981, J. Geophys. Res., 86, 2593-2644, [3] Kelemen et al., 1995, Nature, 375, 747-753, [4] Abily and Ceuleneer, 2013, Geology, 41, 67-70, [5] Rospabé et al., 2017, Geol. Soc. Am., Data Rep. 2017139, [6] Kelemen et al., 2013, Scientific Drilling, 15, 64-71.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: ophiolite, crust-mantle boundary, Moho Transition Zone, ICDP, Oman Drilling Project

©2019. Japan Geoscience Union. All Right Reserved.

Petrological observation of core samples drilled from a mantle section of the Oman ophiolite: A preliminary report of the Oman Drilling Project Phase 2

*Yuji Ichiyama[1], Oman Drilling Project Phase 2 Scientific Party

1. Chiba University

The Oman ophiolite is the world’s largest ophiolite and will help us to understand the crustal formation, processes in the mantle, and evolution and modification of the oceanic lithosphere through the time. The drillings and investigations of the crust-mantle boundaries and mantle sections were operated in the Oman Drilling Project Phase 2. We report the preliminary results of the petrological observation of the drilling samples from the mantle sections in the Phase 2 Holes BA1B, BA3A, and BA4A.

The Hole BA1B is composed of upper dunite and lower harzburgite associated with mafic dikes. The Hole BA3A is dominated mainly by harzburgite and also contains a minor amount of thin dunitic layers and mafic dikes. The Hole BA4A consists of alternation of dunite and harzburgite with abundant mafic dikes. The mafic dikes observed in each hole are gabbro to olivine gabbro, and sometimes wehrlitic. Brown to pale brown hornblende is usually included in almost all lithology. Phlogopite is also present in association with hornblende. Chromian spinel in an olivine-gabbro sample from the BA4A is characterized by high $Fe^{3+}/(Cr + Al + Fe^{3+})$ ratio (>0.15) and intermediate TiO_2 content (1–2 wt.%), which are comparable with those in island arc basalts. In the contact between the mafic dikes and peridotite, orthopyroxene is formed as a reaction product between the mantle peridotite and mafic melt. The petrological characteristics of the mafic dikes indicate that they crystallized from hydrous, oxidized magmas, which imply that the intrusion event occurred in a convergent margin rather than a typical spreading axis.

Keywords: ICDP, Oman ophiolite, Mantle peridotite, Mafic dike

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-CG49] Hard-Rock Drilling Science: From Continental to Deep Sea Drilling, and Oman Project

convener:Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Eiichi TAKAZAWA(Department of Geology, Faculty of Science, Niigata University), Norikatsu Akizawa(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Tomoaki Morishita(Kanazawa University), Katsuyoshi Michibayashi

The Oman Drilling Project (OmDP) has completed to drill numerous hard-rock cores within ancient oceanic lithosphere and the underlying subduction zone of the Samail ophiolite in Oman, with support from ICDP, IODP, Japan Society for the Promotion of Science, the Sloan Foundation's Deep Carbon Observatory, US, and European research agencies. Moreover, a number of IODP expeditions have focused on hard-rock drilling over the last several years including Expedition 352 in 2014, which drilled the volcanic sequence associated with subduction initiation in the Bonin fore-arc, Expedition 357, which drilled the Lost City hydrothermal field, Expedition 360, which drilled the lithosphere associated with ultraslow-spreading at the Southwest Indian Ridge in 2016, and Expedition 366, which drilled the serpentinite seamounts in the Mariana fore-arc. In this session, we invite presentations on the scientific results of hard-rock drilling at these and other sites. We also invite related presentations on oceanic lithosphere, island arc formation, and any other significant issue that could be addressed by future hard-rock drilling. This includes marine studies of oceanic lithosphere and on-land geological investigations of ophiolites, accreted arcs, and subduction complexes. The session is intended to be interdisciplinary, including the fields of geophysics, geochemistry, petrology, engineering, and biology.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG49-12] Structural analyses of ultramafic rocks used by X-ray CT core imaging (Oman Drilling Project Phase 2, D/V CHIKYU)

*Katsuyoshi Michibayashi[1], Yuki Kakihata[1], Ikuo Katayama[2], Atsushi Okamoto[3], Keishi Okazaki[4], Peter B Kelemen[5], Eiichi TAKAZAWA[6], Damon A H Teagle[7], Oman Drilling Project Phase 2 Science Party[8] (1.Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 2.Hiroshima University, 3.Tohoku University, 4.KCC, JAMSTEC, 5.Columbia University of New York, 6.Niigata University, 7.Southampton University, 8.ICDP)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG49-13] Petrophysical characteristics of serpentinized peridotites of Hole BA1B, BA3A and BA4A

*Kakihata Yuki[1], Katsuyoshi Michibayashi[2], Laura Crispini[3], Bjorn Jamtveit[4], Samuel Barbier[5], Joe Aslin[6], Manuel Menzel[7], Marguerite Godard[8] (1.Graduate School of Science, Shizuoka University, 2.Graduate School of Environmental Studies, Nagoya University, 3.University of Genova, 4.University of Oslo, 5.Claude Bernard University Lyon 1, 6.University of Liverpool, 7.Andalusian Earth Science Institute, 8.Géosciences Montpellier, CNRS, Univ. Montpellier)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG49-14] Physical properties of the Moho TZ: Implications from ICDP Oman Drilling Project Phase I & II on-board measurements

*Natsue Abe[1,12], Keishi Okazaki[1], Ikuo Katayama[2], Kohei Hatakeyama[2], Yuya Akamatsu[2], Benoit Ildefonse[3], Ulven Ivar Ole[4], Gilvert Hong[5], Wenlu Zhu[6], Benoit Cordonnier[4], Katsuyoshi Michibayashi[7], Eiichi TAKAZAWA[8], Michell Harris[10], Damon Teagle[11], Peter Kelemen[9], Marguerite Godard[3], Jurg Matter[11], Jude Coggon[11], Oman Drilling Project Scientific Party (1.Japan Agency for Marine-Earth Science and Technology, 2.Hiroshima University, 3.Universitè de Montpellier, 4.University of Oslo, 5.Seoul National University, 6.University of Maryland, 7.Nagoya University, 8.Niigata University, 9.Columbia University, 10.Polymouth University, 11.University of Southampton, 12.Kanazawa University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG49-15] **Seismic anisotropy under high pressure conditions of harzburgite collected from Oman Drilling Project Phase II**

*Kohei Hatakeyama[1], Ikuo Katayama[1], Natsue Abe[2], The Oman Drilling Project Phase II Science Party (1.Department of earth and planetary systems science, Hiroshima University , 2.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG49-16] Understanding of the mode of seafloor spreading and the architecture of upper oceanic crust by oceanfloor drilling at off-Hawaii MoHole candidate site

*Susumu Umino[1], Tomoaki Morishita[1], Mikiya Yamashita[2], Osamu Ishizuka[3] (1.Department of Earth Sciences, Kanazawa University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Geological Survey of Japan, AIST)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Structural analyses of ultramafic rocks used by X-ray CT core imaging (Oman Drilling Project Phase 2, D/V CHIKYU)

*Katsuyoshi Michibayashi[1], Yuki Kakihata[1], Ikuo Katayama[2], Atsushi Okamoto[3], Keishi Okazaki[4], Peter B Kelemen[5], Eiichi TAKAZAWA[6], Damon A H Teagle[7], Oman Drilling Project Phase 2 Science Party[8]

1. Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 2. Hiroshima University, 3. Tohoku University, 4. KCC, JAMSTEC, 5. Columbia University of New York, 6. Niigata University, 7. Southampton University, 8. ICDP

X-ray computed tomography (X-ray CT) images were obtained on all cores drilled during Oman Drilling Project (OmanDP) Phase 2 (Holes CM1A, CM2B, BA1B, BA3A and BA4A) as a routine part of the IODP measurement protocol onboard D/V Chikyu. X-ray CT scanning enables the non-destructive observation of the internal structure of the core, providing information about chemical composition and density. The data are useful for assessing sample locations and quality. X-ray CT images can be used for 3D fabric analyses even after core has been cut in half and subsampled for other analyses.

The X-ray CT scanner (Discovery CT 750HD, GE Medical Systems) scans and reconstructs an image of a 1.4 m section in 10 minutes and produces a series of scan images, each 0.625 mm thick. The X-ray source and detector are installed inside of the gantry opposite each other. The excitation voltage and current for X-ray tube are 140kV and 100 mA, respectively.

Core samples are scanned in the gantry with a scanning rate of 20 mm/sec. The distribution of attenuation values mapped to an individual slice comprises the raw data that are used for subsequent image processing. Successive two-dimensional (2D) slices of 512 x 512 pixels yield a representation of attenuation values in three-dimensional (3D) voxels of 512 x 512 by ~1600 in length. Data generated for each core consist of core-axis-normal planes (XY planes) of X-ray attenuation values with dimensions of 512 ×512 pixels in 9 cm ×9 cm cross-section, with a resolution of 0.176 mm/pixel.

X-ray intensity varies as a function of X-ray path length and the linear attenuation coefficient (LAC) of the target material, which is a function of the chemical composition and density of the target material. The basic measure of attenuation, radiodensity, is the CT number given in Hounsfield units (HU). CT numbers of air and water are -1000 and 0, respectively.

CT numbers of OmanDP cores reveal structural features such as the attitude of foliation in primary peridotites, defined by spinel and orthopyroxene crystal shape. Combined with microstructural analyses such as EBSD mapping, we can study petrophysical properties of the uppermost mantle in the mantle section. Moreover, comparing with density profiles measured onboard, we can also estimate the degree of serpentinization in core from Holes BA1B, BA3A and BA4A, ranging from 80 to almost 100%. Profiles of

©2019. Japan Geoscience Union. All Right Reserved.

the degree of serpentinization with depth may provide insight into ongoing serpentinization processes.

Keywords: Oman, XCT, Structural Analyses, Serpentinization

©2019. Japan Geoscience Union. All Right Reserved.

Petrophysical characteristics of serpentinized peridotites of Hole BA1B, BA3A and BA4A

*Kakihata Yuki[1], Katsuyoshi Michibayashi[2], Laura Crispini[3], Bjorn Jamtveit[4], Samuel Barbier[5], Joe Aslin[6], Manuel Menzel[7], Marguerite Godard[8]

1. Graduate School of Science, Shizuoka University, 2. Graduate School of Environmental Studies, Nagoya University, 3. University of Genova, 4. University of Oslo, 5. Claude Bernard University Lyon 1, 6. University of Liverpool, 7. Andalusian Earth Science Institute, 8. Géosciences Montpellier, CNRS, Univ. Montpellier

Structural characteristics within peridotites of Hole BA1B, BA3A and BA4A have been described during the Oman Drilling Project Phase 2 from 5th August to 3rd September, 2018 on D/V Chikyu. The peridotites consisted of intensely serpentinized harzburgite and dunite, which exhibited foliations defined by elongation and alignment of constituent minerals. Crystal plastic fabrics in harzburgite were described prior to those in dunite because orthopyroxene grains are clearer than spinel grains in serpentinized peridotites at macro scale.

Harzburgites in BA1B show variously deformed textures ranging from pophyroclastic to protomylonitic textures in dependent on the depth. In BA3A, harzburgites with protogranular texture were observed in relatively shallow sections (10-90 m), whereas porphyroclastic to strongly foliated textures were dominant in deeper sections. Most of hartzburgites in BA4A show porphyroclastic texture, partly clear foliation and protomylonitic textures by strongly elongated orthopyroxene grains. Dip angles of measured foliations in BA1B are mostly 0-20˚, which are nearly horizontal. Most of dip angles in BA3A are at around 30˚, up to 50˚. In BA4A, dip angles of orthopyroxene grains take various values between 10-50˚. In BA3A and BA4A show similar dip angles, but significantly steeper than those in BA1B. In each hole, dip angles were nearly constant independent on the depth.

Pyroxene and spinel grains in strongly foliated to protomylonitic peridotites are intensely elongated and aligned, exhibiting clear foliation at thin section scale. In protogranular peridotites, pyroxene and spinel grains have rounded shapes and are not elongated and aligned, and foliations are unclear. Elongated pyroxene and olivine grains in protomylonitic peridotites show kink bands and wavy extinction, whereas few rounded pyroxene grains in protogranular peridotites show these features.

Keywords: Oman Drilling Project, Peridotite, Crystal plastic fabric

©2019. Japan Geoscience Union. All Right Reserved.

Physical properties of the Moho TZ: Implications from ICDP Oman Drilling Project Phase I & II on-board measurements

*Natsue Abe[1,12], Keishi Okazaki[1], Ikuo Katayama[2], Kohei Hatakeyama[2], Yuya Akamatsu[2], Benoit Ildefonse[3], Ulven Ivar Ole[4], Gilvert Hong[5], Wenlu Zhu[6], Benoit Cordonnier[4], Katsuyoshi Michibayashi[7], Eiichi TAKAZAWA[8], Michell Harris[10], Damon Teagle[11], Peter Kelemen[9], Marguerite Godard[3], Jurg Matter[11], Jude Coggon[11], Oman Drilling Project Scientific Party

1. Japan Agency for Marine-Earth Science and Technology, 2. Hiroshima University, 3. Universitè de Montpellier, 4. University of Oslo, 5. Seoul National University, 6. University of Maryland, 7. Nagoya University, 8. Niigata University, 9. Columbia University, 10. Polymouth University, 11. University of Southampton, 12. Kanazawa University

We report physical property measurements of core samples from the Samail ophiolite in Oman, drilled by the ICDP Oman Drilling Project. Onboard core logging was conducted on D/V Chikyu for 4 months in total in the summers of 2017 and 2018. We analyzed 4 holes (GT1A, GT2A, GT3A and BT1B) in 2017, and 5 holes (CM1A, CM2B, BA1B, BA3A and BA4A) in 2018. The total core length of those 9 holes is about 3200 m. Cores from Holes GT1A and GT2A in the lower crust section of the ophiolite are mainly composed of gabbros (gabbro and olivine gabbro), with small amounts of ultramafic rocks (wehrlite and dunite), whereas those from Hole GT3A at the boundary between the sheeted dikes and gabbro are mainly composed of basalt and diabase, followed by gabbros (gabbro, olivine gabbro and oxide gabbro). Minor felsic trondhjemite and tonalite dikes intrude the mafic rocks. In contrast, Hole BT1B penetrated from mantle section through the basal thrust and into the metamorphic sole. The CM holes were drilled through the crust-mantle transition, from gabbroic lower crust, through dunite with minor gabbros, and in to residual mantle harzburgite. BA holes were taken from the mantle section and are composed of dunite and harzburgite intruded by minor gabbroic and pyroxenite dikes. Ultramafic rocks at both sites were extensively serpentinized, but the names of igneous protoliths are used here.

Whole-round data, including X-ray CT images, natural gamma radiation (NGR), gamma ray attenuation (GRA) density, magnetic susceptibility (MS), P-wave velocity (Vp) and noncontact electrical resistivity were obtained. Split core color spectroscopy data were also collected. Magnetic susceptibility, electrical resistivity under both nominally dry and brine-saturated conditions, P-wave velocity, bulk/grain density, porosity and thermal conductivity were measured in discrete samples. Nearly 100% core recovery allowed us to take a large data set of petrophysical data on the cores from Oman ophiolite including fault zones and highly altered intervals.

Generally, gabbroic rock types have higher density, P-wave velocity, and electrical resistivity, and lower porosity than ultramafic lithologies. Serpentinized dunite have lower density, P-wave velocity and electrical resistivity, and higher porosity than serpentinized harzburgite, and these physical properties are correlated with magnetic susceptibility, probably due to crystallization of magnetite during alteration. Average X-ray CT values are also correlated with many other physical properties in most lithologies. Those physical property data and the lithological characteristics of the Moho transition zone in the Oman ophiolite revealed apparent difference and similarities with the oceanic data, especially in the seismic profiles from the oceanic plate. In this paper, we would like to compare the data from ocean drilling, Oman Drilling and seismic profiles.

Keywords: ICDP, Oman Drilling Project, ophiolite, Moho TZ, Oceanic crust

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Seismic anisotropy under high pressure conditions of harzburgite collected from Oman Drilling Project Phase II

*Kohei Hatakeyama[1], Ikuo Katayama[1], Natsue Abe[2], The Oman Drilling Project Phase II Science Party

1. Department of earth and planetary systems science, Hiroshima University , 2. JAMSTEC

The Oman ophiolite interpreted as ancient oceanic lithosphere has been drilled recently, and core samples of harzburgite were collected from mantle section (Oman Drilling Project). These compressional wave velocity of three orthogonal directions (X, Y and Z axis) was measured under ambient condition onboard D/V Chikyu. Velocity of Z axis was lower than that of orthogonal directions (X and Y axis), showing approximately 4% of anisotropy. Although anisotropy caused by preferred orientation of olivine was observed at oceanic mantle, olivine in harzburgite collected from ophiolite is almost transformed to serpentine, implying that anisotropy of core samples is caused by preferred orientation of pyroxene. In addition, the preferred orientation of cracks also causes anisotropy, which is sensitive to the type of pore fluid (Anderson et al., 1974). However, the dominant factor of anisotropy is unclear because both effects are included in the measurement under the ambient condition. In this study, we measured elastic wave velocity of harzburgite under high confining pressure where most pores are closed, and determine a dominant factor causing seismic anisotropy.
Harzburgite collected from Hole BA1B and BA3A were selected as the experimental samples. Density and porosity of these samples are 2.60 to 2.64 g/cm^{3}and 0.5% to 1.0%, respectively.Intra-vessel deformation and fluid flow apparatus at Hiroshima University were used to conduct the measurements under high confining pressure of up to 200 MPa. Two loading cycles were applied to each specimen to measure velocity successively under both dry and wet conditions. In wet condition, pore pressure was set at 10 MPa using a syringe pump.Both compressional and shear wave velocity ($V_P$andV_S) on two orthogonal directions (Y and Z axis) were measured from the pulse transmission method with the amplitude and the frequency of a trigger wave of 5 V and 2 MHz, respectively.
In the preliminary results at 200 MPa of confining pressure under dry conditions, harzburgite collected from Hole BA3A shows V_P = 5.86 km/s and V_S = 3.03 km/s on the direction of Y axis, and V_P = 5.49 km/s and V_S = 2.95 km/s on the direction of Z axis. Anisotropy under high confining pressure indicates 6.5% and 2.7% for compressional and shear wave velocity, respectively. Therefore, the preferred orientation of minerals is likely to be a dominant factor.

Keywords: Oman Drilling Project, Harzburgite, Anisotropy, Preferred orientation, Pyroxene, Crack

©2019. Japan Geoscience Union. All Right Reserved.

Understanding of the mode of seafloor spreading and the architecture of upper oceanic crust by oceanfloor drilling at off-Hawaii MoHole candidate site

*Susumu Umino[1], Tomoaki Morishita[1], Mikiya Yamashita[2], Osamu Ishizuka[3]

1. Department of Earth Sciences, Kanazawa University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Geological Survey of Japan, AIST

Understanding how seafloor spreading and mantle melting are linked to ocean crust architecture is Challenge 9 of the IODP Science Plan for 2013-2023 and is one of the major goals of the mantle drilling project MoHole to Mantle (M2M). Deep basement drilling is skewed to young and slow-spread crust, with a wide gap of crust age between 20 and 110 Ma, including the world average of 62.5 Ma and spreading rate of 7.6 cm/a. Among the three candidate sites of M2M, only off-Hawaii site can provide the information of oceanic crust of the missing age and spreading rate. We propose a deep drilling off-Hawaii to penetrate through the upper crust and into the gabbros to understand the architecture and governing processes of the upper oceanic crust.

ODP Holes 504B and 1256D have brought invaluable information and fruitful insight into the architecture and formation processes of the upper oceanic crust.

Hole 504B is the deepest drill hole that penetrated 1815 m into 6.9-Ma basement formed at an intermediate rate of 6.6 cm/a at the Costa Rica Rift (Dick et al., 1992). The 504B upper crust, consisting of less dense extrusive rocks underlain by denser sheeted dikes than their source magmas, yields an apparent level of neutral buoyancy that traps accreted magma as dike intrusions. Thus, the 504B crust relaxes stress induced by plate movement and extends by both fault displacement and dike intrusions, which leads to development of rugged summit and axial troughs.

On the contrary, the 15-Ma 1256D crust, formed at the East Pacific Rise, has a distinctly high extrusive to intrusive ratio (814 m / 343 m) compared to that of the 504B crust (780 m / >1056 m). As is expected for the ultrafast spreading rate of 22 cm/a, the extrusive rocks are dominantly of massive and lobate sheet flows, which are as dense as the extruding magma (Umino et al., 2008). This results crust without an apparent level of neutral buoyancy and the persistently over pressurized axial magma chamber (AMC). Only a small increase in magmatic pressure or reduction in horizontal stress leads to dike intrusions followed by eruptions. Conversely, extension of the 1256D upper crust was primarily accomplished by dike intrusions without large faults.

These examples articulate how the density structures of upper crust partition magma into extrusive and intrusive rocks and form characteristic architectures.

Density structures are intimately correlated with magma budget, the amount of magma supplied and consumed to keep the same cross-sectional area of the ridge for a time scale of 100 ky.

The Galapagos Spreading Center (GSC) shows thickening on-axis and thinning total extrusive rocks with AMC depth, indicating axial valleys develop to trap thick on-axis flows with deepening AMC and decreasing magma budget (Blacic et al., 2004). For the GSC spreading rate of 4.5–5.5 cm/a, more than

©2019. Japan Geoscience Union. All Right Reserved.

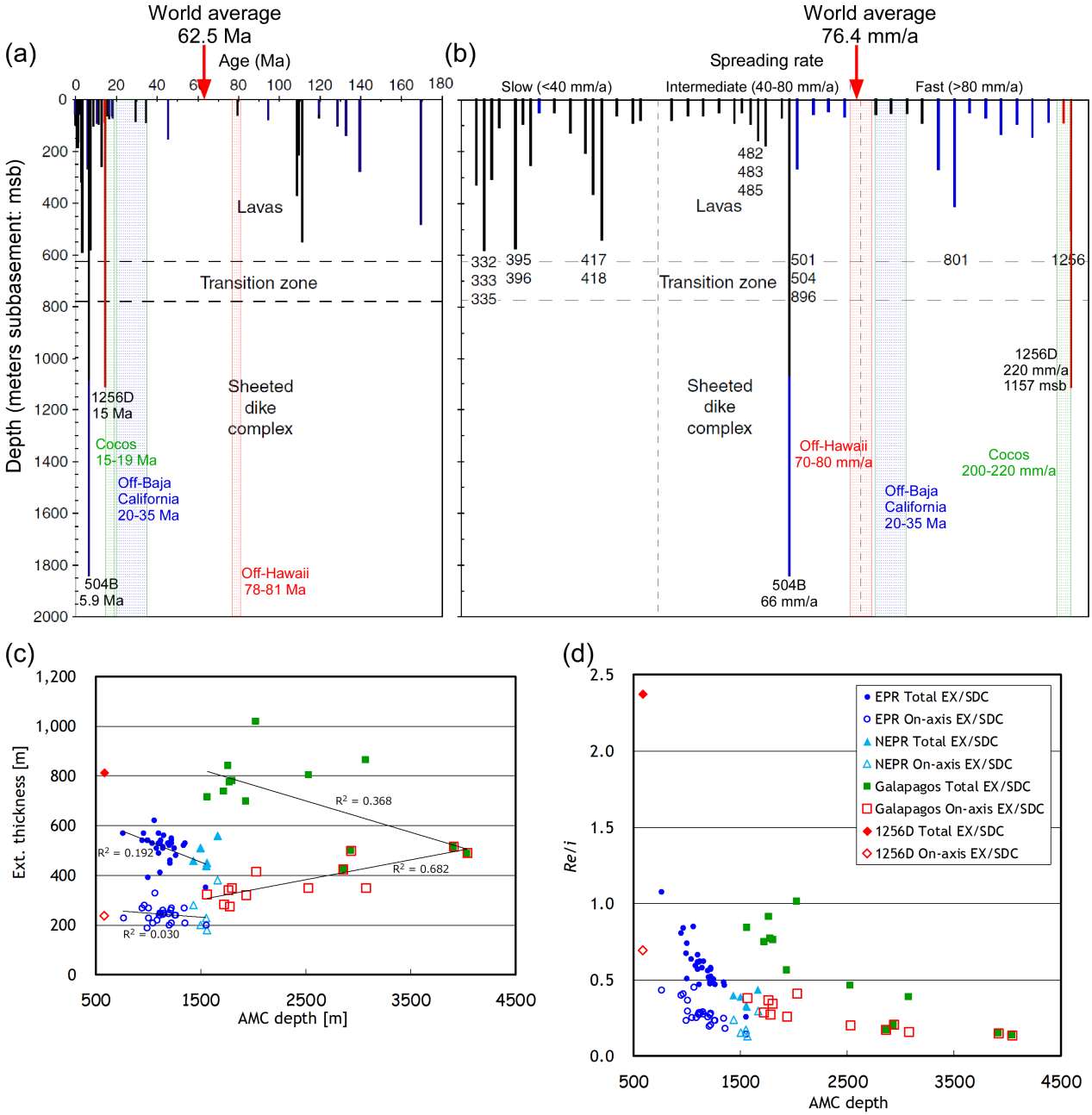
50 % of flows in the axial valleys are pillows. Consequently, the GSC is underlain by less dense pillows interbedded with fault breccias. The density structure of this crust is essentially the same as the 504B crust.

Likewise, the magmatically robust East Pacific Rise (EPR) shows a negative correlation of total extrusive thickness and AMC depth, while on-axis flow thickness remains constant (Hooft et al., 1996, 1997). Accordingly, the axial troughs do not develop, and the upper crust extends mainly by dikes intrusions. This is facilitated by the presence of dense extrusive rocks comprising more than 80 % sheet flows, considering the spreading rates of 11–14 cm/a, primarily the same as the 1256D crust.

How two types of upper crust architecture change from one type to the other is yet to be understood. If any critical threshold that distinguishes two crust types exists, it would reside in the crust with a spread rate between 7 cm/a and 10 cm/a. The off-Hawaii crust spread at 7–8 cm/a will provide a missing link that connects the two crust architectures and brings us thorough understanding of the seafloor spreading.

Keywords: Oceanfloor Drilling, MoHole, Off-Hawaii site, Upper crust architecture, Density structure, Plate spreading

©2019. Japan Geoscience Union. All Right Reserved.



Above: Ocean drill holes deeper than 50 m into the oceanic basement plotted against the basement age (a) and categorized on the basis of spreading rate that formed the basement crust (b). World average age and spreading rate are based on the 3.6 min grid data from EarthByte agegrid 2008 (Muller et al., 2008).
Below: Extrusive thickness (c) and Re/i (ratio of extrusive to intrusive thickness) (d) plotted against the AMC depth for the present GSC and EPR segments and the 15-Ma 1256D crust. Solid and open symbols are data based on total and on-axis extrusive thicknesses.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | B (Biogeosciences)：B-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 201A 2F

[B-CG06] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Shingo Kato(RIKEN), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yuki Morono(JAMSTEC), Masanori Kaneko(AIST/GSJ), Shingo Kato(RIKEN)

Earth and planetary science is currently capable of sampling from four frontiers: space, polar regions, deep ocean and deep underground for the study of the origin and evolution of life. Next generation sequencing technology of nucleic acids and nanotechnology-driven innovation of solid characterizations are very powerful to expand our understanding of many fields of earth and planetary sciences. It is also important for us to be aware of global warming and climate change that dramatically affect biodiversity, biological activities and elemental cycling. The aim of this session is to cross the border of science sections to explore the frontiers of earth and planetary science.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BCG06-01] Earth as an open system to the Universe, and five multi-layered spheres to produce a habitable planet

*Shigenori Maruyama[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[BCG06-02] Holocene Antarctic subglacial weathering and ice-sheet history reconstructed using the $^{10}Be/^{9}Be$ ratios of lake Maruwan Oike sediments

*Adam David Sproson[1], Yusuke Yokoyama[1,2], Yoshinori Takano[2], Yosuke Miyairi[1], Takahiro AZE[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Biogeochemistry, Japan Agency for Marine Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[BCG06-03] Chemical speciation and solubility of heavy elements (lead, zinc, copper, arsenic and cadmium) in contaminated soil from Kamegai mine tailing, Toyama, Japan

*Baasansuren Gankhurel[1], Keisuke Fukushi[2], Akitoshi Akehi[1], Yoshio Takahashi[3], Kazuo Kawasaki[4] (1.Graduate School of Natural Science and Technology, Kanazawa University, 2.Instutute of Nature and Environmental Technology, Kanazawa University, 3.Department of Earth and Planetary Science, The University of Tokyo, 4.Graduate School of Science and Engineering for Research, Toyama University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[BCG06-04] High-mass resolution molecular imaging of organic compounds on the Murchison meteorite.

★Invited Papers

*Minako Hashiguchi[1], Hiroshi Naraoka[1,2] (1.Research Center for Planetary Trace Organic Compounds, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BCG06-05] Fe(II) oxidation processes at the surface of bacterially colonized iron deposits

★Invited Papers

*Fumito Shiraishi[1], Kohei Nakao[1], Chizuru Takashima[2], Akihiro Kano[3], TAKAAKI ITAI[3] (1.Hiroshima University, 2.Saga University, 3.The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BCG06-06] Heme: The distribution and dynamics of a ubiquitous iron-tetrapyrrole molecule

*Yuta Isaji[1], Yoshinori Takano[1], Nanako O. Ogawa[1], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology)

Earth as an open system to the Universe, and five multi-layered spheres to produce a habitable planet

*Shigenori Maruyama[1]

1. Earth-Life Science Institute, Tokyo Institute of Technology

<Purpose>

To understand the Earth’s history including life, we need to treat the Earth as an open system within the Universe. Such an approach has not yet fully considered. Here, I demonstrate it for the first time.

<Method>

Utilizing data set derived from geological evidences that have been collected through systematic rock sampling from all the continents over 30 years, we consider the Earth system as five multi-layered spheres, 1) atmosphere-ocean, 2) biosphere, 3) crust and upper mantle inn the framework of plate tectonics, 4) lower mantle driven by plume and superplume, and 5) metallic core to cause magnetosphere which protect the life on the surface. And this Earth system is driven by the internal heat of the solid Earth and/or the solar energy for the surface. Mutual interaction between these five spheres produce the Earth’s history including life.

<Result>

The most important key factor to keep mutual interactions between spheres is the function of plate tectonics continuing over 4.4 Gyr, which has been maintaining the Earth system as the robust systematic and dynamic equilibria. Specifically, plate tectonics has circulated carbon between atmosphere-ocean, biosphere, and crust and upper mantle through carbon fixation within sediments to produce a habitable planet. Biosphere plays another significant role as a buffer of CO_2 to stabilize atmospheric temperature within habitable status (not to evolve into Venus-like planet). However, biosphere has been critically influenced by galaxy-galaxy collisions happened at 4.5-4.0 Ga (birth of Earth and Prokaryote), 2.5-2.2Ga (birth of Eukarya), 0.8-0.5 Ga (plants and metazoans) appeared in association with frequent mass extinctions.

<Discussion>

Based on the understanding of Earth’s system and its history, we are able to extend it to our future, and predict the Earth’s history including final event of disappearance of the Earth in 8 billion years. I propose the biggest 20 events of Earth’s history including future Earth.

Keywords: Earth system, Habitable planet, The biggest 20 Earth's events

©2019. Japan Geoscience Union. All Right Reserved.

Holocene Antarctic subglacial weathering and ice-sheet history reconstructed using the $^{10}Be/^{9}Be$ ratios of lake Maruwan Oike sediments

*Adam David Sproson[1], Yusuke Yokoyama[1,2], Yoshinori Takano[2], Yosuke Miyairi[1], Takahiro AZE[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Department of Biogeochemistry, Japan Agency for Marine Science and Technology

Glaciers play an important role in the climate system via freshwater storage and the transportation of various materials from the continents to the oceans. Enhanced discharge of the former during melting events can influence global sea-level, while enhanced silicate weathering resulting from the latter can drive a reduction in atmospheric CO_2. Although these processes are known to be important through geological time, temporal changes in chemical weathering intensity and meltwater flux for the East Antarctic Ice Sheet (EAIS) are not well understood. During the last deglaciation, the EAIS retreated significantly (*1, 2*), forming isolated basins via glacio-hydro-isostatic adjustment (GIA) related crustal uplift. Sediment accumulated in these lakes provide a unique record of subglacial weathering and ice-sheet history throughout deglaciations when global temperatures and pCO_2most notably rose.

Meteoric ^{10}Be is produced in the atmosphere by cosmic rays and delivered to the Earth and ocean surface via dust and precipitation. In Antarctica, these sources of ^{10}Be become locked up in ice sheets and are subsequently released to the continental shelf during periods of melting and freshwater discharge (*3*), where they adhere to suspended particles in the water column and subsequently accumulate on the basin floor (*4, 5*). Stable ^{9}Be is present in silicate rocks and is released during subglacial weathering (*5*), with little simultaneous release of ^{10}Be (*4*), and transported to the oceans via meltwater outflow. When Be is incorporated into the authigenic phase of marine sediments, the $^{10}Be/^{9}Be$ reflects that of the overlying water column (*6*), which in turn reflects the relative dominance of freshwater flux and/or subglacial weathering.

Here, we present authigenic $^{10}Be/^{9}Be$ ratios for a sedimentary core from Lake Maruwan Oike situated at the head of the Rundvåg glacier in the Lützow-Holm Bay area of East Antarctica. Sedimentary material from L. Maruwan Oike provides an ~6,000 year record of subglacial weathering and nutrient input from the nearby glacier (*7*). Authigenic $^{10}Be/^{9}Be$ records reflect variations in freshwater flux and subglacial weathering and indicate several periods of enhanced melting of the Rundvåg glacier. This study provides further constraints on EAIS fluctuations during the Holocene and offers an insight into the behaviour of beryllium in high-latitude subglacial-marine systems.

Reference

1. M. Yamane*et al.*, The last deglacial history of Lützow-Holm Bay, East Antarctica. *Journal of Quaternary Science* **26**, 3-6 (2011).
2. A. N. Mackintosh*et al.*, Retreat history of the East Antarctic Ice Sheet since the Last Glacial Maximum. *Quaternary Science Reviews* **100**, 10-30 (2014).
3. Q. Simon*et al.*, Authigenic 10Be/9Be ratios and 10Be-fluxes (230Thxs-normalized) in central Baffin Bay sediments during the last glacial cycle: Paleoenvironmental implications. *Quaternary Science Reviews* **140**, 142-162 (2016).
4. R. P. Scherer*et al.*, Pleistocene Collapse of the West Antarctic Ice Sheet. *Science* **281**, 82 (1998).

©2019. Japan Geoscience Union. All Right Reserved.

5. C. Sjunneskog, R. Scherer, A. Aldahan, G. Possnert, 10Be in glacial marine sediment of the Ross Sea, Antarctica, a potential tracer of depositional environment and sediment chronology. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* **259**, 576-583 (2007).
6. F. von Blanckenburg, J. Bouchez, River fluxes to the sea from the ocean's 10Be/9Be ratio. *Earth and Planetary Science Letters* **387**, 34-43 (2014).
7. Y. Takano, H. Kojima, E. Takeda, Y. Yokoyama, M. Fukui, Biogeochemistry and limnology in Antarctic subglacial weathering: molecular evidence of the linkage between subglacial silica input and primary producers in a perennially ice-covered lake. *Progress in Earth and Planetary Science* **2**, 8 (2015).

Keywords: Beryllium, Holocene, Antarctica, Weathering, Glacier

©2019. Japan Geoscience Union. All Right Reserved.

Chemical speciation and solubility of heavy elements (lead, zinc, copper, arsenic and cadmium) in contaminated soil from Kamegai mine tailing, Toyama, Japan

*Baasansuren Gankhurel[1], Keisuke Fukushi[2], Akitoshi Akehi[1], Yoshio Takahashi[3], Kazuo Kawasaki[4]

1. Graduate School of Natural Science and Technology, Kanazawa University, 2. Instutute of Nature and Environmental Technology, Kanazawa University, 3. Department of Earth and Planetary Science, The University of Tokyo, 4. Graduate School of Science and Engineering for Research, Toyama University

Heavy metals such as lead, zinc, copper, arsenic and cadmium are usually found in surface soils affected by mining or smelting activities, agricultural practices and industrial areas [1,2,3]. Hara et al., [4] showed that some heavy metals including lead, arsenic and cadmium in soil surrounding the mine tailing area in Toyama Prefecture, Japan has largely exceeded the environmental standards. The total amount of trace metals in soils is generally not sufficient to assess environmental impacts of metal contamination. Therefore, chemical forms and binding types of metals enables evaluation of their behavior and bioavailability in the soil environment.The objectives of the present study were to understand the chemical speciation of As, Zn, Cu, Pb and Cd from Kamegai mine tailing area by means of sequential extraction procedure combined with synchrotron based XAFS and electron microscope.

Thirty-two soil samples were analyzed, determining the chemical fractionation of Pb, Cd, As, Zn and Cu using by the five-step sequential extraction (SEP), X-ray absorption fine structure (XAFS), X- ray diffractometer (XRD) and scanning electron microscopy. The results of SEP showed that most of the Pb was associated with non-residual fractions, mainly in crystalline iron oxides (goethite). The Cd appeared mainly associated carbonate fraction in the roots of the dried plants in the soils. The XAFS spectra of the samples showed that Pb in the soil are adsorption forms with Fe-(hydr)oxides surface. Results of XAFS analysis showed Cd in the samples are $CdCO_3$, coprecipitated with $CaCO_3$. Zn, Cu and As appeared mainly associated with the amorphous and crystalline iron oxides. Heavy metals associated with carbonates, amorphous and crystalline iron oxides, thus being potentially more mobile to the environment if conditions were more acidic or reducing.

[1] Kaasalainen, M, and Markku Y. 2003. *Environmental Pollution*126(2): 225–33. [2] Nannoni et al. 2011. *Geoderma*161(1–2): 63–73. [3] Sterckeman et al. 2000. *Environmental pollution*107(3): 377–89. [4] Junko et al. 2014. 3(7): 193–96.

Keywords: soil, heavy metals, speciation

©2019. Japan Geoscience Union. All Right Reserved.

High-mass resolution molecular imaging of organic compounds on the Murchison meteorite.

*Minako Hashiguchi[1], Hiroshi Naraoka[1,2]

1. Research Center for Planetary Trace Organic Compounds, Kyushu University, 2. Department of Earth and Planetary Sciences, Kyushu University

Introduction: Primitive meteorites contain a wide variety of organic molecules. The CHO, CHNO, CHNOS and CHN species have been identified using high-resolution mass spectroscopy for the solvent extracts of carboneceous chondrites [1-3]. These organic compounds could be synthesized and evolved via interaction of fluid with minerals [3-5]. Therefore, spatial distribution of meteoritic organic compounds is important to reveal the organic-mineral association on the parent bodies. Recently, in-situ analysis of polar organic compounds on the meteorite surface was achieved by desorption electrospray ionization/high-resolution mass spectrometry (DESI/HRMS) [7]. In this study, we further performed the DESI-HRMS imaging on the Murchison meteorite to understand the relationship between spatial distribution of polar organic compounds and minerals.

Experimental: The fragment of the Murchison meteorite (CM2) (~ a few mm) obtained by chipping was embedded in indium (In). The DESI-HRMS imaging was performed using a DESI ion source (Omni Spray 2-D, Presolia) equipped with an Orbitrap mass spectrometer (Q-Exactive Plus, Thermo Scientific) with mass resolution of ~140,000 at *m/z* 200. Methanol (LC-MS grade) was sprayed on the sample surface with a 1 or 2 μl/min flow rate. The spatial resolution was approximately 100 μm. FESEM-EDS analysis was also carried out without coating and polishing after the DESI-HRMS imaging. The surface of the Murchison meteorite fragment embedded in indium was also extracted with MeOH, and the resulting solution was applied for HPLC-HRMS to obtain chemical structural information on the organic compounds.

Results and Discussion: Alkylated homologues of $C_nH_{2n-1}N_2^+$ (n = 7–9) and $C_nH_{2n}NO^+$ (n = 9–14) were detected on the sample surface by the DESI-HRMS imaging. HPLC/HRMS analysis of MeOH extracts from the sample surface after the DESI/HRMS imaging indicated that the $C_nH_{2n-1}N_2^+$ homologues correspond to alkylimidazole, and that a few structural isomers of the $C_nH_{2n}NO^+$ homologues were present in the sample.The alkylimidazoles and $C_nH_{2n}NO^+$ homologues displayed different spatial distributions in the Murchison fragment. Moreover, the distribution pattern of compounds also different among the same homologues. These results may be due to the separation of isomers by similar chromatographic effects, or different synthetic pathways. The alkylimidazoles and $C_nH_{2n}NO^+$ homologues are mainly distributed in the matrix region of the Murchison by mineralogical observations, which is consistent with previous reports. Altered minerals (e.g., Fe-oxide, Fe-sulfide, and carbonates) occurred in this region. However, no clear relationship was found between these minerals and the organic compounds detected by DESI/HRMS imaging. Although this result might be due to scale differences between the spatial resolution of DESI-HRMS imaging and the grain size in the matrix of the Murchison, our results would indicate that alkylimidazoles and the $C_nH_{2n}NO^+$ homologues in the Murchison fragment were mainly synthesized by different processes from hydrothermal alteration on the parent body.

References: [1] Schmitt-Kopplin P. *et al.* 2010. *PNAS*, 107:2763. [2] Yamashita Y. and Naraoka H. 2014. *Geochem. J*, 48: 519. [3] Naraoka et al. 2017. *ACS,* 1, 540–550. [5] Le Guillou C. and Brearley A. 2014. *GCA*, 131, 344-367. Ito M. *et al.* 2016, *Goldschmidt Conference*, 2016. #1297. [6] Takáts Z. *et al.* 2004. *Science*, 306: 471. [7] Naraoka H. and Hashiguchi M. 2018. Rapid Commun Mass Spectrom. 32:959.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Carbonaceous chondrite, Molecular imaging of organic compounds

©2019. Japan Geoscience Union. All Right Reserved.

Fe(II) oxidation processes at the surface of bacterially colonized iron deposits

*Fumito Shiraishi[1], Kohei Nakao[1], Chizuru Takashima[2], Akihiro Kano[3], TAKAAKI ITAI[3]

1. Hiroshima University, 2. Saga University, 3. The University of Tokyo

Fe(II) oxidation processes at the surfaces of bacterially colonized iron deposits are examined at three hot springs in Japan for which the chemical profiles of the pH, redox, and O_2 and Fe(II) concentrations at the water/deposit interface are measured via microelectrodes. The three hot springs share similar bulk chemistry with a weakly acidic pH of 5.7–6.3, a high iron concentration of 50–130 μM, and a high dissolved inorganic carbon concentration of 20–60 mM. At the Sambe and Shionoha hot springs where the bulk water O_2 concentration is ca. 80 μM, abiotic Fe(II) oxidation via autocatalysis prevails. At the Okuoku-hachikurou hot spring where the bulk water O_2 concentration is ca. 50 μM, autocatalytic Fe(II) oxidation is suppressed and biotic Fe(II) oxidation induced by cyanobacterial photosynthesis is effective. These observations indicate that an O_2 concentration of ca. 50 μM is the threshold of reversing the relative contribution of biotic and abiotic Fe(II) oxidation. Protons from Fe(II) oxidation are compensated by reactions among the dissolved inorganic carbon species, which sustain the pH condition and continuous Fe(II) oxidation at the deposit surface. The observations of this study provide implications for understanding the deposition of banded iron formations in the geological past.

©2019. Japan Geoscience Union. All Right Reserved.

Heme: The distribution and dynamics of a ubiquitous iron-tetrapyrrole molecule

*Yuta Isaji[1], Yoshinori Takano[1], Nanako O. Ogawa[1], Naohiko Ohkouchi[1]

1. Japan Agency for Marine-Earth Science and Technology

Hemes are Fe(II)-tetrapyrrole complexes that catalyze various electron transfer and redox reactions. They are essential for biological systems, and are possessed by all life forms. Because heme-iron represents as much as 40% of the iron pool in phytoplankton (Gledhill, 2007), hemes in the biomass likely comprise a major fraction in the bioavailable-iron pool which limits primary productivity in over 30% of the world oceans (Moore et al., 2013). They are also expected to be found in the sediments, either as allochthonous compounds deposited from the water column or synthesized in situ by the benthic and subsurface microorganisms. It is noteworthy that etioporphyrin III preserved in various sedimentary rocks, which is supposedly derived from heme, has a highly distinct carbon and nitrogen isotopic compositions ($\delta^{13}C$, $\delta^{15}N$) with respect to other chlorophyll-derived porphyrins in Cretaceous black shales (Ohkouchi et al., unpub. results). As such, hemes are ubiquitous in any environment where life exists, but little is known on their distribution and dynamics in natural environments.

Here, we established a new analytical method to quantify, isolate, and purify heme *b*, a major homolog of hemes, from various environmental samples. Detection of picomole levels of heme *b* is achieved with a photodiode-array detector connected to HPLC, which covers the heme *b* concentration range in particulate (> 0.7 μm; 0.15 nmol L^{-1}) and dissolved organic matter (> 3000 Da; ~0.006 nmol L^{-1}) in the coastal seawater of Tokyo Bay, as well as that in the surface sediments of the Japan Sea (~0.03 μg g^{-1} dry weight). Importantly, concentration of heme *b* in the dissolved phase was contrastingly low with respect to that in the particulate phase of the coastal seawater, which imply that hemes may constitute a major fraction of the regenerated iron in the ocean. The $\delta^{13}C$ and $\delta^{15}N$ values of heme *b* isolated and purified from various environmental samples are determined with our modified EA/IRMS (Ogawa et al., 2010). These isotopic values will be compared with those of chlorophylls and amino acids, which will reveal the sources of hemes in natural environments and the isotopic fractionation associated with their biosynthesis. Our new analytical approach will provide first detailed insights into the ubiquitous iron-tetrapyrrole molecule playing an essential role in biogeochemical cycle.

Keywords: Heme, Iron cycle, Carbon and nitrogen isotopes, HPLC

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | B (Biogeosciences)：B-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 201A 2F

[B-CG06] Earth and Planetary Science Frontiers for Life and Global Environment

convener:Yoshinori Takano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Yohey Suzuki(Graduate School of Science, The University of Tokyo), Shingo Kato(RIKEN), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yoshinori Takano(JAMSTEC), Keisuke Fukushi, Yohey Suzuki(Univ. Tokyo)

Earth and planetary science is currently capable of sampling from four frontiers: space, polar regions, deep ocean and deep underground for the study of the origin and evolution of life. Next generation sequencing technology of nucleic acids and nanotechnology-driven innovation of solid characterizations are very powerful to expand our understanding of many fields of earth and planetary sciences. It is also important for us to be aware of global warming and climate change that dramatically affect biodiversity, biological activities and elemental cycling. The aim of this session is to cross the border of science sections to explore the frontiers of earth and planetary science.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BCG06-07] Diversity and evolution of biosynthetic enzymes for chlorophyll pigments

★Invited Papers

*Yusuke Tsukatani[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

11:00 AM - 11:20 AM JST | 2:00 AM - 2:20 AM UTC

[BCG06-08] **Microdolomites are not MDACs: microbially-derived carbon source for microcrystalline dolomite found within massive gas hydrates and implications for the shallow marine carbon cycle**

★Invited Papers

*Glen Snyder[1], Ryo Matsumoto[1], Naizhong Zhang[1], Yoshihiro Kakizaki[2], Yohey Suzuki[2], Yuji Sano[3], Naoto Takahata[3], Kentaro Tanaka[3], Takumi Imajo[5], Stephen Bowden[4] (1.Gas Hydrate Research Laboratory, Meiji University, 2.University of Tokyo, 3.AORI, University of Tokyo, 4.University of Aberdeen, Scotland, 5.Tokyo University of Marine Science and Technology)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[BCG06-09] **Discriminative biogeochemical signatures of methanotrophs inhabiting different chemosynthetic fields in an active mud volcano of the Canadian Beaufort Sea**

*Dong-Hun Lee[1], Yung Mi Lee[2], Jung-Hyun Kim[2], Young Keun Jin[2], Charles Paull[3], Helge Niemann[4,5], Ji-Hoon Kim[6], Kyung-Hoon Shin[1] (1.Hanyang Univ., 2.KOPRI, 3.MBARI, 4.NIOZ and Utrecht Univ., 5.CAGE, UiT , 6.KIGAM)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[BCG06-10] Determination of the absolute stereochemistry of the hydroxyl group in 2-hydroxyarchaeol, the main lipid core of methanogenic and methanotrophic archaea

*Noriaki YAMAUCHI[1], Masanori Kaneko[2] (1.Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, 2.National Institute of Advanced Industrial Science and Technology)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[BCG06-11] Mineral-Microbe interaction – Identification of extracellular electron transfer mechanisms by using MetaOmics approach

★Invited Papers

*Shunichi Ishii[1], Shino Suzuki[1], Kenneth H Nealson[2] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.University of Southern California)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

[BCG06-12] Interactive discussion with the invited speakers

*Yoshinori Takano[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

Diversity and evolution of biosynthetic enzymes for chlorophyll pigments

*Yusuke Tsukatani[1]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Photosynthesis is the process converting light energy to chemical potential energy. In phototrophic organisms, chlorophyll (Chl) and bacteriochlorophyll (BChl) pigments are essential for harvesting light energy, migrating excited energy, and transferring electrons. How photosynthesis is emerged on early earth is enigmatic, but pigments are theoretically required first in the ancient phototrophs to absorb light and start photo-induced reactions. A classic question on the evolution of pigment biosynthesis is whether Chl was evolved first or BChl first? Chl molecules mainly absorb visible light wavelength, whereas BChls absorb longer wavelength including near-infrared light region. Therefore, to know which pigment is first evolved is important to know atmospheric environment on early earth. The steps diverging to Chl or BChl in pigment biosynthetic pathways are catalyzed by enzymes similar to nitrogenase. One of the nitrogenase-like enzymes is chlorophyllide oxidoreductase which also catalyzes branching steps toward BChl-*a* and BChl-*b*. BChl-*b* absorbs longest light wavelength among naturally occurring pigments. In my talk, pigment structures and their diversified biosynthetic pathways that we recently revealed will be introduced and experimental approach to solve the evolution of chlorophyllous pigments will be presented.

Keywords: Evolution of photosynthesis, Pigment, Bacteriochlorophyll, Chlorophyll

©2019. Japan Geoscience Union. All Right Reserved.

Microdolomites are not MDACs: microbially-derived carbon source for microcrystalline dolomite found within massive gas hydrates and implications for the shallow marine carbon cycle

*Glen Snyder[1], Ryo Matsumoto[1], Naizhong Zhang[1], Yoshihiro Kakizaki[2], Yohey Suzuki[2], Yuji Sano[3], Naoto Takahata[3], Kentaro Tanaka[3], Takumi Imajo[5], Stephen Bowden[4]

1. Gas Hydrate Research Laboratory, Meiji University, 2. University of Tokyo, 3. AORI, University of Tokyo, 4. University of Aberdeen, Scotland, 5. Tokyo University of Marine Science and Technology

Methane derived authigenic carbonates (MDACs) are commonly found associated with both active and remnant submarine seeps and, under favorable conditions of pressure and temperature, are also found in close contact with marine methane hydrate. Recently, we have discovered microdolomitic aggregates inside of massive Japan Sea gas hydrates. These are fundamentally different, both in chemistry, stable isotopic composition and growth habit to the MDACs encountered outside of the hydrates. Phylogenetic analysis of microbial DNA within the dolomites reveals primarily Bacteriodetes, bacteria whose principal energy source is the degradation of complex macromolecules such as oils. Actual analysis of the oils found inside of the Sea of Japan gas hydrate confirms that they are biodegraded during burial. Previous investigations of MDACs have focused on ANME methane oxidizers (ANME) and sulfate reducing bacteria (SRB) as the primary drivers for MDAC precipitation in shallow sediment. The discovery of microbial dolomites inside saline gas-hydrate inclusions opens up a number of research avenues and applications such as: Mars-analogue studies, microbial remediation of marine oil-spills, and investigations into the role of shallow marine microbes in the conversion of organic carbon into dissolved inorganic carbon. This study was conducted under the commission from AIST as part of the methane hydrate research project funded by the Ministry of Economy, Trade and Industry, Japan. Ongoing work is being carried out thanks to a Grant-in-aid provided by the Japan Society for Promotion of Science and the Japanese Ministry of Education, Culture, Sports, and Technology (Kaken Project # 17K05712).

Keywords: Gas Hydrate, Sea of Japan, Dolomite, Biomineralization

©2019. Japan Geoscience Union. All Right Reserved.

Discriminative biogeochemical signatures of methanotrophs inhabiting different chemosynthetic fields in an active mud volcano of the Canadian Beaufort Sea

*Dong-Hun Lee[1], Yung Mi Lee[2], Jung-Hyun Kim[2], Young Keun Jin[2], Charles Paull[3], Helge Niemann[4,5], Ji-Hoon Kim[6], Kyung-Hoon Shin[1]

1. Hanyang Univ., 2. KOPRI, 3. MBARI, 4. NIOZ and Utrecht Univ., 5. CAGE, UiT , 6. KIGAM

In this study, we investigated vertical variations in methanotrophic communities in assosication with varying methane fluxes within a mud volcano (420 m water depth, MV420) of the Canadian Beaufort Sea, by analysing geochemical properties, microbial lipids, and nucleic acid signatures. Three push cores were collected from visually discriminative chemosynthetic fields that were (i) bare of organisms (BO) to the naked eye, (ii) covered with bacterial mats (BM), or (iii) siboglinid tubeworms (ST), by using a remotely operated vehicle (ROV). The methane fluxes were highest at the sites of BO (0.06 mmol cm^{-2} y^{-1}) and BM (0.04 mmol cm^{-2} y^{-1}) and substantially lower at the ST site (0.01 mmol cm^{-2} y^{-1}). All MV420 sites showed the presence of aerobic methane oxidation (MOx)- and anaerobic methane oxidation (AOM)-related lipid biomarkers (4-methyl sterols and *sn*-2-hydroxyarchaeol, respectively), which were distinctly different in comparison to the reference site where these compounds could not be detected. Our lipid biomarker results are furthermore in good agreement with 16S rRNA analyses, which revealed the presence of MOx-related bacteria (*Methlyococcales*) and AOM-related archaea (ANME-2 and ANME-3 groups) at the MV420 sites. The 4-methyl sterols derived from *Methlyococcales* were predominant in the surface layer at the BM site with a moderate methane flux, while their occurrence was limited at the BO and ST sites. Notably, the abundances of AOM-related lipid biomarkers were minor at the BO site where the methane flux was highest. However, ANME-3 and sulfate reducing bacteria (*Desulfobacteraceae* and *Desulfobulbaceae*) were abundant in the downcore sediments at the BM site. On the other hand, the abundances of the ^{13}C-depleted *sn*-2-hydroxyarchaeol potentially derived from ANME-2 and/or ANME-3 groups was predominant at the ST site, indicating their co-occurrence under a lower methane flux. Accordingly, our results suggest that a niche diversification within this MV system has shaped distinct methanotrophic communities due to the availability of electron acceptors in association with varying degree of methane fluxes and bioirrigation activity.

Keywords: Arctic, Mud volcano, chemosynthetic organism, Anaerobic methane oxidation, Aerobic methane oxidation, Methanotroph

©2019. Japan Geoscience Union. All Right Reserved.

Determination of the absolute stereochemistry of the hydroxyl group in 2-hydroxyarchaeol, the main lipid core of methanogenic and methanotrophic archaea

*Noriaki YAMAUCHI[1], Masanori Kaneko[2]

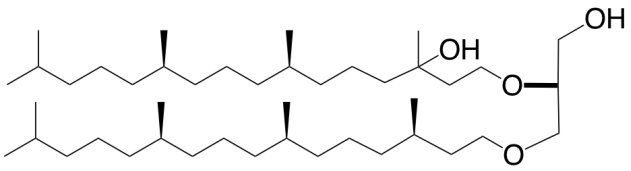
1. Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, 2. National Institute of Advanced Industrial Science and Technology

One of the major characteristics of archaea is the lipid core which consist of saturated isoprenoid chain and glycerol with ether bond formation. Furthermore, main lipid core of methanogenic and methanotrophic archaea is hydroxyarchaeol. The saturated isoprenoid is altered to the isoprenoid which has one hydroxyl group in the C-3 of the isoprenoid. Two regioisomeric structures, *sn*-2- and *sn* -3-hydroxyarchaeol (**1**and **2**), are existed depending on the position of the hydroxylated isoprenoid bonding to glycerol.. The distribution of the two isomer is species-dependent [1].
2-Hydroxyarchaeol (**1**) is an important biomarker indicating accumulation of methane hydrate under the seafloor, anoxic oxidation of methane, methane formation at the lake, marsh, and digestive tract of ruminant. Structure determination [1] and analysis of hydroxyarchaeol from the field samples were performed by many researchers [2][3][4], however, the absolute stereochemistry of the hydroxyl group in the ether chain, the most characteristic feature of the molecule had not been determined so far.
The previous study of the author (NY), the synthetic preparation of 2-hydroxyarchaeol equivalent by “racemic” hydroxyl groups revealed that the “racemic” 2-hydroxyarchaeols behave as two equal amounts of the compounds because of the stereochemistry of the hydroxyl group. The result was different from several analysis of field samples which descrived the 2-hydroxylarchaeol as a single compound [5].
For the determination of the stereochemistry of the hydroxyl group of 2-hydroxyarchaeol, asymmetric synthesis of the hydroxyl-group containing ether chain part was conducted and the two stereoisomers of 2-hydroxyarchaol were synthesized.
The stereochemistry of this hydroxyl group was derived from the Katsuki-Shapless epoxidation of phytol. The two isomers were regioselectivity converted to the 2-hydroxyarchaol. The analyses of “racemic” 2-hydroxylarchaeol, two isomers of synthetic 2-hydroxyarchaeol stereoisomer (**3** and **4**), and 2-hydroxyarchaeol from the lipid of *Methanosarcina barkeri* revealed the absolute stereochemistry of the aforementioned hydroxy group is 3*R* (compound **3**). The comparison of the ^{13}C NMR of synthetic 2-hydroxyarchaeol stereoisomer (**3** and **4**), and 2-hydroxyarchaeol from the methanogen culture showed slight difference because of the stereochemistry of methyl group of saturated hydrocarbon of the synthetic isomers. This result may suggest the stereochemistry of methyl group is influenced at the nature of hydroxyarchaeol-containing lipid.

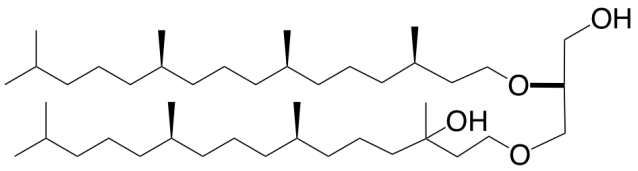
[1] Sprott et al.,J Biol Chem(1990) 265: 13735.
[2] Hinrichs et al., Nature (1999) 398:802.
[3] Blumenberg et al., Science (2004) 101, 11111.
[4] Stadnitskaia et al., Org Geochem (2008) 39:1007.
[5] Yamauchi Res Org Geochem (2014) 30:33.

Keywords: methanogenic archaea, methanotrophic archaea, archaeol, structural determination

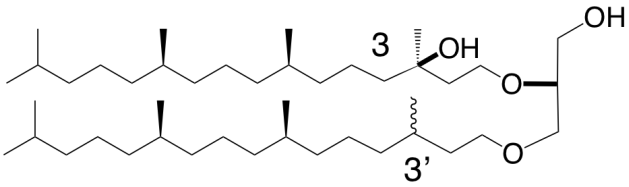
©2019. Japan Geoscience Union. All Right Reserved.



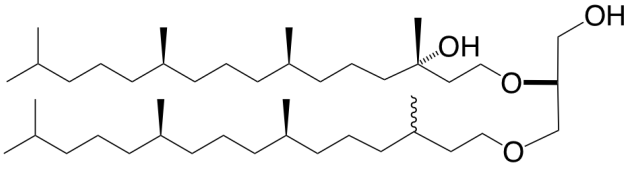
1



2



3



4

©2019. Japan Geoscience Union. All Right Reserved.

Mineral-Microbe interaction –Identification of extracellular electron transfer mechanisms by using MetaOmics approach

*Shunichi Ishii[1], Shino Suzuki[1], Kenneth H Nealson[2]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2. University of Southern California

Microbial reduction of solid minerals such as iron-oxides and manganese-oxides is known to occur as a result of microbial extracellular electron transfer (EET). These electron transfer activities coupled with the oxidation of organic carbon or hydrogen are considered to play important roles within complex microbial communities in soil, sediment, and the deep subsurface environments. The surface redox potentials of solid-phase oxide minerals are known to be highly variable because of variations in the crystal structure, pH, salinity, and levels of hydration, posing major challenges for EET-capable microbes to adapt in the habitats. In fact, the *in situ* redox potentials of solid-state electron acceptors have been regarded as significant geochemical variables linked to the regulation of functional genes in the EET-capable microbes. However, mechanisms that the microbes use to perform respiration of insoluble metal-oxide minerals showing different surface redox potentials are complex and are not yet well understood.

Here, we used bioelectrochemical systems to systematically evaluate the effects of surface redox potentials (e.g. +100 mV, −50 mV, −200 mV vs SHE) on EET-active microbial community development and the overall electron transfer rates. The results clearly indicate that faster biocatalytic rates were observed under electropositive electrode surface potentials than the electronegative potentials. Temporal 16S rRNA-based microbial community analyses showed that *Geobacter* phylotypes were highly diverse and apparently dependent on the surface potentials. The well-known dissimilatory metal-reducing microbes affiliated with *Geobacter metallireducens* clade were associated with lower surface potentials and less current generation, whereas *Geobacter* subsurface clades were associated with higher surface potentials and greater current generation. These results suggest that surface potentials provide a strong selective pressure, at the species and strain level, for solid mineral respirators throughout the EET-active community development.

Next, we show metabolic and transcriptional responses of the EET-active microbial communities established on the three different poised electrodes to changes in the surface redox potentials. Combination of genome-centric stimulus-induced metatranscriptomics and metabolic pathway investigation revealed that nine *Geobacter* / *Pelobacter* microbes performed EET activity differently according to their preferable surface potentials and substrates. While the *Geobacter* / *Pelobacter* microbes coded numerous numbers of multi-heme *c*-type cytochromes and conductive e-pili, wide variations in gene expression were seen in response to altering surrounding substrates and surface potentials, accelerating EET via poised electrode or limiting EET via an open circuit system. These flexible responses suggest that a wide variety of EET-active microbes utilizing diverse EET mechanisms may work together to provide such EET-active communities with an impressive ability to handle major changes in surface potential and carbon source availability.

Conclusively, these results presented here offer a new perspective on the complexity of the EET-active members in the microbial communities that were adapted to the different surface redox conditions, and some initial insights into how they may regulate community function and provide adaptability to the different minerals on the earth. Overall, these results have opened a door toward unraveling the diverse microbial life within the various geological settings especially in the mineral-rich subsurface environments.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Metatranscriptomics, Electromicrobiology, Redox potential

©2019. Japan Geoscience Union. All Right Reserved.

Interactive discussion with the invited speakers

*Yoshinori Takano[1]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Time for interactive discussion with the invited speakers.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 101 1F

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

convener:Mitsuteru Sato(Department of Cosmoscience, Hokkaido University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Hisayuki Kubota(Hokkaido University), Kozo Yamashita(Ashikaga University, Department of Engineering.), Chairperson:Mitsuteru Sato(Faculty of Science, Hokkaido University), Kozo Yamashita(Department of Technology, Ashikaga Institute of Technology)

In order to predict the intensity development of severe weather, lightning and thunderstorm are markers of severe weather, often accompanied by precipitation, hail and strong winds that can create significant natural hazards, especially in disaster-prone area. Lightning is also a strong indicator of convection, and it becomes a key parameter to predict the intensity development of tropical cyclones (typhoons and hurricanes). As the climate warms in the first decades of the 21st century, the intensity and frequency of thunderstorms is projected to increase. The need for detecting and monitoring the development of thunderstorms and lightning activities on global, local, and regional scales is therefore clear and urgent.
This session seeks topics presenting new technologies to monitor thunderstorm and severe weather activities. In addition, observational and theoretical contributions on thunderstorm microphysics and dynamics, convective systems and tropical storms are welcome. Present patterns and distributions of lightning and extreme weather events derived from the ground-based networks and satellites, as well as forecasts of future trends, are also of interest. Lightning detecting and monitoring system performance and validation, and early-warning schemes are requested, either in operational or planning phase. The session will also highlight regional and global lightning and atmospheric electricity networks and invite contributions on technological innovations in this field.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS05-01] Quasi real-time observation of typhoon and thunderstorms by the system of micro-satellites and ground-based lightning sensors

*Yukihiro Takahashi[4,1], Mitsuteru Sato[1,4], Hisayuki Kubota[4], Kozo Yamashita[2], Tetsuro Ishida[4], Ellison Caparas Castro[3], Purwadi Purwadi[1], Kazuhisa Tsuboki[5], Hiroyuki Yamada[6], Taro Shinoda[5], Loren Joy De Vera Estrebillo[1], Doreena Karmina Abril Pulutan[1] (1.Graduate School of Science, Hokkaido University, 2.Department of Engineering, Ashikaga University, 3.University of the Philippines, Diliman, 4.Faculty of Science, Hokkaido University, 5.Institute for Space-Earth Environmental Research (ISEE), Nagoya University, 6.University of the Ryukyus)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS05-02] Towards the Implementation of the Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project

★Invited Papers

*Glenn Vincent C. Lopez[1] (1.Advanced Science and Technology Institute)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS05-03] Airborne observation of Super Typhoon Trami in 2018 for understanding the intensity of tropical cyclone in the Philippine Sea

★Invited Papers

*Hisayuki Kubota[1], Kazuhisa Tsuboki[2], Hiroyuki Yamada[3], Yukihiro Takahashi[1], Taro Shinoda[2], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Kosuke Ito[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Mitsuteru Sato[1] (1.Hokkaido University, 2.Nagoya University, 3.University of the Ryukyus, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Meteorological Research Institute, 6.Meisei Electronic)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS05-04] Relation between Lightning and Typhoon Activities (Typhoon LAN) in the Western Pacific Region

*Mitsuteru Sato[1], Yukihiro Takahashi[1], Hisayuki Kubota[1], Kozo Yamashita[2], Jun-Ichi Hamada[3], Joel J. Marciano[4] (1.Department of Cosmoscience, Hokkaido University, 2.Department of Engineering, Ashikaga University, 3.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 4.ASTI, DOST)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS05-05] Infrasound multi-site observation of thunders 3: preparation process for SATREPS

★Invited Papers

*Masa-yuki Yamamoto[1] (1.Department of systems engineering, Kochi University of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS05-06] Data Acquisition System for an Infrasound Network for Thunderstorm Monitoring

*Doreena Karmina Abril Pulutan[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Hisayuki Kubota[1], Kozo Yamashita[2], Masa-yuki Yamamoto[3] (1.Department of Cosmosciences, Hokkaido University, 2.Department of Engineering, Ashikaga University, 3.Department of Systems Engineering, Kochi University of Technology)

Quasi real-time observation of typhoon and thunderstorms by the system of micro-satellites and ground-based lightning sensors

*Yukihiro Takahashi[4,1], Mitsuteru Sato[1,4], Hisayuki Kubota[4], Kozo Yamashita[2], Tetsuro Ishida[4], Ellison Caparas Castro[3], Purwadi Purwadi[1], Kazuhisa Tsuboki[5], Hiroyuki Yamada[6], Taro Shinoda[5], Loren Joy De Vera Estrebillo[1], Doreena Karmina Abril Pulutan[1]

1. Graduate School of Science, Hokkaido University, 2. Department of Engineering, Ashikaga University, 3. University of the Philippines, Diliman, 4. Faculty of Science, Hokkaido University, 5. Institute for Space-Earth Environmental Research (ISEE), Nagoya University, 6. University of the Ryukyus

We are conducting a SATREPS project “ULAT” and e-ASIA project for the development of extreme weather, including typhoon and individual thunderstorm, monitoring and alert system in the Philippines in 2017-2021 under international cooperation among Japan, Philippines, Indonesia and other SE-Asian countries supported by JST, JICA, PHL-Microsat and other funds. It is well known that intensification of lightning activity is precursor of typhoon growth as well as an indicator of individual thunderstorm activity. In these projects, we apply two new technologies, that is, the lightning activity estimated by the ground-based lightning networks with 12 sites for VLF radio wave measurement in nation-wide of Philippines and with 50 sites for electrostatic field measurement in Metro Manila together with infrasound sensor and automated weather station, and the 3 dimensional capturing of thunderstorms by the on-demand operation of 50-kg micro-satellites, including the Philippine-developed DIWATA-1 and 2, RISESAT, etc. Also few more lightning stations installed in Indonesia and Japan are used. We plan to establish a new methodology to obtain very detail semi-real time information of typhoon and thunderstorm activities that cannot be achieved only with conventional observational equipment. Based on these new observations together with advanced radar measurements and drop/radio sondes campaigns, we will try to construct the cutting-edge observation system to monitor the development of typhoons and thunderstorms, which may greatly contribute to the prediction of disasters and the public alerting system.

By the end of March 2017 we started the test observation for lightning at Quezon city, Philippines, Palau and Guam, forming the network for typhoons. We also succeeded in making 3-D cloud structure with telescope and wide angle spectral camera onboard DIWATA-1, achieving high resolution of ten to several meters. Now we are establishing the real-time target pointing operation with micro-satellites based on the last-minute lightning data measured by ground networks. Adding to DIWATA-1, three more our satellites, namely, RISESAT, MicroDragon and DIWATA-2 with advanced cameras will be used in 2018-2019. In September 2018, drop sonde campaign using aircraft in the eastside of Philippines was carried out under collaboration with Nagoya University team. Here we introduce the latest results of 3-D cloud modeling using images taken by satellite and on the ground together with preliminary lightning analysis, adding to the outline of the project.

Keywords: lightning, micro-satellite, typhoon, thunderstorm

©2019. Japan Geoscience Union. All Right Reserved.

Towards the Implementation of the Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project

*Glenn Vincent C. Lopez[1]

1. Advanced Science and Technology Institute

Monitoring and understanding thunderstorms are key components of mitigating the effects of torrential rainfall and typhoons. The Philippines, where year-round numerous thunderstorms are experienced, the integration of lightning data has the potential to provide short term forecasts of thunderstorms, further meteorological studies, and supplement disaster risk response strategies.

This presents the activities and updates on the Understanding Lightning and Thunderstorm for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project. The ULAT Project aims to deploy a highly dense lightning detection network scattered throughout Metro Manila to gather, analyze, and archive lightning data in order to provide thunderstorm “now-casting” and supplement weather-related research and disaster response strategies.

To enable the study of the correlation between lightning activity and localized severe weather disturbances (such as thunderstorms), the Japan International Cooperation Agency (JICA) and Hokkaido University through the Science and Technology Research Partnership for Sustainable Development (SATREPS) Program has partnered with the Department of Science and Technology Institute through the Advanced Science and Technology Institute to develop local expertise and build relevant lighting monitoring infrastructure in the Philippines.

This presents the activities and updates on the Understanding Lightning and Thunderstorm for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project. The ULAT Project is aimed at the following: a) establishment of a dense network of lightning and weather devices in Metro Manila and nearby municipalities to a) establish of a dense network of lightning and weather devices in the Philippines in order to provide thunderstorm “now-casting” and supplement weather-related research and disaster response studies and strategies; b) establishment of a ground receiving station for direct reception of satellite imagery and utilizing existing ground receiving facilities to develop effective observation methods by comparing to compare 3D structures of thunderclouds from satellite images with lightning/precipitation data; c) establishment of a methodology for short term forecasts; and d) development of software for sharing information on short term forecast weather to concerned agencies.

To further meet the goals of the project, there are challenges during the implementation of the project activities that needs to be addressed in the areas of equipment security, public safety, partnership agreements, site identification and selection, logistics, process, etc. The encountered challenges, alongside with their corresponding solutions, recommendations, next steps and other plans relevant to the project will be also discussed during the meeting.

Keywords: Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project, Advanced Science and Technology and Institute (ASTI)

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Airborne observation of Super Typhoon Trami in 2018 for understanding the intensity of tropical cyclone in the Philippine Sea

*Hisayuki Kubota[1], Kazuhisa Tsuboki[2], Hiroyuki Yamada[3], Yukihiro Takahashi[1], Taro Shinoda[2], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Kosuke Ito[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Mitsuteru Sato[1]

1. Hokkaido University, 2. Nagoya University, 3. University of the Ryukyus, 4. National Research Institute for Earth Science and Disaster Resilience, 5. Meteorological Research Institute, 6. Meisei Electronic

Airborne observation of tropical cyclone (TC) had been conducted until 1987 over the western north Pacific region to measure the TC intensity directly. After that TC intensity was estimated by Dvorak technique using satellite data. Here we conducted dropsonde observation by the aircraft in 2018 under the two projects of T-PARCII (Tropical Cyclone-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts) and ULAT (Understanding Lightning and Thunderstorm) of SATREPS (Science and Technology Research Partnership for Sustainable Development) in the Philippines and penetrated the eye of Super Typhoon Trami during Sep. 25 to 28. TC Trami reached its mature stage when we observed on Sep. 25. The structure of sharp eyewall and warm core in the eye were observed. On the other hand, the intensity of TC was weakened when we observed on the following day. We need to capture the signal of intensification and decay of TC by combining multiple observations for understanding the structure for a short term forecast of tropical cyclone intensity.

Keywords: Tropical cyclone, Airborne observation, Dropsonde observation

©2019. Japan Geoscience Union. All Right Reserved.

Relation between Lightning and Typhoon Activities (Typhoon LAN) in the Western Pacific Region

*Mitsuteru Sato[1], Yukihiro Takahashi[1], Hisayuki Kubota[1], Kozo Yamashita[2], Jun-Ichi Hamada[3], Joel J. Marciano[4]

1. Department of Cosmoscience, Hokkaido University, 2. Department of Engineering, Ashikaga University, 3. Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 4. ASTI, DOST

Recent studies revealed that there is a close relation between the lightning activity and the tropical cyclone intensity, such as the maximum wind velocity and the minimum surface pressure. As many countries in the western Pacific region suffer from the attack of many tropical cyclones (typhoons) and related severe weather events, they have a strong demand to predict the intensity development of these phenomena by means of a cost-effective way. Thus, we started installing the new lightning and weather observation system, named as V-POTEKA, at Guam, Palau, and Manila in the Philippines since September 2017. The lightning observation system consists of a VLF receiver having the sensitivity in the frequency range of 1-5 kHz, an automatic data-processing unit, solar panels, and batteries. Lightning-excited pulse signals detected by the VLF receiver are automatically analyzed by the data-processing unit, and only the extracted information of the trigger time and the pulse amplitude is transmitted to the data server via the 3G data communications. From the V-POTEKA data analysis, we confirmed that there is clear relation between the lightning occurrence number in the typhoon and the maximum wind speed of Typhoon LAN, which is the category-1 weak typhoon. There is ~12-18 h time difference between the peak lightning occurrence number and peak typhoon intensity. At the presentation, we will show the results derived from these lightning observation systems and will present the relation between lightning and typhoon activities more in detail.

Keywords: lightning activity, typhoon, intensity prediction

©2019. Japan Geoscience Union. All Right Reserved.

Infrasound multi-site observation of thunders 3: preparation process for SATREPS

*Masa-yuki Yamamoto[1]

1. Department of systems engineering, Kochi University of Technology

Infrasound, low-frequency sound of 20 Hz or less, is considered as one of the remote-sensing method of lightning/thunders. Sensor network to be deployed for a SATREPS project, Philippine, is planned in Manila region in early 2019. Here, we will deploy two types of infrasound sensors. Small but impulsive pressure changes caused by the rapid expansion of the heated plasma along the path of lightning strikes can be detected by infrasound sensors with higher sensitivity range of 1 mPa. Thus, we will use multiple film type (DC type) infrasound sensor for low frequency measurements. But for the thunder infrasound signals, lower-cost microphone type (AC type) sensors can be applied for measurements. Thus, we will mainly use many microphone type infrasound sensors in Metro Manila region.
For calibrating the both sensors, in order to evaluate precise pressure level as well as detectable frequency range, we used a chamber with a pushing/pulling mechanism on it. The infrasound multi-site observation can reveal the lightning activities as close as 100 m scale when the infrasound sensors can be installed with a mesh of 10 km scale or shorter by using the speed of sound as a precise remote-sensing scale. Recently, we also checked capability of remote-sensing in Fukui area and Kanazawa area by using real thunder signals with some other methods to compare.
In this talk, we will introduce a possibility of infrasonic remote-sensing and its calibration phase, in order to realize future disaster-mitigation studies.

Keywords: Infrasound, Calibration, Remote sensing

©2019. Japan Geoscience Union. All Right Reserved.

Data Acquisition System for an Infrasound Network for Thunderstorm Monitoring

*Doreena Karmina Abril Pulutan[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Hisayuki Kubota[1], Kozo Yamashita[2], Masa-yuki Yamamoto[3]

1. Department of Cosmosciences, Hokkaido University, 2. Department of Engineering, Ashikaga University, 3. Department of Systems Engineering, Kochi University of Technology

Inside a thunderstorm, an updraft pushes ice crystals with positive charge to the top, while a downdraft pushes hailstones with negative charge to the bottom. This charge separation results in lightning. While the electric charge and peak current in lightning events have been extensively studied, they do not indicate the strength of the atmospheric convection that produces thunderstorms. Another parameter, the electrical energy from lightning, has not been thoroughly explored. We will look at the electrical energy from lightning as a possible indicator of the strength of a developing thunderstorm. Electrical energy, however, has not been clearly linked to the peak current of a lightning event. Thus, we cannot rely on peak current measurements to estimate electrical energy. Infrasound emitted by thunderstorms might be a possible way to estimate the electrical energy in lightning events. Microphones can be used to detect infrasound. This work will discuss the development of a data acquisition system that will be used to record and transmit sampled infrasonic data from microphones. This work is being undertaken under the SATREPS/ULAT Project.

Keywords: data acquisition, thunderstorm, lightning, energy

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 101 1F

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

convener:Mitsuteru Sato(Department of Cosmoscience, Hokkaido University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Hisayuki Kubota(Hokkaido University), Kozo Yamashita(Ashikaga University, Department of Engineering.), Chairperson:Yukihiro Takahashi(Hokkaido University), Hisayuki Kubota(Department of Cosmoscience, Hokkaido University)

In order to predict the intensity development of severe weather, lightning and thunderstorm are markers of severe weather, often accompanied by precipitation, hail and strong winds that can create significant natural hazards, especially in disaster-prone area. Lightning is also a strong indicator of convection, and it becomes a key parameter to predict the intensity development of tropical cyclones (typhoons and hurricanes). As the climate warms in the first decades of the 21st century, the intensity and frequency of thunderstorms is projected to increase. The need for detecting and monitoring the development of thunderstorms and lightning activities on global, local, and regional scales is therefore clear and urgent.
This session seeks topics presenting new technologies to monitor thunderstorm and severe weather activities. In addition, observational and theoretical contributions on thunderstorm microphysics and dynamics, convective systems and tropical storms are welcome. Present patterns and distributions of lightning and extreme weather events derived from the ground-based networks and satellites, as well as forecasts of future trends, are also of interest. Lightning detecting and monitoring system performance and validation, and early-warning schemes are requested, either in operational or planning phase. The session will also highlight regional and global lightning and atmospheric electricity networks and invite contributions on technological innovations in this field.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS05-07] Estimation of Lightning Location Using V-POTEKA Lightning Observation Network

*Loren Joy De Vera Estrebillo[1], Mitsuteru Sato[2], Yukihiro Takahashi[2], Hisayuki Kubota[2], Kozo Yamashita[3], Junichi Hamada[4], Joel Marciano[5] (1.Department of Cosmosciences, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Faculty of Engineering, Ashikaga University, 4.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 5.ASTI/DOST)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS05-08] **Observation system for thunderstorm development using ground lightning detection network and thermal infrared camera onboard satellite LAPAN-A4 in Indonesia**

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Mitsuteru Sato[1], Kozo Yamashita[3], M. Arif Saifudin[4] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3.Department of Technology, Ashikaga Institute of Technology, Tochigi 3268558, Japan, 4.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat 16310, Indonesia)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS05-09] Remote Sensing Water Quality Determination using Multi-spectral Analysis

*Ahmad Shaqeer Mohamed Thaheer[1], Yukihiro Takahashi[1] (1.Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS05-10] Study of cloud effects on atmospheric electric field during lightning activities and snowfall using the 95-GHz cloud radar FALCON-I

★Invited Papers

*Hiroyo Ohya[1], Kota Nakamori[1], Masashi Kamogawa[2], Tomoyuki Suzuki[2], Toshiaki Takano[1], Kazuomi Morotomi[3], Hiroyuki Nakata[1], Kazuo Shiokawa[4] (1.Graduate School of Engineering, Chiba University, 2.Tokyo Gakugei University, 3.Japan Radio Co. Ltd., 4.Nagoya University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS05-11] Preferred environmental conditions of precipitation systems in and around Bangladesh observed by ground-based radars

★Invited Papers

*Fumie Murata[1], Shuhei Azuma[2], Toru Terao[3], Quamrul S.M. Hassan[4] (1.Faculty of Science and Technology, Kochi University, 2.Faculty of Science, Kochi University, 3.Faculty of Education, Kagawa University, 4.Bangladesh Meteorological Department)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS05-12] Thundercloud gamma-ray observations at Kashiwazaki aiming at source altitude and beaming measurements and a new trial at Tokyo Skytree in FY2018

★Invited Papers

*Kazuhiro Nakazawa[1], Takahiro Matsumoto[2], Yuuki Wada[2], Alexia Fabiani[1], Teruaki Enoto[3], Kazufumi Okuda[2], Yoshihiro Furuta[4], Yuki Aizawa[2], Takayuki Yuasa[5], Harufumi Tsuchiya[4], Mitsuteru Sato[6], Kazuo Makishima[7] (1.Nagoya University, 2.University of Tokyo, 3.Kyoto University, 4.JAEA, 5.RIKEN, 6.Hokkaido University, 7.Kalvi IPMU, University of Tokyo)

Estimation of Lightning Location Using V-POTEKA Lightning Observation Network

*Loren Joy De Vera Estrebillo[1], Mitsuteru Sato[2], Yukihiro Takahashi[2], Hisayuki Kubota[2], Kozo Yamashita[3], Junichi Hamada[4], Joel Marciano[5]

1. Department of Cosmosciences, Hokkaido University, 2. Faculty of Science, Hokkaido University, 3. Faculty of Engineering, Ashikaga University, 4. Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 5. ASTI/DOST

The Philippines is one of the most disaster-hit countries in the world. Its location in the western North Pacific (WNP) subjects it to numerous tropical cyclones (TC) each year that pose risk to lives, properties and infrastructures. There has been a significant development in the accuracy of TC track forecast that cross and/or make landfall within the Philippine Area of Responsibility (PAR) over the years with the use of ground-based synoptic observations, weather radars, and meteorological satellites. However, prediction of TC intensity remains a significant challenge. Lightning activity is an indicator of the dynamics and microphysics in thunderstorms, as well as severe weather phenomena, such as TCs and torrential rainfall among others. Recent studies suggest that lightning activity in tropical cyclones can give predictive information about its intensity development. Thus, a ground-based lightning observation system (V-POTEKA) has been developed, and it has been installed at three stations in the Philippines, Guam, and Palau to continuously monitor lightning activity in the WNP region since September 2017. The V-POTEKA system uses an event-trigger method that detects radio wave pulses from lightning discharges in the very low frequency (VLF) range of 1-50 kHz. It also consists of an automatic weather station (AWS), VLF sensors, and an automatic data-processing unit. The V-POTEKA system analyzes lightning data, extracts pertinent information, i.e., peak amplitude and time of the triggered waveform, and transmits data to a server through 3G communication. A geolocation software using the time-of-arrival method is being developed using the 3 sites along the WNP region. Further analysis will be conducted by incorporating data from other stations (Sapporo, Japan and Los Banos, Philippines), and an improved geolocation software will be used to investigate the relationship between the lightning activity and typhoon intensification during the dropsonde observation campaign conducted in September 2018.

Keywords: lightning location, V-POTEKA

©2019. Japan Geoscience Union. All Right Reserved.

Observation system for thunderstorm development using ground lightning detection network and thermal infrared camera onboard satellite LAPAN-A4 in Indonesia

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Mitsuteru Sato[1], Kozo Yamashita[3], M. Arif Saifudin[4]

1. Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2. Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3. Department of Technology, Ashikaga Institute of Technology, Tochigi 3268558, Japan, 4. Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat 16310, Indonesia

Indonesia is the tropical maritime country which has potential disaster risk caused by thunderstorm cloud. In this study, we will observe the thunderstorm development using lightning detection networks and micro-satellite. A previous study has shown that electrification process on the cloud started when the peak of the cloud reaches the threshold height and continue to growth vertical with an upward ~8 m/s (Krehbiel, 1986). With the reverse though, the lightning activity can be used to indicate the updraft presence inside the cloud. Moreover, lightning activity represents the intensity and area of precipitation and/or an updraft area. In this study, the Asia VLF lightning Observation Network (AVON) will be used to detect electromagnetic wave emitted by lightning which has been installed in Manila - Philippines, Palau, and the next will be installed in Serpong and Padang Indonesia. We will show coverage area and ambiguity of lightning geolocation created by this lightning networks. The progress in development of algorithms in the determination of the location of lightning, peak currents, and charge moment changes will also be presented. Adding to the lightning observation, cloud observation using thermal infrared camera onboard LAPAN-A4, which will be launched in 2019 FSY, will provide the temperature distribution with the surface resolution of ~180 meters and field of view of ~ 56.3 x 42.2 kilometer. Using this high resolution thermal infrared camera, the cloud top altitude can be estimated, assuming temperature profile of the ambient atmosphere. By making such observation at some time interval, the developing speed of thunderstorm can be calculated in 3D. The first lightning occurrence detected by AVON, which could be assumed as the timing that the cloud has reached the threshold height to become a thunderstorm, will initiate the micro-satellite observation with the thermal infrared camera, from which we could make a prediction of torrential rainfall.

Acknowledgement: This work was supported by Japan Society for the Promotion of Science (JSPS), Core-to-Core Program, B. Asia-Africa Science Platforms, by Japan Science and Technology Agency(JST) together with Technology and Higher Education(RISTEKDIKTI) of the of Indonesia under the e-ASIA Joint Research Program, and by Japan International Cooperation Agency (JICA) and JST, SATREPS.

Keywords: thuderstorm, lightning detection network, microsatellite, infrared thermal camera

©2019. Japan Geoscience Union. All Right Reserved.

Remote Sensing Water Quality Determination using Multi-spectral Analysis

*Ahmad Shaqeer Mohamed Thaheer[1], Yukihiro Takahashi[1]

1. Hokkaido University

Wetlands have three distinct features which are the existence of a water body, hydric soil, and specific vegetation that thrived under those conditions as mentioned. The ecosystem provides benefits to the environment and humans as one of the significant natural resources. The contamination of the waters, especially in the river, poses a serious health and environmental risk. The destruction of the catchment area will lead to the deterioration in quality and quantity of the water resource in Malaysia. The Department of Environment (DOE) under the Ministry of Water, Land and Natural Resources (NRE) has identified that the Malaysian rivers are degraded by both point and non-point sources of pollution. The major point sources of pollution in rivers are from sewage treatment plants, agro-based industries, manufacturing industries, sullage or grey water from commercial and residential premises, and pig farms. Non-point source (or diffuse) pollution is largely due to storm runoff after a downpour. Current methods using in-situ measurements are shown to be infeasible while Remote Sensing methods helps to resolve these issues such as cost, time, accessibility, and repeatability effectively. Multi-spectral Imagery has been a useful in analyzing the spectral characteristics of wetlands.

Keywords: Multi-spectral, Remote sensing, Water quality

©2019. Japan Geoscience Union. All Right Reserved.

Study of cloud effects on atmospheric electric field during lightning activities and snowfall using the 95-GHz cloud radar FALCON-I

*Hiroyo Ohya[1], Kota Nakamori[1], Masashi Kamogawa[2], Tomoyuki Suzuki[2], Toshiaki Takano[1], Kazuomi Morotomi[3], Hiroyuki Nakata[1], Kazuo Shiokawa[4]

1. Graduate School of Engineering, Chiba University, 2. Tokyo Gakugei University, 3. Japan Radio Co. Ltd., 4. Nagoya University

It is known that cloud-to-ground lightning and precipitations generated from thunderclouds are a generator of global electric circuit (e.g., Williams, 2009). In the fair weather, the atmospheric electric field at the ground is generally 100 V/m and downward (positive). The atmospheric electric field varies during not only lightning/thunderstorms, but also snowfall/blizzard (e.g., Minamoto and Kadokura, 2011). The atmospheric electric field had positive correlations with flush rate (R^2 = 0.67) and clouds of more than 30 dBZ with temperature range of -35~-5˚C (R^2 = 0.62) observed by the TRMM satellite [Lavigne et al., 2017]. However, satellite observations cannot monitor cloud internal structures in detail. In this study, we investigate the variations of the atmospheric electric field during lightning activities of 4 July, 2016, and snowfall of 23-24 November, 2016, using a field mill, the 95 GHz cloud radar, FALCON (FMCW Radar for Cloud Observations)-I, and a X-band radar (9.4 GHz). We have observed the atmospheric electric field with a Boltek field mill, and cloud reflectivity and the Doppler velocity with the FALCON-I in Chiba University, Japan, (CHB, 35.63˚N, 140.10˚E). At 16.2 km southeast from the CHB, a phased array X-band radar operated by Japan Radio Corporation observed precipitations/cloud. During lightning activities of 4 July, 2016, there were two variations in the atmospheric electric field: short pulse signals and slow variations due to passage of thunderclouds. Small increase in the atmospheric electric field in the initial phase was caused by positive charges in anvil using the FALCON-I, although the cause of the initial phase has been regarded as negative charges in the bottom of the thunderclouds so far. The duration of the short pulse signals due to lightning itself had a positive correlation with the lightning peak current (r = 0.44). During the snowfall of 23-24 November, 2016, periodic oscillations in the atmospheric electric field with periods of 70-90 minutes were observed at four observation sites; CHB, Kakioka (KAK, 36.23˚N, 140.19˚E), Tokyo Gakugei University (KGN, Kokubunji, Tokyo, 35.71˚N, 139.49˚E), and Seikei High School (MSN, Musashino, Tokyo, 35.72˚N, 139.57˚E). The distances of CHB-KAK, CHB-TGU, and CHB-SHS are 64.8 km, 55.9 km, and 49.0 km, respectively. This is the first observations of similar oscillations in the atmospheric electric field at different observation sites separated by a long distance of 50-65 km. At the end of snowfall, the periods of the oscillations became shorter to be 20-50 minutes at all sites. Based on the FALCON-I and X-band radar observations, we found that the reflectivity of the snow cloud had the same period of 80 minutes at CHB at 0-2 km heights during the snowfall. In the presentation, we will discuss the cause of the variations in the atmospheric electric field.

©2019. Japan Geoscience Union. All Right Reserved.

Preferred environmental conditions of precipitation systems in and around Bangladesh observed by ground-based radars

*Fumie Murata[1], Shuhei Azuma[2], Toru Terao[3], Quamrul S.M. Hassan[4]

1. Faculty of Science and Technology, Kochi University, 2. Faculty of Science, Kochi University, 3. Faculty of Education, Kagawa University, 4. Bangladesh Meteorological Department

Severe storms tend to occur in Bangladesh. In the pre-monsoon season (March-May) storms with intense rainfall, lightning, hails, and tornadoes are frequently observed. Precipitation systems in the monsoon season (June-September) bring large amount of rainfall and floods tend to occur. The purpose of this study is to elucidate the environmental conditions which cause severe weather. This study analyzed the ground-based radars observed during 2010-2014 with TRMM-based precipitation products and JRA55 reanalysis. The precipitation systems were classified into four types: arc-type (77 cases), line-type (59 cases), scattered-type (178 cases) and broad-type (172 cases) systems. Arc-type systems tended to occur in the pre-monsoon season, and the environmental condition had large vertical shear with dry in the mid troposphere. Line-type systems had no preferred season, and the environmental condition had weak vertical shear. The formation process seemed back building type. The scattered-type systems in the pre-monsoon season occurred in the large vertical shear, whereas that in the monsoon season occurred in the weak vertial shear. Most of the broad-type systems were occurred in the active spells of the intraseasonal variation during the monsoon season, and the scattered-type tended to appear in 1-3 days before the formation of the broad-type systems.

Keywords: Monsoon, Precipitation system, Radar

©2019. Japan Geoscience Union. All Right Reserved.

Thundercloud gamma-ray observations at Kashiwazaki aiming at source altitude and beaming measurements and a new trial at Tokyo Skytree in FY2018

*Kazuhiro Nakazawa[1], Takahiro Matsumoto[2], Yuuki Wada[2], Alexia Fabiani[1], Teruaki Enoto[3], Kazufumi Okuda[2], Yoshihiro Furuta[4], Yuki Aizawa[2], Takayuki Yuasa[5], Harufumi Tsuchiya[4], Mitsuteru Sato[6], Kazuo Makishima[7]

1. Nagoya University, 2. University of Tokyo, 3. Kyoto University, 4. JAEA, 5. RIKEN, 6. Hokkaido University, 7. Kalvi IPMU, University of Tokyo

MeV gamma rays from lightning and thundercloud reaching the groud are sometimes observed from the winter thunderstorm activities along the coastline of Japan Sea. We, the Gamma-Ray Observation of Winter Thunderclouds (GROWTH) collaboration, are observing such phenomena from 2006 at Kashiwazaki, Niigata prefecture (e.g. Tsuchiya et al. 2007), and recently increasing the number of observation sites, including Ishikawa prefecture (e.g. Wada et al. at M-IS27 session). Since FY2016, we have been operating new detectors at Kashiwazaki dedicated to measure the altitude and beaming of gamma-ray source in thundercloud. Three collimated detectors aiming at different sky regions are deployed. A minute-long gamma-ray emission (or "long-burst") was observed on Jan 26th, 2019 with the system, and we are analyzing the peaking time difference among the three detectors to perform triangulation using the wind speed. Preliminary results suggest the altitude to be lower than ~300 m, but because the emission was relatively weak and photon statistics are not enough, we are estimating the upper-limit of the source altitude and its beaming. Independently, we also started an observation campaign at the 450 m altitude of Tokyo Skytree, aiming at gamma-ray detection from lightning (so called downward TGF) of summer thunderstorm. The tower is one of the locations most frequently hit by lightning. We had three hits on May-Sep. 2018, but no TGF was observed to date, confirming the fact that not all the lightnings are observationally associated with gamma rays. Because our team is observing several downward TGFs from winter thunderstorms (e.g. Enoto et al. 2017), increasing data will enable us to compare the difference among the lightning with and without TGF. The study will be also boosted with the launch of TARANIS satellite in early 2020, dedicated for simultaneous observation of TGF, electrons, optical and radio emission from lightning.

Keywords: Thundercloud, lightning, MeV gamma rays, TGF

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 301B 3F

[M-GI29] Near Surface Investigation and Modeling for Groundwater Resources Assessment and Conservation

convener:Jui-Pin Tsai(National Cheng Kung University, Taiwan), Hwa-Lung Yu(National Taiwan University), Ching-Chung Cheng(National Chiao Tung University Taiwan), Jing-Sen Cai(China University of Geosciences), Chairperson:Jui-Pin Tsai(National Cheng Kung University, Taiwan), Hwa-Lung Yu(National Taiwan University, Taiwan)

Groundwater resources serve as a vital source for regional water supply under the climate change condition. However, improper use of the available groundwater resources leads to serious environmental disasters such as land subsidence or seawater intrusion. Therefore, groundwater management is a key issue for groundwater resources conservation. Before applying any management practice, it is essential to accurately assess the groundwater system in multi-scales. In this session, we focus on the issues associated with the application of near-surface investigation and modeling on groundwater resources assessment. We welcome studies related to numerical modeling, spatiotemporal modeling, data fusion, and field investigation using hydrogeological approaches, geophysical approaches, geochemical approaches, and remote sensing. We also welcome the studies associated with groundwater contamination transport and remediation, geothermal energy exchange, groundwater microorganisms, hot spring, volcanic hydrology, and environmental disasters evaluation and prevention. We especially encourage the pilot groundwater management studies that solve multi-scale and interdisciplinary problems.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MGI29-01] Groundwater management for global sustainability

★Invited Papers

*Makoto Taniguchi[1] (1.Research Institute for Humanity and Nature)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MGI29-02] **Building the large-scale specific yields over the Zhuoshui river alluvial fan and Minzhu basin with gravimetric technique**

*Ren-Jhih Yang[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Zhen-Yu Wu[1] (1.National Chung Hsing University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI29-03] **Poro-elastic Deformation of a Heterogenous Geologic Medium due to Groundwater Withdrawal**

*Ajit Joshi[1], Masaatsu Aichi[1] (1.Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI29-04] **Analytical Solution of a Ditch Drainage System for the restoration of waterlogged site considering a Subsurface Source/Sink**

*SHUBHAM TIWARI[1], BRIJESH KUMAR YADAV[1], RATAN SARMAH[2] (1.Indian Institute of Technology Roorkee, 2.Indian Institute of Technology Ropar)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI29-05] **Variable-density flow and mass transport in unsaturated-saturated aquifers under horizontal groundwater flow conditions**

*Jiaqi Liu[1], Tomochika Tokunaga[1] (1.The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI29-06] A practical approach to evaluating water inflow for underground water-sealed storage cavern

*Jing-Sen Cai[1] (1.China University of Geosciences)

Groundwater management for global sustainability

*Makoto Taniguchi[1]

1. Research Institute for Humanity and Nature

Groundwater management is important for global sustainability, because of not only large groundwater footprints through global trade of agricultural/industrial materials, but also climate change impacts on groundwater resources directly and indirectly, and carbon emissions through human activities using groundwater. Interactions between groundwater-food-energy nexus and environmental/economical impacts under the conditions of climate change and urbanization, are essential for global sustainability as the center of information among nature, society and humanity. Natural and social tipping points related to groundwater such as land subsidence and saltwater intrusion, regime shifts, and resilience, are the keys for the future of hydrogeology and a sustainable society. Sustainable groundwater management has cultural dependency because of differences in hydroclimate, hydrogeology, water management, and water culture in each area. Therefore, an interaction between humanity and nature is the most important for finding solutions of groundwater management towards sustainability for the current complicated and wicked global environmental problems.

Keywords: groundwater management, global sustainability, groundwater-energy-food nexus

©2019. Japan Geoscience Union. All Right Reserved.

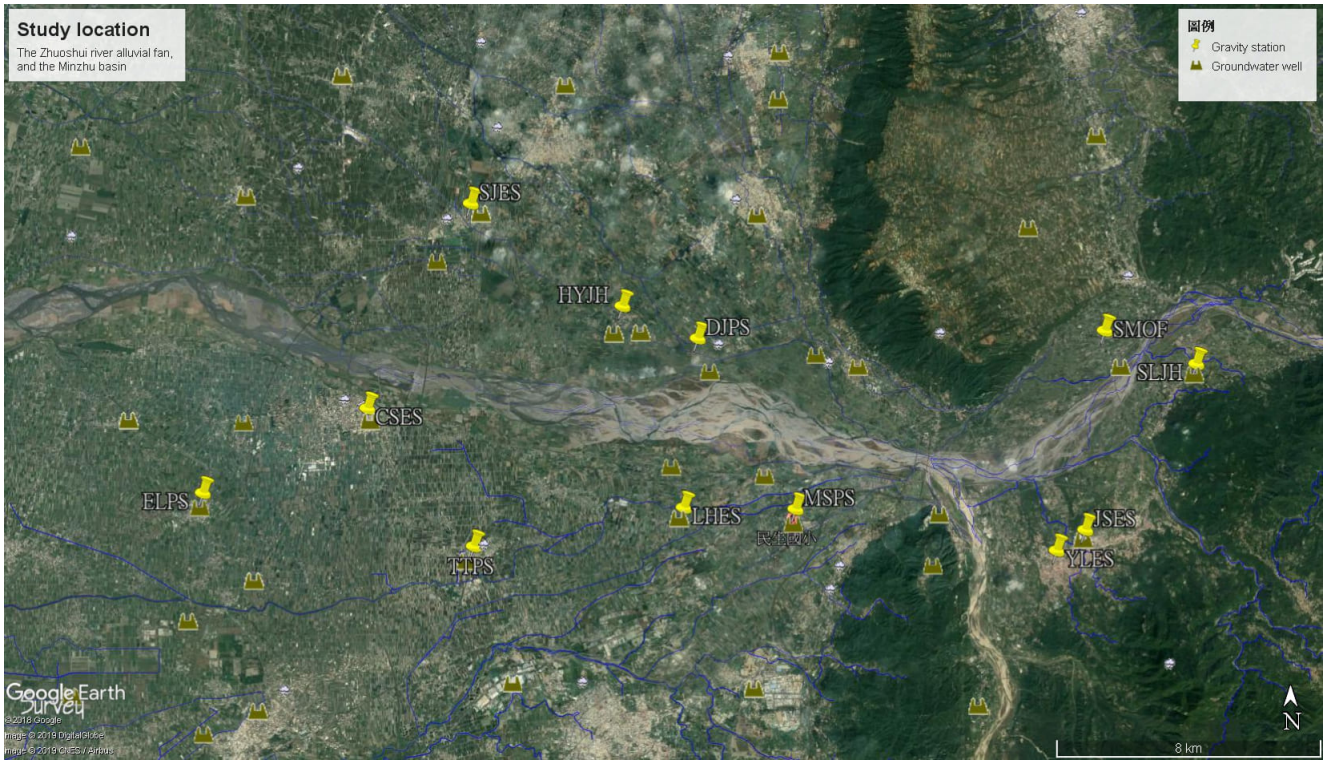
Building the large-scale specific yields over the Zhuoshui river alluvial fan and Minzhu basin with gravimetric technique

*Ren-Jhih Yang[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Zhen-Yu Wu[1]

1. National Chung Hsing University

This study estimates the large-scale specific yields (S_y) of the aquifer in the Zhuoshui river alluvial fan and its upstream, Minzhu basin, by gravity data combined with groundwater level data and electrical resistivity tomography (ERT) data. The S_y results from gravimetric technique are rigorously compared with those from hydraulic technique. There are eight gravity stations over the Zhuoshui river alluvial fan, and four over the Minzhu basin.The distribution of all gravity stations is shown in the attached figure. The ERT data are only used for S_y estimation in the "SMOF" gravity station in the Minzhu basin. The strategies for modeling groundwater level changes include the terrain correction method and the Bouguer correction method. The environmental factors influencing the S_y estimation are also discussed. We expect that the groundwater resources in the Zhuoshui river alluvial fan and Minzhu basin can be accurately explored by this study and the results can provide an important reference for groundwater resource management.

Keywords: Gravimetry, Large-scale specific yield, Groundwater resource



©2019. Japan Geoscience Union. All Right Reserved.

Poro-elastic Deformation of a Heterogenous Geologic Medium due to Groundwater Withdrawal

*Ajit Joshi[1], Masaatsu Aichi[1]

1. Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo

Land subsidence around coastal cities in the world have been recognized as a major concern due to risk of flooding from seawater. As an example, land surface near the Tokyo and surrounding regions in Chiba Prefecture in Japan have been subsiding at rates of few centimeters per year based on data from satellite observations and ground survey measurements. Such changes in land surface elevations may have caused due to subsurface fluid (water/methane) extraction from the Plio-Pleistocene sand reservoirs of the Kanto groundwater basin located in and around Tokyo and Chiba. Fluid removal from subsurface geologic medium can reduce pore fluid pressures underneath and subsequently strain the medium causing pore spaces to collapse. Stratigraphic and lithological interpretation of rocks exposed in outcrops from the Kujukuri region in Chiba showed alternations of sandstone-mudstone units and were characterized by transgressive-regressive cycles of vertical heterogeneity indicating a gradual transition of sediment size from coarse-grained sandstone to fine-grained siltstone/mudstone. The present research hypothesized that presence of local geological heterogeneities in a geologic medium can alter hydraulic properties of the medium affecting its deformation. The main purpose of this research was to determine effect of vertical heterogeneity on rock deformation and to predict land surface subsidence due to groundwater extraction. The research hypothesis was tested using a one-dimensional solution to equations for pore fluid mass conservation and Darcy’ s flow mechanics for a poro-elastic medium saturated with water. Porosity and permeability, both dependent upon clay content, were related by a modified form of Kozeny-Carman equation.

Simulations results for a hypothetical 130 m thick water-saturated porous medium under different geological conditions were compared to investigate heterogeneity effect on deformation. Results showed hydraulic strain in mudstone increased by orders of magnitude higher than less compressible and more diffusive sandstone. Simulation results also confirmed that geological heterogeneity would affect poro-elastic deformation by altering hydraulic diffusivity and bulk compressibility of a geologic medium. Moreover, model predicted land surface subsidence, using stratigraphic sections from the Kanto basin, were in good agreement with field deformation measurements from leveling survey. In addition, local heterogeneity can be more important for a geologic medium saturated with multiple fluids (methane/water) which will be addressed in future research.

Keywords: Poro-elastic modeling, Geological heterogeneity, Land subsidence

©2019. Japan Geoscience Union. All Right Reserved.

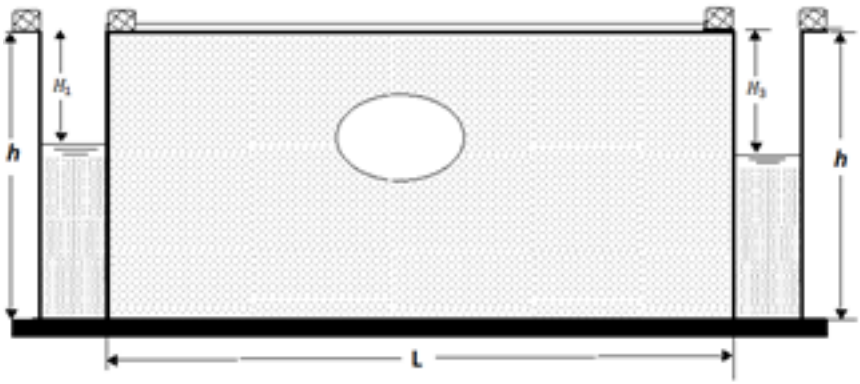
Analytical Solution of a Ditch Drainage System for the restoration of waterlogged site considering a Subsurface Source/Sink

*SHUBHAM TIWARI[1], BRIJESH KUMAR YADAV[1], RATAN SARMAH[2]

1. Indian Institute of Technology Roorkee, 2. Indian Institute of Technology Ropar

Drainage plays an important role in the field of agricultural science, as it helps in removing excess water from the soil quickly. An analytical solution is developed for the prediction of transient seepage to a fully penetrating ditch drainage system receiving water from a ponded surface with an influence of subsurface source/sink. The proposed solution is quite versatile to tackle the presence of source and sink effect in the flow domain. A subsurface flow domain of confined nature is assumed as study area which is having finite extends in horizontal and vertical directions. The hydraulic property of the soil matrix is considered as homogeneous and anisotropic in nature. The accuracy of this solution is analyzed by comparing with numerical solution obtained from finite difference method and other existing simplified case on MATLAB programming software. With the imposition of the source and sink term in the flow domain, the path line and travel time of water molecules started deviating from their original position. It was observed that discharge to the drains has a strong influence of the source/sink term. It is expected that the proposed model will help in the understanding of the flow dynamics associated with the ditch drainage system subjected to source/sink in real field conditions.

Keywords: Transient seepage, Ditch drains, Source/sink, Water logging



©2019. Japan Geoscience Union. All Right Reserved.

Variable-density flow and mass transport in unsaturated-saturated aquifers under horizontal groundwater flow conditions

*Jiaqi Liu[1], Tomochika Tokunaga[1]

1. The University of Tokyo

Density-induced fingering is an important mass transport process in a variety of groundwater flow settings. This study numerically investigated density-driven flow and mass transport in a 2-D vertical conceptual model of an unsaturated-saturated aquifer. The modeled domain consisted of 300 m long, with horizontal groundwater flow and vertical injection of dense solute from the top. In total, 158 numerical simulation cases were designed with various configurations of horizontal groundwater flow, the rate of solute injection, aquifer properties, and dispersivity. The numerical code FEFLOW was adopted which can solve both variable-density groundwater flow and unsaturated-saturated flow in porous media. Three dimensionless numbers, the convective ratios M_x and M_z and the Rayleigh number Ra_d, were applied to quantitively evaluate the relative magnitudes among the driving forces in the simulation cases. Three end-member flow regimes were identified that were dominated by the horizontal hydraulically-driven flow, the vertical hydraulically-driven flow, and the vertical density-driven flow, respectively. The plots of the simulation results in the M_x-M_z-Ra_d diagram enabled a clear distinction among the clusters of flow regimes and suggested the dominant driving force of each flow regime. The parameter sensitivity and regime shifts were also analyzed with the M_x-M_z-Ra_d diagram. The classification of flow regimes and the proposed M_x-M_z-Ra_d diagram provided a basic reference and a useful tool for understanding the mechanisms of variable-density flow processes under complex field situations.

Keywords: Variable-density flow, Numerical simulations, Dimensionless numbers

©2019. Japan Geoscience Union. All Right Reserved.

A practical approach to evaluating water inflow for underground water-sealed storage cavern

*Jing-Sen Cai[1]

1. China University of Geosciences

A practical approach that has been successfully applied to evaluate the water inflow for the project of underground water-sealed storage cavern in fractured granite in China are introduced. This approach consists of two steps: investigation of the distribution of groundwater flow path and modeling to evaluate the water inflow in the cavern. Firstly, field investigation methods such as geological survey and mapping, engineering drilling, borehole imaging and engineering geophysical prospecting are used to investigate the distribution of fracture zones and faults. Subsequently, the piecewise water pressure test is performed in the existing boreholes to search the seepage passage which is dictated by the section with large permeability coefficient. Based on this, models such as Hirishi Oshima empirical equation, Misaki Sato Kuniki empirical equation and the empirical analytical equation are utilized to evaluate the water inflow in the traffic tunnel, main cavern and shaft during the construction stage. Results indicate that the seepage passage determined by the piecewise water pressure test corresponds well to the location of fracture zones revealed by field investigation. The evaluation results are confirmed by the surrounding rock quality and water inflow location uncovered by the excavation afterward, which demonstrate the validity of this comprehensive approach.

Keywords: field study, underground water-sealed storage cavern, fractured granite, water inflow, borehole imaging, piecewise water pressure test

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-ZZ Others

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 304 3F

[M-ZZ50] Governance for Trans-boundary Volcanic Disaster

convener:Mayumi Sakamoto(Graduate School of Disaster Resilience and Governance, University of Hyogo), Haruhisa Nakamichi(Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University), MASARU ARAKIDA(Asian Disaster Reduction Center), Chairperson:Mayumi Sakamoto(兵庫県立大学大学院減災復興政策研究科), Haruhisa Nakamichi(京都大学防災研究所), Masaru Arakida(アジア防災センター)

Volcanic monitoring systems are developed and managed for the purpose to observe a specific volcanic activity in each country based on its own regulation. However, the experience of Icelandic volcano Eyjafjallajokull eruption in 2010 caused huge air traffic disturbances, and left large economic and social impact to international community. In order to reduce possible financial, environmental, health or social damages caused by trans-boundary volcanic disaster, it is important to develop international cooperative system to monitor and share the information of emission, dispersion or deposition of volcanic products. In this session, we discuss trans-boundary effect of volcanic eruption, and how to establish international collaborative mechanism from different research disciplines such as disaster management, volcanology, environmental politics or international law.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

Introduction

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[MZZ50-01] The development of the European collaborative mechanism of volcanic monitoring systems after 2010 Eyjafjallajokull eruption - from the perspective of European Union law -

*Chizu Arashima[1] (1.KOBE GAKUIN UNIVERSITY)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[MZZ50-02] Preparing for volcanic disasters: Risk communication issues when dealing with international tourists.

★Invited Papers

*Ana Maria Cruz Naranjo[1], Giuseppe Aliperti[1] (1.Kyoto University Disaster Prevention Research Institute)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MZZ50-03] Mitigation of volcanic hazard in Sakurajima, Japan, through the coordinating committee and through communication with the public

*Haruhisa Nakamichi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MZZ50-04] An experimental forecasting technique for the ash hazard from Sakurajima volcano, Japan

*Alexandros Panagiotis Poulidis[1], Tetsuya Takemi[1], Masato Iguchi[1] (1.Disaster Prevention Research Institute, Kyoto University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MZZ50-05] Utilization of Space Technology for Early Warning and Efficiently Response Against Transboundary Disaster

★Invited Papers

*Koji Suzuki[1] (1.Asian Disaster Reduction Center, Research Center for Urban Safety and Security Kobe University)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[MZZ50-06] Discussion -Research Framework for Trans-boudary Disaster

*Mayumi Sakamoto[1] (1.Graduate School of Disaster Resilience and Governance, University of Hyogo)

The development of the European collaborative mechanism of volcanic monitoring systems after 2010 Eyjafjallajokull eruption - from the perspective of European Union law -

*Chizu Arashima[1]

1. KOBE GAKUIN UNIVERSITY

The eruption of Icelandic volcano Eyjafjallajokull in 2010 caused huge international air traffic disturbances and left significant economic and social damages to the international society. The lesson learned from the disaster is that not only the estimates by Volcanic Ash Advisory Centre (VAAC) but also the on-going observations are needed to estimate the concentration more accurately. These observations are carried out by various volcanic observatory institutions. They play key roles in reducing/preventing possible economic, environmental, health or social damages caused by such trans-boundary volcanic disaster, by providing key scientific information and interpretation during eruption crises. To address the fragmentation of scientific data and make use of scientific information, the European collaborative mechanism of volcanic monitoring systems to share information should be established on a sufficient financial basis.
At present, European Network of Observatories and Research Infrastructures for Volcanology (EUROVOLC) is coordinated by Icelandic Meteorological Office with 16 other partners from 7 European countries. EUEOVOLC is a 3-year project from February 1 2018 and is funded by the European Commission of the European Union (EU) under “Horizon 2020” with 5 million Euros. Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) was established by REGULATION (EU) No 1291/2013. Its Article 7 provides association of third countries to Horizon 2020. Associated countries include European Free Trade Association members, including Iceland. Therefore, EUROVOLC is funded by the EU. Horizon 2020 falls under the areas of research, technological development and space where the EU has shared competence with the Member States and the EU “shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs” (Article 4(3) of the Treaty on the Functioning of the European Union (TFEU)).
Concerning natural disasters, the 2007 Treaty of Lisbon introduced new provisions of TFEU. They are included both in the areas of civil protection under PART THREE UNION POLICIES AND INTERNAL ACTIONS of TFEU and humanitarian aid under PART FIVE THE UNION'S EXTERNAL ACTION of TFEU. Disaster prevention is provided in the former, as Article 196(1) of TFEU provides that “(t)he Union shall encourage cooperation between Member States in order to improve the effectiveness of systems for preventing and protecting against natural or man-made disasters”. Civil protection is the area where “(t)he Union shall have competence to carry out actions to support, coordinate or supplement the actions of the Member States” (Article 6 of TFEU).
For the implementation, the Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO) of the European Commission plays the role. Under ECHO, there is EU Civil Protection Mechanism (UCPM). It was established by DECISION No 1313/2013/EU. Iceland is a participating state of the UCPM. UCPM is not at present a forum to establish a European collaborative mechanism of volcanic monitoring systems. However, it is worthy to note that Proposal for a DECISION amending Decision No 1313/2013/EU in 2017 acknowledges that disaster prevention efforts are crucial to limit the need for crisis and emergency support. It proposes that UCPM "shall support, complement and facilitate coordination of Member States’ action" "to increase the availability and use of scientific knowledge on

©2019. Japan Geoscience Union. All Right Reserved.

disasters". It also proposes that the Commission shall "take actions to improve the knowledge base on disaster risks and facilitate the sharing of knowledge, the results of scientific research, best practices and information, including among Member States that share common risks".
At present, the European collaborative mechanism of volcanic monitoring systems is financially supported by project-based funds of Horizon 2020. However, if the Proposal is adopted and the importance of sharing scientific information in disaster prevention is recognized, more opportunity and regular financial support to develop European collaborative mechanism of volcanic monitoring systems may be given.

Keywords: European Union, EU civil protection mechanism, EUROVOLC, Eyjafjallajokull, disaster prevention, volcanic eruption

©2019. Japan Geoscience Union. All Right Reserved.

Preparing for volcanic disasters: Risk communication issues when dealing with international tourists.

*Ana Maria Cruz Naranjo[1], Giuseppe Aliperti[1]

1. Kyoto University Disaster Prevention Research Institute

This paper provides insights on the risk communication behavior of international tourists visiting Japan. The study builds on the premise that even if tourism-oriented risk communication has been strongly investigated, tourists' risk information seeking and processing has been under-investigated. We thus explore risk information seeking and processing of international tourists in Japan. Japan has been selected as a case study for several reasons. First, the level of exposure of the country to natural hazards, such as volcanic eruptions, tsunamis, earthquakes, and typhoons, is high. Second, due to the increasing presence of tourists in recent years, the number of people exposed to disaster-related risk in Japan has also drastically increased. In the case of a major volcanic eruption with disruption to air traffic, the provision of risk information to tourists already in Japan, as well as those preparing to travel is of critical importance. The overall aim of the study consists on providing cross-country evidence to inform risk-communication strategies and improve tourists' disaster preparedness. In order to investigate the tourists' perspective, we adopted the Risk Information Seeking and Processing (RISP) model.

Keywords: risk communication, tourists, disasters

©2019. Japan Geoscience Union. All Right Reserved.

Mitigation of volcanic hazard in Sakurajima, Japan, through the coordinating committee and through communication with the public

*Haruhisa Nakamichi[1]

1. Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University

The Sakurajima Volcanological Observatory, at present the Sakurajima Volcano Research Center (SVRC), was founded in 1960 as a part of the Disaster Prevention Research Institute, Kyoto University, following the request from local governments and residents of the volcanic area. The SVRC contributes to society by releasing scientific results and knowledge on volcanic hazard to the public, as well as by advising national and local governments on hazard mitigation strategies. Volcano experts are required to issue a warning when a volcanic eruption is ongoing or imminent. The SVRC evaluates volcanic activity using observational data. It communicates and interacts often with local government offices, such as the ones in Kagoshima Prefecture, Kagoshima City, Tarumizu City, local branches of ministries of the national government, the Osumi Office of Rivers and National Highways (OORNH), and the Kagoshima Local Meteorological Office (KLMO). The SVRC and these offices work in close cooperation. For example, the meeting of the Coordinating Committee for Hazard Mitigation of Sakurajima Volcano has been taking place regularly every two months since 2006. The purpose of the Coordinating Committee is to share up-to-date observational results, to cooperate and to examine special topics to respond in terms of hazard mitigation in case of volcanic eruptions of the Sakurajima. The KLMO provides information on the volcanic activity of the Sakurajima as necessary, on the basis of the continuous observation and monitoring conducted in cooperation with the SVRC, OORNH, and other relevant bodies.

The Kyoto University has research facilities located across Japan, and organizes open-doors weeks at these facilities, i.e. the “KYODAI Weeks”, every year in October and November. As a part of this event, the SVRC opens not only the observatory, but also an underground observation tunnel to the public, so that the visitors can understand the instrumentation employed to monitor volcanic phenomena. We installed a group of PC displays at the Sakurajima Visitor Center in March 2017 to show real-time seismic and ground deformation data to the general public visiting Sakurajima. In addition, we explained to “volcano guides” how to interpret these monitoring data, so that they can explain these data from the point of view of volcanology to the general public in a straightforward manner.

Keywords: Volcano Hazard, Coordinating Committee, Monitoring Data Display, Doors Open

©2019. Japan Geoscience Union. All Right Reserved.

An experimental forecasting technique for the ash hazard from Sakurajima volcano, Japan

*Alexandros Panagiotis Poulidis[1], Tetsuya Takemi[1], Masato Iguchi[1]

1. Disaster Prevention Research Institute, Kyoto University

Introduction

The long-lasting activity from Sakurajima volcano introduces hazardous amounts of volcanic ash into the atmosphere, adversely affecting the surrounding areas (e.g. Biass *et al.* (2017), Poulidis *et al.*, (2018)), making accurate localized forecasts a necessity. Here, we present initial results from an experimental forecasting methodology carried out by the Sakurajima Volcanological Observatory (SVO), Kyoto University, focusing on three points: *(i)* high resolution (333m mesh), *(ii)* use of Eruption Source Parameters (ESPs) that are derived from geophysical signals (Iguchi, 2016) and allow for a proactive forecasting approach, and *(iii)* use of dedicated models in order to properly represent the plume structure.

Forecast Methodology

A combined modelling approach is presented: Japan Meteorological Agency (JMA) forecast data are dynamically downscaled to 333m using the Weather Research and Forecasting (WRF) model (Skamarock and Klemp, 2008), while the FALL3D volcanic ash transport and deposition (VATD) model (Folch *et al.*, 2009) is used for the introduction of the plume and dispersal modelling. A quasi-online coupling approach is used here, with WRF data output every 10mins so that the resolved variablity in the wind fields is well-represented in the ash dispersal simulations. In order to study the sensitivity of results to the timing relative to eruption, a total of 5 pseudo-forecast simulations were carried out using data up to 13 hours before the eruption.

June 16, 2018 Eruption

Sakurajima erupted at 0719 JST (JST=UTC+9), June 16 2018, with a reported plume height of 4700 m above the vent. Deposition occurred west and southwest of the volcano, reaching the southern coast of the Satsuma peninsula. Ashfall locations were reported by the JMA, while the SVO carried out a post-eruption survey to collect samples. A comparison of disdrometer observations (which measure airborne ash size) and ground deposits suggest the presence of large aggregates (e.g. Bagheri *et al.*, (2016)), a fact that needs to be accounted for in order to have successful simulations.

Forecast Simulation Results and Conclusions

Initially, a control simulation was carried out using the final mass discharge rate output. Although qualitatively similar to the JMA ash forecast, it offered two key improvements: *(i)* ash deposition over the volcano occured along a narrow path, correctly reproducing the observed pattern, and *(ii)* the observed area of maximum ashfall (>1 mm deposit thickness) was reproduced correctly at a distance from the vent, over the southwestern shore of the volcano.

Forecast time sensitivity simulations showed consistent ash dispersal patterns. Simulation results using forecast data up to 10 hours before the eruption time were qualitatively similar. Up to 4 hours before the eruption, the observation to estimate ratios for the two disdrometers were constrained to factor of 4, allowing for the proposed methodology to be confidently used in forecast timescales.

©2019. Japan Geoscience Union. All Right Reserved.

References
Bagheri *et al.* (2016) *J. Volcanol. Geophys. Res.*
Biass *et al.* (2017) *Bull. Volcanol.*
Folch *et al.* (2009) *Comput. Geosci.*
Iguchi (2016) *J. Disaster. Res.*
Poulidis *et al.* (2018) *Atmos. Environ.*
Skamarock and Klemp (2008) *J. Comput. Phys.*

Keywords: Ash dispersal, Hazard forecasting, Sakurajima, FALL3D, Weather Research and Forecasting

©2019. Japan Geoscience Union. All Right Reserved.

Utilization of Space Technology for Early Warning and Efficiently Response Against Transboundary Disaster

*Koji Suzuki[1]

1. Asian Disaster Reduction Center, Research Center for Urban Safety and Security Kobe University

Space-based Technology contributes DRR field via Sentinel Asia. It provides near real-time observations from space, delivered online, can be used as early warning, as well as information to guide response and post-disaster recovery planning or operations. Eight space agencies in Asia are providing satellite data to Asian countries for emergency response, mapping, evaluation, and recovery. Furthermore, Michibiki, a kinds of GPS satellite developed by Japan has avility to disseminate early warning message through the local speakers and smartphones.

Keywords: Space-based technology, Sentinel Asia, QZSS, Early warning message platform, Transboudary disaster

©2019. Japan Geoscience Union. All Right Reserved.

Discussion -Research Framework for Trans-boudary Disaster

*Mayumi Sakamoto[1]

1. Graduate School of Disaster Resilience and Governance, University of Hyogo

Volcanic disaster occurred in one country may cause different environmental or health effect in other country. In order to mitigate direct or secondary effect caused by eruption, it is important to discuss international collaborative mechanism to share information and take necessary measures. In this session, we discuss about how to establish a research framework for trans-boudary volcanic disaster.

Keywords: governance, trans-boudary, volcano, disaster

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS02] Regolith Science

convener:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Akiko Nakamura(Graduate School of Science, Kobe University), Patrick Michel(Observatoire De La Cote D'Azur), Kevin John Walsh(Southwest Research Institute Boulder), Chairperson:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology)

Recent planetary explorations have revealed that almost all solid bodies in the solar system are covered with small particles, called regolith. The surface geology, especially regolith behavior on the surfaces of solid bodies, becomes increasingly more important as represented by Hayabusa mission and other on-going and planned sample-return missions such as Hayabusa2, OSIRIS-REx, and MMX.

For fully understanding the regolith science, it is required to know and compare the regolith conditions on various celestial bodies, from asteroids to planets, with various methods.

Therefore, this session welcomes broad topics related to regolith on various celestial bodies, such as asteroids, comets, the Moon, the martian moons, Mars, etc. Papers on the formation, evolution, and alteration processes of regolith particles and regolith systems on the surface of planetary bodies, remote and in-situ observational results and techniques, analyses and results of returned samples, and laboratory, numerical, and theoretical studies on the fundamental physical and chemical processes are all welcome.

Note that what we call regolith is not just fine grains: all kinds of materials (more or less loose) that lie on the surface, from cobbles to finer grains, are our targets.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS02-01] Moganite in a lunar meteorite as a trace of H_2O ice in the lunar regolith

★Invited Papers

*Masahiro KAYAMA[1] (1.Tohoku University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS02-02] Simulating the Lunar Soil: a Japanese Lunar Soil Simulant FJS-1 and Its Properties

★Invited Papers

*Naohiro Uyama[1], Hiroshi Kanamori[1], Shigeru Aoki[1] (1.Shimizu Corporation)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS02-03] Experimental estimation of regolith scattering behavior when a space lander touches on a planetary body

★Invited Papers

*Mitsuhisa Baba[1], Ronald Louis Ballouz[2], Masatsugu Otsuki[1] (1.Japan Aerospace Exploration Agency, 2.The University of Arizona)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS02-04] Ray systems in granular cratering

*Tapan Sabuwala[1], Christian Butcher[1], Gustavo Gioia[1], Pinaki Chakraborty[1] (1.Okinawa Institute of Science and Technology Graduate University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS02-05] Scaling of oblique impact cratering onto inclined granular layer

Shinta Takizawa[1], *Hiroaki Katsuragi[1] (1.Graduate School of Environmental Studies, Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS02-06] Experimental study on gravitational effects on crater size formed by low-velocity impacts into granular media

*Masato Kiuchi[1], Akiko M Nakamura[2], Koji Wada[3] (1.Japan aerospace exploration agency, Institute of space and astronautical science, 2.Department of Planetology, Kobe University, 3.Planetary Exploration

Research Center, Chiba Institute of Technology)

Moganite in a lunar meteorite as a trace of H_2O ice in the lunar regolith

*Masahiro KAYAMA[1]

1. Tohoku University

A large amount of H_2O ice has been observed on the regolith surface near the lunar poles by remote sensing spacecraft. However, only sparse evidence for H_2O ice beneath the top few millimeters of the regolith exists because neutron spectrometers cannot distinguish forms of H and near-infrared spectrometers are only sensitive to the optical surface. Furthermore, traces of H_2O ice have not yet been found from the lunar samples. Here, 13 different lunar meteorites with various lithologies have been investigated using micro-Raman spectrometry, electron microscopy, and synchrotron angle-dispersive x-ray diffraction (SR-XRD) to find a trace of H_2O ice in the subsurface. Consequently, moganite has been discovered from the KREEP (high potassium, rare-earth element, and phosphorous)-like gabbroic-basaltic brecciated meteorite NWA 2727 that may originate from the local crater sites within the Procellarum terranes.

Moganite (monoclinic SiO_2 phase that belongs to the *I2/a* space group) coexisting with coesite and stishovite (high-pressure SiO_2 polymorphs) was discovered only in NWA2727 by the micro-Raman spectrometry. NWA 2727 is mainly composed of gabbroic and basaltic clasts containing their breccia matrix, where only the breccia matrix contain moganite-bearing silica micrograins (2 to 13 mm in radius) between the constituent minerals (olivine, pyroxene and plagioclase). The SR-XRD analyses of these silica micrograins in the breccia matrix indicate a characteristic diffraction pattern that is in good agreement with the structure of moganite. However, no moganite was discovered from the basaltic and gabbroic clasts of NWA 2727 as well as in the other lunar meteorites selected here. Transmission electron microscopy of the silica micrograins demonstrates the aggregates of numerous euhedral or subhedral moganite nanoparticles (average radius of 4.5 nm).

Moganite was discovered in only one of those 13 samples. If terrestrial weathering had produced moganite in the lunar meteorites, there should be moganite present in all the samples, especially lunar meteorites fell to Earth around the same time (NWA 2977, 3333, and 6950 as measured here), but this was not the case. Furthermore, many previous researches on natural occurrences and laboratory experiments conclude that moganite is restricted to formation by precipitating from alkaline silicic acid (H_4SiO_4) water under high-pressure consolidation at >100 MPa, which is distinctly different environment from the desert that NWA 2727 found. A part of the moganite had changed into the coesite and stishovite, indicating their formation through heavy impact collisions on the Moon. These facts confirm our theory that it could not have formed in the desert.

Formation of lunar moganite can be interpreted based on the present and previous works as follows. Alkaline water-bearing carbonaceous chondrite collisions delivered abundant alkaline water to the lunar surface at <2.67 Ga. After the collisions, the delivered water was captured as fluid inside the breccia during the shock-induced consolidation. On the sunlit surface, lunar moganite precipitated from this captured alkaline water. Simultaneously, such captured water got cold-trapped at the lunar regolith in the subsurface and may still remain as ice underneath the local crater sites within the Procellarum terranes. Lunar moganite coexists with coesite and stishovite, thereby implying that a trace of the subsurface water ice was brought from the Moon by the recent impact at <1–30 Ma. Our moganite-precipitation simulation

©2019. Japan Geoscience Union. All Right Reserved.

modeling concludes a subsurface H_2O concentration higher than the estimated bulk content of 0.6 wt % is expected to still remain as ice. This value is in excellent agreement with the concentrations of H_2O ice on the poles by remote sensing spacecraft observation. Thus, the subsurface is expected to be the abundant and available water resource for future lunar explorations.

Keywords: Moganite, Lunar meteorite, H2O ice, Regolith

©2019. Japan Geoscience Union. All Right Reserved.

Simulating the Lunar Soil: a Japanese Lunar Soil Simulant FJS-1 and Its Properties

*Naohiro Uyama[1], Hiroshi Kanamori[1], Shigeru Aoki[1]

1. Shimizu Corporation

Going back to the Moon is a world-wide trend of space exploration based on the international cooperation as the Global Exploration Roadmap (GER3) stated. JAXA also proposed future human exploration missions around 2030 within the international cooperation. All scenarios have their bases on the scientific observation that a plenty of water (hydrogen) is trapped in the polar regions, especially inside the craters of permanent shadow. In order to investigate those water and other existing volatiles, however, many engineering challenges wait for human and robotic missions even only from the view of lunar soil, such as traversing the soft soil, drilling and/or excavating the soil, and handling the soil for desired sample collections and scientific processes, and more for the in-situ resource utilization and human missions. Thus, the ground tests prior to launches are of great importance to increase the possibility of mission success.

In order to offer opportunities for the community to perform ground tests, we have manufactured a lunar soil simulant, called FJS-1. The investigation of FJS-1 shows that many properties of FJS-1 lies close to the data collected from Apollo samples. For instance, the particle size distribution lies below 2 [mm]; the median particle size is between 70 and 75 [micro-m]; the shear strength, i.e. cohesion c, is 0 to 10 [kN/m2]; and the internal friction angle, phi, is 30 to 50 [deg]. The chemical composition is also close to Apollo samples with slight difference that FJS-1 contains more ferric oxide and Alkaline components than Apollo samples.

In addition to the basic properties, we started investigating the strength of frozen lunar soil using FJS-1. Determining the optimized configuration of a sampler such as a drill or an excavator needs the information of actual lunar soil; however, nobody knows the actual state, in other words, the ground truth of lunar water/ice yet. We therefore decided to investigate the strength of frozen soil, utilizing FJS-1, for the future use for drill or excavator designs. The qualitative observation from our first experiment is that the frozen FJS-1 at temperature below 0 [degC] became slightly loose when FJS-1 contained 0.5 to 1.0 [wt%] of water, and that the strength drastically increased above 2 [wt%]. We will conduct more experiments to collect a set of frozen soil strength to offer the estimates of the strength of lunar soil for future lunar exploration missions.

Keywords: Lunar soil, Soil simulant, FJS-1, Soil simulant properties, Frozen soil

©2019. Japan Geoscience Union. All Right Reserved.

Experimental estimation of regolith scattering behavior when a space lander touches on a planetary body

*Mitsuhisa Baba[1], Ronald Louis Ballouz[2], Masatsugu Otsuki[1]

1. Japan Aerospace Exploration Agency, 2. The University of Arizona

A planetary lander, which needs to land on and lift up from a planetary surface, needs to be concerned with levitated regolith. Regolith scattered by the landing foot pad might attach to or damage on-board instruments, such as the spacecraft’ s camera suite. To design the landing probe, it is necessary to estimate the expected area of the regolith that the probe may scatter. Here we show an experimental approach that was developed to study the behavior of scattered regolith under a vacuum environment. For the probe design, it is necessary to precisely measure the initial ejection angle, ejection velocity, and the amount of regolith that the landing foot pad scatters.

In order to characterize scattered-particle behavior, drop tests in a large vacuum chamber were conducted. A cylindrical mass projectile, mimicking the lander foot pad, fell freely from various heights in the vacuum chamber. The mass lands in a sandbox filled with silica sand and forms a crater with scattered sand particles. During silica sand scattering, a high-speed camera detected particle highlighted by a line laser. Initial ejection velocities and the ejection angles were estimated by processing the images of the impact site, captured by the high-speed camera.

The result of our study revealed that the ejection angle of scattered grains is not sensitive to the impact kinetic energy of the projectile. Our results are consistent with previous studies that showed a similar relationship between impact kinetic energy and ejection angle, but for lower impact energies. Moreover, we find that for impact speeds of ~ 4 m/s, the initial ejection velocity of a majority of the silica sand particle is distributed around 1 m/s.

Our experimental approach can be applied to various kinds of planetary regolith, such as Phobos simulant for the Martian Moons eXploration(MMX). These results help us to understand how to determine the optimal design conditions for a landing probe. Further studies that account for the effect of microgravity and changes to the bulk density and porosity of the regolith need to be undertaken based on drop tower test and numerical simulation.

Keywords: Regolith, Laboratory Experiment, Landing Gear

©2019. Japan Geoscience Union. All Right Reserved.

Ray systems in granular cratering

*Tapan Sabuwala[1], Christian Butcher[1], Gustavo Gioia[1], Pinaki Chakraborty[1]

1. Okinawa Institute of Science and Technology Graduate University

In classical experiments of granular cratering, a ball dropped on a smooth bed of grains ends up within a crater surrounded by a uniform blanket of ejecta. We show that such a uniform blanket of ejecta changes to a ray system, or set of radial streaks of ejecta, where the surface of the granular bed includes undulations. By carrying out numerous experiments and computational simulations thereof, we ascertain that the number of rays in a ray system $\propto D/\lambda$, where D is the diameter of the ball and λ the wavelength of the undulations. Further, we show that the ejecta in a ray system originates from valleys located in a narrow annulus of diameter D with center at the site of impact. The impacting ball creates a hemispherical shockwave, whose interaction with the surficial valleys engenders the ray system. Our findings may help shed light on the enigmatic ray systems that ring many impact craters on the Moon and other planetary bodies.

Keywords: impact crater, crater rays, granular cratering

©2019. Japan Geoscience Union. All Right Reserved.

Scaling of oblique impact cratering onto inclined granular layer

Shinta Takizawa[1], *Hiroaki Katsuragi[1]

1. Graduate School of Environmental Studies, Nagoya University

Empirical (Pi-group) scaling laws for craters created on an inclined granular layer by an oblique impact of a spherical projectile were experimentally obtained. In the experiment, inclination angle and incident angle were systematically (and independently) varied in the ranges of 0 to 33 degree and 10 to 170 degree, respectively. A spherical projectile (diameter 6 mm) was impacted onto a surface of inclined granular layer with an impact speed 10 - 100 m/s. Two high-speed cameras and laser profilometry system were used to measure the impact speed, angle, and final crater shape. From the experimental results, we found following behaviors. When the incident angle is small, almost symmetric craters were observed. However, the collapse of the upper crater wall was triggered when the inclination angle is large enough. The scale of the collapse grows as the inclination angle is increased. In addition, the crater volume strongly depends on inclination angle. By combining these experimental findings, we developed the empirical scaling for crater dimensions and aspect ratios. The obtained scaling is consistent with previous works on the normal impact to horizontal granular surface with high impact speed. We also discuss a possible way to evaluate the impact conditions from the actual astronomical impact craters.

Keywords: oblique impact , inclined granular layer

©2019. Japan Geoscience Union. All Right Reserved.

Experimental study on gravitational effects on crater size formed by low-velocity impacts into granular media

*Masato Kiuchi[1], Akiko M Nakamura[2], Koji Wada[3]

1. Japan aerospace exploration agency, Institute of space and astronautical science, 2. Department of Planetology, Kobe University, 3. Planetary Exploration Research Center, Chiba Institute of Technology

Craters on regolith surface can be formed at various impact velocities. When secondary craters form on the surface of small bodies, such as asteroids and comets, the impactors have very low-velocities of several m s^{-1} or less due to the small escape velocity of the bodies. These secondary collisions can increase the number of small craters on the surface and will affect the surface topography of small bodies. Therefore, it is important to investigate low-velocity impacts on granular materials that simulate regolith particles to understand the low-velocity cratering process on the surface of small bodies.

Low-velocity impact experiments with velocities in the range of several m s^{-1} and granular targets have been conducted to investigate crater size and develop empirical relationships between impact conditions and crater size under 1 G (e.g., Uehara et al., 2003; Walsh et al., 2003). However, it was found that the impact velocity dependence of crater diameter was inconsistent between the hypervelocity impact experiments conducted at low and high-gravity conditions (Gault and Wedekind, 1977; Schmidt and Housen, 1987) and the low-velocity impact experiments conducted under 1 G (Kiuchi et al., 2018, JpGU meeting).

We collected data of crater diameter on granular materials with impact velocities ranging from 1 to 4.6 m s^{-1} under a gravity range of 0.20 to 1 G to investigate the effects of gravity on crater diameter using a drop system developed for reduced gravity impact experiments (Kiuchi and Nakamura, 2015 JPGU meeting). Most of our experiments were conducted under 10^5 Pa for comparison with the low-velocity experiments under 1 G reported in previous studies, but we also conducted several experiments under 7 Pa according to the atmosphere-less condition of small bodies.

This time we newly organized our experimental results in which the gravity was changed using the atmospheric pressure dependence. As a result, the exponent values of gravity became close to that obtained by the high-velocity experiment (Gault and Wedekind, 1977). We compared our results with high-velocity experiments reported in previous studies. Our results for the glass projectile and the sand target almost agreed with the previous high-velocity crater-size scaling- law (Housen and Holsapple, 2011) when the atmospheric effect was taken into account, but the crater diameter for the steel projectile and the sand target was lower than that for the glass projectile. This result shows that the crater-size scaling- law obtained for high-velocity impact can be applied to low-velocity impacts of several m s^{-1} under reduced pressure when the density ratio of the projectile to the target is close to unity. The same scaling applies over a very wide range of impact velocities.

Keywords: Impact experiments at low-velocity, Gravitational effects on crater size

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS02] Regolith Science

convener:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Akiko Nakamura(Graduate School of Science, Kobe University), Patrick Michel(Observatoire De La Cote D'Azur), Kevin John Walsh(Southwest Research Institute Boulder), Chairperson:Akiko Nakamura(Graduate School of Science, Kobe University)

Recent planetary explorations have revealed that almost all solid bodies in the solar system are covered with small particles, called regolith. The surface geology, especially regolith behavior on the surfaces of solid bodies, becomes increasingly more important as represented by Hayabusa mission and other on-going and planned sample-return missions such as Hayabusa2, OSIRIS-REx, and MMX.

For fully understanding the regolith science, it is required to know and compare the regolith conditions on various celestial bodies, from asteroids to planets, with various methods.

Therefore, this session welcomes broad topics related to regolith on various celestial bodies, such as asteroids, comets, the Moon, the martian moons, Mars, etc. Papers on the formation, evolution, and alteration processes of regolith particles and regolith systems on the surface of planetary bodies, remote and in-situ observational results and techniques, analyses and results of returned samples, and laboratory, numerical, and theoretical studies on the fundamental physical and chemical processes are all welcome.

Note that what we call regolith is not just fine grains: all kinds of materials (more or less loose) that lie on the surface, from cobbles to finer grains, are our targets.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS02-07] **Impact Ejecta Environment of an Eccentric Asteroid: 3200 Phaethon**

*Jamey Szalay[1], Peter Pokorny[2], Mihaly Horanyi[3], Diego Janches[2], Menelaos Sarantos[2], Ralf Srama[4] (1.Princeton University, 2.NASA/GSFC, 3.University of Colorado Boulder, 4.University of Stuttgart)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS02-08] On the Detection of an Ejecta Dust Cloud Around Asteroid (3200) Phaethon by the DESTINY$^+$ Dust Analyzer

*Hiroshi Kimura[1], Masanori Kobayashi[1], Koji Wada[1], Tomoko Arai[1], Hiroki Senshu[1], Masateru Ishiguro[2], Hidekazu Hanayama[3], Ko Ishibashi[1], Takayuki Hirai[1], Fumi Yoshida[1], Peng Hong[1] (1.Planetary Exploration Research Center, 2.Seoul National University, 3.Ishigakijima Astronomical Observatory)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS02-09] Close-up thermal and optical observation of asteroid Ryugu

★Invited Papers

*Naoya Sakatani[1], Tatsuaki Okada[1], Satoshi Tanaka[1], Hiroki Senshu[2], Yuri Shimaki[1], Takehiko Arai[3], Toru Kouyama[5], Hirohide Demura[6], Kentaro Suko[6], Tomohiko Sekiguchi[4], Jun Takita[15], Tetsuya Fukuhara[4], Makoto Taguchi[4], Thomas Müller[7], Axel Hargermann[8], Jens Biele[9], Matthias Grott[9], Marco Delbo[10], Seiji Sugita[13], Rie Honda[12], Tomokatsu Morota[11], Manabu Yamada[2], Shingo Kameda[4], ERI TATSUMI[13], Yasuhiro Yokota[1], Hidehiko Suzuki[14], Chikatoshi Honda[6], Kazunori Ogawa[16], Masahiko Hayakawa[1], Moe Matsuoka[1], Yuichiro Cho[13], Hirotaka Sawada[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Chiba Institute of Technology, 3.Ashikaga University, 4.Rikkyo University, 5.National Institute of Advanced Industrial Science and Technology, 6.University of Aizu, 7.Max-Planck Institute for Extraterrestrial Physics, 8.University of Stirling, 9.German Aerospace Center, 10.Observatoire de la Côte d'Azur, CNRS, 11.Nagoya University, 12.Kochi University, 13.University of Tokyo, 14.Meiji University, 15.Hokkaido University for Education, 16.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS02-10] **In-Situ Investigation of Asteroid (162173) Ryugu by the Hayabusa2 MASCOT Lander**

★Invited Papers

*Hajime Yano[1], Tra-Mi Ho[2], Ralf Jaumann[3], Jean-Pierre Bibring[4], Karl-Heinz Glassmeier[5], Matthias Grott[3], David Hercik[5], Jens Biele[6], Maximilian Hamm[3], Nicole Schmitz[3], Stefanus Schröder[3], Katharina Otto[3], Christian Krause[6], Laurence Lorda[7], Aurelie Moussi-Soffys[7], Cedric Pilorget[4], Vincent Hamm[4], Lucie Riu[1], Tatsuaki Okada[1], Naoya Sakatani[1], Josef Reill[8], Kaname Sasaki[2], Markus Schlotterer[2], Yuichi Tsuda[1], Stephan Ulamec[6], Friederike Wolff[8], Patrick Michel[9], Marco Delbo[9], Kazunori Ogawa[10], Hiroki Senshu[11], Tetsuo Yoshimitsu[1], Frank Preusker[3], Frank Scholten[3], Stephan Elgner[3], Stefano Mottola[3], Ekkehard Kührt[3], Takanao Saiki[1], Yuya Mimasu[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, Japan, , 2.German Aerospace Center DLR Bremen, Bremen, Germany, 3.German Aerospace Center, Berlin, Germany, 4.Univ. de Paris Sud-Orsay, IAS, Orsay, France, 5.TU Braunschweig, Braunschweig, Germany, 6.German Aerospace Center DLR Cologne, Cologne, Germany, 7.National Centre for Space Studies, CNES, Toulouse, France, 8.German Aerospace Center, DLR, Oberpfaffenhofen, Germany, 9.Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France, 10.Department of Planetology, Graduate School of Science, Kobe University, Kobe, Japan, 11.Planetary Exploration Research Center, Chiba Institute of Technology, Narashino, Japan)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS02-11] Evidence of Mass Movement and Boulder Transport on Bennu from NASA's OSIRIS-REx Space Mission

★Invited Papers

*Erica R Jawin[1], Kevin J Walsh[2], Tim McCoy[1], Harold C Connolly[3], Dante S Lauretta[4], Ron L Ballouz[4], Jamie L Molaro[5], Olivier S Barnouin[6], Mike Nolan[4] (1.Smithsonian National Institute, Washington, DC, USA, 2.Southwest Research Institute, Boulder, CO, USA, 3.Dept. of Geology, Rowan University, Glassboro, NJ, USA, 4.Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA , 5.Planetary Science Institute, Tucson, AZ, USA, 6.The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS02-12] Resurfacing processes on small asteroids constrained by crater size distributions on Ryugu, Itokawa, and Eros

*Naofumi Takaki[1], Yuichiro Cho[1], Tomokatsu Morota[3], ERI TATSUMI[1], Kazuo Yoshioka[1], Hirotaka Sawada[5], yokota yasuhiro[2,5], Naoya Sakatani[5], Masahiko Hayakawa[5], Moe Matsuoka[5], Rie Honda[2], Shingo Kameda[4], Manabu Yamada[6], Toru Kouyama[8], Hidehiko Suzuki[10], Chikatoshi Honda[7], Kazunori Ogawa[9], Hideaki Miyamoto[1], Olivier Barnouin[11], Patrick Michel[12], Carolyn Ernst[11], Seiji Sugita[1,6] (1.University of Tokyo, 2.Kochi University, 3.Nagoya University, 4.Rikkyo University, 5.JAXA, 6.Chiba Institute of Technology, Planetary Exploration Res. Center, 7.University of Aizu, 8.AIST, 9.Kobe University, 10.Meiji University, 11.Johns Hopkins University Applied Physics Laboratory, 12.Nice Observatory)

Impact Ejecta Environment of an Eccentric Asteroid: 3200 Phaethon

*Jamey Szalay[1], Peter Pokorny[2], Mihaly Horanyi[3], Diego Janches[2], Menelaos Sarantos[2], Ralf Srama[4]

1. Princeton University, 2. NASA/GSFC, 3. University of Colorado Boulder, 4. University of Stuttgart

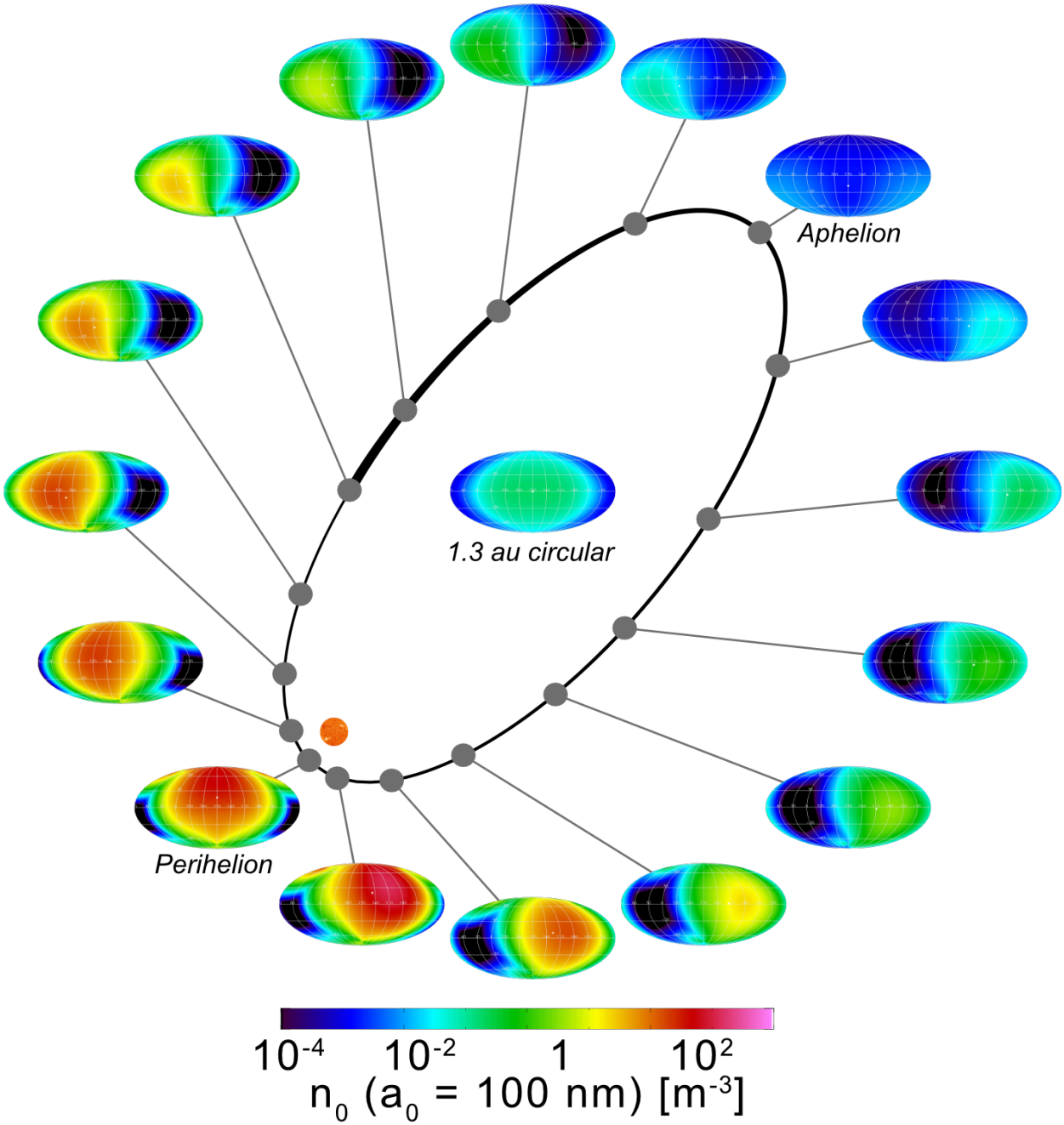
Airless regolith bodies in the solar system are continually bombarded by meteoroids, modifying their surfaces and sustaining impact ejecta clouds. While large bodies like the Moon retain a significant fraction of ejected regolith, small asteroids shed this material into the interplanetary dust complex. Measurements of the lunar impact ejecta cloud found it was sustained by the known sporadic meteoroid sources. Here, we extend lunar ejecta measurements using a model of the meteoroid environment at 1 au to investigate the structure of an ejecta cloud at an eccentric airless body, asteroid 3200 Phaethon: the target of JAXA’s DESTINY+ mission.

Due to Phaethon's large eccentricity, Phaethon's peak ejecta density at 1 au is approximately 30 times higher compared to a body in a circular orbit at 1 au, largely due to enhanced ejecta production from meteoroids shed from Jupiter Family Comets. Such asymmetric ejecta production suggests Phaethon experiences significantly different meteoroid-specific space weathering processes than a body with a similar semi-major axis on a circular orbit. We estimate impact ejecta processes at Phaethon shed approximately 1 ton per year, which is not sufficient to appreciably contribute to the Geminids meteoroid complex, yet provides ample ejecta densities to measure with an in-situ dust detector aboard DESTINY+. These results suggest eccentric asteroids shed more material than those on near-circular orbits, and are suitable candidates for in-situ dust detection and chemical characterization due to their amplified asymmetric ejecta production.

In this presentation, we will summarize recent efforts to constrain the evolution and ejection of asteroid regolith for 3200 Phaethon. We will present predicted impact counts for a dust detector on close flybys of Phaethon in preparation for JAXA’s DESTINY+ mission and discuss how such measurements would provide critical insight into Phaethon’s origin and evolution in a manner unique to dust detection data.

Keywords: Ejecta, Meteoroids, Regolith

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

On the Detection of an Ejecta Dust Cloud Around Asteroid (3200) Phaethon by the DESTINY$^+$ Dust Analyzer

*Hiroshi Kimura[1], Masanori Kobayashi[1], Koji Wada[1], Tomoko Arai[1], Hiroki Senshu[1], Masateru Ishiguro[2], Hidekazu Hanayama[3], Ko Ishibashi[1], Takayuki Hirai[1], Fumi Yoshida[1], Peng Hong[1]

1. Planetary Exploration Research Center, 2. Seoul National University, 3. Ishigakijima Astronomical Observatory

We will provide the most recent report on the detectability of an ejecta cloud around Asteroid (3200) Phaethon by the DESTINY$^+$ Dust Analyzer (DDA), based on a model of dust dynamics in the cloud. We demonstrate that solar radiation pressure plays a vital role in shaping the spatial distribution of dust particles in Phaethon's ejecta cloud, because small particles, albeit the majority, are expelled from the sunward direction. We find that the DDA will have an opportunity of detecting dust particles in the ejecta cloud of Phaethon during a flyby, depending on the closest approach to the asteroid, heliocentric distance, and the initial velocity of ejecta. There are no hazard from impacts of 100 μm-sized ejecta particles that potentially could make tiny holes on the surface of the spacecraft during a flyby.

Keywords: Asteroid (3200) Phaethon, ejecta dust cloud, DESTINY+

©2019. Japan Geoscience Union. All Right Reserved.

Close-up thermal and optical observation of asteroid Ryugu

*Naoya Sakatani[1], Tatsuaki Okada[1], Satoshi Tanaka[1], Hiroki Senshu[2], Yuri Shimaki[1], Takehiko Arai[3], Toru Kouyama[5], Hirohide Demura[6], Kentaro Suko[6], Tomohiko Sekiguchi[4], Jun Takita[15], Tetsuya Fukuhara[4], Makoto Taguchi[4], Thomas Müller[7], Axel Hargermann[8], Jens Biele[9], Matthias Grott[9], Marco Delbo[10], Seiji Sugita[13], Rie Honda[12], Tomokatsu Morota[11], Manabu Yamada[2], Shingo Kameda[4], ERI TATSUMI[13], Yasuhiro Yokota[1], Hidehiko Suzuki[14], Chikatoshi Honda[6], Kazunori Ogawa[16], Masahiko Hayakawa[1], Moe Matsuoka[1], Yuichiro Cho[13], Hirotaka Sawada[1]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Chiba Institute of Technology, 3. Ashikaga University, 4. Rikkyo University, 5. National Institute of Advanced Industrial Science and Technology, 6. University of Aizu, 7. Max-Planck Institute for Extraterrestrial Physics, 8. University of Stirling, 9. German Aerospace Center, 10. Observatoire de la Côte d'Azur, CNRS, 11. Nagoya University, 12. Kochi University, 13. University of Tokyo, 14. Meiji University, 15. Hokkaido University for Education, 16. Kobe University

In 2018, the Hayabusa2 spacecraft successfully carried out four descend operations toward Ryugu’s surface. During these operations, we acquired highly resolved optical and thermal images from altitudes below several hundred meters, using Hayabusa2’s Optical Navigation Camera (ONC-T) and Thermal Infrared Imager (TIR), respectively. Close-up thermal images by TIR indicate thermophysical properties of the surface materials and its regional difference, which cannot be resolved by higher altitude observations (e.g., home-position observations from 20 km altitude). The temperature depends mainly on the thermal inertia of the observed medium; higher thermal inertia materials have lower daytime temperatures. Optical images by ONC-T show detailed physical conditions of the surface materials, such as particle size distribution of pebbles, surface morphology of small boulders and craters. At the spacecraft altitude of 100 m, for example, TIR and ONC-T have pixel resolutions of 8.9 cm/pix and 1.1 cm/pix, respectively. In this study, we report on a comparison of TIR and ONC images, especially for boulders and craters.

BOULDERS: TIR close-up observations showed various boulders with different daytime temperatures, or different thermal inertia. Typical thermal inertia of boulders is about 300 J m^{-2} K^{-1} $s^{-0.5}$, but there are a few boulders with thermal inertia up to 1000 J m^{-2} K^{-1} $s^{-0.5}$. The thermal inertia of rocks is mainly controlled by porosity, and porous rock has lower thermal inertia. Therefore, TIR observations show that the porosity of boulders is variable. Furthermore, boulders with high thermal inertia (low porosity) observed by ONC-T were found to be relatively brighter and had a smooth surface. Such variation in porosity, optical brightness, and surface morphology of boulders on Ryugu’s surface might reflect the degree of thermal metamorphism (depth of the source) in the parent body. If the constituents of Ryugu originate from variable depths inside the parent body, this supports the idea of a rubble pile formation of Ryugu after the catastrophic disruption of the parent body. This will place important constraints on the thermal evolution of the parent body.

CRATERS: During the MINERVA descend operations at 21st Sep., we acquired highly resolved images of two craters with diameter of less than 35 m by TIR, but both craters exhibit different thermal characteristics. One crater has a hot spot close to the center of crater, where the thermal inertia is estimated to be less than 150 J m^{-2} K^{-1} $s^{-0.5}$. On the other hand, there seems to be no hot spot in the other crater. The difference in thermophysical properties between these craters might be attributed to formation age or original surface conditions. Our finding of a hot spot with low thermal inertia indicates the presence of a fine-particle deposit in the crater and regolith generation related to the cratering process on this low-gravity asteroid.

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

In-Situ Investigation of Asteroid (162173) Ryugu by the Hayabusa2 MASCOT Lander

*Hajime Yano[1], Tra-Mi Ho[2], Ralf Jaumann[3], Jean-Pierre Bibring[4], Karl-Heinz Glassmeier[5], Matthias Grott[3], David Hercik[5], Jens Biele[6], Maximilian Hamm[3], Nicole Schmitz[3], Stefanus Schröder[3], Katharina Otto[3], Christian Krause[6], Laurence Lorda[7], Aurelie Moussi-Soffys[7], Cedric Pilorget[4], Vincent Hamm[4], Lucie Riu[1], Tatsuaki Okada[1], Naoya Sakatani[1], Josef Reill[8], Kaname Sasaki[2], Markus Schlotterer[2], Yuichi Tsuda[1], Stephan Ulamec[6], Friederike Wolff[8], Patrick Michel[9], Marco Delbo[9], Kazunori Ogawa[10], Hiroki Senshu[11], Tetsuo Yoshimitsu[1], Frank Preusker[3], Frank Scholten[3], Stephan Elgner[3], Stefano Mottola[3], Ekkehard Kührt[3], Takanao Saiki[1], Yuya Mimasu[1]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, Japan, , 2. German Aerospace Center DLR Bremen, Bremen, Germany, 3. German Aerospace Center, Berlin, Germany, 4. Univ. de Paris Sud-Orsay, IAS, Orsay, France, 5. TU Braunschweig, Braunschweig, Germany, 6. German Aerospace Center DLR Cologne, Cologne, Germany, 7. National Centre for Space Studies, CNES, Toulouse, France, 8. German Aerospace Center, DLR, Oberpfaffenhofen, Germany, 9. Université Côte d’Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France, 10. Department of Planetology, Graduate School of Science, Kobe University, Kobe, Japan, 11. Planetary Exploration Research Center, Chiba Institute of Technology, Narashino, Japan

After a journey of almost four years to the C-type asteroid (162173) Ryugu, the MASCOT lander of the Hayabusa2 mission was delivered to the asteroid’s surface on October 3rd in 2018 and successfully performed in situ investigations. MASCOT was released from the mother spacecraft at an altitude of 41 m and came to rest on the surface at a site located at 22.31±0.05°S, 317.16±0.05°E. MASCOT observed the surface for a full day-night cycle using its four science instruments until batteries ran out after 17h and 7min. The payload consisting of a wide angle camera (MASCAM), an imaging IR spectrometer (MicrOmega), a multi-channel radiometer (MARA), and a magnetometer (MasMAG) provided a wealth of data which helped to characterize the asteroid’s surface down to millimeter scale. MasCAM images revealed a surface dominated by rocks and boulders without showing fine-grained material. Boulders appeared either bright with smooth faces and sharp edges or dark with cauliflower-like crumbly surfaces. Inclusions observed in high-resolution images showed that rocks had strong similarities with carbonaceous chondrites. Temperatures of a ~60 cm diameter rock that have been measured in situ, were found to be consistent with a thermal inertia of 282(+93, -35) J m^{-2} K^{-1} $s^{-1/2}$, much lower than anticipated when compared to samples in our meteorite collections. This indicated that rocks on Ryugu were highly porous and likely very friable. The remnant magnetization of Ryugu's surface material on scales larger than 1 m was estimated to be lower than $3 \cdot 10^{-6}$ Am^2/kg (the measurement limit of MasMAG). A preliminary analysis of the induction effect in Ryugu caused by the variation in the solar wind magnetic field revealed significantly high electrical conductivity (of the order 1 S/m).

Keywords: Ryugu, Hayabusa2, Asteroid Surface, Lander, Carbonaceous Chondrites, High Porosity

©2019. Japan Geoscience Union. All Right Reserved.

Evidence of Mass Movement and Boulder Transport on Bennu from NASA's OSIRIS-REx Space Mission

*Erica R Jawin[1], Kevin J Walsh[2], Tim McCoy[1], Harold C Connolly[3], Dante S Lauretta[4], Ron L Ballouz[4], Jamie L Molaro[5], Olivier S Barnouin[6], Mike Nolan[4]

1. Smithsonian National Institute, Washington, DC, USA, 2. Southwest Research Institute, Boulder, CO, USA, 3. Dept. of Geology, Rowan University, Glassboro, NJ, USA, 4. Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA , 5. Planetary Science Institute, Tucson, AZ, USA, 6. The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA

The near-Earth Asteroid (101955) Bennu is currently being studied by the NASA OSIRIS-REx mission. This small, top-shaped asteroid has evidence of a diverse suite of geologic units, including impact craters, linear features, and abundant boulders at a range of sizes, geometric albedos, and morphologies. The surface of the asteroid appears to be old; however localized evidence of mass movement has been detected in various locations that suggests the surface is dynamic. The abundance of boulders on the surface varies widely with location, with concentrations of boulders located in local topographic lows (e.g. the interior of candidate impact craters, between linear ridges), suggesting that boulders travelled across the surface to result in these concentrations. Several locations that are abundant in boulders show evidence of imbrication in the local downslope direction, but evidence of imbrication is more localized than on other asteroids such as Itokawa. Evidence of mass movement at smaller particles sizes is also evident by burial of boulders: evidence of largescale W-E movement of material and burial of rocks has been identified, as well as pileup of boulders at locations downslope of scarps. In addition, the largest boulder on Bennu (~95 m diameter) appears to be partly buried, with a portion of the boulder of unknown size remaining in the subsurface. This boulder has an exposed face that extends vertically off the surface by ~20 m, suggesting that several tens of meters of finer-grained material could have accumulated to bury part of the boulder. The direction that material would have traveled to bury this boulder follows the regional slopes. As a comparison, the second largest boulder on Bennu (~50 m diameter) that is nearby albeit at a slightly higher latitude (45 S latitude, versus the buried boulder at 25 S latitude) is not buried –rather, this boulder appears to be perched on the surface. The variation in very large boulder burial suggests the surface of Bennu has potentially experienced large-scale material transport.

Keywords: OSIRIS-REx, Bennu, Mass-movement, Asteroid, Regolith

©2019. Japan Geoscience Union. All Right Reserved.

Resurfacing processes on small asteroids constrained by crater size distributions on Ryugu, Itokawa, and Eros

*Naofumi Takaki[1], Yuichiro Cho[1], Tomokatsu Morota[3], ERI TATSUMI[1], Kazuo Yoshioka[1], Hirotaka Sawada[5], yokota yasuhiro[2,5], Naoya Sakatani[5], Masahiko Hayakawa[5], Moe Matsuoka[5], Rie Honda[2], Shingo Kameda[4], Manabu Yamada[6], Toru Kouyama[8], Hidehiko Suzuki[10], Chikatoshi Honda[7], Kazunori Ogawa[9], Hideaki Miyamoto[1], Olivier Barnouin[11], Patrick Michel[12], Carolyn Ernst[11], Seiji Sugita[1,6]

1. University of Tokyo, 2. Kochi University, 3. Nagoya University, 4. Rikkyo University, 5. JAXA, 6. Chiba Institute of Technology, Planetary Exploration Res. Center, 7. University of Aizu, 8. AIST, 9. Kobe University, 10. Meiji University, 11. Johns Hopkins University Applied Physics Laboratory, 12. Nice Observatory

Recent ion irradiation experiments in laboratories suggest that space weathering may take place very rapidly [1], but telescopic observations of asteroids support much slower space weathering [2]. The spectral rejuvenation process on asteroid surfaces may hold a key for bridging the gap between the two opposite conclusions [3]. However, the nature of the spectral rejuvenation process has not been understood well yet. One approach for understanding the spectral rejuvenation process is to constrain the depth-age relation of surface layers on asteroids. In fact, imaging observations by Hayabusa2 revealed that smaller craters are highly depleted on the surface of the asteroid Ryugu [4], strongly suggesting that resurfacing is acting efficiently on near-surface layers. This depletion was already observed on Eros and Itokawa [5]. In this study, we analyze this depletion in small craters to constrain the resurfacing mechanism on small asteroids, such as Ryugu, Itokawa, and Eros. More specifically, we estimate the resurfacing age of Ryugu, Itokawa and Eros based on crater counting and crater production functions. Then we compare the analysis results with theoretical models for resurfacing mechanisms on such small asteroids.

Crater retention age can be estimated by using both the crater size frequency distribution (CSFD) and the crater production function (CPF). The CSFD on Ryugu shows that the large craters distribution (≧100m in diameter) is close to saturation level, but the number density of small craters (~10 m) is reduced by a factor of 100 [4]. Similar depletion in small craters is also observed on Itokawa [5]. We calculated crater retention ages for different size craters and derived the relation between crater retention ages and excavation depth of craters.

The CPFs on Ryugu, Itokawa, and Eros are estimated based on a classical main belt collisional evolution model and a scaling relation for crater formation. We used a scaling relation including armoring effect [6] for Ryugu and Itokawa to account for the high abundance of boulders on them. In this analysis, we used larger craters than ~10m in diameter. Finally, we derived the relation between crater retention age, t, and depth, d, of crater, $t \sim d^a$, where a is found to be 1.8±0.4 on Ryugu, 1.1±0.3 on Itokawa, and 1.9±0.3 on Eros, respectively. If crater degradation is controlled by a diffusion process, the relation between crater retention age t is proportional to the square of crater depth d, i.e., $t \sim d^2$. Ryugu's and Eros's power-law indices (a ~1.8-1.9) are consistent with diffusion (a = 2), which is not the case of Itokawa's power-law index. However, Itokawa's power-law index a increase to 1.9 if we include smaller craters than ~10m in

©2019. Japan Geoscience Union. All Right Reserved.

diameter in this analysis. This value is consistent with diffusion (a = 2). Actually, Michel et al. 2009 suggests that the depletion of small craters on Itokawa is reproduced by a seismic shaking model without taking an armoring effect into account [7]. The efficiency of an armoring effect for small craters on asteroids is uncertain, but an armoring effect may change the interpretation of CSFDs. In order to understand crater scaling for smaller craters, Small Carry-on Impactor (SCI) experiment on Hayabusa2 is important.

[1] Lantz+2018, Icarus, **302**, 10–17

[2] Lazzarin+2009 AA, **498**, 307-311

[3] Shestopalov+2013, Icarus, **225**, 781-798

[4] Sugita+2019, Science in revision

[5] Hirata+2009, Icarus, **200**, 486-502

[6] Tatsumi & Sugita 2018, Icarus, **300**, 227-248

[7] Michel+2009, Icarus, **200**, 503-513

Keywords: asteroid, crater, resurfacing, Ryugu, Itokawa, Hayabusa2

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Taishi Nakamoto(Tokyo Institute of Technology)

In June 2018, the Hayabusa 2 spacecraft arrived at the target asteroid Ryugu after three and half years journey. In addition, another spacecraft, OSIRIS-REx will soon arrive at its destination Bennu. With these arrivals, the solar system research is about to enter a new era. We have organized this small bodies session since 2012 and had a broad range of discussions from viewpoints of laboratory experiments, observations, space explorations, theoretical modeling, and sample analyses. In particular, this time, we aim to hold this session to bring the latest research on solar system small bodies, focusing on the initial results of Hayabusa 2 and OSIRIS-REx. Presentations in the related fields other than these two asteroidal missions are also welcomed.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS03-19] The shape of Bennu: Implications for internal structure.

★Invited Papers

*Olivier S Barnouin[1], Micheal G. Daly[2], Eric E Palmer[3], Robert W Gaskell[3], John R. Weirich[3], Catherine L Johnson[4], Manar Al Asad[4], James H Roberts[1], Mark E. Perry[1], Hannah C.M. Sursorney[4], R. Terik Daly[1], Edward B. Bierhaus[5], Jeff A Seabrook[2], Raymond C. Espiritu[1], A. Hari Nair[1], Lilian Nguyen[1], Gregory A Neumann[6], Carolyn M Ernst[1], William V Boynton[7], Micheal C. Nolan[7], Coralie D. Adams[9], Micheal C. Moreau[6], Bashar Rizk[7], Christian Drouet D'Aubigny[7], Erica R. Jawin[8], Kevin J Walsh[10], Patrick Michel[11], Stephen R. Schwartz[7], Ronald L. Ballouz[7], Erwan M Mazarico[6], Daniel J. Scheeres[12], Jay W. McMahon[12], W Bottke[10], Seiji Sugita[13], Naru Hirata[14], Noayuki Hirata[15], Sei-ichiro Watanbe[16], Keara N. Burke[7], Daniella N. DellaGuistina[7], Carinna A. Bennet[7], Dante Lauretta[7] (1.Johns Hopkins University Applied Physics Laboratory, 2.The Centre for Research in Earth and Space Science, York University, Toronto, Ontario, Canada., 3.Planetary Science Institute, Tucson, AZ, USA, 4.Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, Canada., 5.Lockheed Martin Space Systems Company, Denver, CO, USA., 6.NASA Goddard Space Flight Center, Greenbelt, MD, USA., 7.Lunar Planetary Laboratory, University of Arizona, Tucson, AZ, USA., 8.Smithsonian Institution National Museum of Natural History, Washington, DC, USA., 9.KinetX Aerospace, Inc. Simi Valley, CA, USA, 10.Southwest Research Institute, Boulder, CO, USA., 11.Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France., 12.Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA., 13.University of Tokyo, Tokyo, Japan., 14.Aizu University, Aizu-Wakamatsu, Japan., 15.Kobe University, Kobe, Japan., 16.Nagoya University, Nagoya, Japan.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS03-20] Global Geology of Bennu from NASA's OSIRIS-REx Space Mission

★Invited Papers

*Erica R Jawin[1], Kevin J Walsh[2], Tim McCoy[1], Harold C Connolly[3], Dante S Lauretta[4], Ron L Ballouz[4], Olivier S Barnouin[5], C Beddingfield[6], Carina A Bennett[4], Edward B Bierhaus[7], Keara N Burke[4], Ben Clark[8], Michael G Daly[9], Marco Delbo[10], Daniella DellaGiustina[4], Jason P Dworkin[11], Christine Hartzell[12], John Marshall[6], Patrick Michel[10], Jamie L. Molaro[13], Mike Nolan[4], Maurizio Pajola[14], Mark Perry[5], Bashar Rizk[4], Scott Sandford[15], Dan J Scheeres[16], Stephen R Schwartz[4], David Trang[17] (1.Smithsonian National Institute, Washington, DC, USA, 2.Southwest Research Institute, Boulder, CO, USA, 3.Dept. of Geology, Rowan University, Glassboro, NJ, USA, 4.Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA , 5.The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA, 6.SETI Institute, Mountain View, CA, USA, 7.Lockheed Martin Space Systems Company, USA, 8.Space Science Institute, Boulder CO, USA, 9.York University, Canada, 10.Laboratoire Lagrange, Université Côte d'Azur, Observatoire

de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France, 11.NASA Goddard Space Flight Center, Greenbelt, MD, USA, 12.Department of Aerospace Engineering, University of Maryland, College Park MD, USA, 13.Planetary Science Institute, Tucson, AZ, USA, 14.INAF - Astronomical Observatory of Padova, Italy, 15.NASA Ames Research Center, USA, 16.Dept. of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA, 17.HIGP/University of Hawaii at Manoa, USA)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS03-21] Modeling surface mobility mechanisms on a top-shaped near-Earth asteroid

★Invited Papers

*Ronald Ballouz[1], Nicola Baresi[2], Olivier S Barnouin[3], Carina A Bennet[1], Edward B Bierhaus[4], Keara N Burke[1], Harold C Connolly[5], Sarah T Crites[2], Daniella DellaGiustitna[1], Erica Jawin[6], Dante S Lauretta[1], Patrick Michel[7], Derek C Richardson[8], Dan J Scheeres[9], Stephen Schwartz[1], Seiji Sugita[10], Eri Tatsumi[10], Florian Thuillet[7], Kevin Walsh[11] (1.Lunar and Planetary Lab, University of Arizona, Tucson, AZ, USA, 2.Institute of Space and Astronautical Science, Sagamihara, Japan, 3.The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA, 4.Lockheed Martin, Boulder, CO, USA, 5.Department of Geology, Rowan University, Glassboro, NJ, USA, 6.Smithsonian National Museum of Natural History, Washington, DC, USA, 7.UCA-OCA-CNRS, Lagrange Laboratory, Nice, France, 8.Dept. of Astronomy, University of Maryland, College Park, MD, USA, 9.Dept. of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA, 10.University of Tokyo, Tokyo, Japan, 11.Southwest Research Institute, Boulder, CO, USA)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS03-22] **Visualization and Analysis of Solar System Small Bodies with NASA's Solar System Treks Project**

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS03-23] Density Distribution within Small Solar System Bodies Based on Smooth Terrain Shape: Asteroid 25143 Itokawa and Comet 67P/Churyumov-Gerasimenko

*Masanori Kanamaru[1], Sho Sasaki[1], Mark Wieczorek[2] (1.Osaka University, 2.Côte d'Azur Observatory)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS03-24] Low temperature hydration experiments of cometary analog materials towards the Comet Astrobiology Exploration Sample Return (CAESAR) mission

*Aki Takigawa[1,4], Yuki Kimura[1], Yoshihiro Furukawa[2], Tomoki Nakamura[3] (1.Graduate School of Science, Kyoto University, 2.Institute of Low Temperature Science, 3.Graduate School of Science, Tohoku University, 4.The Hakubi Center for Advanced Research)

The shape of Bennu: Implications for internal structure.

*Olivier S Barnouin[1], Micheal G. Daly[2], Eric E Palmer[3], Robert W Gaskell[3], John R. Weirich[3], Catherine L Johnson[4], Manar Al Asad[4], James H Roberts[1], Mark E. Perry[1], Hannah C.M. Sursorney[4], R. Terik Daly[1], Edward B. Bierhaus[5], Jeff A Seabrook[2], Raymond C. Espiritu[1], A. Hari Nair[1], Lilian Nguyen[1], Gregory A Neumann[6], Carolyn M Ernst[1], William V Boynton[7], Micheal C. Nolan[7], Coralie D. Adams[9], Micheal C. Moreau[6], Bashar Rizk[7], Christian Drouet D'Aubigny[7], Erica R. Jawin[8], Kevin J Walsh[10], Patrick Michel[11], Stephen R. Schwartz[7], Ronald L. Ballouz[7], Erwan M Mazarico[6], Daniel J. Scheeres[12], Jay W. McMahon[12], W Bottke[10], Seiji Sugita[13], Naru Hirata[14], Noayuki Hirata[15], Sei-ichiro Watanbe[16], Keara N. Burke[7], Daniella N. DellaGuistina[7], Carinna A. Bennet[7], Dante Lauretta[7]

1. Johns Hopkins University Applied Physics Laboratory, 2. The Centre for Research in Earth and Space Science, York University, Toronto, Ontario, Canada., 3. Planetary Science Institute, Tucson, AZ, USA, 4. Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, Canada., 5. Lockheed Martin Space Systems Company, Denver, CO, USA., 6. NASA Goddard Space Flight Center, Greenbelt, MD, USA., 7. Lunar Planetary Laboratory, University of Arizona, Tucson, AZ, USA., 8. Smithsonian Institution National Museum of Natural History, Washington, DC, USA., 9. KinetX Aerospace, Inc. Simi Valley, CA, USA, 10. Southwest Research Institute, Boulder, CO, USA., 11. Université Côte d’Azur, Observatoire de la Côte d’Azur, CNRS, Laboratoire Lagrange, Nice, France., 12. Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA., 13. University of Tokyo, Tokyo, Japan., 14. Aizu University, Aizu-Wakamatsu, Japan., 15. Kobe University, Kobe, Japan., 16. Nagoya University, Nagoya, Japan.

Introduction: We used data collected by the Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) spacecraft since November 1, 2018 to develop a global digital terrain model (DTM) of Bennu. The DTM is developed from images collected by the OSIRIS-REx Camera Suite using stereophotoclinometry (SPC). We validated the DTM independently using limb data and by the identification of keypoints between actual images and synthetic images rendered from the DTM. The results are also compared to an independent model derived from range measurements collected by the OSIRIS-REx Laser Altimeter (OLA). While developing the global model, we also refine the pole orientation and rotational state of the asteroid. The characteristics of the resulting global digital terrain model provide constraints on the factors responsible for the origin and evolution of Bennu’s shape and surface.

Digital Terrain Model Construction from Imaging: About 1500 OCAMS images with ground sample distance ranging from 30 to 200 m were used to develop the global DTM of Bennu. We used distant limb data of Bennu to construct an initial DTM of Bennu. Then a combination of geometric stereo data and surface lighting conditions (or photoclinometry) modeled small patches (or maplets) of terrain across the asteroid. Geometric stereo typically defines the location of the center of each maplet, while the surface tilts across the maplet are estimated by best fitting the brightness variations of images that contain some portion of the maplet. These maplets are then combined to build a global model. The model increases in detail, accuracy, and precision as higher-resolution images and images with different viewing conditions are incorporated.

©2019. Japan Geoscience Union. All Right Reserved.

Digital Terrain Model Construction from Laser Altimetry: We collated several six-hour linear scans obtained by OLA during orbit around Bennu to make an independent shape model of Bennu at a resolution equivalent to the one derived from imaging. This DTM is improved relative to the SPC-derived model because OLA better resolves the heights, and extent of 1 to 3m boulders across the surface of the asteroid.

Bennu’ s Geomorphological and Structural Properties: The evaluation of the both models shows that the average size of the asteroid is 490.06 ±0.16 m.

The model shows the presence of several features:
-An equatorial ridge that is muted, and is diamond-shaped when viewed from the pole;
-Topographic north-south ridges that extend in some instances from pole to pole. The ridges influence the distribution of boulders, which are frequently concentrated between the ridges;
-Large craters that influence some of the attributes of the shape, primarily along the equator;
-A few large protruding boulders >40 m in diameter and >10 m high, mostly in the southern hemisphere;
-Grooves, scarps, and troughs that in some instances extend several 10s to 100s of meters, with depths ranging from 2–10 m.

Conclusion: The initial shape characteristics suggest that Bennu has some interior stiffness. Considering past modeling efforts investigating deformation due to spin-up, the lack of a circular equatorial ridge with a pronounced bulge, and the presence of high standing north-south ridges indicate that in spite of an abundance of evidence for material moving towards the equator, Bennu has interior structure that resists deformation.

Keywords: (101955) Bennu, Asteroids, OSIRIS-REx mission

©2019. Japan Geoscience Union. All Right Reserved.

Global Geology of Bennu from NASA's OSIRIS-REx Space Mission

*Erica R Jawin[1], Kevin J Walsh[2], Tim McCoy[1], Harold C Connolly[3], Dante S Lauretta[4], Ron L Ballouz[4], Olivier S Barnouin[5], C Beddingfield[6], Carina A Bennett[4], Edward B Bierhaus[7], Keara N Burke[4], Ben Clark[8], Michael G Daly[9], Marco Delbo[10], Daniella DellaGiustina[4], Jason P Dworkin[11], Christine Hartzell[12], John Marshall[6], Patrick Michel[10], Jamie L. Molaro[13], Mike Nolan[4], Maurizio Pajola[14], Mark Perry[5], Bashar Rizk[4], Scott Sandford[15], Dan J Scheeres[16], Stephen R Schwartz[4], David Trang[17]

1. Smithsonian National Institute, Washington, DC, USA, 2. Southwest Research Institute, Boulder, CO, USA, 3. Dept. of Geology, Rowan University, Glassboro, NJ, USA, 4. Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA , 5. The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA, 6. SETI Institute, Mountain View, CA, USA, 7. Lockheed Martin Space Systems Company, USA, 8. Space Science Institute, Boulder CO, USA, 9. York University, Canada, 10. Laboratoire Lagrange, Université Côte d’Azur, Observatoire de la Côte d’Azur, CNRS, Laboratoire Lagrange, Nice, France, 11. NASA Goddard Space Flight Center, Greenbelt, MD, USA, 12. Department of Aerospace Engineering, University of Maryland, College Park MD, USA, 13. Planetary Science Institute, Tucson, AZ, USA, 14. INAF - Astronomical Observatory of Padova, Italy, 15. NASA Ames Research Center, USA, 16. Dept. of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA, 17. HIGP/University of Hawaii at Manoa, USA

NASA’s OSIRIS-REx sample return mission has been observing the near-Earth Asteroid (101955) Bennu since December 2018 and will be collecting a sample of the surface in the summer of 2020, to be returned to Earth in 2023. Preliminary and ongoing observations have yielded much information about Bennu’s formation, evolution, and ongoing geologic activity. Here we report on the global geology of Bennu based on analyses of images combined with shape, mass, and slope measurements. Initial results suggest that Bennu is a rubble-pile asteroid, formed from a parent body that was collisionally disrupted and reaccumulated. The asteroid has a “top” shape which is spherical with an equatorial bulge, similar to other near-Earth asteroids including Ryugu as observed by the Hayabusa2 sample return space mission. Candidate impact craters have been observed at a range of diameters between ~10-150 m across the surface of Bennu, leading to a crater retention age of 100 million to 1 billion years. An apparent concentration of large crater candidates at low latitudes suggest that the equatorial ridge is stratigraphically old, and may have formed early in Bennu’s history or been inherited from the reaccumulation event which created the asteroid. Several linear features have been identified on Bennu, the largest of which are topographic highs that extend longitudinally from the northern polar regions to the equator. Boulders are concentrated between several of these linear ridges, as well as in the interior of large candidate craters. Boulders on Bennu appear to be geologically diverse. Boulder sizes range from < 3 m to ~95 m in diameter with large variations in geometric albedo, morphology, degree of burial, and state of degradation. Fractured boulders have been identified with various numbers, orientations, and widths of fractures. Distinct clasts within several boulders indicate they may be breccias, while piles of boulders may represent disaggregated polymict or brecciated boulders. Current imaging resolution cannot resolve centimeter-sized particles, so direct detections of regolith or other sub-cm sized particles have not been made. However, several small candidate craters (< 20 m diameter) have a significant lack of boulders relative to the surrounding terrain, and additional datasets suggest the presence of a component of fine-grained particles. Improved image resolution will aid in the identification of regolith deposits on Bennu.

Keywords: OSIRIS-REx, Bennu, Asteroid, Geology

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Modeling surface mobility mechanisms on a top-shaped near-Earth asteroid

*Ronald Ballouz[1], Nicola Baresi[2], Olivier S Barnouin[3], Carina A Bennet[1], Edward B Bierhaus[4], Keara N Burke[1], Harold C Connolly[5], Sarah T Crites[2], Daniella DellaGiustitna[1], Erica Jawin[6], Dante S Lauretta[1], Patrick Michel[7], Derek C Richardson[8], Dan J Scheeres[9], Stephen Schwartz[1], Seiji Sugita[10], Eri Tatsumi[10], Florian Thuillet[7], Kevin Walsh[11]

1. Lunar and Planetary Lab, University of Arizona, Tucson, AZ, USA, 2. Institute of Space and Astronautical Science, Sagamihara, Japan, 3. The Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, USA, 4. Lockheed Martin, Boulder, CO, USA, 5. Department of Geology, Rowan University, Glassboro, NJ, USA, 6. Smithsonian National Museum of Natural History, Washington, DC, USA, 7. UCA-OCA-CNRS, Lagrange Laboratory, Nice, France, 8. Dept. of Astronomy, University of Maryland, College Park, MD, USA, 9. Dept. of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA, 10. University of Tokyo, Tokyo, Japan, 11. Southwest Research Institute, Boulder, CO, USA

The advent of near-Earth asteroid (NEA) encounters with spacecraft has provided a view of planetary surfaces evolving on the smallest objects yet explored. The arrival of OSIRIS-REx and Hayabusa2 at their target asteroids (101955) Bennu, with average diameter (d) = 0.49 km, and (162173) Ryugu (d = 0.90 km), revealed cratered top-shaped worlds with signs of surface mobility [1, 2]. Compared to larger planetary bodies, Bennu and Ryugu’s small sizes and gravities challenge the conventional understanding of surface modification mechanisms, such as the redistribution of boulders on the surface or the erasure of craters.

On the larger NEA (433) Eros (d = 16.8 km), boulders were spatially correlated with impact craters, which degrade through impact-induced seismic shaking [3]. However, our poor understanding of rubble-pile interiors [4], combined with processes that operate more efficiently on smaller NEAs (such as thermal re-radiation torques, i.e., the YORP effect [5]), introduces new complexities to understanding surface mobility on Bennu and Ryugu.

Here, we first present evidence of a dynamic surface on Bennu and Ryugu. Then, we present an analysis of the dynamical processes that may dominate the surface modification of small top-shaped NEAs. We model the redistribution of material on the surface due to different input energy sources: i) impact-induced seismic shaking, ii) YORP spin-up, iii) impact cratering, and iv) planetary encounters. We use a combination of techniques that allows us to approach the problem at multiple length and time scales. The first step models the global effect of the energy sources using analytical techniques. In the second step, we model the fine grain scale interactions in a microgravity environment in short timescales using a particle dynamics code [6,7]. Finally, we propagate the accumulated effect of the fine-scale interactions by integrating individual surface modifications over the typical timescale of each individual process. The results are used to assess which of the above listed mechanisms are the most effective at transforming small NEA surfaces.

References:

1. Walsh et al. 2019, Nature Geoscience, Accepted.

2. Sugita et al. 2019, Science, Accepted.

©2019. Japan Geoscience Union. All Right Reserved.

3. Richardson, J.E. et al. (2005) Icarus, 179, 324–349.

4. Scheeres, D.J. et al. (2015) in Asteroids IV (eds. Michel, DeMeo, & Bottke), pp. 745–766.

5. Bottke, W.F. et al. (2006) Annual Reviews of E&PS, 34, 157–191.

6. Richardson, D.C. et al. (2011) Icarus, 212, 427–437.

7. Schwartz, S.R. et al. (2012) Granular Matter, 14, 363–380.

Acknowledgements:

This material is based upon work supported by NASA under Contract NNM10AA11C issued through the New Frontiers Program and from Grant no. 80NSSC18K0226 as part of The OSIRIS-REx Participating Scientist Program. P.M. and F.T. P.M. acknowledge funding support from the French space agency CNES and from Academies of Excellence: Complex systems and Space, environment, risk, and resilience, part of the IDEX JEDI of the Université Côte d’Azur.

Keywords: Near Earth Asteroids, OSIRIS-REx, Hayabusa2

©2019. Japan Geoscience Union. All Right Reserved.

Visualization and Analysis of Solar System Small Bodies with NASA's Solar System Treks Project

*Brian Hamilton Day[1], Emily Law[2]

1. NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2. NASA Jet Propulsion Laboratory, California Institute of Technology

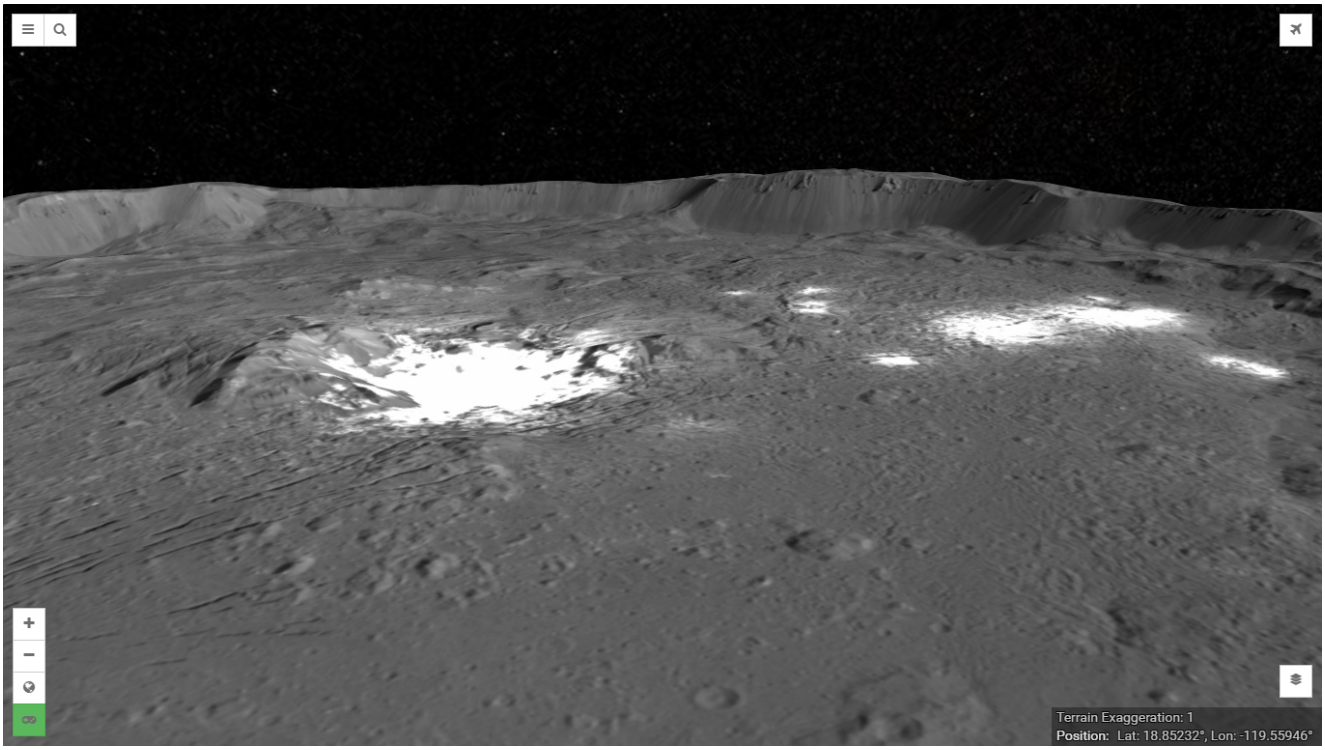
In its investigations of Vesta and Ceres, NASA's Dawn mission has returned spectacular data detailing the surfaces of these two prominent small bodies in our Solar System's asteroid belt. In order to greatly facilitate dissemination, visualization, and analysis of this data, and public understanding of the mission, the Dawn mission has partnered with NASA's Solar System Treks Project (SSTP). SSTP has recently released an update to the Vesta Trek online portal (https://trek.nasa.gov/vesta/) and has released a new Ceres Trek portal (https://trek.nasa.gov/ceres/).

This presentation will showcase the use of the Ceres Trek and Vesta Trek portals and demonstrate how they can be used to visualize and analyze particularly interesting landforms such as the pitted terrain on Vesta and relic cryovolcanoes on Ceres. We will also demonstrate the new VR capability that has been added to the portals, allowing users to generate their own virtual reality flyovers for any user-defined paths along the bodies' surfaces. In addition to highlighting the portals for Ceres and Vesta, the presentation will preview additional portals being planned/developed for other small bodies. NASA and JAXA have requested the development of a portal for the asteroid Ryugu to facilitate dissemination, visualization, and analysis of data from Japan's Hayabusa2 mission, and a portal for Mars' moon Phobos in support of mission planning for Japan's MMX mission. We are also planning a portal for the asteroid Bennu with data from the OSIRIS-Rex mission.

All of these products are efforts in the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools to enable mission planners, planetary scientists, students, and the general public to access mapped data products from past and current missions for a growing number of planetary bodies including the Moon, Mars, Vesta, etc. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions. In addition to demonstrating the capabilities of selected portals in this presentation, we will solicit input from the community for ideas for future enhancements to the portals.

Keywords: Ceres, Vesta

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Density Distribution within Small Solar System Bodies Based on Smooth Terrain Shape: Asteroid 25143 Itokawa and Comet 67P/Churyumov-Gerasimenko

*Masanori Kanamaru[1], Sho Sasaki[1], Mark Wieczorek[2]

1. Osaka University, 2. Côte d'Azur Observatory

Small solar system bodies are the remnants of the early stage of the solar system formation. Shapes and interior structures of small bodies tell us about how they formed and evolved. Particularly, the interior density distribution of small bodies is an important clue for better understanding of planetesimal collisions and subsequent accumulation processes. However, we have much less information about their interiors than their surface properties, partly because it is difficult to measure the exterior gravity precisely in a small body mission. We have investigated a method to estimate density distribution within a small body based on combining spacecraft imagery and the simulated gravity field on the surface of the small body (Kanamaru and Sasaki, 2019; Kanamaru, Sasaki and Wieczorek, in prep.).

If a small body possesses loose regolith sufficiently, over geologic time, impact-induced seismic shaking or cometary activity may have triggered mass movement from a high standing region to a low standing region (Richardson and Bowling, 2014). Our inversion of density distribution assumes that a very flat region on a small body, which is covered with fine gravels and associated with the low standing area in gravitational potential, might approximate an equi-potential surface. Therefore, the inversion processes include (1) mapping a smooth terrain on a 3D shape model of the small body using the Small Body Mapping Tool, and (2) computing dynamic elevations above a reference potential surface given ununiform density distribution (as shown in the upper left panel in Figure). As a criteria for mapping the smooth terrain, we also used a surface roughness defined as the standard deviation of the dynamic elevations within a circle of a specific scale (upper right panel in Figure). The misfit between the smooth terrains and the equi-potential surface is characterized by the standard deviation of the surface elevations within the flat region. On the above assumption of the topographic erosion process, the minimum misfit gives a best fitting density. We applied this method to asteroid Itokawa and comet 67P/Churyumov-Gerasimenko to investigate whether each of their lobes has a different density from the other or not.

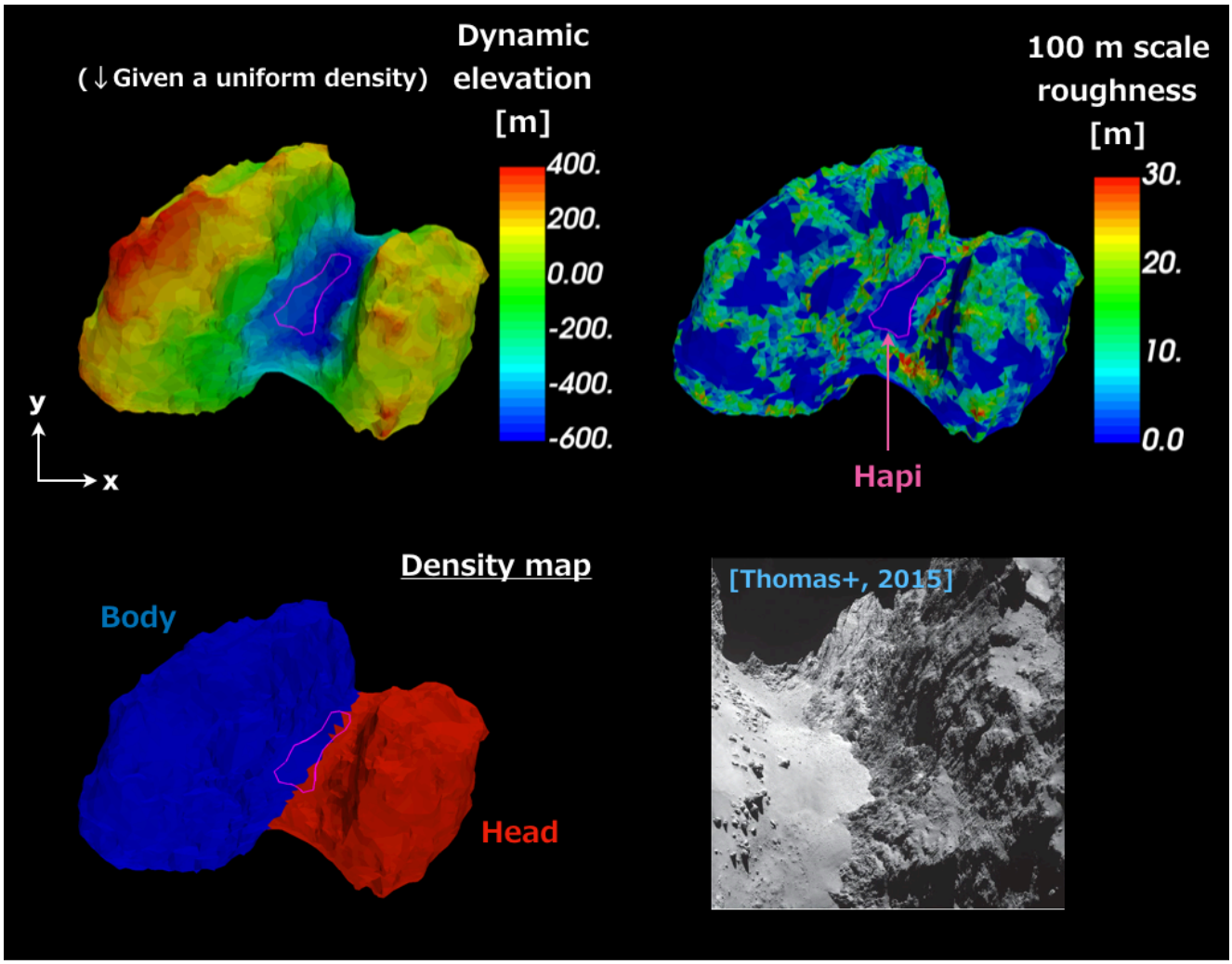
There exists three major smooth terrains on Itokawa, named MUSES-C Regio, Sagamihara Regio and Uchinoura Regio. Given different densities to the two lobes of Itokawa (the head and body), the misfit for the smooth terrains is minimized where the head of Itokawa has a higher density than the mean bulk density. Based on the consideration of the systematic errors that arise from the uncertainty of the shape model itself and the calculation error of the gravity field, the allowable range of the head density is estimated to be 2,450 (2,220-2,670) kg/m^3 in contrast to the body density of 1,930 (1,976-1,879) kg/m^3 . Such a great contrast in density between the two lobes is consistent with the independent estimate of the center-of-mass/center-of-figure offset of Itokawa based on the YORP spin-up observation (Lowry et al., 2014).

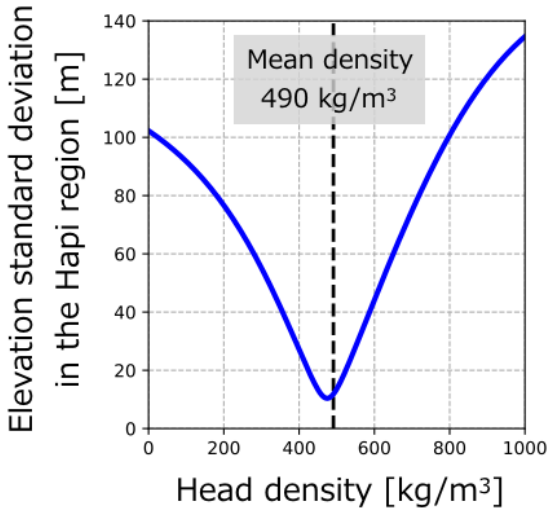
The comet nucleus of 67P also has a smooth terrain called Hapi, which is likely to be covered with particles falling from other regions. In the density inversion for the two lobes of 67P, the head and body (see the middle left panel in Figure), the best fitting density of the head is similar to the mean bulk density unlike the case of Itokawa (lower panel in Figure). This result indicates a global scaled homogeneity of

©2019. Japan Geoscience Union. All Right Reserved.

67P, which is consistent with the gravity measurement by Patzold et al. (2016). If the bi-lobed shape of the comet was formed by a sub-catastrophic disruption of its parent body and merger of two main fragments (Jutzi and Benz, 2017), it is possible for the two lobes to have the same density.

Keywords: Small solar system body, Asteroid 25143 Itokawa, Comet 67P/Churyumov-Gerasimenko, Interior density distribution, Gravity field





©2019. Japan Geoscience Union. All Right Reserved.

Low temperature hydration experiments of cometary analog materials towards the Comet Astrobiology Exploration Sample Return (CAESAR) mission

*Aki Takigawa[1,4], Yuki Kimura[1], Yoshihiro Furukawa[2], Tomoki Nakamura[3]

1. Graduate School of Science, Kyoto University, 2. Institute of Low Temperature Science, 3. Graduate School of Science, Tohoku University, 4. The Hakubi Center for Advanced Research

The Comet Astrobiology Exploration Sample Return (CAESAR) mission is a final candidate for selection as the fourth mission in NASA’s New Frontiers Program. CAESARaims to acquire and return to Earth for laboratory analysis a minimum of 80 g of surface material from the nucleus of comet 67P/Churyumov-Gerasimenko (67P) (Squyres et al. 2018).Near-infrared spectra of a short-period comet 67P taken by the spectrometer onboard Rosseta spacecraft also indicate the absence of phyllosilicates in this comet (Capaccioni et al. 2015). In order to return anhydrated samples from 67P, optimal conditions for sampling should be determined because cometary dust particles especially amorphous silicates are highly reactive. Hydration process of anhydrous crystalline silicates such as olivine is already well-characterized, whereas reaction of water vapor or ice with amorphous silicates and organic matters at temperatures below H_2O freezing points has been poorly understood. In this study, we performed incubation experiments of amorphous silicates and organic matters under low temperature conditions with ice or vapor of D_2O/NH_3.

Amorphous silicate nanoparticles with three different chemical compositions and textures (S1, S2, and S3), and commercial glycine and ribose powder were used in the experiments. S1 is composed of ~100 nm particles having $MgSi_2O_5$composition prepared with sol-gel processing. S2 and S3 are condensates from high temperature gases. S2 is amorphous Mg_2SiO_4nanoparticles of ~80 nm in size synthesized in a Radio Frequency plasma system (Koike et al. 2010). S3 is 30-100 nm sized amorphous silicate with Mg/Si~0.93 embedded with metallic Fe-Ni particles condensed from a high temperature vapor of the CI chondritic ratios of Mg, Al, Ca, Fe, and Nito Si in an induction thermal plasma system (Kim et al. 2017).

Two types of ice were used in the experiments to evaluate the effects of corrosive gases in 67P; (A) Pure D_2O ice (99.90% purity) and (B) Mixture D_2O ice with 0.3% H_2O and 0.15% NH_3. Experiments with different ices were performed in different vacuum containers placed in a cryogenic box. About 5 mg of three silicate and glycine samples were put in different open-top glass bottles (2 ml). Approximately 50 mg of chipped ice fragments were put in the glass bottles and directly contact with the silicate and glycine samples. Roughly ~500 mg of the same ice fragments were put in the vacuum containers as a vapor source. The temperature of the cryogenic box sets at -17 or -27˚C. The samples were exposed with saturated vapor of ices for 10-120 days. As a comparison, exposure experiments of amorphous silicate samples (S1, S2, and S3) to H_2O vapor were also conducted at 25 and 50˚C for 10 days.

The exposed silicate samples were analyzed with a powder X-ray diffraction (XRD, Rigaku SmartLab) and Fourier-transform infrared spectroscopy (FT-IR; JASCO MFT-680, Thermo Nicolet iS5). The recovery rate of glycine (i.e., molar ratio of recovered glycine over starting glycine) and ribose were obtained by liquid chromatography tandem mass spectrometer (LC/MSMS; Shimadzu LCMS-8040).

No clear change of the XRD patterns and FT-IR spectra for S1, S2, and S3 was confirmed after the

©2019. Japan Geoscience Union. All Right Reserved.

experiments for <120 days at -17 and -27˚C. The recovery of glycine exposed to D_2O ice and NH_3 -containing D_2O ice for 10 days was 108±8 mol% and 105±8 mol%, respectively. The recovery of ribose exposed to D_2O ice and NH_3-containing D_2O ice for 10 days was 108±12 mol% and 105±12 mol%, respectively. Bicause the ice sublimation timescale is very short at the exoerimental temperatures, the present results indicate that cometary silicates at <-20˚C in comets are pristine even if they have high surface to volume ratio and amorphous structures as GEMS grains in anhydrous CP-IDPs.

Keywords: comet, space exploration, hydration experiment

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

convener:Masateru Ishiguro(Department of Physics and Astronomy, Seoul National University), Taishi Nakamoto(Tokyo Institute of Technology), Masanao Abe(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory), Chairperson:Masateru Ishiguro(Seoul National University)

In June 2018, the Hayabusa 2 spacecraft arrived at the target asteroid Ryugu after three and half years journey. In addition, another spacecraft, OSIRIS-REx will soon arrive at its destination Bennu. With these arrivals, the solar system research is about to enter a new era. We have organized this small bodies session since 2012 and had a broad range of discussions from viewpoints of laboratory experiments, observations, space explorations, theoretical modeling, and sample analyses. In particular, this time, we aim to hold this session to bring the latest research on solar system small bodies, focusing on the initial results of Hayabusa 2 and OSIRIS-REx. Presentations in the related fields other than these two asteroidal missions are also welcomed.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS03-25] Overview and current status of DESTINY$^+$ mission

★Invited Papers

*Tomoko Arai[1], Masanori Kobayashi[1], Ko Ishibashi[1], Fumi Yoshida[1], Hiroshi Kimura[1], Takayuki Hirai[1], Hong Peng[1], Manabu Yamada[1], Hiroki Senshu[1], Koji Wada[1], Ralf Srama[2], Harald Kruger[3], Jun-ichi Watanabe[4], Takashi Ito[4], Masateru Ishiguro[5], Tomoki Nakamura[6], Hikaru Yabuta[7], Shogo Tachibana[8], Takashi Mikouchi[8], Shinsuke Abe[9], Katsuhito Ohtsuka[10], Seitaro Urakawa[11], Keiko Nakamura-Messenger[12], Mutsumi Komatsu[13], Shingo Kameda[14], Masato Kagitani[6], Naru Hirata[15], Hirohide Demura[15], Sho Sasaki[16], Takahiro Hiroi[17], Goro Komatsu[18], Hidehiro Kaneda[19], Takaya Inamori[19], Takaya Okamoto[20], Toshifumi Yanagisawa[20], Makoto Yoshikawa[20], Hajime Yano[20], Tatsuaki Okada[20], Takahiro Iwata[20], Takafumi Ootsubo[20], Yasuhiro Kawakatsu[20], Hiroyuki Toyota[20], Kazutaka Nishiyama[20], Takeshi Takashima[20] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.University of Stuttgart, 3.Max Planck Institute, 4.National Astronomical Observatory of Japan , 5.Seoul National Universtiy, 6.Tohoku University, 7.Hiroshima University, 8.The University of Tokyo, 9.Nihon University, 10.Tokyo Meteor Network, 11.Japan Spaceguard Association, 12.NASA , 13.The Graduate University for Advanced Studies, 14.Rikkyo University, 15.Aizu University, 16.Osaka University, 17.Brown University, 18.D'Annunzio University, 19.Nagoya University, 20.JAXA)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS03-26] Observational campaign of (3200) Phaethon and (155140) 2005UD in 2017-2018

*Fumi Yoshida[1], Tomoko Arai[1], Ko Ishibashi[1], Peng Hong[1], Ryo Ishimaru[1], DESTINY+ International observation collaborators (1.Planetary Exploration Research Center, Chiba Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS03-27] Rotationally-resolved spectroscopic observations of Phaethon - 2005 UD, and their fragments detected by lunar impact flashes.

*Shinsuke Abe[1], Nicholas Moskovitz[2], Fumi Yoshida[3], Katsutoshi Ohtsuka[4], Ito Takashi[5], Ryota Fuse[1], Masahisa Yanagisawa[6], Ryuhei Yamada[7] (1.Department of Aerospace Engineering, College of Science and Technology, Nihon University, 2.Lowell Observatory, 3.Planetary Exploration Research Center, Chiba Institute of Technology, 4.Tokyo Meteor Network, 5.National Astronomical Observatory of Japan, 6.The University of Electro-Communications, 7.The University of Aizu, Department of Computer Science and Engineering)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS03-28] Thermal Radiation Pressure Force on Regolith Particles of Atmosphereless Bodies

*Yoonsoo P. Bach[1], Masateru Ishiguro[1] (1.Department of Physics and Astronomy, Seoul National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS03-29] A kilometre-sized Kuiper belt object revealed by OASES stellar occultation observations

*Ko Arimatsu[1,2], Kohji Tsumura[3], Fumihiko Usui[4], Shinnaka Yoshiharu[5], Kohei Ichikawa[3,6,7], Takafumi Ootsubo[8], Takayuki Kotani[2,9], Takehiko Wada[8], Koichi Nagase[8], Jun-ichi Watanabe[2] (1.Astronomical Observatory, Graduate School of Science, Kyoto University, 2.National Astronomical Observatory of Japan, 3.Frontier Research Institute for Interdisciplinary Science, Tohoku University, 4.Center for Planetary Science, Graduate School of Science, Kobe University, 5.Laboratory of Infrared High-resolution Spectroscopy, Koyama Astronomical Observatory, Kyoto Sangyo University, 6.Department of Astronomy, Columbia University, 7.Department of Physics and Astronomy, University of Texas at San Antonio, 8.Department of Space Astronomy and Astrophysics, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 9.Astrobiology Center, National Institutes of Natural Sciences)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS03-30] AKARI/IRC near-infrared asteroid spectroscopic survey: AcuA-spec

*Fumihiko Usui[1], Sunao Hasegawa[2], Takafumi Ootsubo[2], Takashi Onaka[3,4] (1.Kobe University, 2.ISAS/JAXA, 3.The University of Tokyo, 4.Meisei University)

Overview and current status of DESTINY$^+$ mission

*Tomoko Arai[1], Masanori Kobayashi[1], Ko Ishibashi[1], Fumi Yoshida[1], Hiroshi Kimura[1], Takayuki Hirai[1], Hong Peng[1], Manabu Yamada[1], Hiroki Senshu[1], Koji Wada[1], Ralf Srama[2], Harald Kruger[3], Jun-ichi Watanabe[4], Takashi Ito[4], Masateru Ishiguro[5], Tomoki Nakamura[6], Hikaru Yabuta[7], Shogo Tachibana[8], Takashi Mikouchi[8], Shinsuke Abe[9], Katsuhito Ohtsuka[10], Seitaro Urakawa[11], Keiko Nakamura-Messenger[12], Mutsumi Komatsu[13], Shingo Kameda[14], Masato Kagitani[6], Naru Hirata[15], Hirohide Demura[15], Sho Sasaki[16], Takahiro Hiroi[17], Goro Komatsu[18], Hidehiro Kaneda[19], Takaya Inamori[19], Takaya Okamoto[20], Toshifumi Yanagisawa[20], Makoto Yoshikawa[20], Hajime Yano[20], Tatsuaki Okada[20], Takahiro Iwata[20], Takafumi Ootsubo[20], Yasuhiro Kawakatsu[20], Hiroyuki Toyota[20], Kazutaka Nishiyama[20], Takeshi Takashima[20]

1. Planetary Exploration Research Center, Chiba Institute of Technology, 2. University of Stuttgart, 3. Max Planck Institute, 4. National Astronomical Observatory of Japan , 5. Seoul National Universtiy, 6. Tohoku University, 7. Hiroshima University, 8. The University of Tokyo, 9. Nihon University, 10. Tokyo Meteor Network, 11. Japan Spaceguard Association, 12. NASA , 13. The Graduate University for Advanced Studies, 14. Rikkyo University, 15. Aizu University, 16. Osaka University, 17. Brown University, 18. D'Annunzio University, 19. Nagoya University, 20. JAXA

DESTINY$^+$ (Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science) was selected in 2017 as a mission for JAXA/ISAS small-class program. It is a joint mission of technology demonstration and scientific observation. It will test high performance electric propelled vehicle technology and high-speed flyby of asteroid (3200) Phaethon and possibly asteroid 2005UD, which a break-up body from Phaethon as an extended mission. Engineering challenges include an up-close encounter at a distance of 500 km from Phaethon with radio-optical hybrid navigation guidance and control, and autonomous imaging based on optical information for target tracking during a high-speed flyby of 33km/sec. The science goal is to understand the nature and origin of cosmic dust brought onto the Earth, in the context of exogenous contribution of carbon and organics for possible prebiotic seeds of the terrestrial life. Phaethon is a parent body of Geminid meteor shower, and thus a known source to periodically provide dust to the Earth, via the dust stream. The science objectives are two folded: (1) in-situ analyses of velocity, arrival direction, mass and chemical composition of interplanetary and interstellar dust particles around 1 au, the dust trail, and nearby Phaethon, and (2) flyby imaging of Phaethon to study its geology, for understanding dust ejection mechanism of active asteroid and the surface compositional variation. High-spatial-resolution images of less than 5 meter per pixel are obtained with Telescopic camera (TCAP), and VIS-NIR spectral images of less than 100 meter per pixel are taken with multiband camera (MCAP). Mass, speed, arrival direction and chemical composition for each dust particle are analyzed with dust analyzer (DDA). Here, we present an overview and the current status of DESTINY$^+$ mission.

Keywords: DESTINY+, Phaethon, Flyby, Geminid meteor shower, IDP

©2019. Japan Geoscience Union. All Right Reserved.

Observational campaign of (3200) Phaethon and (155140) 2005UD in 2017-2018

*Fumi Yoshida[1], Tomoko Arai[1], Ko Ishibashi[1], Peng Hong[1], Ryo Ishimaru[1], DESTINY+ International observation collaborators

1. Planetary Exploration Research Center, Chiba Institute of Technology

(3200) Phaethon is the flyby target and (155140) 2005UD is a second flyby candidate of the DESTINY+ mission. Each asteroid approached to the Earth and became bright in 2017-2018. We utilize this opportunity and organized an observation campaign for both asteroids with international collaborators. The following people participated to the observational campaign : F. Yoshida, R. Ishimaru, K. Ishibashi, P. Hong, T. Arai (PERC/ChiTech), R. Okazaki, T. Sekiguchi, H. Naito, M. Imai, T. Ono (Hokkaido University of Education), S. Urakawa (Japan Spaceguard Association, Bisei Spaceguard Center), Y. Shinnaka (Kyoto Sanyo Univ.), T. Tanigawa (Sumoto high school), T. Yanagisawa, H. Kurosaki (JAXA), S. Abe, R. Kato (Nihon Univ.), N. Natira, T. Nishiumi (Univ. of Tokyo), M. Ishiguro (Seoul National University), M.-J. Kim, Y.-J. Choi, H.-K. Moon (KASI), D.-H. Kim, H.-J. Lee, S.-M. Lee (Chungbuk National University), Zhong-Yi Lin (Institute of Astronomy, National Central University), Xiaobin Wang (Yunnan Observatories, CAS), A. Serebryanskiy, M. Krugov, I. Reva (Fesenkov Astrophysical Institute), O. Burkhonov, E. Kamoliddin (UBAI), A. Peyrot, J-P. Teng (Les Makes Observatory), Y. Krugly (Institute of Astronomy of V.N. Karazin Kharkiv National University), I. M. Volkov (SAI MSU, INASAN), I. V. Nikolenko, S. I. Barabanov (INASAN), M. Kaplan, O. Erece (Akdeniz university), A. Sonka, S. Anghel (Astronomical Institute of Romanian Academy, Bucharest University), M. Birlan, F. Vachier, J. Berthier (Observatoire de Paris, IMCCE, CNRS), A. Klotz (CNRS-OMP-IRAP), P. Thierry (Auragne Observatory), O. Ivanova, M. Husarik (Astronomical Institute of the Slovak Academy of Sciences), E. Kuznetsov, D. Glamazda, G. Kaiser, E. Koren, V. Krushinsky, A. Popov, A. Shagabutdinov, Y. Vibe (Ural Federal University), M. Lazzarin, V. Petropoulou, I. Bertini, F. La Forgia (University of Padova), E. Palomba, E. D'aversa, A. Migliorini (INAF-IAPS), J. Vaubaillon (Observatoire de Paris), T. G. Wilson (University College London, Isaac Newton Group), O. Vaduvescu (Isaac Newton Group, Instituto de Astrofísica de Canarias), M. Popescu, Julia de Leon (Instituto de Astrofísica de Canarias), V. Lorenzi (Fundación Galileo Galilei - INAF, Instituto de Astrofísica de Canarias), M. Granvik (University of Helsinki / Luleå University of Technology), A. Penttilä (University of Helsinki), K. O. Muinonen (University of Helsinki / National Land Survey of Finland), T. Kareta, V. Reddy, D. S. Lauretta, B. Sharkey, C. Hergenrother (LPL, University of Arizona), J. A. Sanchez (PSI), T. Linder (Astronomical Research Institute), O. Kuhn, A. Conrad (Large Binocular Telescope Observatory), N. Moskovitz (Lowell Observatory), J. Masiero, A. Mainzer, L. Benner, M. Brozovic, S. Naidu, J. Giorgini (NASA JPL), E.L. Wright, D. Jewitt (UCLA), P. Taylor, E. Rivera-Valentin, S. Bhiravarasu, B. Aponte-Hernandez (Lunar and Planetary Institute), S. Marshall, F. Venditti, A. Virkki, L. Zambrano-Marin (Arecibo Observatory & University of Central Florida), C. R. Sanchez-Vahamonde (University of Western Ontario) (in the order from east to west in Fig.1).

Most of results obtained from the campaign were presented in IDP2019, which was held at Tokyo Skytree Town Campus of CIT, Japan, on February 12-14, 2019 (Fig. 2). So far, for both asteroids, rotation period, average colors, absolute magnitudes, spectra (0.4-2.5 μm) were obtained by photometry and spectroscopy during this observation campaign. Radar observation were done for Phaethon, and polarimetric observations were done for both asteroids. As preliminary results, the following properties were reported. Rotation periods: 5.2 hr (or 7.85 hr) for 2005UD, 3.6hr for Phaethon. Average colors : B-V=0.71, V-R=0.37, V-I=0.32 for 2005UD, B-V=0.73, V-R=0.36 for Phaethon. Absolute magnitude is 17.25 mag for 2005UD. No significant variation of rotationally resolved VIS-NIR spectra were seen for

©2019. Japan Geoscience Union. All Right Reserved.

both asteroids. However, a slight variation of visual spectra of Phaethon taken in 2017 was reported. Both asteroids are in C-complex. Interestingly, in the NIR spectra, both asteroids show totally different spectra each other: concave-up and blue for Phaethon, linear and red for 2005UD. The results from polarimetric observation show both asteroids are very similar. As for Phaethon, rotational variation in polarization was reported. Lightcurve observations revealed Phethon has top shape. Radar observation estimated the Phaethon's diameter is about 6km, and revealed no coma, no satellite. Possible craters (D>1km below 30 deg latitude, D=1.5km near equator), 600m wide dark spot (likely a flattened region) were discovered.

Keywords: Asteroids, (3200) Phaethon, (155140) 2005UD

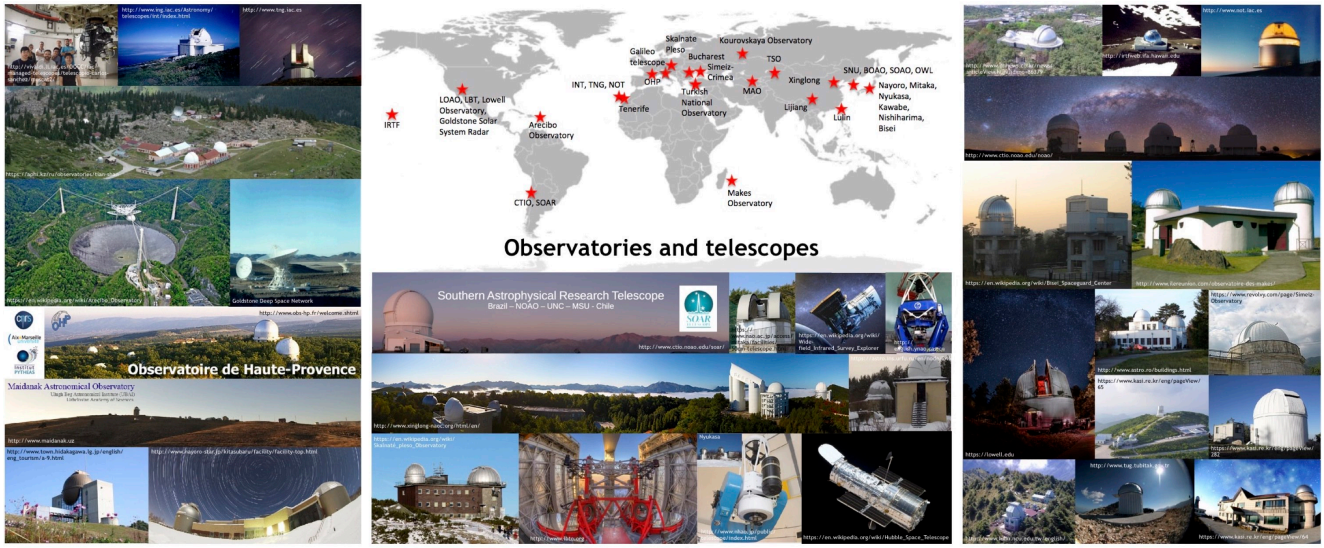


Fig1. Observatories and telescopes participating to the observation campaign of Phaethon and 2005UD in 2017 and 2018.

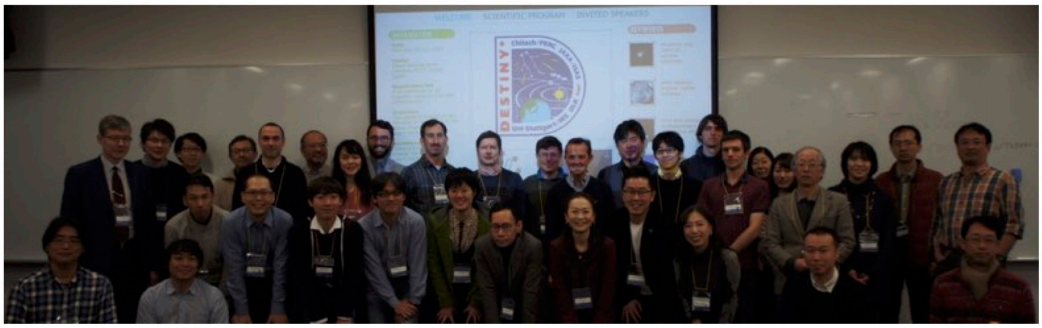


Fig2. IDP2019 held at Tokyo Skytree Town Campus of CIT, Chiba, Japan, on February 12–14, 2019.

©2019. Japan Geoscience Union. All Right Reserved.

Rotationally-resolved spectroscopic observations of Phaethon - 2005 UD, and their fragments detected by lunar impact flashes.

*Shinsuke Abe[1], Nicholas Moskovitz[2], Fumi Yoshida[3], Katsutoshi Ohtsuka[4], Ito Takashi[5], Ryota Fuse[1], Masahisa Yanagisawa[6], Ryuhei Yamada[7]

1. Department of Aerospace Engineering, College of Science and Technology, Nihon University, 2. Lowell Observatory, 3. Planetary Exploration Research Center, Chiba Institute of Technology, 4. Tokyo Meteor Network, 5. National Astronomical Observatory of Japan, 6. The University of Electro-Communications, 7. The University of Aizu, Department of Computer Science and Engineering

3200 Phaethon is an Apollo type near-Earth asteroid (NEA) categorized as a B-type asteroid which has been associated with the most intense meteor shower, Geminids. Cometary activity of Phaethon has been observed during its perihelion passage, ~0.140 AU, that motivates us to do direct exploration by the spacecraft, DESTINY+. It is also suggested that (155140) 2005 UD is a break-up pair of Phaethon because of dynamically similarity and same B-type spectrum type which is only ~5 % in NEA population. We examined the spectral properties of this asteroid pair to find the surface heterogeneity. Rotationally-resolved spectroscopic observations of Phaethon were carried out using 1.0-m telescopes at Lulin/Taiwan, and Kawabe/Wakayama, observatories in 2007 and 2017 apparitions, respectively. While Rotationally-resolved spectroscopic observation of 2005 UD was performed by using 4.1-m SOAR telescope at Cerro Tololo, Chili in 2018. It is presumably revealed that the surface heterogeneity, C-type like red slope surface area, of Phaethon was clearly seen from 2017 data, while no-existing surface heterogeneity was observed for 2005 UD.

When a meteoroid impacts the moon at several 10s of km/s, a brilliant flash at the point of impact can be observed as a flash in visible and near-infrared light. Lunar impact monitoring has a great advantage to detect large meteoroids in the mass range between 10s of grams and few kilograms corresponding to centimeters and tens of centimeters, which is as a bridge between visual meteors and small asteroids. We observed lunar impact flashes during Geminids maximum in 2018. 11 events were simultaneously detected from 2 locations at Nihon university and UEC, suggesting existence of relativity large fragments, several cm to several tens of cm in diameter, in the Geminid meteor stream.

In order to understand the Phaethon-Geminid stream Complex (PGC), ground-based telescopic observations of Geminids meteoroids and its parent splitting-bodies will be presented.

Keywords: Asteroids, Comets, Meteoroids, Lunar impact flash

©2019. Japan Geoscience Union. All Right Reserved.

Thermal Radiation Pressure Force on Regolith Particles of Atmosphereless Bodies

*Yoonsoo P. Bach[1], Masateru Ishiguro[1]

1. Department of Physics and Astronomy, Seoul National University

It is suggested that thermal fracture near the perihelion is a possible mechanism to produce the dust trail of the near-Earth asteroid, (3200) Phaethon (Jewitt and Li, 2013, ApJ 771, L36). For this scenario to be true, generated dust particles should have been ejected from the surface before its next apparition to show the detectable activities (Li and Jewitt, 2013, ApJ, 145, 154). It is, however, not well understood how these particles were escalated from the regolith against the asteroid's gravity. In this study, we hypothesize that the thermal radiation pressure around the perihelion passage would exert substantial force on dust grains to be lifted up and contributes the dust tail formation with further help of solar radiation pressure. As a result, we find that roughly ~1-10 micron size dust grains can be ejected from Phaethon by the mechanism, while a detailed model of gravitational field is required for accurate range of the particle sizes. Our idea is not necessarily limited to Phaethon case, but is applicable to any atmosphereless bodies. We will explain how the thermal radiation pressure is effective at different distances from the sun.

Keywords: asteroids, regolith, thermal radiation

©2019. Japan Geoscience Union. All Right Reserved.

A kilometre-sized Kuiper belt object revealed by OASES stellar occultation observations

*Ko Arimatsu[1,2], Kohji Tsumura[3], Fumihiko Usui[4], Shinnaka Yoshiharu[5], Kohei Ichikawa[3,6,7], Takafumi Ootsubo[8], Takayuki Kotani[2,9], Takehiko Wada[8], Koichi Nagase[8], Jun-ichi Watanabe[2]

1. Astronomical Observatory, Graduate School of Science, Kyoto University, 2. National Astronomical Observatory of Japan, 3. Frontier Research Institute for Interdisciplinary Science, Tohoku University, 4. Center for Planetary Science, Graduate School of Science, Kobe University, 5. Laboratory of Infrared High-resolution Spectroscopy, Koyama Astronomical Observatory, Kyoto Sangyo University, 6. Department of Astronomy, Columbia University, 7. Department of Physics and Astronomy, University of Texas at San Antonio, 8. Department of Space Astronomy and Astrophysics, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 9. Astrobiology Center, National Institutes of Natural Sciences

We will report the first detection of a single stellar occultation event candidate by a kilometer-sized (radius= 1-10 km) Kuiper belt object (KBO). Since the kilometer-sized KBOs are too faint to be detected directly, the monitoring of stellar occultation events is one possible way to discover them. With the aim of detecting the stellar occultation events, we launched an optical observation project named Organized Autotelescopes for Serendipitous Event Survey (OASES). We installed two low-cost OASES observation systems in different positions on the rooftop of the Miyako open-air school on Miyako Island, Miyakojima-shi, Okinawa Prefecture, Japan, and monitored up to 2000 stars simultaneously with a sampling cadence of 15.4Hz. In the 60-hour dataset obtained with the two-year OASES observations, we discovered one occultation candidate event by a KBO with a radius of approximately 1.3 km. Our present detection yields a surface number density of KBOs with radii exceeding 1.2 km is approximately 6×10^5 deg^{-2}. This surface number density favors a theoretical size distribution model with an excess signature at a radius of 1–2 km. The present results suggest that planetesimals before their runaway growth phase grew into kilometer-sized objects in the primordial outer Solar System and remain as one of the major populations in the present-day Kuiper belt.

Keywords: trans-Neptunian objects, Kuiper belt , ground based observations by optical telescopes

©2019. Japan Geoscience Union. All Right Reserved.

AKARI/IRC near-infrared asteroid spectroscopic survey: AcuA-spec

*Fumihiko Usui[1], Sunao Hasegawa[2], Takafumi Ootsubo[2], Takashi Onaka[3,4]

1. Kobe University, 2. ISAS/JAXA, 3. The University of Tokyo, 4. Meisei University

Water is found in various forms in our solar system and is one of the most important ingredients in the origin of life. It provides evidence for the evolution of the solar system, especially its thermal history. Hydrated minerals are formed in environments where anhydrous rock and liquid water exist together, resulting from aqueous alteration. Because hydrated minerals are stable even above the sublimation temperature of water ice, they become an important reservoir to trace the water present in the history of the solar system unless they were reset by a temperature change after formation. Asteroids are considered to record the initial conditions of our solar nebula of 4.6 Ga ago. To explore the existence of water in the present solar system, it is indispensable to investigate the presence of hydrated minerals and water ice on various types of asteroids. Hydrated minerals and water ice exhibit diagnostic absorption features in the so-called 3 micron band (approximately 2.5-3.5 micron wavelength range). Many spectroscopic surveys have been conducted in the 3 micron band using ground-based observatories, which are severely affected by telluric absorption at around 2.8 micron. Space-borne observations, free from the effect, therefore, offer an excellent opportunity to study and identify the mineral species in asteroids.

The Infrared Camera (IRC) on board the AKARI satellite has a unique spectroscopic capability covering 2.5-5 microns continuously with a spectral resolution of R~100, which provides valuable data thanks to its high sensitivity and unique wavelength coverage. We conducted a spectroscopic survey of asteroids in the 3 micron band using IRC. In the warm mission period of AKARI, 147 pointed observations were performed for 66 asteroids in the grism mode in 2.5-5 microns. According to our observations, it is found that most C-complex asteroids, especially all Ch-, Cgh-, B-, and Cb-type asteroids, have obvious absorption features in the reflectance spectra at around 2.75 micron, which is attributed to OH-stretch in hydrated minerals. The peak wavelength of the 2.7 micron band feature is concentrated at around 2.75 micron: in particular, there is a correlation between the peak wavelength and the band depth among 13 C-complex asteroids. This trend can be understood in terms of the process where hydrated minerals are being heated up and gradually losing water, that is, the dehydration process.

In this talk, we present the spectroscopic survey of asteroids with AKARI for detecting the 2.7 micron absorption features and discuss scenarios for the formation and evolution of C-complex asteroids.

Keywords: asteroids, hydrated minerals, near-infrared spectroscopy

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Patrick Espy(Norwegian University of Science and Technology), Astrid Maute(National Center for Atmospheric Research, US)

Vertical coupling mechanisms throughout the whole atmosphere are critical to understanding the near Earth space environment, as well as its sensitivity to the solar, geomagnetic, and atmospheric drivers. This international session focuses on physical/chemical processes occurring in the mesosphere, thermosphere, and ionosphere (MTI). Both quiet and disturbed states in response to lower atmospheric forcing or solar forcing are important for understanding the MTI system and its coupling to other regions. We invite presentations of observations and observational concepts with ground-based and/or space-borne instruments, theoretical studies, numerical simulations, and development of data analysis systems for various kinds of temporal and spatial variations in atmosphere-ionosphere coupled system.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PEM09-01] **Vertical Coupling from the Atmosphere to Geospace at Arrival Heights in Antarctica**

★Invited Papers

*Xinzhao Chu[1] (1.University of Colorado Boulder)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[PEM09-02] Vertical structure of terdiurnal tides in the Antarctic MLT region: 15 years observation over Syowa

*Huixin Liu[1], Masaki Tsutsumi[2], Hanli Liu[3] (1.Earth and Planetary Science Division, Kyushu University, Japan, 2.National Institute for Polar Research, Japan, 3.National Center for Atmospheric Research, US)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[PEM09-03] **3D Investigation of gravity waves propagation by Continuous Doppler sounding**

*Jaroslav Chum[1], Katerina Podolska[1] (1.Institute of Atmospheric Physics of the Czech Academy of Sciences)

2:35 PM - 2:55 PM JST | 5:35 AM - 5:55 AM UTC

[PEM09-04] **Observations of MLT dynamics using meteor radars and meteor radar networks**

★Invited Papers

*Gunter Stober[1], Vivien Matthias[2], Sven Wilhelm[1], Dimitry Pokhotelov[1], Alexander Kozlovsky[3], Evgenia Belova[4], Johan Kero[4], Chris Hall[5], Masaki Tsutsumi[6] (1.Leibniz Institute of Atmospheric Physics, 2.Potsdam Institute for Climate Impact Research, Earth System Analysis - Research Domain 1, Potsdam, Germany, 3.Sodankylä Geophysical Observatory, Sodankylä, FIN-99600, Finland, 4.Swedish Institute of Space Physics, Box 812, 98128 Kiruna, Sweden, 5.Tromsø Geophysical Observatory UiT-the Arctic University of Norway, Tromsø, Norway, 6.National Institute of Polar Research, Tokyo, Japan)

2:55 PM - 3:15 PM JST | 5:55 AM - 6:15 AM UTC

[PEM09-05] Ionospheric Variability Associated with the Quasi-6-day Planetary Wave

★Invited Papers

*Yosuke Yamazaki[1] (1.GFZ German Research Centre for Geosciences)

Vertical Coupling from the Atmosphere to Geospace at Arrival Heights in Antarctica

*Xinzhao Chu[1]

1. University of Colorado Boulder

The observational campaign with Fe Boltzmann and Na Doppler lidars has entered its 9th year at Arrival Heights near McMurdo (77.8S, 166.7E), Antarctica. The unique datasets have opened an exceptional window for exploration in the vertical coupling from the lower atmosphere to the thermosphere, and vertical coupling among the neutral atmosphere, ionosphere, and magnetosphere. Collaborating with theoreticians and modelers, we are attempting to establish a vertical picture of gravity waves in Antarctica from near the surface to the thermosphere, and a key concept is the secondary gravity wave generation initially hypothesized by Dr. Sharon Vadas. Combining observations with numerical modeling, we are also trying to understand how metal layers with cosmic dust origins are formed high in the thermosphere and ionosphere F-region via a complex atmosphere-ionosphere-magnetosphere (AIM) coupling and even correlating with solar wind activity. In this paper we will report a few studies that may be intriguing for advancing the understandings of vertical coupling from the atmosphere to the geospace at Arrival Heights that is a gravity-wave hotspot and by the edge of polar cap and auroral zone.

©2019. Japan Geoscience Union. All Right Reserved.

Vertical structure of terdiurnal tides in the Antarctic MLT region: 15 years observation over Syowa

*Huixin Liu[1], Masaki Tsutsumi[2], Hanli Liu[3]

1. Earth and Planetary Science Division, Kyushu University, Japan, 2. National Institute for Polar Research, Japan, 3. National Center for Atmospheric Research, US

The terdiurnal tide (TDT) in the Antarctica mesosphere and lower thermosphere (MLT) region is poorly known. In this study, we examine its characteristics using long-term neutral wind observations at Syowa (69S, 39E) between January 2004 and July 2018. The analysis reveals TDT being a significant tidal component in the Antarctica with distinct vertical structures and seasonal evolution. (1) It shows a prominent height-dependent seasonal variation, being in opposite phase above and below 94 km altitude, with peak amplitude in June –July at altitudes below 94 km, but in November –December above it. (2) The zonal wind component is 90 phase shifted from the meridional, with its amplitude of comparable or larger values than the meridional in all seasons except for November –December. (3) The vertical wavelength is shortest (50 –65 km) in local summer (Nov.–Jan.) and longes (80 –110 km) in local winter (Jun.–Aug.). Most of these features differ from those reported in the Arctic, indicating hemispheric asymmetry. Furthermore, the phase structure reveals a dominant upward propagating mode in local summer, but superposition of more than one mode in other seasons. Especially in local winter, a downward propagating mode above 95 km suggests Joule heating/ion drag as likely tidal sources from above, in addition to those from lower atmosphere. The nearly 15 years Syowa observations provide new constrains and benchmark for model simulations that seek to understan terdiurnal tidal forcing mechanisms in polar regions.

Keywords: Terdiurnal tide, Antarctica, vertical coupling

©2019. Japan Geoscience Union. All Right Reserved.

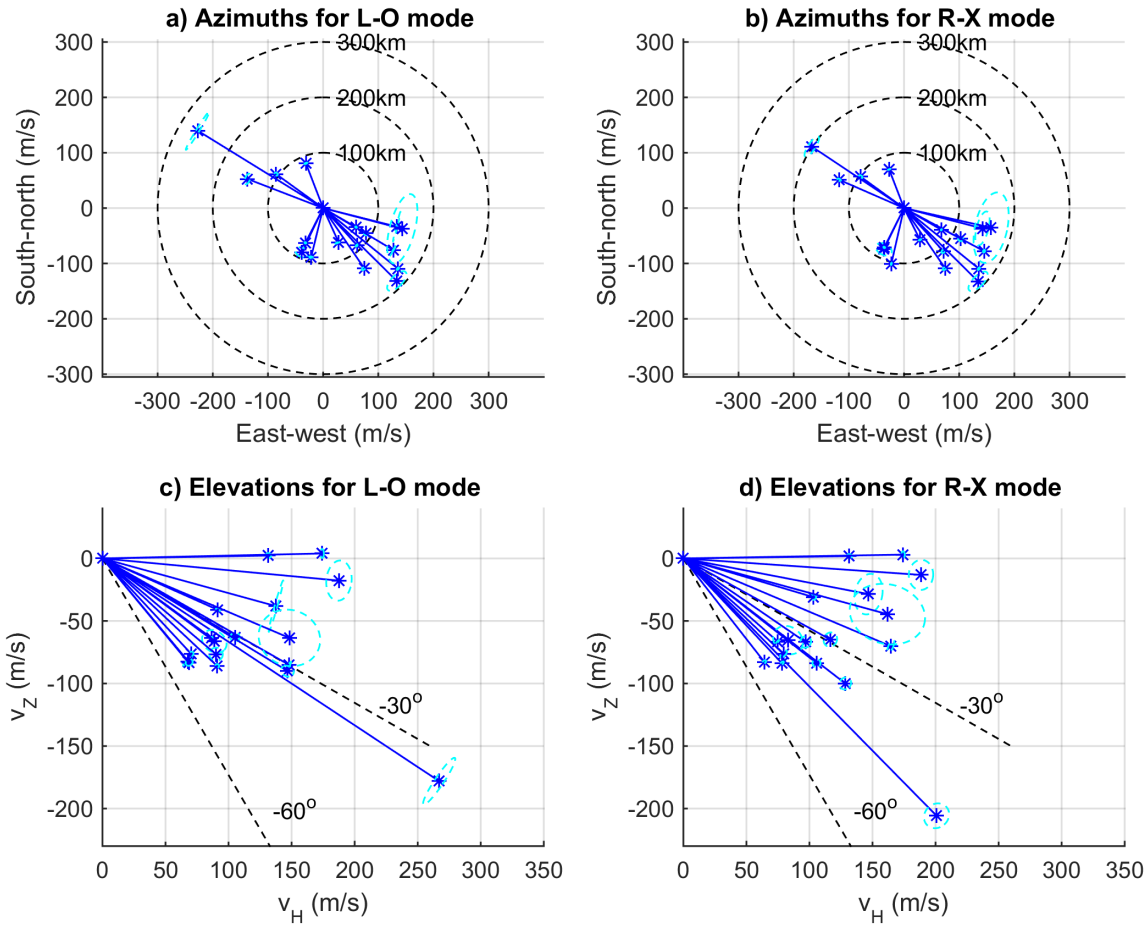
3D Investigation of gravity waves propagation by Continuous Doppler sounding

*Jaroslav Chum[1], Katerina Podolska[1]

1. Institute of Atmospheric Physics of the Czech Academy of Sciences

Multi-point continuous Doppler sounding is a useful tool to investigate short-time fluctuations in the ionosphere. We present analysis of GW propagation in the upper atmosphere and ionosphere in 3D. It is based on multi-point continuous Doppler sounding at three different frequencies; sounding radio waves of various frequencies reflect at different altitudes. The advantage of this analysis is information about the GW propagation in 3D and about the attenuation of wave power with height. The disadvantage is a relatively small number of events that can be analyzed as critical frequency of the ionosphere foF2 has to be larger than the highest sounding frequency and also significant cross-correlation between signals reflecting at different altitudes is necessary.

Keywords: atmospheric internal gravity waves, ionosphere , Doppler sounding, 3D analysis, Attenuation



©2019. Japan Geoscience Union. All Right Reserved.

Observations of MLT dynamics using meteor radars and meteor radar networks

*Gunter Stober[1], Vivien Matthias[2], Sven Wilhelm[1], Dimitry Pokhotelov[1], Alexander Kozlovsky[3], Evgenia Belova[4], Johan Kero[4], Chris Hall[5], Masaki Tsutsumi[6]

1. Leibniz Institute of Atmospheric Physics, 2. Potsdam Institute for Climate Impact Research, Earth System Analysis - Research Domain 1, Potsdam, Germany, 3. Sodankylä Geophysical Observatory, Sodankylä, FIN-99600, Finland, 4. Swedish Institute of Space Physics, Box 812, 98128 Kiruna, Sweden, 5. Tromsø Geophysical Observatory UiT-the Arctic University of Norway, Tromsø, Norway, 6. National Institute of Polar Research, Tokyo, Japan

The winter 2015/16 was characterized by an unusually strong polar vortex with values up to 2 standard deviations guiding the mid-latitude planetary waves into the subtropical mesosphere. This exceptionally strong wave activity in the subtropical mesosphere led to a regionally reversed meridional temperature gradient resulting in a zonal wind reversal between 70 and 80 km at polar latitudes due to the thermal wind relation. This regional wind reversal changes the propagation conditions for waves propagating upward from the mesosphere into the thermosphere/ionosphere. The variability of the thermosphere/ionosphere is influenced by forcing from below and thus by gravity waves and atmospheric tides propagating upward from the mesosphere into the thermosphere.
To investigate the change in propagation characteristics of gravity waves and tides in the upper mesosphere/ lower thermosphere (MLT) during this unusual zonal wind reversal in winter 2015/16 we use data from a meteor radar network in Scandinavia. With this network we are able to apply tomographic wind field analysis obtaining horizontally resolved wind fields and horizontal wavelength spectra. Further, we are able to assess the spatial and temporal day-to-day variability of tides.

Keywords: meteor radar, horizontally resolved winds, planetary waves, atmospheric tides and gravity waves, vertical coupling

©2019. Japan Geoscience Union. All Right Reserved.

Ionospheric Variability Associated with the Quasi-6-day Planetary Wave

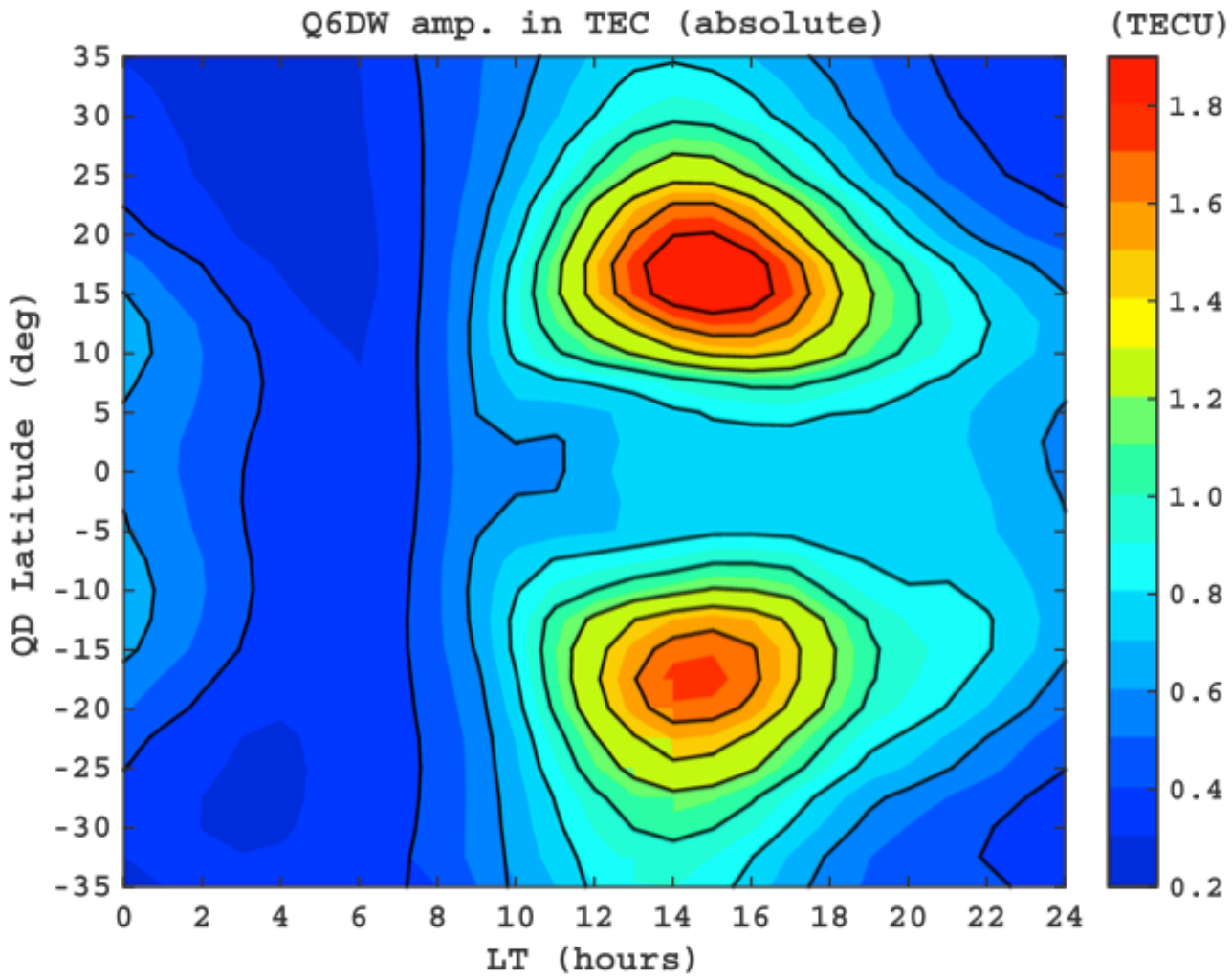
*Yosuke Yamazaki[1]

1. GFZ German Research Centre for Geosciences

The state of the ionosphere varies from day to day. This is partly due to atmospheric waves that propagate to the upper atmosphere from below. The present study investigates the ionospheric variability associated with the quasi-6-day wave (Q6DW), which is a westward-traveling planetary wave with zonal wave number s=1 and period around t=6d. First, the Q6DW effect on the equatorial ionospheric electric field is examined using the equatorial electrojet measurements from CHAMP and Swarm satellites, as well as ground-based magnetometer and radar observations. Case studies are presented where westward-propagating disturbances with s=1 and t~6d are observed in the daytime equatorial ionospheric electric field. Geopotential height measurements from the Aura satellite confirm the presence of the Q6DW in the lower thermosphere during those events. Next, the impact of the Q6DW on the equatorial ionization anomaly (EIA) is assessed using global maps of total electron content (TEC) from Global Positioning System data. It is shown that the amplitude of the Q6DW in TEC is largest at the EIA crest latitudes and its intra-annual variability closely follows the Q6DW variability in the lower thermosphere.

Keywords: ionosphere/thermosphere, quasi-6-day wave, equatorial region

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Yuichi Otsuka, Yosuke Yosuke Yamazaki(GFZ Potsdam, Germany)

Vertical coupling mechanisms throughout the whole atmosphere are critical to understanding the near Earth space environment, as well as its sensitivity to the solar, geomagnetic, and atmospheric drivers. This international session focuses on physical/chemical processes occurring in the mesosphere, thermosphere, and ionosphere (MTI). Both quiet and disturbed states in response to lower atmospheric forcing or solar forcing are important for understanding the MTI system and its coupling to other regions. We invite presentations of observations and observational concepts with ground-based and/or space-borne instruments, theoretical studies, numerical simulations, and development of data analysis systems for various kinds of temporal and spatial variations in atmosphere-ionosphere coupled system.

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[PEM09-06] Results of FORMOSAT-3/COSMIC to the most recent developments on FORMOSAT-7/COSMIC-2

★Invited Papers

*JANN-YENQ Liu[1] (1.Center for Astronautical Physics and Engineering; Graduate Institute of Space Science, National Central University, Taiwan)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[PEM09-07] A morphological study on the relationship between electron density fluctuations and magnetic fluctuations observed by low altitude satellites in low and middle latitudes

*Toshihiko Iyemori[1], Tadashi Aoyama[1], Yoshihiro Yokoyama[1] (1.Kyoto University)

4:05 PM - 4:25 PM JST | 7:05 AM - 7:25 AM UTC

[PEM09-08] Observations of the Thermosphere and Ionosphere by the NASA GOLD Mission

★Invited Papers

*Stanley C Solomon[1], Alan G. Burns[1], Richard W. Eastes[2], William E. McClintock[2] (1.National Center for Atmospheric Research, 2.University of Colorado)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[PEM09-09] Temporal and spatial evolutions of storm enhanced density in the mid- and low-latitude regions as seen in the variation of global total electron content

*Atsuki Shinbori[1], Takuya Sori[1], Yuichi Otsuka[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2.National Institute of Information and Communications Technology (NICT))

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[PEM09-10] **Tidal Forcing Effects on the Zonal Variation of Solstice Equatorial Plasma Bubbles**

*Loren Chang[1], Jude Salinas[1], Yi-Chung Chiu[1], Pei-yun Chiu[1], Charles Lin[2] (1.Institute of Space Science and Engineering, Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2.Department of Earth Science, National Cheng Kung University, Taiwan)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

Discussion

Results of FORMOSAT-3/COSMIC to the most recent developments on FORMOSAT-7/COSMIC-2

*JANN-YENQ Liu[1]

1. Center for Astronautical Physics and Engineering; Graduate Institute of Space Science, National Central University, Taiwan

The FORMOSAT-3 Project is also named Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC), or FORMOSAT-3/COSMIC (F3/C) for short. The project is targeted to place six micro-satellites into six different orbits with 72-deg inclination at 700~800 kilometer above the earth ground. These satellites orbit around the earth to form a low-earth-orbit constellation that conduct radio occultation (RO) by receiving signals transmitted by the 24 US GPS satellites. The satellite observation covers the entire global ionosphere, providing over 2,500 global RO sounding data (electron density and S4 scintillation profiles) per day since 15 April 2006. This for the first time allows scientists observing the 3D ionospheric electron density structure and dynamics. Simultaneous F3/C RO observations and ground-based receiver measurements of International GNSS (global navigation satellite system) Service (IGS) further initiate constructing three different models for monitoring (near real-time), nowcasting (few minutes to hours), and forecasting (few hours to days) the ionospheric weather resulted from the space weather (solar disturbances, solar winds, magnetic storms, etc.); the atmospheric severe weathers (typhoons, fronts, volcano eruptions, etc.); and the lithosphere weather (earthquakes, tsunami, etc.). The monitoring model is combining the total electron content (TEC) or the GNSS satellite signal scintillations of F3/C and ground-based IGS observations to construct an advanced GIM (global ionospheric map) to report the ionospheric bias and develop L-band scintillation models for communication, positioning, and navigation applications. The nowcast model is a global 3D ionospheric data assimilation model based on the Gauss-Markov Kalman filter with an existing background model to assimilate the TEC observations from the ground-based IGS receivers and space-based F3/C to output the global electron density for coming few minutes to hours. On the other hand, to carry out a long-term forecast, the neutral compositions in the atmosphere should be taken into consideration. Therefore, to develop a forecast model assimilating the observations of F3/C and IGS ground-based receivers into a neutral-ion coupled model. Following the F3/C, FORMOSAT-7/COSMIC (F7/C2) consists of six small-satellites with 24-deg inclination and about 500 km altitude will be launched in 2019. The developed models with F7/C2 RO by receiving signals transmitted by the GPS/GLONASS satellites and IVM (ionospheric velocity meter) plasma measurements as well as ground-based IGS GNSS data shall significantly improve the space weather monitoring/nowcast/forecast in the near future.

Keywords: ionospheric space weather, FORMOSAT-3/COSMIC, FORMOSAT-7/COSMIC, Kalman filter

©2019. Japan Geoscience Union. All Right Reserved.

A morphological study on the relationship between electron density fluctuations and magnetic fluctuations observed by low altitude satellites in low and middle latitudes

*Toshihiko Iyemori[1], Tadashi Aoyama[1], Yoshihiro Yokoyama[1]

1. Kyoto University

Polar orbiting low-altitude satellites such as the Swarm satellites observe magnetic and electron density fluctuations in low and middle latitudes along satellite orbit. The magnetic fluctuations typically have the period about 10-30seconds along satellite orbit and they are mostly small-scale field-aligned current effects and named as 'magnetic ripples'. They are supposed to be generated in lower ionosphere by dynamo mechanism caused by neutral atmospheric waves from lower atmosphere. On the nightside, they still exist with smaller amplitude because of lower ionospheric conductivity. Plasma bubbles also exist on the nightside and they normally accompany magnetic fluctuations to keep pressure balance. If we trace down to the dynamo layer around 120km altitude from magnetic ripples and compare the electron density fluctuations, they correspond better than the correspondence on the orbit. This indicates vertical propagation of atmospheric waves which causes both magnetic ripples and electron density fluctuations. On the other hand, in well-developed plasma bubbles, plasma density fluctuation and magnetic fluctuation occur at the same location on the orbit. In this study, we present morphological relationship between the two phenomena. That is, we investigate how magnetic ripples relate to plasma bubbles.

Keywords: magnetic ripples, ionospheric electron density, plasma bubbles

©2019. Japan Geoscience Union. All Right Reserved.

Observations of the Thermosphere and Ionosphere by the NASA GOLD Mission

*Stanley C Solomon[1], Alan G. Burns[1], Richard W. Eastes[2], William E. McClintock[2]

1. National Center for Atmospheric Research, 2. University of Colorado

The new Global-scale Observations of the Limb and Disk (GOLD) mission is an imaging spectrograph deployed in geostationary orbit on the SES-14 communications satellite. GOLD measures airglow emitted by the Earth in the far-ultraviolet region of the spectrum from 132 to 164 nm, notably including the 135.6 nm doublet of atomic oxygen (O), and most of the LBH bands of molecular nitrogen (N_2). During the day, the ratios of the oxygen to nitrogen emissions indicate the relative column densities of O and N_2, and temperature can be inferred from the spectral shape of the LBH bands. During the night, radiative recombination emissions by the O doublet indicate the density of the ionosphere, particularly the equatorial ionization anomalies and the structured instabilities that form within them. GOLD also measures exospheric temperatures on the limb, it infers molecular oxygen densities from stellar occultations, and it can also see northern hemisphere aurora. SES-14 was launched in January 2018, the satellite achieved geostationary orbit in, and GOLD observations commenced in October. We will give an overview of the GOLD mission and show preliminary results from its first months of operations. Despite the recent quiet conditions with low solar activity, composition images reveal daily and seasonal variations, indicative of global vertical wind patterns. The equatorial ionization anomalies are seen to be surprisingly variable and dynamic, with instabilities forming on most nights, even at solar minimum. We will compare GOLD results with global general circulation models and airglow emissions modeling, and discuss how these data could be used in assimilation models of the upper atmosphere and ionosphere.

Keywords: Thermosphere, Ionosphere, Ultraviolet Imaging

©2019. Japan Geoscience Union. All Right Reserved.

Temporal and spatial evolutions of storm enhanced density in the mid- and low-latitude regions as seen in the variation of global total electron content

*Atsuki Shinbori[1], Takuya Sori[1], Yuichi Otsuka[1], Takuya Tsugawa[2], Michi Nishioka[2]

1. Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2. National Institute of Information and Communications Technology (NICT)

The global electron density distribution in the ionosphere depends strongly on geographical latitude, longitude, and local time. The structure changes severely from the high-latitude to the equatorial regions associated with geomagnetic storms. The storm-time prominent ionospheric phenomena are tongue of ionization (TOI), storm-enhanced density (SED), and equatorial ionization anomaly (EIA). These phenomena are very dynamic because ionospheric electric fields and particle precipitation from the magnetosphere vary significantly during the development and decay of the geomagnetic storms. The generation mechanism of SED has been thought as local upward ExB drifts [e.g., Huang et al., 2005, Liu et al., 2016], westward plasma transportation from the nightside to the dayside by sub-auroral polarization stream (SAPS) [Foster et al., 2007], equatorward neutral winds [Anderson, 1976], and latitudinal expansion of the EIA [e.g., Kelley et al., 2004]. However, since such different mechanisms of the formation of SED have been proposed by many researchers, a comprehensive understanding of the cause of SED formation has not yet been done. In this study, we investigate the temporal and spatial evolutions of SED during the development and decay of geomagnetic storms using Global Navigation Satellite System (GNSS) Total Electron Content (TEC) data with high time and spatial resolutions, to identify the main mechanism responsible for SED. We also use solar wind data and geomagnetic indices to see the interplanetary condition and geomagnetic activity during geomagnetic storms. In the present analysis, we first calculate the average absolute TEC (ATEC) of 10 geomagnetically quiet days every month, referring to the list of quiet and disturbed days provided by GFZ. Next, we subtract the storm-time ATEC from the average ATEC and create global maps of the difference ATEC in geographical and geomagnetic coordinates. Several hours after the onset of the main phase of the geomagnetic storms, the enhanced TEC region with a narrow latitudinal width (5-10 degrees) appears at high latitudes (60-70 degrees in geomagnetic latitude (GMLAT)) of the afternoon sector (12-16 h, MLT: magnetic local time). The enhanced TEC region is located at a lower latitude of the equatorward wall of the midlatitude trough. As the geomagnetic storms grow, the enhanced TEC region expands to the nightside (~20 h, MLT) within a time scale of 20-30 minutes, and the region moves equatorward within several hours. After that, apart from the midlatitude enhanced TEC phenomena, another TEC enhancement takes place in the low-latitude region (15-30 degrees, GMLAT) on both sides of the dip equator. This observational fact cannot be explained by the latitudinal expansion of the EIA and westward transportation of a part of the higher latitude EIA by SAPS [Kelley et al., 2004; Foster et al., 2007]. As already proposed by Liu et al. [2016], the midlatitude enhanced TEC signature may be caused by upward ExB drifts that lift the ionosphere in the sunlit region to higher altitudes. In future study, we verify the effect of the localized ExB drifts on the formation of SED from a comparison between the global TEC and ionospheric plasma flow observed by the SuperDARN radars.

Keywords: Geomagnetic storm, Ionosphere, Storm enhanced density, Equatorial ionization anomaly, Midlatitude, Convection electric field

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Tidal Forcing Effects on the Zonal Variation of Solstice Equatorial Plasma Bubbles

*Loren Chang[1], Jude Salinas[1], Yi-Chung Chiu[1], Pei-yun Chiu[1], Charles Lin[2]

1. Institute of Space Science and Engineering, Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2. Department of Earth Science, National Cheng Kung University, Taiwan

Equatorial plasma bubbles are elongated plasma depletions that can occur in the nighttime ionospheric F region, causing scintillation in satellite navigation and communications signals, and manifesting in ionograms as spread F. Equatorial plasma bubbles are believed to be Rayleigh-Taylor instabilities seeded by vertically propagating gravity waves. A necessary pre-condition for plasma bubble formation is believed to be a threshold vertical ion drift from the E region, which is required to produce the vertical plasma gradients conducive to such an instability. Factors affecting the zonal and seasonal variation of equatorial plasma bubbles therefore include magnetic declination, as well as the strength of the equatorial electojet, and neutral winds in the lower thermosphere controlling vertical plasma drifts via the wind dynamo. In most longitude zones, the above factors result in elevated occurrence rates of equatorial plasma bubbles during the equinoxes. The notable exception is over the central Pacific and African sectors, where equatorial plasma bubble activity maximizes during solstice. As the zonal separation of the two sectors is roughly half the Earth’ s circumference, *Tsunoda et al.* (2015) hypothesized that the solstice maxima in these two sectors could be driven by a zonal wavenumber 2 atmospheric tidal component in the mesosphere and lower thermosphere (MLT). In this study, we find that the post-sunset electron density observed by FORMOSAT-3/COSMIC during the boreal summer does indeed exhibit a wave-2 zonal distribution in both the equatorial and northern mid latitude regions. The equatorial wave-2 is consistent with results expected from elevated vertical ion drift over the Central Pacific and African sectors, while the mid- latitude wave-2 is consistent with the Mid-Summer Nighttime Anomaly. Using COSMIC, the seasonal, longitudinal, and local time variation of ionospheric tidal and stationary planetary wave (SPW) components that produce zonal wavenumber 2 disturbances when viewed in a constant local time frame is examined. Numerical experiments are also carried out using the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) to determine the effect of the aforementioned tidal and SPW components on vertical ion drift, showing a clear wave-2 modulation of vertical ion drift when subject to forcing from wave-2 atmospheric tidal components in the mesosphere and lower thermosphere. The aforementioned results are consistent with the solstice maxima hypothesis.

Keywords: Ionosphere, Scintillation, Tides

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Hiroshi Hasegawa(Institute of Space and Astronautical Science, JAXA)

This session provides an opportunity to present recent results from satellite and ground-based observations and theoretical and simulation studies on the magnetosphere, ionosphere, and their coupling processes. We invite talks and posters discussing various phenomena related to the magnetosphere-ionosphere system: solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, field-aligned current, magnetic storms/substorms, neutral-plasma interaction, ionospheric ion inflow and outflow, aurora phenomena, and so forth. Discussions on planetary and satellite ionosphere and magnetospheres, future missions and instrument developments are also welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM11-01] **A Case Study Based on Ground Observations of the Conjugate Ionospheric Response to Interplanetary Shock in Polar Regions**

*He Fang[1], Zejun HU[1], Hongqiao HU[1] (1.Polar Research Institute of China)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM11-02] **Effects of Solar Illumination on the Auroral Electrojet Intensity**

*Shinichi Ohtani[1], Jesper W Gjerloev[1] (1.The Johns Hopkins University Applied Physics Laboratory)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM11-03] Quasi-persistent multiple mesoscale field-aligned currents in the duskside auroral oval

*Yoshihiro Yokoyama[1], Satoshi Taguchi[1], Toshihiko Iyemori[2], Keisuke Hosokawa[3] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Kyoto University, 3.Department of Communication Engineering and Informatics, University of Electro-Communications)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM11-04] Generation of dispersive Alfvenic turbulence in magnetosphere-ionosphere feedback coupling

*Tomo-Hiko Watanabe[1], Masatoshi Kaneyama[1], Shinya Maeyama[1] (1.Graduate School of Science, Nagoya University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM11-05] Aspects of simulating magnetosphere-ionosphere coupling via field-aligned current

*Astrid I Maute[1], Arthur D Richmond[1], Gang Lu[1] (1.High Altitude Observatory, National Center for Atmospheric Research, Boulder CO, 80301, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM11-06] **Revisiting the energy conversion process of Birkeland current generation**

*Akimasa Yoshikawa[1] (1.Department of Earth and Planetary Sciences, Kyushu University)

A Case Study Based on Ground Observations of the Conjugate Ionospheric Response to Interplanetary Shock in Polar Regions

*He Fang[1], Zejun HU[1], Hongqiao HU[1]

1. Polar Research Institute of China

This study uses data acquired by an imaging riometer, an ionosphere total electron content (TEC) monitor, and three specific wavelength auroral imagers at the conjugate Antarctic Zhongshan (ZHS) and Arctic Yellow River (YRS) stations to investigate the response of the polar ionosphere to a space weather event induced by solar flare activity on July 14, 2012. After the geomagnetic storm suddenly commenced and a magnetospheric substorm was triggered by the arrival of an interplanetary shock wave and its interaction with the magnetosphere at 18:10 UT, significantly enhanced auroral activity was observed by the auroral imagers at the ZHS. Meanwhile, the polar conjugate observation stations in the two hemispheres recorded notable growth of the two-dimensional cosmic noise adsorption and similar motion tendencies. According to our analysis and comparison of the ionospheric TEC data acquired by the conjugate stations, the TEC at both locations presented a considerable growth tendency after the interplanetary shock wave arrived, although the two stations experienced different sunlight conditions (polar night in the Antarctic region and polar day in the Arctic region). However, a comparison with high-frequency radar data demonstrated that different sources were responsible for the electron density enhancement of the ionosphere. In the Arctic polar day region, the increased electron density may have been caused by anti-sunward convection of the plasma irregularity, whereas in the Antarctic polar night region, the increased electron density may have been caused by energetic particle precipitation at the magnetospheric tail. Different physical processes might be the cause of the differential responses of the ionosphere at the two studied geomagnetic conjugate stations in the same solar activity event due to different local photoionization conditions.

Keywords: polar ionosphere, conjugate, substorm, response, irregularity

©2019. Japan Geoscience Union. All Right Reserved.

Effects of Solar Illumination on the Auroral Electrojet Intensity

*Shinichi Ohtani[1], Jesper W Gjerloev[1]

1. The Johns Hopkins University Applied Physics Laboratory

The present study investigates the dependence of the local auroral electrojet (AEJ) intensity on the solar illumination by statistically examining the northward geomagnetic disturbance in terms of the solar zenith angle (SZA) χ. It is found that on the day side, both westward and eastward electrojets (WEJ and EEJ) are more intense for smaller χ suggesting that the solar EUV-induced conductance is the dominant factor for the AEJ intensity. On the night side, in contrast, the χ dependence of the AEJ intensity, if sorted solely by the magnetic local time (MLT), is apparently different for stations at different longitudes and in different hemispheres. However, if additionally sorted by the dipole tilt angle ϕ, a consistent pattern emerges. It is therefore suggested that although ϕ and χ are correlated, the dipole tilt angle and SZA have physically different effects on the local AEJ intensity. The nightside AEJ, especially the WEJ, tends to be more intense for small $|\phi|$. Moreover, whereas the WEJ is statistically more intense when the ionosphere is dark, the EEJ is more intense when sunlit. The preference of the WEJ for the dark ionosphere extends widely in MLT from premidnight to dawn, and therefore, it cannot be linked exclusively with the substorms or be attributed to the previously proposed processes of the preferred auroral precipitation in the dark ionosphere. Instead, it may be explained at least morphologically in terms of the conductance enhancement due to the diffuse auroral precipitation, which is also prevalent from premidnight to dawn and is more intense in the dark hemisphere.

Keywords: Auroral electrojets, Solar illumination, Ionospheric conductance, Dipole tilt, Solar zenith angle, Diffuse aurora

©2019. Japan Geoscience Union. All Right Reserved.

Quasi-persistent multiple mesoscale field-aligned currents in the duskside auroral oval

*Yoshihiro Yokoyama[1], Satoshi Taguchi[1], Toshihiko Iyemori[2], Keisuke Hosokawa[3]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. Kyoto University, 3. Department of Communication Engineering and Informatics, University of Electro-Communications

Within a large-scale field-aligned current, whose latitudinal width is a few hundred kilometers in the ionosphere, smaller-scale current structures are often embedded. Previous studies have shown that a mesoscale upward field-aligned current with widths of order 10 km generally agree with auroral arcs. However, we still do not understand how this relation forms. In this study, using multispacecraft Swarm data and aurora data from a ground-based all-sky imager at Longyearbyen, Svalbard, we have examined mesoscale features of the field-aligned current and auroral arcs in the duskside auroral oval. We focused on the situation when the large-scale Region 1 current diminishes so that mesoscale features can stand out. Through the cross-correlation analysis of the magnetic perturbations observed by Swarm A and Swarm C, we took events in which the observed magnetic perturbations represent the spatial structure of multiple pairs of upward/downward mesoscale field-aligned currents, not Alfven wave. Conjugate observations between Swarm satellites and the all-sky imager have shown that auroral arcs actually occur in the region of the upward field-aligned current. The result of the analysis of the all-sky image data obtained before and after the conjunction event has shown that the auroral arcs have quasi-persistent features, and also indicated when the auroral arcs appear and disappear. From these results, we discuss how the mesoscale field-aligned current can form.

Keywords: Field-aligned current, Postnoon aurora, Swarm satellites

©2019. Japan Geoscience Union. All Right Reserved.

Generation of dispersive Alfvenic turbulence in magnetosphere-ionosphere feedback coupling

*Tomo-Hiko Watanabe[1], Masatoshi Kaneyama[1], Shinya Maeyama[1]

1. Graduate School of Science, Nagoya University

Magnetosphere-ionosphere (M-I) feedback coupling is considered to provide possible explanations to self-excitatation of auroral arc structures with enhancements of the ionospheric density and the field-aligned current. Recent theoretical and numerical studies have revealed generation of Alfvenic turbulence in the nonlinear evolution of the feedback instability, following the Kelvin-Helmholtz instability accompanied with curl structures of the ionospheric density.
Our recent study has extented to include effects of the electron intertia in the magnetospheric dynamics, where the dispersive Alfven waves with the parallel electric field play a key role in the M-I coupling. The linear stability analysis incuding the electron inertia term has shown the stabilization effect while the mean parallel acceleration of electrons is self-consistently included in the model of auroral arc growth. Nonlinear simulations of the feedback instability have also demonstrated generation of the Alfvenic turbulence with finite parallel electric fields, where a power law energy spectra are obtained for the parallel and perpendicular wavenumbers. The physical picture of Alfvenic turbulence obtained in the persent study is consistent to FAST spacecraft observations of the dispersive Alfven waves and the electron acceleration in the Alfvenic aurora.

Keywords: aurora, magnetosphere-ionosphere coupling, turbulence, electron acceleration, Alfven waves

©2019. Japan Geoscience Union. All Right Reserved.

Aspects of simulating magnetosphere-ionosphere coupling via field-aligned current

*Astrid I Maute[1], Arthur D Richmond[1], Gang Lu[1]

1. High Altitude Observatory, National Center for Atmospheric Research, Boulder CO, 80301, USA

Magnetosphere-ionosphere (MI) coupling is crucial in modeling the thermosphere-ionosphere (TI) response to geomagnetic activity. In general circulation models (GCMs) the MI coupling is frequently realized by specifying the ion convection and auroral particle precipitation patterns from, e.g., empirical models or assimilative models. Using assimilative models, such as the Assimilative Model of Ionospheric Electrodynamics (AMIE), has the advantage that the ion convection and auroral particle precipitation patterns are self-consistent and based on available observations. However, assimilating data can be time consuming and requires expert knowledge, and therefore it is so far not the standard way of MI coupling in GCMs. With the availability of AMPERE data, there is an increased interest of employing field-aligned currents (FAC) in GCMs to represent the MI coupling. The FAC from AMPERE captures interhemispheric differences in the MI coupling not represented by empirical ion convection models. However, since GCMs mostly employ prescribed high latitude ion convection patterns little is known about differences in the TI response to high latitude forcing by prescribed FACs.

In this study, we will compare with the help of a simulated geomagnetic storm the different MI coupling methods, i.e., AMIE, empirical ion convection and AMPERE field-aligned current. We illustrate the sensitivity of the Joule heating and low latitude electric field with respect of the spatial distribution of the aurora and ion convection for the different cases. The influence of interhemispheric differences in the MI coupling on the middle and low latitude thermosphere-ionosphere system will be examined.

Keywords: Magnetosphere-ionosphere coupling via field-aligned current, Interhemispheric assymetries, Middle and low latitude effects

©2019. Japan Geoscience Union. All Right Reserved.

Revisiting the energy conversion process of Birkeland current generation

*Akimasa Yoshikawa[1]

1. Department of Earth and Planetary Sciences, Kyushu University

As shown by Vasyliunas [1970], the magnetospheric diamagnetic current has a finite divergece when it crosses the region with a finite B gradient and connects to the Field-Aligned Current (FAC). A pressure gradient force, the origin of the diamagnetic current in a force balance to the Ampere force, never twists plasma flow. While for the development of magnetic shear, which corresponds to FAC, combination of Ampere’s law , Faraday’s induction law and MHD Ohm’s law require the gradient of plasma vortex along B-field. In other words, for the existence of a quasi-steady FAC in the MHD scheme, the plasma vorticity along the B-field is inevitably required.

Of course, for the development of plasma vorticity, we need a dynamical process that twists the plasma. What is the dynamical process that twists the plasma as FACs are generated due to the divergence of the diamagnetic current? A conventional answer to this question is a mode conversion between the compressional mode and the Alfven mode when the diamagnetic current is growing (in inductive process). However, in principle, the magnetosphere-ionosphere coupling system forms a dissipative structure in the open solar-terrestrial system. Therefore, even in a macroscopic quasi-steady system, the constant conversion from the thermal energy to the magnetic energy and the internal mode conversion from magnetic compression to the magnetic shear should continuously take place. In this sense, we need to revisit the dynamical process of FAC. In this presentation, we will discuss what is the dynamical process and what is the quasi-steady state of FACs in a dissipative structure of the open magnetosphere-ionosphere system.

Keywords: Birkeland Current, Magnetosphere-Ionosphere Coupling, Energy Conversion

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Shinji Saito(ISEE, Nagoya University), Yusuke Ebihara(RISH, Kyoto University)

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM13-11] Nonlinear Damping of Oblique Whistler Mode Waves Via Landau Resonance

*Yikai HSIEH[1], Yoshiharu Omura[1] (1.Reserach Institute for Sustainable Humanosphere, Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM13-12] Instantaneous Frequency Analysis on Nonlinear EMIC Emissions: Arase Observation

*Masafumi Shoji[1], Yoshizumi Miyoshi[1], Yoshiharu Omura[2], Lynn M Kistler[1,3], Yasumasa Kasaba[4], Shoya Matsuda[5], Yoshiya Kasahara[6], Ayako Matsuoka[5], Reiko Nomura[7], Keigo Ishisaka[8], Atsushi Kumamoto[4], Fuminori Tsuchiya[4], Satoshi Yagitani[6], Mariko Teramoto[1], Kazushi Asamura[5], Takeshi Takashima[5], Iku Shinohara[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Research Institute for Sustainable Humanosphere, Kyoto University, 3.Institute for the Study of Earth Oceans and Space, University of New Hampshire, 4.Tohoku University, 5.Institute of Space and Astronautical Science, 6.Kanazawa University, 7.National Astronomical Observatory of Japan, 8.Toyama Prefecture University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM13-13] Rapid Precipitation by EMIC Rising-tone Emissions of Relativistic Electrons Observed by the Van Allen Probes Mission

*Satoko Nakamura[1], Yoshiharu Omura[1], Craig Kletzing[2], Daniel Baker[3] (1.Research Institute for Sustainable Humanosphere, Kyoto University., 2.Department of Physics and Astronomy University of Iowa , 3.The Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM13-14] Plasmaspheric EMIC waves excited through mode conversion from equatorial noise under existence of M/Q=2 ions

*Yoshizumi Miyoshi[1], Shoya Matsuda[2], Satoshi Kurita[1], koji nomura[1], Kunihiro Keika[3], Masafumi Shoji[1], Naritoshi Kitamura[3], Yoshiya Kasahara[4], Ayako Matsuoka[2], Iku Shinohara[2], Kazuo Shiokawa[1], Shinobu Machida[1], Ondrej Santolik[5], Scott Boardsen[6], Richard Horne[7], Wygant John[8] (1.Institute for Space-Earth

Environmental Research, Nagoya University, 2.JAXA, 3.University of Tokyo, 4.Kanazawa University, 5.CAS, 6.NASA, 7.British Antarctic Survey, 8.University of Minnesota)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM13-15] Generation Mechanism of Non-thermal Continuum Radiation

*Yoshiharu Omura[1], Miroslav Horky[1,2] (1.Reserach Institute for Sustainable Humanosphere, Kyoto University, 2.Department of Space Physics, Institute of Atmospheric Physics, Czech Academy of Sciences)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM13-16] Influence of kappa distributions on the sweep rate of whistler mode chorus waves

*Danny Summers[1] (1.Memorial University of Newfoundland)

Nonlinear Damping of Oblique Whistler Mode Waves Via Landau Resonance

*Yikai HSIEH[1], Yoshiharu Omura[1]

1. Reserach Institute for Sustainable Humanosphere, Kyoto University

Nonlinear trapping of electrons via Landau resonance is an important mechanism of oblique whistler mode wave-particle interactions. Electrons trapped by Landau resonance gain energies from waves. The Landau resonance velocity becomes very close to the group velocity of nearly parallel whistler mode waves at frequencies around half the electron gyrofrequency, resulting in a long interaction time and possible wave damping. We perform test particle simulations with parameters at L = 5 and a small wave normal angle 10 degrees to study the wave-particle interactions via the Landau resonance. Analyzing the wave electric fields and the resonant currents formed by electrons undergoing Landau and cyclotron resonances, we show that effective wave damping occurs near half the electron gyrofrequency. This nonlinear wave damping is contributed by Landau resonance rather than cyclotron resonance. Furthermore, we confirm that this damping is dominated by perpendicular components of the wave electric field and perpendicular resonant currents. The simulation results indicate that nonlinear damping via Landau resonance is one of the mechanisms dividing chorus emissions into the upper band and the lower band.

Keywords: whistler mode waves, wave-particle interaction, relativistic electrons, Landau resonance

©2019. Japan Geoscience Union. All Right Reserved.

Instantaneous Frequency Analysis on Nonlinear EMIC Emissions: Arase Observation

*Masafumi Shoji[1], Yoshizumi Miyoshi[1], Yoshiharu Omura[2], Lynn M Kistler[1,3], Yasumasa Kasaba[4], Shoya Matsuda[5], Yoshiya Kasahara[6], Ayako Matsuoka[5], Reiko Nomura[7], Keigo Ishisaka[8], Atsushi Kumamoto[4], Fuminori Tsuchiya[4], Satoshi Yagitani[6], Mariko Teramoto[1], Kazushi Asamura[5], Takeshi Takashima[5], Iku Shinohara[5]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Research Institute for Sustainable Humanosphere, Kyoto University, 3. Institute for the Study of Earth Oceans and Space, University of New Hampshire, 4. Tohoku University, 5. Institute of Space and Astronautical Science, 6. Kanazawa University, 7. National Astronomical Observatory of Japan, 8. Toyama Prefecture University

In the inner magnetosphere, the Arase spacecraft has observed electromagnetic ion cyclotron (EMIC) emissions with both rising and falling frequencies. The instantaneous frequency analyses on the electromagnetic fields of the EMIC rising tone emission have been performed by the Hilbert-Huang transform. The time variation of the instantaneous frequency shows a good agreement with the nonlinear theory for the frequency evolutions. Rapid instantaneous frequency modulation is also found during the rising tone emission. We estimate the peak-to-peak time of the fluctuation in the frequency and find that the fluctuation is caused around a half of the particle trapping time. From the motion of the phase-bunched particle around the resonant velocity, it is expected that the nonlinear resonant current, which induces the falling frequency is formed in half the trapping time.

Keywords: nonlinear wave particle interaction, Arase spacecraft

©2019. Japan Geoscience Union. All Right Reserved.

Rapid Precipitation by EMIC Rising-tone Emissions of Relativistic Electrons Observed by the Van Allen Probes Mission

*Satoko Nakamura[1], Yoshiharu Omura[1], Craig Kletzing[2], Daniel Baker[3]

1. Research Institute for Sustainable Humanosphere, Kyoto University., 2. Department of Physics and Astronomy University of Iowa , 3. The Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado

On 23 February 2014, Van Allen Probes sensors observed quite strong electromagnetic ion cyclotron waves (EMIC) in the outer dayside magnetosphere. The maximum amplitude was more than 14 nT, comparable to 7 % of the magnitude of the ambient magnetic field. The EMIC waves consisted of a series of coherent rising tone emissions. Rising tones are excited sporadically by energetic protons. At the same time, the probes detected drastic fluctuations in fluxes of MeV electrons. It was found that the electron fluxes decreased by more than 30 % during the one minute following the observation of each EMIC rising tone emissions. Furthermore, it is concluded that the flux reduction is a non-adiabatic (irreversible) process since holes in the particle flux levels appear as drift echoes with energy dispersion. We examine the process of the electron pitch angle scattering by nonlinear wave trapping due to anomalous cyclotron resonance with EMIC rising tone emissions. The energy range of precipitated electrons corresponds to the presumed energy for the threshold amplitude for nonlinear wave trapping. This is the first report of rapid precipitation by this mechanism of relativistic electrons by EMIC rising tone emissions and their drift echoes in time observed by spacecraft.

©2019. Japan Geoscience Union. All Right Reserved.

Plasmaspheric EMIC waves excited through mode conversion from equatorial noise under existence of M/Q=2 ions

*Yoshizumi Miyoshi[1], Shoya Matsuda[2], Satoshi Kurita[1], koji nomura[1], Kunihiro Keika[3], Masafumi Shoji[1], Naritoshi Kitamura[3], Yoshiya Kasahara[4], Ayako Matsuoka[2], Iku Shinohara[2], Kazuo Shiokawa[1], Shinobu Machida[1], Ondrej Santolik[5], Scott Boardsen[6], Richard Horne[7], Wygant John[8]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. JAXA, 3. University of Tokyo, 4. Kanazawa University, 5. CAS, 6. NASA, 7. British Antarctic Survey, 8. University of Minnesota

Equatorial noise (EN, and referred to as magnetosonic mode waves) emissions are observed inside and outside the plasmapause and propagate across the magnetic field. In this study, we found the mode conversion from EN to EMIC waves in the plasmasphere using the plasma wave data from Van Allen Probes and Arase. When EN propagates into the earthward across the field line toward the Earth, EN splits into different waves modes; EN, and EMIC waves with the existence of M/Q=2 ions (deuteron or alpha particles) in the deep plasmasphere and the topside ionosphere. The oblique EMIC waves are excited through this mode conversion process, which are different characteristics of the propagation directions from EMIC waves generated from other processes. This mode conversion contributes to an origin of the plasmaspheric EMIC waves, especially at L<2.

Keywords: Arase, Plasmaspheric EMIC waves, M/Q=2 ions

©2019. Japan Geoscience Union. All Right Reserved.

Generation Mechanism of Non-thermal Continuum Radiation

*Yoshiharu Omura[1], Miroslav Horky[1,2]

1. Reserach Institute for Sustainable Humanosphere, Kyoto University, 2. Department of Space Physics, Institute of Atmospheric Physics, Czech Academy of Sciences

We study a possible nonlinear mechanism which could be responsible for generation of the non-thermal continuum radiation. We propose a theoretical model and perform numerical simulations using a 2-D electromagnetic particle code (KEMPO2) [1] to verify the mechanism [2]. In the simulation system, we have density gradient and ring beam electrons in the dense region as a source of electrostatic waves through ring-beam instability. These electrostatic waves cause non-gyrotropy of the ring velocity distribution which is necessary for generation of the harmonic waves. Velocity component V_y together with magnetic field B_z of the generated Z-mode waves creates Lorentz force in the x-direction (along the magnetic field). Hence, oscillating energetic electrons work as an anntenna emiting O-mode waves to the low density region. Electromagnetic O-mode waves are emitted at harmonics of the cyclotron frequency up to the maximal plasma frequency of the high density region, and they are observed as non-thermal continuum radiation in the low density region.

References:
[1] M. Horky, Y. Omura, and O. Santolik, Particle simulation of electromagnetic emissions from electrostatic instability driven by an electron ring beam on the density gradient, Physics of Plasmas 25, 042905, doi: 10.1063/1.5025912, 2018.
[2] M. Horky, and Y. Omura, Novel nonlinear mechanism of the generation of non-thermal continuum radiation, Physics of Plasmas 26, 2019.

Keywords: wave-particle interaction, nonlinear process, plasma_pause

©2019. Japan Geoscience Union. All Right Reserved.

Influence of kappa distributions on the sweep rate of whistler mode chorus waves

*Danny Summers[1]

1. Memorial University of Newfoundland

Kappa particle distributions typically possess a high-energy power-law tail characterized by a spectral index kappa. Here we consider the bi-kappa and kappa-loss-cone distributions. The influence of kappa distributions on the linear growth rate of whistler-mode waves is mediated by the electron anisotropy. The linear growth rate corresponding to kappa distributions (for kappa=2) exceeds that for a bi-Maxwellian distribution for electron anisotropies less than a critical value; for anisotropies greater than the critical value the opposite applies. The influence of kappa distributions on the threshold wave amplitude for nonlinear growth depends on the wave frequency, the electron anisotropy and the temperature of the (hot) energetic electrons that generate the waves. We construct time profiles of the amplitude and frequency of chorus wave elements for various sets of parameters. We examine how the sweep (chirp) rate of the waves depends on the kappa index. Nonlinear growth of whistler mode waves can be enhanced or inhibited by kappa distributions,dependent on the values of the parameters of the background plasma and the properties of the injected energetic electron population that generates the waves.

Keywords: kappa distributions, whistler mode waves, chorus sweep rates

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Yusuke Ebihara(RISH, Kyoto University), Shinji Saito(ISEE, Nagoya University)

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[PEM13-17] The Impacts of Substorms on the Ring Current

★Invited Papers

*Jasmine Kaur Sandhu[1], I. J. Rae[1], M. Gkioulidou[2], C. Forsyth[1], G. D. Reeves[3], M. P. Freeman[4], K. R. Murphy[5], M.-T. Walach[6], H. E. Spence[7] (1.Mullard Space Science Laboratory, University College London, UK., 2.Applied Physics Laboratory, John Hopkins University, USA., 3.Los Alamos National Laboratory, USA., 4.British Antarctic Survey, UK., 5.University of Maryland, USA., 6.Lancaster University, UK., 7.University of New Hampshire, USA.)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[PEM13-18] Dipolarization in the Inner Magnetosphere: Comparison between Geosynchronous Orbit and Further Inside

★Invited Papers

*Shinichi Ohtani[1], Tetsuo Motoba[1], Matina Gkioulidou[1], Kazue Takahashi[1] (1.The Johns Hopkins University Applied Physics Laboratory)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[PEM13-19] Substorm-associated particle injection near/at geosynchronous orbit: Observations from ERG and GOES

*Tzu-Fang Chang[1,2], Chio-Zong Cheng[2], Sunny Wing-Yee Tam[2], Chih-Yu Chiang[2], Yoshizumi Miyoshi[1], Tomoaki Hori[1], Takefumi Mitani[3], Takeshi Takashima[3], Ayako Matsuoka[3], Mariko Teramoto[1], Iku Shinohara[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 2.Institute of Space and Plasma Sciences, National Cheng Kung University, Tainan, Taiwan, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[PEM13-20] Substorm -like energetic electron injection observed at the plasma sheet boundary in the inner magnetosphere

*Iku Shinohara[1], Nagai Tsugunobu[1], Takefumi Mitani[1], Nana Higashio[2], Satoshi Kasahara[3], Yoichi Kazama[4], Shiang-Yu Wang[4], Sunny Tam[5], Ayako Matsuoka[1], Kazushi Asamura[1], Shoichiro Yokota[6], Takeshi Takashima[1], Yoshizumi Miyoshi[7] (1.Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science, 2.Japan Aerospace Exploration Agency, 3.The University of Tokyo, 4.Academia Sinica/Institute of Astronomy and Astrophysics, 5.National Cheng Kung University, 6.Osaka University, 7.Nagoya University/Institute for Space-Earth Einvironment Research)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[PEM13-21] Magnetic field disturbances associated with the magnetic dipolarization observed by Arase (ERG) in the inner magnetosphere

*Ayako Matsuoka[1], Masahito Nose[2], Yoshizumi Miyoshi[2], Iku Shinohara[1], Mariko Teramoto[2], Reiko Nomura[3], Akiko Fujimoto[4], Yoshimasa Tanaka[5], Manabu Shinohara[6], Yoshiya Kasahara[7], Yasumasa Kasaba[8], Keigo Ishisaka[9], Shoya Matsuda[1], Masafumi Shoji[2], Tomoko Nakagawa[10], Yoichi Kazama[11], Shiang-Yu Wang[11], Satoshi Kasahara[12], Shoichiro Yokota[13], Takefumi Mitani[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.RISE, National Astronomical Observatory of Japan, 4.School of Computer Science and Systems Engineering, Kyushu Institute of Technology, 5.National Institute of Polar Research, 6.National Institute of Technology, Kagoshima College, 7.Information Media Center, Kanazawa University, 8.Planetary Plasma and Atmospheric Research Center, Tohoku University, 9.Faculty of Engineering, Toyama Prefectural University, 10.Faculty of Engineering, Tohoku Institute of Technology, 11.Academia Sinica Institute of Astronomy and Astrophysics, 12.School of Science, The University of Tokyo, 13.School of Science, Osaka University)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

Discussion

The Impacts of Substorms on the Ring Current

*Jasmine Kaur Sandhu[1], I. J. Rae[1], M. Gkioulidou[2], C. Forsyth[1], G. D. Reeves[3], M. P. Freeman[4], K. R. Murphy[5], M.-T. Walach[6], H. E. Spence[7]

1. Mullard Space Science Laboratory, University College London, UK., 2. Applied Physics Laboratory, John Hopkins University, USA., 3. Los Alamos National Laboratory, USA., 4. British Antarctic Survey, UK., 5. University of Maryland, USA., 6. Lancaster University, UK., 7. University of New Hampshire, USA.

Substorms are a highly dynamic process that result in the global redistribution of energy within the magnetosphere. The occurrence of a substorm can provide the inner magnetosphere with hot ions and consequently intensify the ring current population. However, substorms are a highly variable phenomenon that can occur as an isolated event or as part of a sequence. In this study we determine the extent to which substorms enhance the ring current energy content and compare how the energy enhancement varies with substorm type.

Using ion observations (H^+, O^+, and He^+) from the RBSPICE and HOPE instruments onboard the Van Allen Probes, we quantify how the total ring current energy content changes during the substorm process. A statistical analysis demonstrates the impact of a typical substorm on the ring current region. We find that ~ 5% of the total energy released at substorm onset is transferred into the ring current population, and energises the ring current by 12% on average. The features of the energy enhancement correlate well with the expected properties of particle injections into the inner magnetosphere, and large enhancements in the O^+ contribution to the energy content suggest important compositional variations.

Analysis also reveals that the ring current response to substorms is strongly dependent upon the type of substorm activity. The results show that substorms followed by a series of successive substorms are associated with significantly different ring current conditions and enhancements compared to isolated substorms. We present clear magnitude and local time differences that illustrate the complexity and variability of the substorm-ring current coupling, along with an interpretation of the details of this relationship.

Keywords: Ring Current, Substorms, Van Allen Probes, Magnetosphere

©2019. Japan Geoscience Union. All Right Reserved.

Dipolarization in the Inner Magnetosphere: Comparison between Geosynchronous Orbit and Further Inside

*Shinichi Ohtani[1], Tetsuo Motoba[1], Matina Gkioulidou[1], Kazue Takahashi[1]

1. The Johns Hopkins University Applied Physics Laboratory

The present study addresses the current system associated with dipolarization in the inner magnetosphere. *Ohtani et al.* [2018] examined dipolarization events observed by the Van Allen Probes (RBSP) satellites within 5.8 R_E from Earth, and by statistically comparing signatures at nearby RBSP or GOES satellites, they found that dipolarization signatures are often highly correlated (c.c. > 0.8) within 1 hr in MLT and 1 R_E in R_{XY}, and the dipolarization region expands earthward as well as azimuthally. In the present study we use, as a reference, the GOES geosynchronous satellites instead, and we examine how the magnetic field at the RBSP position changes responding to sharp dipolarizations at geosynchronous orbit. As expected from the aforementioned result, the two spacecraft occasionally observe similar dipolarization signatures with some time delay. It is, however, also found that in some events the magnetic field changes far less systematically at the RBSP probes, and in other events it barely changes or changes very gradually even if the RBSP probes are located very close to the GOES location in longitude (DMLT = 0.0 ~ 0.5 hr in MLT). By examining such variability with respect to the radial distance and magnetic latitude of the RBSP probes, we address the spatial structure of the associated current system. We also examine the variation of particle fluxes at the RBSP probes for each type of the magnetic response, and discuss the result in terms of the enhancement of local plasma pressure and the formation of a R2-sense field-aligned current system, which we suggest coexists along with the conventional substorm wedge current system.

Reference:

Ohtani, S., Motoba, T., Gkioulidou, M., Takahashi, K., & Singer, H. J. (2018). Spatial development of the dipolarization region in the inner magnetosphere. Journal of Geophysical Research: Space Physics, 123, 5452–5463. https://doi.org/10.1029/2018JA025443.

Keywords: Dipolarization, Inner magnetosphere, Substorms, Field-aligned currents

©2019. Japan Geoscience Union. All Right Reserved.

Substorm-associated particle injection near/at geosynchronous orbit: Observations from ERG and GOES

*Tzu-Fang Chang[1,2], Chio-Zong Cheng[2], Sunny Wing-Yee Tam[2], Chih-Yu Chiang[2], Yoshizumi Miyoshi[1], Tomoaki Hori[1], Takefumi Mitani[3], Takeshi Takashima[3], Ayako Matsuoka[3], Mariko Teramoto[1], Iku Shinohara[3]

1. Institute for Space-Earth Environmental Research, Nagoya University, Japan, 2. Institute of Space and Plasma Sciences, National Cheng Kung University, Tainan, Taiwan, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan

The injection of electrons during the substorm event, occurring on Apr. 5, 2017, was observed by the ERG (Arase), GOES-15 and GOES-13 spacecraft near/at geosynchronous orbit. The ERG satellite observed the nearly-dispersionless injection and the subsequent drift echoes while the GOES-15 and GOES-13 captured the drift echoes with dispersion. The multipoint observations provide constraints for us to simulate the substorm-associated injection. We improve an existing model in the literature to study the substorm injection event. Since the electron energies of interest are comparable to the rest mass energy, our work further provides the relativistic form of the previous model and employs a semi-empirical model instead of a dipole-based one in the previous study. Our simulations successfully reproduce the key features of the nearly-dispersionless injection and the drift echoes. The periods of drift echoes show a better fit to the spacecraft observations when relativistic effects are taken into account. The substorm-associated injection event can be better simulated by the further-developed model shown in this study.

Keywords: ERG, Arase, substorm injection, drift echoes, relativistic effects

©2019. Japan Geoscience Union. All Right Reserved.

Substorm -like energetic electron injection observed at the plasma sheet boundary in the inner magnetosphere

*Iku Shinohara[1], Nagai Tsugunobu[1], Takefumi Mitani[1], Nana Higashio[2], Satoshi Kasahara[3], Yoichi Kazama[4], Shiang-Yu Wang[4], Sunny Tam[5], Ayako Matsuoka[1], Kazushi Asamura[1], Shoichiro Yokota[6], Takeshi Takashima[1], Yoshizumi Miyoshi[7]

1. Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science, 2. Japan Aerospace Exploration Agency, 3. The University of Tokyo, 4. Academia Sinica/Institute of Astronomy and Astrophysics, 5. National Cheng Kung University, 6. Osaka University, 7. Nagoya University/Institute for Space-Earth Einvironment Research

The Arase (ERG) satellite is possible to observe higher L-value plasma sheet close to the plasma sheet boundary because of its characteristic orbit, and, actually, Arase has observed several lobe entry events just outside of the outer radiation belt. In some of these events, we found that energetic electron bursts up to (sometimes, over) 300 keV appear at the plasma sheet boundary. The purpose of this study is to address where do the energetic electron bursts at higher latitude come from and what is the contribution of magnetotail reconnection and its associated acceleration process to the generation of the energetic electron bursts.

However, the observed energetic electron bursts look quite similar to typical dispersionless substorm injection events. If the observed electron bursts are due to the substorm injection, the observation cannot be explained by the standard understanding of the injection because (1) the injection occurs associated with local magnetic field dipolarizations in downstream of the magnetotail reconnection jets (in deep inside of the plasma sheet) and (2) energetic electrons observed at the plasma sheet boundary are thought to be directly accelerated from magnetotail reconnection sites. Since the pitch angle distribution of 100-200 keV electron shows enhancement both of parallel and perpendicular fluxes, the observed results suggest the coexistence of (1) and (2). In this presentation, we will discuss the physical meanings of the observed electron bursts. The discussion is important to address the relationship between magnetotail reconnection and injections, and the results might contribute to a better understanding of electron acceleration processes and energy input to the inner magnetosphere.

Keywords: plasma sheet boundary, electron acceleration

©2019. Japan Geoscience Union. All Right Reserved.

Magnetic field disturbances associated with the magnetic dipolarization observed by Arase (ERG) in the inner magnetosphere

*Ayako Matsuoka[1], Masahito Nose[2], Yoshizumi Miyoshi[2], Iku Shinohara[1], Mariko Teramoto[2], Reiko Nomura[3], Akiko Fujimoto[4], Yoshimasa Tanaka[5], Manabu Shinohara[6], Yoshiya Kasahara[7], Yasumasa Kasaba[8], Keigo Ishisaka[9], Shoya Matsuda[1], Masafumi Shoji[2], Tomoko Nakagawa[10], Yoichi Kazama[11], Shiang-Yu Wang[11], Satoshi Kasahara[12], Shoichiro Yokota[13], Takefumi Mitani[1]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. RISE, National Astronomical Observatory of Japan, 4. School of Computer Science and Systems Engineering, Kyushu Institute of Technology, 5. National Institute of Polar Research, 6. National Institute of Technology, Kagoshima College, 7. Information Media Center, Kanazawa University, 8. Planetary Plasma and Atmospheric Research Center, Tohoku University, 9. Faculty of Engineering, Toyama Prefectural University, 10. Faculty of Engineering, Tohoku Institute of Technology, 11. Academia Sinica Institute of Astronomy and Astrophysics, 12. School of Science, The University of Tokyo, 13. School of Science, Osaka University

The magneto-hydrodynamic waves propagating in the plasma sheet are recognized to transport substantial energies in the magnetosphere. We investigated magnetic field disturbances of the Alfven waves observed by the Arase spacecraft at about 5 earth-radii distance in the midnight. In the inner plasma sheet Alfven waves were often accompanied by the magnetic dipolarization.
We examined the magnetic disturbances in the plane perpendicular to the ambient magnetic field. In the two events examined in our study, the magnetic field disturbances were linearly polarized and the polarization direction gradually rotated 180 degrees in 200 seconds. It is well interpreted that Arase traversed a magnetic flux tube where torsional Alfven waves propagated. The change of the polarization direction reflected the change of observation location in the flux tube. Torsional-mode is significantly common and natural as the parallel-propagating Alfven wave. It is known that large-scale energy transfer and dissipation of the torsional Alfven waves take place on the solar surface.
Meanwhile, in the boundary plasma sheet adjacent to the lobe, the magnetic field disturbances were linearly polarized again and confined to the dawn-dusk direction. They are interpreted as plane Alfven waves having uniformity in the dawn-dusk direction and propagating obliquely. The kinetic effect of the Alfven waves has been often discussed in previous works in association with the auroral emission at the ionospheric altitude.

Keywords: Arase, magnetic field, dipolarization, Alfven wave

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM13] Inner magnetosphere: Recent understanding and new insights

convener:Yusuke Ebihara(Research Institute for Sustainable Humanosphere, Kyoto University), Danny Summers(Memorial University of Newfoundland), Yoshizumi Miyoshi(Institute for Space-Earth Environmental Research, Nagoya University), Shinji Saito(Graduate School of Science, Nagoya University), Chairperson:Yoshizumi Miyoshi(ISEE, Nagoya University), Yusuke Ebihara(RISH, Kyoto University)

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PEM13-22] Statistical Property of Long Lasting Poloidal Pc 4-5 Waves and Relation with Particle Dynamics in the Inner Magnetosphere: Van Allen Probes Observations

★Invited Papers

*Kazuhiro Yamamoto[1], Masahito Nose[2], Kunihiro Keika[3], Charles W. Smith[4], Robert J. MacDowall[5], Donald G. Mitchell[6], Hyomin Kim[7], John Wygant[8] (1.Graduate School of Science, Kyoto University, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Graduate School of Science, the University of Tokyo, 4.Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 5.Solar System Exploration Division, Goddard Space Flight Center, 6.The Johns Hopkins University Applied Physics Laboratory, 7.Center for Solar Terrestrial Research, New Jersey Institute of Technology, 8.School of Physics and Astronomy, University of Minnesota)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PEM13-23] Subauroral Polarization Streams: Indication of Magnetosphere–Ionosphere Coupling

★Invited Papers

*Fei He[1,2,3], Xiao-Xin Zhang[4], Wenbin Wang[5], Zhonghua Yao[1,2,3], Yong Wei[1,2,3], Zhi-Peng Ren[1,2,3], Xinan Yue[1,2,3], Weixing Wan[1,2,3] (1.Institute of Geology & Geophysics, CAS, 2.Institutions of Earth Science, CAS, 3.College of Earth and Planetary Sciences, UCAS, 4.National Center for Space Weather, CMA, 5.High Altitude Observatory, NCAR)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[PEM13-24] Simultaneous Arase-ground observations of a purple and green auroral arc

*Kazuo Shiokawa[1], Masahito Nose[1], Satoshi Tsuchiya[1], Yuki Takagi[1], Shun Imajo[1], Yoshimasa Tanaka[2], Yoshizumi Miyoshi[1], Keisuke Hosokawa[3], Yoichi Kazama[4], Shiang-Yu Wang[4], Sunny W.Y. Tam[4], Kazushi Asamura[5], Satoshi Kasahara[6], Shoichiro Yokota[7], Tomoaki Hori[1], Kunihiro Keika[6], Ayako Matsuoka[5] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Polar Research, 3.The University of Electro-Communications, 4.National Cheng Kung University, 5.Institute of

Space and Astronautical Science, Japan Aerospace Exploration Agency, 6.University of Tokyo, 7.Osaka University)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[PEM13-25] Multiple Satellite Observations of Oxygen Torus in the Inner Magnetosphere

*Masahito Nose[1], Ayako Matsuoka[2], Atsushi Kumamoto[3], Yoshiya Kasahara[4], J Goldstein[5,6], Mariko Teramoto[1], Fuminori Tsuchiya[3], Shoya Matsuda[2], Masafumi Shoji[1], Shun Imajo[1], Oimatsu Satoshi[7], Kazuhiro Yamamoto[7], Yuki Obana[8], Reiko Nomura[9], Akiko Fujimoto[10], Iku Shinohara[2], Yoshizumi Miyoshi[1], W S Kurth[11], C A Kletzing[11], C W Smith[12], R J MacDowall[13] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Graduate School of Science, Tohoku University, 4.Information Media Center, Kanazawa University, 5.Space Science and Engineering Division, Southwest Research Institute, 6.University of Texas at San Antonio, 7.Graduate School of Science, Kyoto University, 8.Faculty of Engineering, Osaka Electro-Communication University, 9.National Astronomical Observatory of Japan, 10.Kyushu Institute of Technology, 11.Department of Physics and Astronomy, University of Iowa, 12.Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 13.Solar System Exploration Division, Goddard Space Flight Center)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[PEM13-26] Study of characteristics of storm-time Pc5 ULF waves excited by the drift-bounce resonance with ring current ions based on the global drift-kinetic simulation

*Tomotsugu Yamakawa[1], Kanako Seki[1], Takanobu Amano[1], Yoshizumi Miyoshi[2], Naoko Takahashi[1] (1.Department of Earth and Planetary Science, School of Science, The University of Tokyo, 2.ISEE, Nagoya University)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

Discussion

Statistical Property of Long Lasting Poloidal Pc 4-5 Waves and Relation with Particle Dynamics in the Inner Magnetosphere: Van Allen Probes Observations

*Kazuhiro Yamamoto[1], Masahito Nose[2], Kunihiro Keika[3], Charles W. Smith[4], Robert J. MacDowall[5], Donald G. Mitchell[6], Hyomin Kim[7], John Wygant[8]

1. Graduate School of Science, Kyoto University, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Graduate School of Science, the University of Tokyo, 4. Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 5. Solar System Exploration Division, Goddard Space Flight Center, 6. The Johns Hopkins University Applied Physics Laboratory, 7. Center for Solar Terrestrial Research, New Jersey Institute of Technology, 8. School of Physics and Astronomy, University of Minnesota

Poloidal ULF waves in the inner magnetosphere have been attracting many attentions because they can interact with plasma particles. A lot of event analysis of the drift-bounce resonance, the bounce resonance, and the drift resonance have been conducted (e.g., *Hughes et al.*, 1978; *Takahashi et al.*, 1990, 2018; *Liu et al.*, 2013; *Dai et al.*, 2013; *Min et al.*, 2017; *Oimatsu et al.*, 2018; *Rubtsov* et al., 2018). However, the statistical relation between the poloidal mode waves and particles is rarely reported, and the phase relation between poloidal oscillations and resonance particles is only studied by *Ren et al.* (2018).

To reveal the importance of a poloidal ULF wave in the dynamics of the inner magnetosphere, we statistically analyzed 91 events of the poloidal waves detected by Van Allen Probes with duration time larger than 2 hr, because significant wave particle interaction is expected for such long lasting waves. We calculated eigen-frequencies of the selected waves using the Tsyganenko 89 model (*Tsyganenko*, 1989), and found that most of them are second harmonic mode waves. The cross phase between the radial magnetic field and the azimuthal electric field also supports this result. Using the ion sounding technique (*Su et al.*, 1977; *Min et al.*, 2017; *Yamamoto et al.*, 2018), we estimated the azimuthal wave number (*m* number) for 47 events from RBSPICE observation. Most of the 47 events have m = -120 to -200 (i.e., westward propagation). These high-m waves can be excited by wave-particle interaction.

Relation between the high-m poloidal waves and the plasmasphere was investigated. When the poloidal waves were observed, cold electron density increased by a factor of ~2. When the electron density decreased to the original state, the poloidal waves disappeared. This implies that the poloidal waves are excited in the structured high electron density region like plasma plume. The scenario of wave excitation through bounce resonance proposed by *Liu et al.* (2013) can explain the density variations during wave appearance.

We will also discuss the variations of proton flux around resonance energy and evaluate the importance of poloidal ULF waves in the dynamics of the inner magnetosphere. During quiet period ($|Dst| < 10$ nT), the proton flux at energy of (0.3-1)W_{res} (W_{res}: resonance energy) was slightly smaller than that on the orbit just before the wave onset. The decrease of resonance particle flux may be caused by wave-particle interaction.

Keywords: poloidal ULF waves, ring current, plasmasphere, wave particle interaction, Van Allen Probes (RBSP)

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Subauroral Polarization Streams: Indication of Magnetosphere–Ionosphere Coupling

*Fei He[1,2,3], Xiao-Xin Zhang[4], Wenbin Wang[5], Zhonghua Yao[1,2,3], Yong Wei[1,2,3], Zhi-Peng Ren[1,2,3], Xinan Yue[1,2,3], Weixing Wan[1,2,3]

1. Institute of Geology & Geophysics, CAS, 2. Institutions of Earth Science, CAS, 3. College of Earth and Planetary Sciences, UCAS, 4. National Center for Space Weather, CMA, 5. High Altitude Observatory, NCAR

Subauroral polarization streams, or SAPS, are narrow channels of strong westward ion flows in both the subauroral ionosphere and the conjugated inner magnetosphere in the nightside during geomagnetic storms and substorms. The SAPS are closely related with ionospheric conductivity and region–2 field–aligned currents. Many characteristics of SAPS have been determined from space–based measurements of electric fields and ion drifts in the ionosphere and the magnetosphere, and ground–based radar observations, such as the global occurrence based on the statistics of many individual event, long term variabilities, hemispheric asymmetries, electromagnetic wave structures, double peak signatures, and evolution patterns during intense storms and quiet time substorms. Multisatellite observations during a geomagnetic storm indicated that the SAPS were first initiated around the dusk sector and then expanded toward the midnight, moved to low latitudes and formed a wedge-shaped structure during the main phase. More recently, multisatellite observations during a severe storm revealed that strong oscillations occurred in the SAPS channel when IMF By changed from positive to negative. The SAPS oscillations were first observed in the pre–midnight sector and propagated towards the dusk sector. The oscillations may be related to the waves generated by the interaction between the fast–flowing energetic plasma sheet ions and the cold plasmasphere. The new features of SAPS provide new insights in to the coupling dynamics in the magnetosphere.

Keywords: SAPS, Large-scale structure, Oscillations, plasma sheet, storm

©2019. Japan Geoscience Union. All Right Reserved.

Simultaneous Arase-ground observations of a purple and green auroral arc

*Kazuo Shiokawa[1], Masahito Nose[1], Satoshi Tsuchiya[1], Yuki Takagi[1], Shun Imajo[1], Yoshimasa Tanaka[2], Yoshizumi Miyoshi[1], Keisuke Hosokawa[3], Yoichi Kazama[4], Shiang-Yu Wang[4], Sunny W.Y. Tam[4], Kazushi Asamura[5], Satoshi Kasahara[6], Shoichiro Yokota[7], Tomoaki Hori[1], Kunihiro Keika[6], Ayako Matsuoka[5]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. National Institute of Polar Research, 3. The University of Electro-Communications, 4. National Cheng Kung University, 5. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 6. University of Tokyo, 7. Osaka University

The purple auroral emission at a wavelength of 427.8nm is often caused by resonant scattering of sunlight by nitrogen molecular ions at the high-latitude part of auroral arcs, and can be a manifestation of ion upflow in the auroral ionosphere. We report the first particle observation for the source region of a purple/green auroral arc in the inner magnetosphere, which was made by the Arase satellite. The auroral arc appeared and expanded equatorward from ~0310 UT (midnight in local time) on September 11, 2018 at Nain, Canada, in association with the expansion phase of a substorm that occurred during the arrival of a corotating interaction region (CIR) in the solar wind. The auroral arc is characterized by purple and green emissions at the top and bottom parts, respectively, suggesting resonant-scattering of sunlight by auroral nitrogen molecular ions. Bi-directional field-aligned electrons with energies of ~keV were observed by the LEP-e onboard the Arase satellite during the arc crossing at L ~ 6.4, while source electrons become isotropic in the diffuse aurora afterwards. Electrons at energies of ~20 keV measured by the MEP-e of Arase also show a bi-directional (nearly) field-aligned distribution, while electron loss cone was identified at the arc crossing. The low-energy protons measured by LEP-i of Arase show time-pitch-angle dispersion from anti-earthward (180 degree) to earthward (0 degree) during the arc crossing. Based on these observations, we discuss physical mechanisms that cause these particle features and the observed purple/green auroral arc.

Keywords: purple auroral arc, simultaneous satellite-ground observation, field-aligned electron precipitation

©2019. Japan Geoscience Union. All Right Reserved.

Multiple Satellite Observations of Oxygen Torus in the Inner Magnetosphere

*Masahito Nose[1], Ayako Matsuoka[2], Atsushi Kumamoto[3], Yoshiya Kasahara[4], J Goldstein[5,6], Mariko Teramoto[1], Fuminori Tsuchiya[3], Shoya Matsuda[2], Masafumi Shoji[1], Shun Imajo[1], Oimatsu Satoshi[7], Kazuhiro Yamamoto[7], Yuki Obana[8], Reiko Nomura[9], Akiko Fujimoto[10], Iku Shinohara[2], Yoshizumi Miyoshi[1], W S Kurth[11], C A Kletzing[11], C W Smith[12], R J MacDowall[13]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3. Graduate School of Science, Tohoku University, 4. Information Media Center, Kanazawa University, 5. Space Science and Engineering Division, Southwest Research Institute, 6. University of Texas at San Antonio, 7. Graduate School of Science, Kyoto University, 8. Faculty of Engineering, Osaka Electro-Communication University, 9. National Astronomical Observatory of Japan, 10. Kyushu Institute of Technology, 11. Department of Physics and Astronomy, University of Iowa, 12. Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, 13. Solar System Exploration Division, Goddard Space Flight Center

A recent study employing the Arase and Van Allen Probes A satellites at different MLT revealed an event in which the inner magnetospheric O^+ density enhancement (know as the dense oxygen torus) does not extend over all MLT. Rather, the torus is skewed toward the dawn sector, being described more precisely as a crescent-shaped torus or a pinched torus [Nosé et al., 2018]. In the reported event of 24 April 2017, Arase flying in the morning sector detected an enhancement of the average plasma mass up to ~3.5 amu around *L*=4.9–5.2, while Van Allen Probe A flying in the afternoon sector observed no clear enhancements in the average plasma mass. In the present study, we focus on simultaneous observations of the magnetic field and plasma waves made by the Arase and Van Allen Probes A and B satellites on 12 September 2017. For this event the orbital configuration of the satellites is opposite to that in the study by Nosé et al. [2018]; that is, Arase is in the afternoon and the Van Allen Probes are in the morning. It is found that only Probe B observed a clear enhancement in the average plasma mass up to ~4 amu around *L*=3.5 and MLT=9.0 hr. This result demonstrates that the crescent-shaped O^+ torus is not a unique (single-event) occurrence, and thus may be a general feature of the density enhancement in the inner magnetosphere.

©2019. Japan Geoscience Union. All Right Reserved.

Study of characteristics of storm-time Pc5 ULF waves excited by the drift-bounce resonance with ring current ions based on the global drift-kinetic simulation

*Tomotsugu Yamakawa[1], Kanako Seki[1], Takanobu Amano[1], Yoshizumi Miyoshi[2], Naoko Takahashi[1]

1. Department of Earth and Planetary Science, School of Science, The University of Tokyo, 2. ISEE, Nagoya University

Storm-time Pc5 waves are electromagnetic fluctuations in the inner magnetosphere with the frequency of 1.67-6.67 mHz, and are considered to be generated by ring current ions associated with the injection from the magnetotail during substorms. The excitation mechanism and global distribution of Pc5 waves are keys to understand dynamic variation of the outer radiation belt, since Pc5 waves are considered to contribute to the radial diffusion of radiation belt electrons [e.g. Elkington et al., 2003]. Promising candidates of excitation mechanism of the storm-time Pc5 waves are the drift or drift-bounce resonance [Southwood, 1976]. Although previous spacecraft observations suggest the resonant excitation [e.g., Dai et al., 2013; Yeoman and Wright., 2001], there are other possibilities such as periodic pressure inhomogeneity formed by time-dependent injections. Theoretically, Yamakawa et al. [2019] confirmed the drift resonance excitation of storm-time Pc5 waves in 3D dipole structure based on the drift-kinetic simulation. However, in what kind of situation the drift resonance is switched to the drift-bounce resonance is far from understood.

In order to simulate the excitation of the storm-time Pc5 waves, we perform a kinetic simulation for ring current particles using GEMSIS-RC model [Amano et al., 2011], in which five-dimensional drift-kinetic equation for the phase space density (PSD) of ring current ions and Maxwell equations are solved self-consistently under assumption that the first adiabatic invariant is conserved. In order to simulate consequence of ion injection from the plasma sheet, we set a localized high-pressure region around midnight consisting of H+ ions. We compare two cases of the initial velocity distribution; the Maxwellian velocity distribution with the isotropic temperature of 16 keV (Case a) and the velocity distribution with the phase bunching in the southern hemisphere due to the bounce motion of ions in addition to the background Maxwellian distribution (Case b). For the Case b, we changed the strength of the initial phase bunching to investigate the conditions for drift-bounce resonance to be dominant.In Case a, the simulation results show the drift resonance excitation of both poloidal and toroidal mode waves in Pc5 frequency range in the dayside dusk sector. These waves are fundamental mode waves with azimuthal wave number m ~ - 20 propagating westward. Global distribution of the excited Pc5 waves indicates that they are excited where the local growth rate resultant from the positive PSD gradient in energy is positive. In Case b, excitation of the second harmonic poloidal-mode Pc4 ULF waves due to the drift-bounce resonance was identified in the dayside dusk sector in the strong bunching case. We will also report on characteristics of excited ULF waves and their dependence on the initial bunching strength of injected ions with a focus of the relative contribution of the drift and drift-bounce resonances.

References:

©2019. Japan Geoscience Union. All Right Reserved.

Amano et al., J. *Geophys. Res.*, vol.116, No.A2, 216, 2011.

Elkington et al., J. *Geophys*. Res., vol.108, No.A3, 1116, 2003.

Dai et al., *Geophys. Res. Lett.*, vol.40, No.16, 4127-4132, 2013.

Yeoman et al., *Ann. Geophys.*, vol.19, No.2, 159-170, 2001.

Southwood, J. *Geophys. Res.*, vol.81, No.19, 3340-3348, 1976.

Yamakawa et al., *Geophys. Res. Lett.*, in press, 2019.

Keywords: ring current, Pc5 ULF, drift-bounce resonance, drift-kinetic simulation, magnetic storm

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 104 1F

[A-AS01] High performance computing for next generation weather, climate, and environmental sc iences

convener:Hiromu Seko(Meteorological Research Institute), Takemasa Miyoshi(RIKEN), Chihiro Kodama(Japan Agency for Marine-Earth Science and Technology), Masayuki Takigawa(Japan Agency for Marine-Earth Science and Technology), Chairperson:Hiromu Seko(Meteorological Research Institute), Chihiro Kodama(Japan Agency for Marine-Earth Science and Technology)

A lot of advanced simulation studies are being conducted by high performance supercomputers, such as K computer and Earth Simulator, in various fields including meteorology. The high performance supercomputers enable us to conduct numerical simulations and data assimilation of observation big-data (huge high-density and high-frequency data) with an order of magnitude higher resolutions and ensemble numbers than those with the previous supercomputers. In addition, the post-K computer will be available as a successor of K, and studies for the post-K computer are in progress. At this session, we comprehensively pick up the topics in the Atmospheric and Hydrospheric Sciences Sessions of the 2019 Union Meeting that comprise the atmospheric, oceanic and land sciences. This session aims to promote recent studies related to the issues on high performance computing in weather, climate, and environmental studies using the K computer and other supercomputers, and to enhance discussions on future directions of numerical simulations in meteorology.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AAS01-01] Data Assimilation Studies using Big Observation Data in the Projects of Post K and BDA

*Hiromu Seko[1], Masaru Kunii[2], Yohei Sawada[1], Kozo Okamoto[1], Sho Yokota[1], Kosuke Ito[3], Kazuki Shimoji[2] (1.Meteorological Research Institute, 2.Japan Meteorological Agency, 3.University of the Ryukyus)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AAS01-02] **High-resolution Numerical Weather Simulation with a Large Domain for Extreme Heavy Rainfall Events**

*Tsutao OIZUMI[1,2], Kazuo Saito[4,3], le duc[1], Junshi Ito[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, 3.The Atmosphere and Ocean Research Institute, 4.Japan Meteorological Business Support Center)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS01-03] A Numerical Case Study on a Tornado that Formed in a Quasi Linear Convective System

★Invited Papers

*Eigo Tochimoto[1], Hiroshi Niino[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

[AAS01-04] Improving the observation operator for Phased Array Weather Radar in the SCALE-LETKF system

*Arata Amemiya[1], Takumi Honda[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS01-05] Data assimilation and forecast experiments for the record-breaking rainfall event in Japan in July 2018 with NICAM-LETKF at 112-km and 28-km resolution

*Koji Terasaki[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS01-06] Model Parameter Estimation with Data Assimilation Using NICAM-LETKF

★Invited Papers

*Shunji Kotsuki[1], Yousuke Sato[2], Koji Terasaki[1], Hasashi Yashiro[1], Hirofumi Tomita[1], Masaki Satoh[3], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science, 2.Graduate School of Engineering, Nagoya University, 3.Atmosphere and Ocean Research Institute, the University of Tokyo)

Data Assimilation Studies using Big Observation Data in the Projects of Post K and BDA

*Hiromu Seko[1], Masaru Kunii[2], Yohei Sawada[1], Kozo Okamoto[1], Sho Yokota[1], Kosuke Ito[3], Kazuki Shimoji[2]

1. Meteorological Research Institute, 2. Japan Meteorological Agency, 3. University of the Ryukyus

In the projects of 'Advancement of meteorological and global environmental predictions utilizing observational Big Data' of 'The post K computer development plan of the FLAGSHIP2020 Project' and 'Innovating "Big Data Assimilation" Technology for Revolutionizing Very-short-range Severe Weather Prediction', the data assimilation techniques including the coupling with the ocean model have been developed to improve the prediction accuracy of heavy rainfalls, typhoons and tornadoes, and to obtain the longer leading time (the time from the prediction to the occurrences of severe phenomena). The most of these studies were conducted by using the super computer 'K' and Big Observation Data. In this presentation, the impacts of rapid scan'atmospheric motion vector' and sea surface temperature of Himawari-8 on the Typhoon intensity and track predictions and on the rainfall predictions of heavy rainfalls, the assimilation results of all-sky radiance data in the convection scale prediction, and the reproduction of rainfall system that caused tornadoes by the data of Polarization radar and dense surface observation network will be presented.

Keywords: Data Assimilation, Big Observation Data

©2019. Japan Geoscience Union. All Right Reserved.

High-resolution Numerical Weather Simulation with a Large Domain for Extreme Heavy Rainfall Events

*Tsutao OIZUMI[1,2], Kazuo Saito[4,3], le duc[1], Junshi Ito[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Meteorological Research Institute, 3. The Atmosphere and Ocean Research Institute, 4. Japan Meteorological Business Support Center

In Japan, heavy rainfall occasionally causes disasters such as debris flows. For example, debris flows induced severe societal damages in Izu Oshima Island on 15-16 October 2013 and in Hiroshima City on 19-20 August 2014, western Japan on July 5th –8th 2018. To mitigate these disasters damage and evacuate residents in a timely fashion, an accurate numerical weather prediction (NWP) system is important.
In this study, we conducted an ultra-high resolution NWP simulations (grid spacing is 5 km to 150 m) with a large and small domain area to above heavy rainfall events. Several important model factors (grid spacing, PBL scheme model domain size) influencing heavy rainfall forecasting in NWP models were investigated. The model was an optimized version of the Japan Meteorological Agency Non-Hydrostatic Model for the supercomputer “K”.
The result showed the 2-km grid spacing models showed better precipitation performance than 5-km resolution models. And the 500-m resolution models showed better precipitation performance than 2-km grid spacing models. The 2-km and 500-m grid spacing models with the large model domain show better performance than those with the small domain. Overall, the results indicated that using a high-resolution model (500-m grid spacing) with the large model domain area provides an advantage for simulating heavy rain events.

Keywords: heavy rainfall, high resolution simulation, JMA-NHM

©2019. Japan Geoscience Union. All Right Reserved.

A Numerical Case Study on a Tornado that Formed in a Quasi Linear Convective System

*Eigo Tochimoto[1], Hiroshi Niino[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Tornadoes are mainly classified into three groups based on different types of convective systems: supercells, quasi-linear convective systems (QLCSs), and non-supercells. In the United States, it is estimated that 18% of all tornadoes are spawned by QLCSs. In Japan, although tornadoes associated QLCSs also occur and cause severe damages, the detailed features and formation mechanism of tornadoes have not been well under stood. Thus, we performed a high-resolution numerical simulation to reproduce and examine the formation process of a tornado that formed in a quasi linear convective system at Chiyoda-town, Ibaraki prefecture, Japan on 8 December 1992.

A quadruple-nested simulation using Japanese Meteorological Agency non-hydrostatic model was performed. A simulation with horizontal scale of 2km successfully reproduced the QLCS, which propagated eastward quickly and reached around Chiyoda-town at 0830 JST. A cold pool and its associated downdrafts existed behind the convection region with strong updrafts (>10m/s). A simulation with the finest horizontal scale of 50m successfully reproduced the tornado in the QLCS. The vertical vorticity and horizontal velocity exceeded 0.7 $s^{-1}$and 47m/s, respectively. At around 500m height, a low-level mesocyclone, which was accompanied by strong updrafts (>20m/s), formed and developed around the location of tornadogenesis. Near the surface, at 1 or 2 minutes before the tornadogenesis, strong rear-inflow jet (RIJ) accompanied by relatively cold air developed, and then tornado formed in the north of the RIJ. Thus, it is suggested that the RIJ play some roles in the formation and development of the tornado.

Keywords: Tornado, Convection

©2019. Japan Geoscience Union. All Right Reserved.

Improving the observation operator for Phased Array Weather Radar in the SCALE-LETKF system

*Arata Amemiya[1], Takumi Honda[1], Takemasa Miyoshi[1]

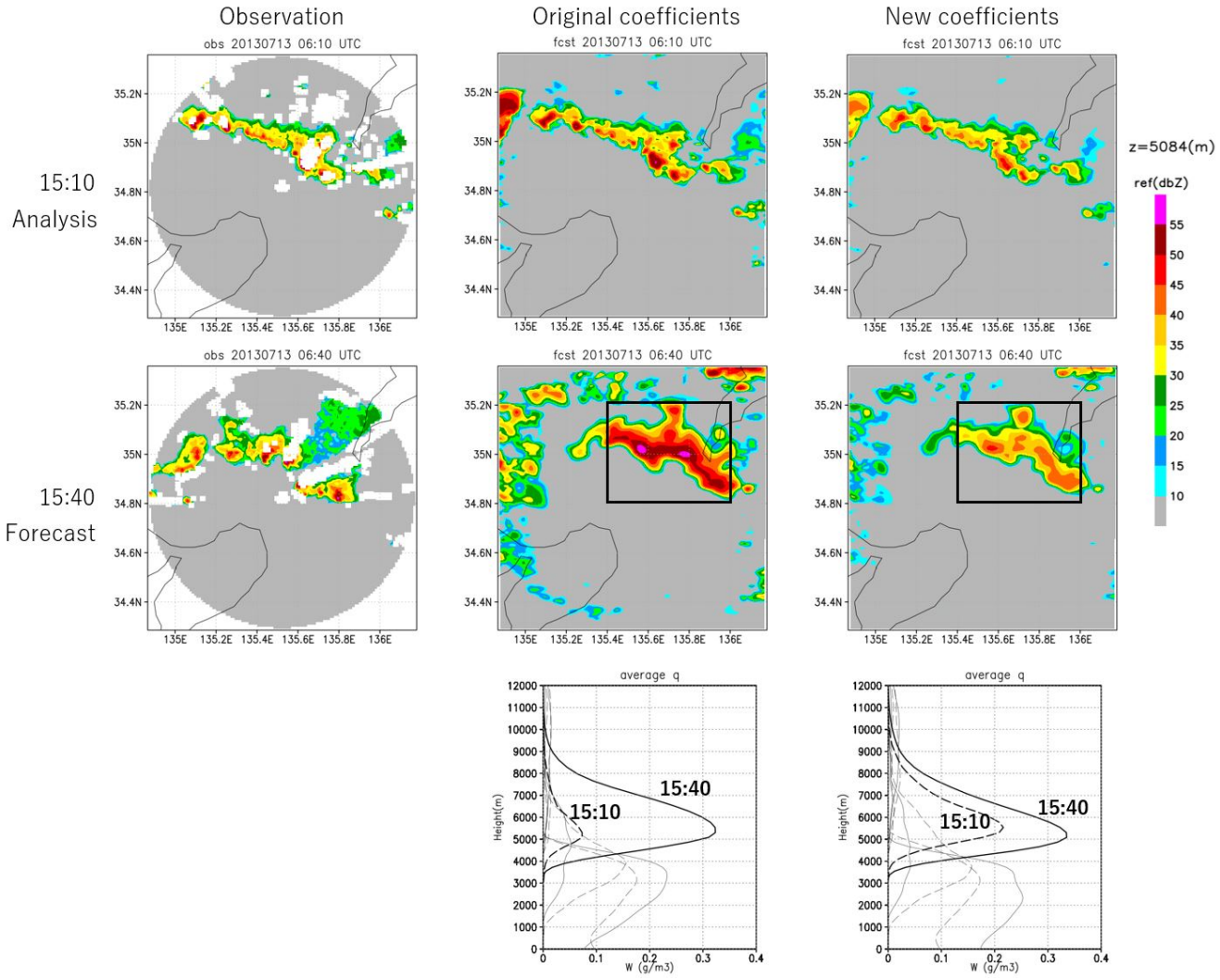
1. RIKEN Center for Computational Science

The observation operator of Phased Array Weather Radar (PAWR; Ushio et al. 2014; Yoshikawa et al. 2013) in the SCALE-LETKF data assimilation system (Lien et al., 2017) is revisited, and the impact of improving the observation operator on the analysis is examined.
Previous studies (Miyoshi et al., 2016, *IEEE*; Miyoshi et al., 2016, *BAMS*) have shown that the three-dimensional fine-scale structure of radar signals observed by PAWR can be successfully assimilated to produce a high-resolution analysis using a regional model SCALE-RM and the local ensemble transformed Kalman filter (LETKF). Forecasts using a high-resolution regional model from the analysis field has a potential to provide reliable precipitation forecasts for longer period of time than a simple nowcasting technique based on an advection scheme, since the explicit physical processes would allow us to capture the development of new convective cells. However, even with an analysis field incorporating such detailed observational data, accurate forecasting of localized convection systems is generally a challenging issue. In the previous studies mentioned above, there was a known problem that the area of strong radar echo calculated from the forecast field starts to expand unrealistically even within several minutes. Along with systematic model biases and imbalance, the observation operator could be the cause of this misrepresentation. Therefore, the observation operator of PAWR is revisited in this study.
The observation operator calculates equivalent radar reflectivity factor (Z_e [mm6/m3]) from hydrometeor mass density of each particle categories (W [g/m^2]). The cloud microphysics scheme in SCALE-RM (Tomita et al., 2008) is a 1-moment 6-caterogy scheme. They include 3 categories for precipitation particles, namely, rain, snow, and graupel. The relation between Z_e and each of W is obtained by an offline numerical calculation of Mie scattering and approximated in the form of an exponential function.
$Z_e = \alpha_r \exp(\beta_r) + \alpha_s \exp(\beta s) + \alpha_g \exp(\beta_g)$
Previous studies used values from a literature (Xue et al., 2009) for the coefficients. However, the coefficients used for graupel (α_g and β_g) has been originally calculated using assumptions about the particle size distribution different from those in SCALE-RM. In particular, a multiplicative factor of the particle size distribution of graupel in SCALE-RM is much smaller in their calculation ($N_0 = 3 \times 10^4$ m^{-4}) than that in SCALE-RM ($N_0 = 4 \times 10^6$ m^{-4}). This leads to an underestimation in sensitivity of graupel mass to observed radar reflectivity factor.
The new coefficients for graupel are chosen to be consistent with the SCALE-RM cloud microphysics scheme using the Joint-Simulator developed by Japan Aerospace Exploration Agency (JAXA). The results are $\alpha_g = 5.54 \times 10^3$, $\beta_g = 1.70$, where the original values from the literature are $\alpha_g = 8.18 \times 10^4$, $\beta_g = 1.50$.
The case study of PAWR assimilation on the localized short-duration heavy rain event on July 13, 2013 is performed again using the new coefficients and compared to previous results (Miyoshi et al., 2016, *IEEE*; Miyoshi et al., 2016, *BAMS*).
The results are shown in Fig. 1. With the new set of coefficients in PAWR observation operator, the evolution for the 30-minute forecast period is closer to the observation than that with the original coefficients. The rapidly-growing unrealistic spread of a large reflectivity area are significantly suppressed. The difference is also clear in the vertical profiles of area-averaged graupel mass. The rapid increase of graupel in the middle troposphere in the conventional forecast experiment implies the recovery from the imbalance by inconsistency between the observation operator and cloud microphysics scheme. The new coefficients lead to improve hte imbalance and provide physically more consistent analysis fields. To

©2019. Japan Geoscience Union. All Right Reserved.

further improve PAWR assimilation, this modification to the observation operator allows us to focus on other factors such as a model error treatment as the next step.

Keywords: Data Assimilation, Weather forecasting, Precipitation radar



©2019. Japan Geoscience Union. All Right Reserved.

Data assimilation and forecast experiments for the record-breaking rainfall event in Japan in July 2018 with NICAM-LETKF at 112-km and 28-km resolution

*Koji Terasaki[1], Takemasa Miyoshi[1]

1. RIKEN Center for Computational Science

In July 2018, an active Baiu front caused record-breaking rainfalls and disasters in broad areas in western Japan. This study performs data assimilation and forecast experiments using the NICAM-LETKF system (Terasaki et al. 2015, Terasaki et al. 2017) at 112-km and 28-km resolution with 32 ensemble members. The computational efficiency is essential to run the high-resolution data assimilation cycle. Yashiro et al. (2016) developed a new NICAM-LETKF system to reduce the computational cost of the LETKF part by considering a throughput-aware framework. Data assimilation experiments are performed with conventional observations and advanced microwave sounding unit-A (AMSU-A) satellite radiances for one month starting at 0000 UTC 10 June 2018. Next, forecast experiments are initialized every day at 0000 UTC on 1-5 July 2018. The results show that the 28-km resolution experiment outperforms the 112-km resolution experiment for the location and intensity of the heavy rainfall, although the precipitation amount is significantly underestimated compared with the observation. The locations of the Pacific and Okhotsk highs determine the location of the Baiu front. The 112-km resolution may be too coarse to resolve these phenomena sufficiently.
More than a half of the computational time of the LETKF was occupied by file I/O in the previous NICAM-LETKF system. The new NICAM-LETKF system successfully accelerated by reducing the I/O time to be about 20% of the computational time of the LETKF.

Keywords: Data assimilation, Numerical weather prediction, NICAM-LETKF, Heavy rainfall

©2019. Japan Geoscience Union. All Right Reserved.

Model Parameter Estimation with Data Assimilation Using NICAM-LETKF

*Shunji Kotsuki[1], Yousuke Sato[2], Koji Terasaki[1], Hasashi Yashiro[1], Hirofumi Tomita[1], Masaki Satoh[3], Takemasa Miyoshi[1]

1. RIKEN Center for Computational Science, 2. Graduate School of Engineering, Nagoya University, 3. Atmosphere and Ocean Research Institute, the University of Tokyo

This study aims to improve forecasts of numerical weather prediction (NWP) models by optimizing model parameters with data assimilation. Kotsuki et al. (2018a, JGR) succeeded in improving global precipitation forecasts at 112-km-resolution NICAM (Nonhydrostatic ICosahedral Atmospheric Model) by estimating a parameter called B1 of Berry (1967)' s large-scale condensation scheme using satellite-observed precipitation data and the Local Ensemble Transform Kalman Filter (LETKF).

Extending the previous study, this study explores to improve the forecasts further using other satellite observations. This study estimates the parameter B1 as a global-constant parameter with cloud liquid water (CLW) data observed by GCOM-W/AMSR2. The parameter estimation successfully reduces excessive bias in CLW although precipitation forecasts are degraded. In addition, this study extends to estimate spatial distributions of the B1 parameter. The spatially-varying B1 parameter shows the best agreement to the spatial pattern of observed LWP. This presentation will include the most recent progress up to the time of the meeting.

Keywords: Model Parameter Estimation, Large Scale Condensation, Ensemble Kalman Filter, Liquid Water Path, Radiation Budget, NICAM-LETKF

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 104 1F

[A-AS01] High performance computing for next generation weather, climate, and environmental sc iences

convener:Hiromu Seko(Meteorological Research Institute), Takemasa Miyoshi(RIKEN), Chihiro Kodama(Japan Agency for Marine-Earth Science and Technology), Masayuki Takigawa(Japan Agency for Marine-Earth Science and Technology), Chairperson:Masayuki Takigawa(Japan Agency for Marine-Earth Science and Technology), Takemasa Miyoshi(RIKEN Advanced Institute for Computational Science)

A lot of advanced simulation studies are being conducted by high performance supercomputers, such as K computer and Earth Simulator, in various fields including meteorology. The high performance supercomputers enable us to conduct numerical simulations and data assimilation of observation big-data (huge high-density and high-frequency data) with an order of magnitude higher resolutions and ensemble numbers than those with the previous supercomputers. In addition, the post-K computer will be available as a successor of K, and studies for the post-K computer are in progress. At this session, we comprehensively pick up the topics in the Atmospheric and Hydrospheric Sciences Sessions of the 2019 Union Meeting that comprise the atmospheric, oceanic and land sciences. This session aims to promote recent studies related to the issues on high performance computing in weather, climate, and environmental studies using the K computer and other supercomputers, and to enhance discussions on future directions of numerical simulations in meteorology.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AAS01-07] 3D debris flow simulations by using smoothed particle hydrodynamics (SPH) method

*Shoji Ueta[1], Natsuki Hosono[2], Yosuke Alexandre Yamashiki[1] (1.Kyoto University, 2.JAMSTEC)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AAS01-08] **Regional atmospheric data assimilation coupled with an ocean mixed layer model: a case of typhoon Soudelor (2015)**

*Kohei Takatama[1], Takumi Honda[1], Takemasa Miyoshi[1] (1.RIKEN)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS01-09] Effective Radiative Forcing and Climate Response to Short-Lived Climate Pollutants Under Different Scenarios

Hua Zhang[1], *Bing Xie[1], Zhili Wang[1] (1.China Meteorological Administration)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS01-10] **The NICAM–SPRINTARS simulation of the long-range transport of black carbon using the K computer**

★Invited Papers

*Yousuke Yamashita[1], Masayuki Takigawa[1], Daisuke Goto[2], Hisashi Yashiro[3], Masaki Satoh[4,1], Yugo Kanaya[1], Fumikazu Taketani[1], Takuma Miyakawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Environmental Studies, 3.RIKEN Advanced Institute for Computational Science (AICS), 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS01-11] High-resolution, ensemble simulations of intense tropical cyclones and their stochasticity during the El Niños of 1997 and 2015

*Yohei Yamada[1], Chihiro Kodama[1], Masaki Satoh[1,2], Masuo Nakano[1], Tomoe Nasuno[1], Masato Sugi[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, The university of Tokyo, 3.Meteorological Research Institute, Japan Meteorological Agency)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS01-12] **NICAM results of the project DYAMOND for global storm-resolving model intercomparison**

★Invited Papers

*Masaki Satoh[1], Ryosuke Shibuya[2], Chihiro Kodama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.JAMSTEC)

3D debris flow simulations by using smoothed particle hydrodynamics (SPH) method

*Shoji Ueta[1], Natsuki Hosono[2], Yosuke Alexandre Yamashiki[1]

1. Kyoto University, 2. JAMSTEC

Yamashiki et al. (2012) and Yamashiki et al. (2013) perform laboratory experiments that represent a debris flow. We use smoothed particle hydrodynamics (SPH), Lagrangian numerical hydrodynamics method, and reproduce the experiments by 2D simulations. We find that water does not erode rock by using same size particles between water and rock, but that water can erode rock by using smaller size water particles than rock particle. We could extend this 2D simulation to 3D one and reproduce more realistic results.
Also, debris flows include not only rock and water but also mud. We developed a 3D SPH code that includes the solid-liquid mutual interaction with fully SPH manner to deal with multiphase flow well. We compare the results of the code with the results of a land slide experiment and some simulations in Igarashi et al. (2012) and find that we can get the results similar to those of experiments. We also try to perform more realistic debris flow simulationsin Hiroshima in 2014’s cases.

Keywords: debris flow, smoothed particle hydrodynamics

©2019. Japan Geoscience Union. All Right Reserved.

Regional atmospheric data assimilation coupled with an ocean mixed layer model: a case of typhoon Soudelor (2015)

*Kohei Takatama[1], Takumi Honda[1], Takemasa Miyoshi[1]

1. RIKEN

This study investigates the effect of atmosphere-ocean coupling in a regional atmospheric data assimilation system for a case of Typhoon Soudelor (2015). A simple ocean mixed layer model, known as the Price-Weller-Pinkel (PWP) model, has been implemented into a regional atmospheric data assimilation system SCALE-LETKF.

The results show that the PWP model produced reasonable sea surface temperature (SST) fields in response to the atmospheric flow, particularly, dropping SST associated with the typhoon’ s mixing the ocean upper layers. However, the analyzed track and intensity of the typhoon were not improved by coupling the PWP model. This can be explained by lower SSTs and by smaller ensemble spread of near surface atmospheric temperature. In the atmosphere-ocean coupling system, the stronger a typhoon, the cooler the SSTs via heat releases from the ocean surface and via vertical mixing of the upper ocean. These processes induce negative feedback for the typhoon development, so that the typhoon growth rates are suppressed (enhanced) in ensemble members with strong (weak) typhoon. This results in more similar typhoon intensities among ensemble members. Therefore, the coupled system reduces the ensemble spreads in the atmospheric fields associated with typhoon. The presentation will include the most up-to-date results at the time of the conference.

Keywords: Data Assimilation, Typhoon, Air-Sea Interaction

©2019. Japan Geoscience Union. All Right Reserved.

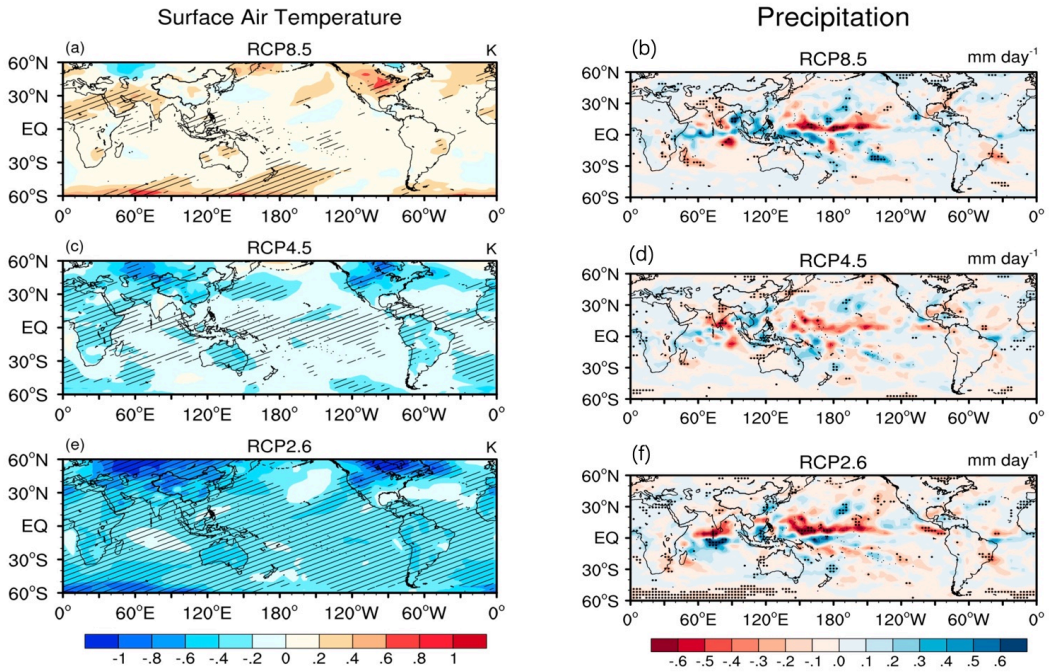
Effective Radiative Forcing and Climate Response to Short-Lived Climate Pollutants Under Different Scenarios

Hua Zhang[1], *Bing Xie[1], Zhili Wang[1]

1. China Meteorological Administration

We used an online aerosol-climate model (BCC_AGCM2.0_CUACE/Aero) to simulate effective radiative forcing and climate response to changes in the concentrations of short-lived climatic pollutants (SLCPs), including methane, tropospheric ozone, and black carbon, for the period 2010–2050 under Representative Concentration Pathway scenarios (RCPs) 8.5, 4.5, and 2.6. Under these three scenarios, the global annual mean effective radiative forcing were 0.1, 0.3, and 0.5 W m^{-2}, respectively. Under RCP 8.5, the change in SLCPs caused significant increases in surface air temperature (SAT) in middle and high latitudes of the Northern Hemisphere and significant decreases in precipitation in the Indian Peninsula and equatorial Pacific. Global mean SAT and precipitation increased by 0.13 K and 0.02 mm d^{-1}, respectively. The reduction in SLCPs from 2010 to 2050 under RCPs 4.5 and 2.6 led to significant decreases in SAT at high latitudes in the Northern Hemisphere. Precipitation increased slightly in most continental regions, and the Intertropical Convergence Zone moved southward under both of these mitigation scenarios. Global mean SAT decreased by 0.20 and 0.44 K, and global averaged precipitation decreased by 0.02 and 0.03 mm d^{-1}under RCPs 4.5 and 2.6, respectively.

Keywords: SLCP/SLCF, ERF, Climate response



The spatial distribution of (left column) surface air temperature and (right column) precipitation resulting from changes of SLCPs, from 2010 to 2050, in (a and b) Representative Concentration Pathway 8.5 (RCP8.5), (c and d) RCP4.5, and (e and f) RCP2.6. The areas with “・” and “/” passed the 95% significance test.

©2019. Japan Geoscience Union. All Right Reserved.

The NICAM–SPRINTARS simulation of the long-range transport of black carbon using the K computer

*Yousuke Yamashita[1], Masayuki Takigawa[1], Daisuke Goto[2], Hisashi Yashiro[3], Masaki Satoh[4,1], Yugo Kanaya[1], Fumikazu Taketani[1], Takuma Miyakawa[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Institute for Environmental Studies, 3. RIKEN Advanced Institute for Computational Science (AICS), 4. Atmosphere and Ocean Research Institute, The University of Tokyo

The Nonhydrostatic Icosahedral Atmospheric Model (NICAM)–SPRINTARS is the global aerosol transport model, which has been developed to calculate global aerosol transport and its influences on radiation and precipitation incorporated with the NICAM. The latest model is developed to include the forest fire emission with daily time-scales and has fine horizontal resolution with 56 km, which is capable of simulating fine scales transport processes of aerosols such as the accumulation of black carbon (BC) behind the cold front, and the wetdeposition process around the low-pressure system.
The large and continuous forest fire emission occurred around Lake Baikal of Siberia in September 2016. The observation of BC was performed from August to October by observational cruise of R/V Mirai (MR16-06) possessed by Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and the maximum BC concentration was detected in 25–26 September around Aleutian Islands. These results imply the long-range transport of BC from Lake Baikal to Aleutian Islands, however, possibility of detection of anthropogenic BC emitted in Asia is not ruled out.
To analyze the origin and transport pathway of observed BC by R/V Mirai observation, we performed the experiments of the NICAM–SPRINTARS with anthropogenic and forest fire emission (Ant+Fire simulation) using the K computer. To estimate anthropogenic BC impact, the simulation without fire emission was performed (Ant simulation). Without fire emission, the BC concentration in 25–26 September is much smaller than observation, indicating small impact of anthropogenic BC on this event. In this event the BC is trapped behind the cold front and beyond the warm front to indicate high concentration peak (about 300 ng/m^3) of surface BC with sharp temporal change. This high concentration event is well simulated by the latest 56-km model, however, the low horizontal resolution experiments about 220-km show relatively low concentration peak (about 100–150 ng/m^3) with roughly temporal change.
We also estimate the BC transport to Arctic. The 56-km model simulation with Siberian forest fire emission (Ant+FireSb simulation) indicates a larger increase in Arctic column BC from 22 to 27 September than the Ant simulation, however, the 220-km model simulations indicate no significant difference of the Arctic column BC level to the Ant simulation.
These results indicate that one noticeable impact of latest model development is achieved by replacing the model’s horizontal resolution being 56-km, which is capable of simulating the fine structure of long-range BC transport to impact on the low human activity area such as Arctic and ocean.

Keywords: black carbon, aerosol transport model, K computer

©2019. Japan Geoscience Union. All Right Reserved.

High-resolution, ensemble simulations of intense tropical cyclones and their stochasticity during the El Niños of 1997 and 2015

*Yohei Yamada[1], Chihiro Kodama[1], Masaki Satoh[1,2], Masuo Nakano[1], Tomoe Nasuno[1], Masato Sugi[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Atmosphere and Ocean Research Institute, The university of Tokyo, 3. Meteorological Research Institute, Japan Meteorological Agency

Extreme El Niño events affect the number of intense tropical cyclones (ITCs) over the western North Pacific (e.g., Camargo and Sobel, 2005; Chan 2007). Extreme El Niño events were observed in 1997 and 2015. In the both years, the number of ITC were above normal in the western North Pacific. In order to clarify how, and to what extent, sea surface temperature (SST) anomaly distributions control the ITCs genesis, we conducted 50-member ensemble simulations for boreal summer in 1997 and 2015 using a global nonhydrostatic model called NICAM (Satoh et al. 2014) with a horizontal grid interval of 14 km. Clouds were explicitly calculated using a single-moment bulk microphysics scheme without cumulus convection scheme. The sea surface temperature was nudged toward observed SST data using a slab ocean model.

We found no robust control of ITCs by a prescribed SST distribution. These simulations showed that, even if the same SST was used as the boundary condition for each ensemble simulation, the number of ITCs varied substantially among members. This means that uncertainty remains large for seasonal forecasts of ITC activity. However, the ensemble simulations showed a clear relationship between the number of ITCs and their genesis locations in the western North Pacific. We compared environmental conditions between ensemble members. We found that the simulated numbers of ITCs in the western North Pacific were also closely related to the strength of the monsoon trough, which stochastically varies under given SST conditions. This indicates that reliable seasonal forecasting of ITCs depends on our ability to accurately reproduce the monsoon trough, whose strength is modulated mainly by internal atmospheric variability as well as SST.

Keywords: intense tropical cyclone, monsoon trough, El Niño, high resolution global nonhydrostatic model, ensemble simulation

©2019. Japan Geoscience Union. All Right Reserved.

NICAM results of the project DYAMOND for global storm-resolving model intercomparison

*Masaki Satoh[1], Ryosuke Shibuya[2], Chihiro Kodama[2]

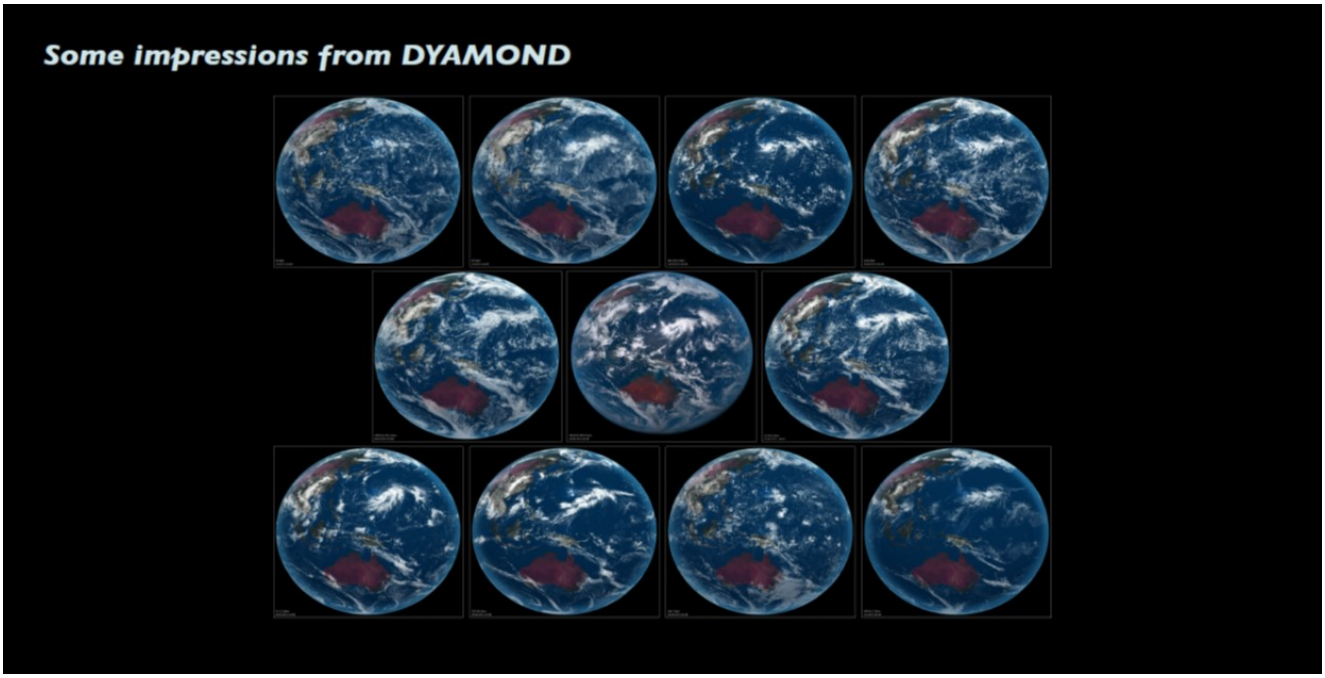
1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. JAMSTEC

Project DYAMOND (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains; https://www.esiwace.eu/services/dyamond) describes a framework for the intercomparison of an emerging class of atmospheric circulations model that, through their resolution of the major modes of atmospheric heat transport, endeavor to represent the most important scales of the full three-dimensional fluid dynamics of the atmospheric circulation.

Nine models submitted simulations of the forty day intercomparison period. Eight of these employed a tiling of the sphere that was uniformly less than 5km. At these scales vertical accelerations that are non-hydrostatic become important, and convective storms in the tropics can be resolved by the underlying equations of motion. The models and some basic characteristics of their output are described in more detail, as is the availability and planned use of this output for future scientific study.

In this presentation, I will show some results of the DYAMOND simulations with NICAM and current status of DYAMOND with a list of possible participants, together with diagnostics considered.

Keywords: Global nonhydrostatic model, NICAM, DYAMOND, global storm-resolving model



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 105 1F

[A-OS08] ECS-Kuroshio and Ryukyu Current System -Observation, modeling and theory-

convener:Hirohiko Nakamura(Kagoshima University, Faculy of Fisheries), Xiao-Hua Zhu(Second Institute of Oceanography), Chairperson:Hirohiko Nakamura(Kagoshima University), Jae-Hun Park(Inha University)

The East China Sea (ECS) is separated from the North Pacific basin by the Ryukyu Islands. On each side of the Ryukyu Islands, there lies two western boundary currents -the Kuroshio on the northwest and the Ryukyu Current on the southeast. These two currents play an important role in the global substance cycle and have a remarkable impact on the climate and adjacent marginal seas. Our knowledge of the Kuroshio and the Ryukyu Current's dynamics, variability, and impact has advanced significantly over the last decade, because of recent international collaborative field programs, improvement in satellite measurements, and advancement in high-resolution numerical models. This session seeks contributions from ECS-Kuroshio and Ryukyu Current studies and will cover a wide range of topics of observation, modeling and theory. The dynamics of the Kuroshio and the Ryukyu Current's variability at all spatio-temporal scales, the influence of the Kuroshio on typhoons and climate, the interactions among the Kuroshio, Ryukyu Current and eddies, internal waves including near-internal waves and their interactions with background currents, and the water mass exchanges through the gaps between the Ryukyu Islands are welcome to be discussed in this session.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[AOS08-01] Downstream Evolution of the Kuroshio Velocity Structure and Transport

★Invited Papers

*Magdalena Andres[1], Sen Jan[2] (1.Woods Hole Oceanographic Institution, 2.National Taiwan University)

2:10 PM - 2:25 PM JST | 5:10 AM - 5:25 AM UTC

[AOS08-02] **Non-seasonal variability of the Kuroshio shelf intrusion and its associated changes in the ocean environment over the East China Sea during 1993-2017**

*Jiwon Kang[1], Hanna Na[1] (1.School of Earth and Environmental Sciences, Seoul National University, Republic of Korea)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[AOS08-03] The temporal and spatial variability of the Kuroshio in the East China Sea and its associated mechanisms

*Yanzhou Wei[1] (1.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[AOS08-04] The Joint Kuroshio–Ryukyu Current System Study and a rapid report about mooring observations southeast of Miyakojima

*Xiao-Hua Zhu[1], Hirohiko Nakamura[2], Jae-Hun Park[3], Ruixiang Zhao[1], Ayako Nishina[2], Chuanzheng Zhang[1], Chanhyung Jeon[4], Hanna Na[5], Ze-Nan Zhu[1], Hong Sik Min[6] (1.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China, 2.Faculty of Fisheries, Kagoshima University, Kagoshima, Japan, 3.Department of Ocean Sciences, Inha University, Incheon, South Korea, 4.Department of Marine Science and Biological Engineering, Inha University, Incheon, Korea, 5.School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea, 6.Ocean Circulation and Climate Research Center, Korea Institute of Ocean Science and Technology, Busan, Korea)

2:55 PM - 3:10 PM JST | 5:55 AM - 6:10 AM UTC

[AOS08-05] Relationship of the Kuroshio with the current fields in the East China Sea from observations and model results

*Hong Sik Min[1], Chorong Hwang[1], Dong Guk Kim[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Jae-Hun Park[4], Chanhyung Jeon[4], Hanna Na[5], Naoki Hirose[6] (1.Korea Institute of Ocean Science & Technology, 2.Kagoshima University, 3.Second Institute of Oceanography, 4.Inha University, 5.Seoul National University, 6.Kyushu University)

3:10 PM - 3:15 PM JST | 6:10 AM - 6:15 AM UTC

Discussion

Downstream Evolution of the Kuroshio Velocity Structure and Transport

*Magdalena Andres[1], Sen Jan[2]

1. Woods Hole Oceanographic Institution, 2. National Taiwan University

The Kuroshio flows along the North Pacific western boundary carrying heat, mass and momentum poleward. Along this route, the Kuroshio’ s strength and vertical structure undergo significant temporal and spatial variability. Recent observational studies have examined the Kuroshio between Luzon and Taiwan, just before the Kuroshio flows into the East China Sea and upstream of the beginning of the Ryukyu Current (a subsurface-intensified current that carries part of the total poleward western boundary current flow). These observations were part of the recent US Origins of the Kuroshio and Mindanao Currents (OKMC) and Taiwan Observations of Kuroshio Transport Variability (OKTV) and Study of the Kuroshio II (SK-II) observational programs. These studies, together with previous observational efforts, build a comprehensive picture of the Kuroshio on its route from its origins near Luzon to southeastern Japan, where the current finally transitions from a western boundary current into the Kuroshio Extension, a vigorously meandering free jet. Through the joint OKMC/OKTV efforts, Kuroshio strength and velocity structure were measured between June 2012 and November 2014 with pressure-sensor equipped inverted echo sounders (PIESs) and upward- looking acoustic Doppler current profilers (ADCPs) deployed across the current northeast of Luzon, Philippines, and east of Taiwan with an 8 month overlap in the two arrays’ deployment periods. The time-mean net (i.e., integrated from the surface to the bottom) absolute transport increases downstream and the observed downstream increase is consistent with the return flow predicted by the simple Sverdrup relation and the mean wind stress curl field over the North Pacific (despite the complicated bathymetry and gaps along the North Pacific western boundary). Northeast of Luzon, the Kuroshio is shallower than 750 dbar, while east of Taiwan areas of positive flow reach to the seafloor (3000 m). A similar deepening of the subtropical western boundary current is observed in the North Atlantic in the region where the Gulf Stream leaves Cape Hatteras. In addition, there is a deep counterflow beneath the poleward-flowing Kuroshio. Time-varying transports and velocities indicate the strong influence at both sections of westward propagating eddies from the ocean interior. Topography associated with the ridges east of Taiwan also influences the mean and time-varying velocity structure there. By comparison, in the North Atlantic there is also a deep counterflow beneath the Gulf Stream at Cape Hatteras, however, this is likely due to different processes than those at play in the North Pacific, due to the presence of the Deep Western Boundary Current there which carries equatorward flow in the Atlantic Meridional Overturning Circulation (AMOC) cold limb flow.

Keywords: Kuroshio, mesoscale eddies, PIES, ADCP

©2019. Japan Geoscience Union. All Right Reserved.

Non-seasonal variability of the Kuroshio shelf intrusion and its associated changes in the ocean environment over the East China Sea during 1993-2017

*Jiwon Kang[1], Hanna Na[1]

1. School of Earth and Environmental Sciences, Seoul National University, Republic of Korea

The Kuroshio in the East China Sea (ECS) exhibits strong variability over the northeast of Taiwan; weakening of the Kuroshio has been understood to be associated with shelf-ward shift of the Kuroshio axis, which induces shelf intrusion of the Kuroshio water. The Kuroshio intrusion plays an important role for understanding the characteristics of water masses over the shelf region that, in turn, influences ocean environment in the marginal seas. In this study, non-seasonal variability of the intrusion, which was reported to be more significant in comparison with its seasonal variability, is examined during 1993-2017.

The Kuroshio intrusion index was defined based on the Empirical Orthogonal Function analysis of satellite-altimetry-derived geostrophic velocity data. The composite analysis of oceanic and atmospheric variables according to the intrusion index reveals that strong Kuroshio intrusion is associated with increase of sea surface temperature and eddy kinetic energy, strengthening of northwesterly wind and upward surface heat flux in the continental shelf region. The strong Kuroshio intrusion would also be related to sub-mesoscale eddy variability inside the ECS, and its relationship is discussed by examining surface drifter data over the region.

Keywords: Kuroshio, shelf intrusion, East China Sea, sub-mesoscale eddy

©2019. Japan Geoscience Union. All Right Reserved.

The temporal and spatial variability of the Kuroshio in the East China Sea and its associated mechanisms

*Yanzhou Wei[1]

1. State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China

The Kuroshio is a strong western boundary current of the North Pacific subtropical gyre. It transports huge amounts of heat and nutrients poleward, and has a profound effect on the hydrography, fisheries, and climate of countries surrounding the Northwestern Pacific. As such, the temporal and spatial variability of the Kuroshio on multiple scales is of wide interest to the oceanographic and climate communities. In this study, we examine the temporal and spatial variability of the Kuroshio based on long term hydrographic observation and satellite data, and discuss the associated mechanisms.

Keywords: Kuroshio, East China Sea

©2019. Japan Geoscience Union. All Right Reserved.

The Joint Kuroshio–Ryukyu Current System Study and a rapid report about mooring observations southeast of Miyakojima

*Xiao-Hua Zhu[1], Hirohiko Nakamura[2], Jae-Hun Park[3], Ruixiang Zhao[1], Ayako Nishina[2], Chuanzheng Zhang[1], Chanhyung Jeon[4], Hanna Na[5], Ze-Nan Zhu[1], Hong Sik Min[6]

1. State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou, China, 2. Faculty of Fisheries, Kagoshima University, Kagoshima, Japan, 3. Department of Ocean Sciences, Inha University, Incheon, South Korea, 4. Department of Marine Science and Biological Engineering, Inha University, Incheon, Korea, 5. School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea, 6. Ocean Circulation and Climate Research Center, Korea Institute of Ocean Science and Technology, Busan, Korea

From June 2015 to June 2017, an international cooperative research project called “Joint Kuroshio-Ryukyu Current System Study” (JKRYCSS) was conducted by scientists from Japan, China, and South Korea. Tall moorings with current meters (CMs) and upward-looking acoustic Doppler current profilers (ADCPs), and current and pressure-recording inverted echo sounders (CPIESs) were deployed on northwestern and southeastern sides of Miyakojima Island to observe the Kuroshio and the Ryukyu Current, simultaneously. These mooring sites lay along the altimeter track used by TOPEX/Poseidon and Jason-1/2/3, which is roughly perpendicular to the isobath of the continental shelf break.

In this talk, we will illustrate the velocity structure and variability of the Ryukyu Current by analyzing the 2-year record from a mooring array southeast of Miyakojima Island. The results showed that the shoreward intensified currents flowed northeastward. The subsurface core of the Ryukyu Current was located near the 1000 m isobath, with a maximum of 19.4 cm/s at 500 m. The observed velocity structure was reproduced well by the HYCOM reanalysis, except that the observed current core was stronger and shallower. The mean estimated volume transport across the observation section was 9.0 Sv with a standard deviation of 8.7 Sv, with a near 100-day variability dominant in the upper layer but absent in the deep layer.

©2019. Japan Geoscience Union. All Right Reserved.

Relationship of the Kuroshio with the current fields in the East China Sea from observations and model results

*Hong Sik Min[1], Chorong Hwang[1], Dong Guk Kim[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Jae-Hun Park[4], Chanhyung Jeon[4], Hanna Na[5], Naoki Hirose[6]

1. Korea Institute of Ocean Science & Technology, 2. Kagoshima University, 3. Second Institute of Oceanography, 4. Inha University, 5. Seoul National University, 6. Kyushu University

We investigated relationship between variations of the Kuroshio in the southern East China Sea (ECS) and the current structure across the Korea/Tsushima Strait (KTS) using observational data and numerical simulation results. Variability of the Kuroshio in the southern ECS was obtained from moored current measurements located near the Kuroshio axis for 2 years (June 2015-June 2017), while current pattern across the KTS was obtained from acoustic Doppler current profiler (ADCP) measurements by a ferryboat between Hakata and Pusan. Comparisons between the two time series of observations reveal a significant relationship : when the Kuroshio in the southern ECS was strengthened the current in the western channel of KTS was also strengthened with a shift of the Tsushima Current (TC) to the coast. This correlated feature was also seen in the data-assimilated HYCOM, confirming that the HYCOM can reasonably reproduce the current field in the ECS. Further investigations using 25-year-long HYCOM outputs exhibit that the Kuroshio can vary the TC in the KTS. This presentation will show the connectivity of current fields in the northern ECS to the Kuroshio in the southern ECS.

Keywords: Kuroshio, East China Sea, observation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 105 1F

[A-OS08] ECS-Kuroshio and Ryukyu Current System -Observation, modeling and theory-

convener:Hirohiko Nakamura(Kagoshima University, Faculy of Fisheries), Xiao-Hua Zhu(Second Institute of Oceanography), Chairperson:Jae-Hun Park(Inha University), Hirohiko Nakamura(Kagoshima University)

The East China Sea (ECS) is separated from the North Pacific basin by the Ryukyu Islands. On each side of the Ryukyu Islands, there lies two western boundary currents -the Kuroshio on the northwest and the Ryukyu Current on the southeast. These two currents play an important role in the global substance cycle and have a remarkable impact on the climate and adjacent marginal seas. Our knowledge of the Kuroshio and the Ryukyu Current's dynamics, variability, and impact has advanced significantly over the last decade, because of recent international collaborative field programs, improvement in satellite measurements, and advancement in high-resolution numerical models. This session seeks contributions from ECS-Kuroshio and Ryukyu Current studies and will cover a wide range of topics of observation, modeling and theory. The dynamics of the Kuroshio and the Ryukyu Current's variability at all spatio-temporal scales, the influence of the Kuroshio on typhoons and climate, the interactions among the Kuroshio, Ryukyu Current and eddies, internal waves including near-internal waves and their interactions with background currents, and the water mass exchanges through the gaps between the Ryukyu Islands are welcome to be discussed in this session.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

Introduction

3:35 PM - 3:55 PM JST | 6:35 AM - 6:55 AM UTC

[AOS08-06] Separating Small-Scale Oceanic Internal Waves and Vortical Motions

★Invited Papers

*Ren-Chieh Lien[1] (1.University of Washington, Seattle, WA, USA)

3:55 PM - 4:10 PM JST | 6:55 AM - 7:10 AM UTC

[AOS08-07] Structure and variability of the Kuroshio current in the Tokara Strait

*Zhao-Jun Liu[1], Hirohiko Nakamura[2], Xiao-Hua Zhu[1], Ayako Nishina[2], Xinyu Guo[3], Menghong Dong[1] (1.Second Institute of Oceanography, China, 2.Kagoshima University, Japan, 3.Ehime University, Japan)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[AOS08-08] **Near-inertial waves advected by the Kuroshio from observation and simulation**

*CHANHYUNG JEON[1], Jae-Hun Park[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Dong Guk Kim[4], Hong Sik Min[4], Sok Kuh Kang[4], Hanna Na[5], Naoki Hirose[6], Youngseok Choi[1] (1.Inha University, 2.Kagoshima University, 3.Second Institute of Oceanography, 4.Korea Institute of Ocean Science and Technology, 5.Seoul National University, 6.Kyushu University)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[AOS08-09] Turbulent mixing and near-inertial internal waves induced by the Kuroshio over seamounts in the Tokara Strait

*Takeyoshi Nagai[1], Daisuke Hasegawa[2], Eisuke Tsutsumi[3], Hirohiko Nakamura[4], Ayako Nishina[4], Tomoharu Senjyu[3], Takahiro Endoh[3], Takeshi Matsuno[3], Ryuichiro Inoue[5], Amit Tandon[6] (1.Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Kyushu University, Research Institute for Applied Mechanics, 4.Faculty of Fisheries Kagoshima University, 5.Ocean Circulation Research Group, Japan Agency for Marine-Earth Science and Technology, 6.Mechanical Engineering Department & SMAST, University of Massachusetts Dartmouth)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[AOS08-10] Microstructure and mooring observations of enhanced mixing in the Kerama Gap

*Ryuichiro Inoue[1], Hirohiko Nakamura[2], Takahiro Tanaka[3], Shinzou Fujio[4], Daigo Yanagimoto[4], Ichiro Yasuda[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kagoshima University, Faculy of Fisheries, 3.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 4.The University of Tokyo, Atmosphere and Ocean Research Institute)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

Discussion

Separating Small-Scale Oceanic Internal Waves and Vortical Motions

*Ren-Chieh Lien[1]

1. University of Washington, Seattle, WA, USA

Internal waves and vortical motions coexist in the ocean, sometimes at same temporal and spatial scales. Observations taken by 20 EM-APEX floats in the upper ocean thermocline of the summer Sargasso Sea capture the temporal and vertical variations of Ertel potential vorticity (PV) in 7–70 m vertical scale, averaged over horizontal scales of *O*(4–8 km). PV is dominated by its linear components —vertical vorticity and vortex stretching, each with rms value of ~0.15 *f*. In the internal wave frequency band, they are coherent and in phase, expected for linear internal waves. Packets of strong vertical vorticity and vortex stretching, > 0.2 *f*, balance each other closely such that the rms PV ~0.03 *f*. PV is dominant at frequencies less than 1.4 *f* and peaks at vertical wavenumber *<~0.1* cpm , our highest resolvable vertical wavenumber. PV frequency spectrum plateaus at subinertial frequencies and has a −1 spectral slope in the internal wave frequencies with a small peak at inertial frequency. The PV at near-inertial frequency is likely attributed to the differential advection of background PV by near inertial waves. Measurement errors might also contribute to PV in the internal wave frequency band. Vertical vorticity and vortex stretching are separated into linear vortical mode and internal wave components following the normal mode decomposition. The theoretical prediction of a negative correlation between vertical vorticity and vortex stretching for the linear vortical mode, i.e., reinforcing PV, is confirmed at subinertial frequencies. The Burger number of the vortical mode is ~0.84, implying HKE/APE of ~0.7. The vortical mode frequency and vertical wavenumber spectra are 1-2 decades less than internal wave components. A joint experiment will be conducted in Tokara Strait in the next 3 years to study Kuroshio interaction with seamounts in Tokara Strait. We will discuss the importance of separating internal lee waves and vortical motions behind the seamount on quantifying turbulence mixing and watermass transformation.

Keywords: Internal Lee Waves, Vortical Motions, Turbulence, Kuroshio, Tokara Strait

©2019. Japan Geoscience Union. All Right Reserved.

Structure and variability of the Kuroshio current in the Tokara Strait

*Zhao-Jun Liu[1], Hirohiko Nakamura[2], Xiao-Hua Zhu[1], Ayako Nishina[2], Xinyu Guo[3], Menghong Dong[1]

1. Second Institute of Oceanography, China, 2. Kagoshima University, Japan, 3. Ehime University, Japan

Transverse-vertical structure and temporal variability of the Kuroshio current across the Tokara Strait during 2003–2012 measured by ferryboat acoustic Doppler current profiler (ADCP) with a 2-km horizontal resolution and a 2-day interval are presented. The Kuroshio passing through the Tokara Strait exhibits a nearly permanent multicore velocity structure. The mean eastward Kuroshio transport is 25.84 Sv (1 Sv ≡10^6 m^3 s^{-1}) and the net baroclinic transport relative to 700 m is 19.57 Sv. The seasonal variation of the Kuroshio transport via the Tokara Strait is a “W”-shaped curve with a maximum in July and a second maximum in December–January. The baroclinic transport shows seasonal variation similar to that of the undecomposed transport, with a maximum in July. However, the barotropic transport displays a reversed seasonal variation—a “V”-shaped distribution—with a maximum in December. In the empirical orthogonal function (EOF) analyses of the cross-sectional velocity, with the exception of the well-known meander (EOF1: 41.1%) and transport (EOF2: 26.3%) modes, the third mode (EOF3: 19.2%) is first observed. The EOF3 mode exhibits a band-like structure, with a smaller horizontal scale than the first two EOF modes; such a band-like structure may be related to the wakes in the lee of the Tokara Islands. Additional analysis based on high-resolution JCOPE-T reanalysis data revealed that (1) many vortexes were generated around the Tokara Strait due to the strong flow-topography interaction; (2) the intensities of the island-induced wakes depend on the Kuroshio path position around the Tokara Strait.

Keywords: Tempo-spatial variations, Kuroshio, Tokara Strait

©2019. Japan Geoscience Union. All Right Reserved.

Near-inertial waves advected by the Kuroshio from observation and simulation

*CHANHYUNG JEON[1], Jae-Hun Park[1], Hirohiko Nakamura[2], Ayako Nishina[2], Xiao-Hua Zhu[3], Dong Guk Kim[4], Hong Sik Min[4], Sok Kuh Kang[4], Hanna Na[5], Naoki Hirose[6], Youngseok Choi[1]

1. Inha University, 2. Kagoshima University, 3. Second Institute of Oceanography, 4. Korea Institute of Ocean Science and Technology, 5. Seoul National University, 6. Kyushu University

Advection of near-inertial waves (NIWs) by background currents has been predicted using numerical simulations, while supporting in-situ observations were rare. A pair of tall current moorings, deployed around 26˚N and 125˚E in Okinawa Trough from June 2015 to June 2016, provides a clear evidence exhibiting NIWs advected by the Kuroshio. Energetic NIWs are observed after two-typhoon passages in early August and late September 2015. Both typhoon passages occurred across the Kuroshio east of Taiwan upstream of the observation sites about 250-km southwest with a difference of about 2-degree in latitude. One site (KCM1), relatively close to the center of the Kuroshio axis, exhibits more energetic NIWs than near the edge of the Kuroshio (KCM2), ~32 km away from KCM1. The frequency of NIWs shifts to the lower band from the local inertial frequency (0.91*f*), inferring propagation from the south. The data-assimilative three-dimensional numerical model forced by 6-hourly atmospheric forcings including tides and oceanic circulation demonstrates local NIW generation is weak at observation sites during and after typhoon passages, while its generation upstream of observation sites is quite energetic. Current patterns and frequency shifts of NIWs between observation and simulation agree well at observation sites. Analyses of simulation provide that negative relative vorticity region works like a waveguide for NIW propagation, and the strong Kuroshio current advects the waves poleward with a speed ~85% of the local current.

Keywords: Near-inertial waves, Advection, Kuroshio, observation, simulation

©2019. Japan Geoscience Union. All Right Reserved.

Turbulent mixing and near-inertial internal waves induced by the Kuroshio over seamounts in the Tokara Strait

*Takeyoshi Nagai[1], Daisuke Hasegawa[2], Eisuke Tsutsumi[3], Hirohiko Nakamura[4], Ayako Nishina[4], Tomoharu Senjyu[3], Takahiro Endoh[3], Takeshi Matsuno[3], Ryuichiro Inoue[5], Amit Tandon[6]

1. Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Kyushu University, Research Institute for Applied Mechanics, 4. Faculty of Fisheries Kagoshima University, 5. Ocean Circulation Research Group, Japan Agency for Marine-Earth Science and Technology, 6. Mechanical Engineering Department & SMAST, University of Massachusetts Dartmouth

Recent observations in the upstream side of the Tokara Strait during November 2016, where the Kuroshio south of Kyushu flows over a number of seamounts, show banded structures of large amplitude high vertical wavenumber shear roughly along isopycnal, which are suggestive of near-inertial internal waves. The measured vertical section of laterally high resolution (~1 km) tow-yo microstructure measurements show the banded layers of large turbulent kinetic energy dissipation rates clearly associated with the near inertial shear banding. In this study, the results from the similar tow-yo microstructure surveys during November 2017 and June 2018 cruise, which are extended further downstream side of the Tokara Strait in the Kuroshio are analyzed. It is found that the high vertical wavenumber near-inertial shear is amplified near the seamounts in the Kuroshio, and that turbulent kinetic energy dissipation rates are elevated near the seamounts over 100 km along the Kuroshio axis by a factor of 100-1000. This length scale, over 100 km, is much larger than that of the hydraulically controlled isopycnal displacements with large Froude number in close proximity to the seamounts ~5km. In the presentation, mechanisms of the amplified near-inertial shear and elevated turbulence over such a wide length scale are discussed with the results from June 2018 cruise and using numerical simulations with and without tide.

Keywords: Kuroshio, Near-inertial internal waves, Turbulence

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Microstructure and mooring observations of enhanced mixing in the Kerama Gap

*Ryuichiro Inoue[1], Hirohiko Nakamura[2], Takahiro Tanaka[3], Shinzou Fujio[4], Daigo Yanagimoto[4], Ichiro Yasuda[4]

1. Japan Agency for Marine-Earth Science and Technology, 2. Kagoshima University, Faculy of Fisheries, 3. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 4. The University of Tokyo, Atmosphere and Ocean Research Institute

Microstructure and mooring observations were conducted around the Kerama Gap, near the midpoint of the Ryukyu Island chain, in December 2016. We observed the enhanced mixing near the topography, with vertical diffusivities of 10^{-2}~10^{-1} m^2 s^{-1} and found that tides are important to drive the enhanced mixing at the sill. To understand tidal processes, we conducted two-dimensional numerical simulations. The numerical simulation indicated that hydraulic jump or lee wave breaking are important for the enhanced mixing behind the sill. It also indicated that there are interferences between M2 internal tides radiated from entrance and exit of the Kerama Gap, which may correspond to observed enhanced vertical shear and mixing at a bottom of the North Pacific Intermediate Water in the Kerama Gap. These results suggest that enhanced mixing around Kerama Gap is important for ventilating deep water as well as renewal of the North Pacific Intermediate Water in the Okinawa Trough.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 301A 3F

[A-OS11] Continental-Oceanic Mutual Interaction: Planetary scale Material Circulation

convener:Yosuke Alexandre Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Swadhin Behera(Climate Variation Predictability and Applicability Research Group, Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001), Takanori Sasaki(Department of Astronomy, Kyoto University), Chairperson:Yukio Masumoto, Behera Swadhin(JAMSTEC)

The main purpose of this session is to promote discussion on mutual interaction between Continental zone and Oceanic zone. The global-scale material circulation induced by River runoff through oceanic general circulation as major topic on Continental-Oceanic Interaction, where the ENSO / IOD influence into continental climate as major topics on Oceanic-Continental Interaction. Numerical simulation and field observation of radionuclide transport from continental zone into ocean and its potential impact is also important topics of this session. The session also extend discussion on planetary hydrology and oceanography focusing on subsurface ocean in Jupiter's moon & Ancient Martian Oceanography & Hydrology by possible application of terrestrial GCM into Ancient Mars.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS11-01] Explorations and current understandings for subsurface ocean of icy bodies

★Invited Papers

*Jun Kimura[1] (1.Osaka University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS11-02] **Climate predictability for societal applications including AI/ML**

*Swadhin Behera[1], Manali Pal[2], J.V. Ratnam[1], Rajib Maity[2], Takeshi Doi[1], Yushi Morioka[1], Masami Nonaka[1] (1.Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001, 2.Indian Institute of Technology, Kharagpur, India)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS11-03] Re-entry of giant-impact fragments and early evolution of the Earth's ocean

*Takanori Sasaki[1] (1.Department of Astronomy, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS11-04] Modeling of Extreme Freshwater Discharge and influence from Japanese First-Class Rivers to Coastal zones

*Ryusuke Kuroki, Yosuke Alexandre Yamashiki[1], Sergey Varlamov[2], Yasumasa Miyazawa[2], Racault Fanny Marie[3], Hoshin Vijai Gupta[4] (1.Kyoto University, 2.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan, 3.Plymouth Marine Laboratory, Plymouth, United Kingdom, 4.University of Arizona)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS11-05] Establishment of new curriculum at Biosphere 2

*Kenji Miki[1], Takao Doi[2], Yosuke Yamashiki[3], Masahiro Terada[2] (1.Kyoto University Graduate School of Agriculture, 2.Kyoto University Unit of Synergetic Studies for Space, 3.Graduate School of Advanced Integrated Studies in Human Survivability)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS11-06] Development of the highly precise high-speed photometry technique with the photometer mounted with PIRKA telescope

*Nami Kimura[1] (1.Hokkaido University)

Explorations and current understandings for subsurface ocean of icy bodies

*Jun Kimura[1]

1. Osaka University

Most of solid bodies in the outer solar system, around Jupiter's orbit and beyond, are covered with ice on its surface, which are called as "Icy bodies".
In these icy bodies, e.g., Jovian moon Europa and Saturnian moon Enceladus, existence of the global liquid water ocean under the icy crust, called as "subsurface ocean", has been strongly suggested through the past remote sensing (mainly by geodetic and electromagnetic measurement) and theoretical modelling.
In this talk, I introduce the results of previous observations and theoretical calculations, and summarize the current
understandings focusing on the geophysical knowledge about the subsurface ocean of icy bodies.

©2019. Japan Geoscience Union. All Right Reserved.

Climate predictability for societal applications including AI/ML

*Swadhin Behera[1], Manali Pal[2], J.V. Ratnam[1], Rajib Maity[2], Takeshi Doi[1], Yushi Morioka[1], Masami Nonaka[1]

1. Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001, 2. Indian Institute of Technology, Kharagpur, India

The tropical Indo-Pacific domain is important for global climate. Particularly, the warm pool region rooted in both basins plays an important role in the modulation of ocean and atmosphere variability on several spatio-temporal scales. While both basins share the extended warm pool, each of the two basins has its own modes of ocean and climate variations. Tropical Pacific Ocean is well-known for the El Niñ o/Southern Oscillation (ENSO) phenomenon, the influence of which is seen world-wide during ENSO occurrence years. Recently, another mode of climate variability called the ENSO Modoki is discovered in the tropical Pacific Ocean. The ENSO Modoki is distinct from ENSO in terms of its characteristics and global impacts. Therefore, predictability of ENSO and ENSO Modoki is important for reducing their impacts on the society. Coupled models like SINTEX-F has been predicting the ENSO Modokis quite well. Here an attempt is made to compare those predictabilities using predictions from an AI/ML based statistical approach.

Keywords: ENSO , ENSO Modoki, Prediction

©2019. Japan Geoscience Union. All Right Reserved.

Re-entry of giant-impact fragments and early evolution of the Earth's ocean

*Takanori Sasaki[1]

1. Department of Astronomy, Kyoto University

The late stages of Earth's formation remain a mystery. No building blocks remain in Earth's orbit and no geological evidence is available for the first 700 million years Earth's history. Herein we propose that protoplanetary fragments produced by the giant impacts during terrestrial planet formation may give some important clues to the era. Iron-bearing giant impact fragments provide significant reducing agent that could transform primitive CO2–H2O atmosphere and ocean into more reducing H2-bearing atmosphere. Re-entry of the giant-impact fragments into eary Earth would be important for the origin of Earth’ s life and its early evolution.

Keywords: Earth, ocean, giant impact

©2019. Japan Geoscience Union. All Right Reserved.

Modeling of Extreme Freshwater Discharge and influence from Japanese First-Class Rivers to Coastal zones

*Ryusuke Kuroki, Yosuke Alexandre Yamashiki[1], Sergey Varlamov[2], Yasumasa Miyazawa[2], Racault Fanny Marie[3], Hoshin Vijai Gupta[4]

1. Kyoto University, 2. Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan, 3. Plymouth Marine Laboratory, Plymouth, United Kingdom, 4. University of Arizona

We estimated the effects of extreme fresh water discharge from Japanese first-class rivers to coastal zones of the Japanese coast. Our targeted event was a typhoon Etau from 06/09/2015 to 12/09/2015, a week, and we could success to optimize 5 parameters, soil roughness coefficient, river roughness coefficient, effective porosity, saturated hydraulic conductivity, and effective rainfall by using Shuffled Complex Evolution method developed by University of Arizona (SCE-UA method), that is one of the optimization method for hydrologic model during this week. In addition to this, we made a set of hourly simulated river outflow data of almost all of Japanese first-class rivers from these basins to the Pacific Ocean and the Sea of Japan during the period by using our model “Cell Distributed Runoff Model Version 3.1.1 (CDRMV3.1.1)”. After the simulation, we used these calculated discharge data with a coupled hydrological-oceanographic model JCOPE-T for estimation of sea surface salinity distribution (SSS) in Japanese coastal zones. And simulated SSS results were verified by comparison with Chlorophyll-a distribution, observed by satellite re-mote sensing. Therefore we successfully reproduced peak discharge prediction of extreme typhoon events on river mouth and the coastal oceanic circulation.

©2019. Japan Geoscience Union. All Right Reserved.

Establishment of new curriculum at Biosphere 2

*Kenji Miki[1], Takao Doi[2], Yosuke Yamashiki[3], Masahiro Terada[2]

1. Kyoto University Graduate School of Agriculture, 2. Kyoto University Unit of Synergetic Studies for Space, 3. Graduate School of Advanced Integrated Studies in Human Survivability

We are currently planning to start up a new practical training programme at Biosphere 2 under a contract between Kyoto University and Arizona State University.
Biosphere 2 was established in1991 and was designed to produce a closed-complete ecosystem in the institute. Although the ecosystem-establishment was not fully successful, the institute still has been used for various research such as ecology, terraforming, and closed-environental impact to human health.
Our practical training programme will include hands-on training for exoplanet observation, and lectures about water-cycle and atmospheric science.
Although the programme is going to be carried out in August 2019, the pilot programme were put into practice with ten participants including lecturers and students from the states and Japan.
At the conference, we would give a presentation about the detailed programme schedule and expected educational and academic results from this programme.

Keywords: Biosphere 2, ecosystem

©2019. Japan Geoscience Union. All Right Reserved.

Development of the highly precise high-speed photometry technique with the photometer mounted with PIRKA telescope

*Nami Kimura[1]

1. Hokkaido University

There is a few striped pattern on Jupiter when we observe by visible light, and we can see white bands called " belt” and dark band called " zone". The cloud top altitude is high at zone, low at belt by infrared observation.Various models are proposed to figure out, but we cannot elucidate the mechanism of this large scale structure.The Galileo datas tell us that the zonal jets are located on boundaries between the belts and zones, with the westward jets on the poleward edges of belts and the eastward jets on the poleward edges of zones.It is still not clear that the wind occurs by sun light in atmospheric layer or internal heat source makes the global structure including the wind.One of the mechanism making zonal wind is that small eddies combine each other and make eddy flow, but it is not sufficiently to observe the cumulonimbus the source of small eddies. In the case of thunders of the earth, the study of the activity of cumulonimbus such a strong upward current and thunder storms makes progress. Upward current can help hydrologic cycle. There is a relationship of frequency of thunders and the altitude go the cumulonimbus on the earth, and the CMC is known to be proportion to brightness of the thunder, too. I developed a photometer equipped to PIRKA telescope to arrest the time change and the frequency of thunder lightning in the Jupiter.First I estimated the time of the duration and freqency and spatial distribution of lightnings of Jupiter by using parameters of lightnings on the earth and observation data of satellites.Then it is necessary to divide into 10 to observe lightning activity which continue 1ms and to focus on one cumulonimbus and to get high signal-noise ratio. I designed the equipment which can achieve these numerical goal and examined observation methods for example exposure time and field of view.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 301A 3F

[A-OS11] Continental-Oceanic Mutual Interaction: Planetary scale Material Circulation

convener:Yosuke Alexandre Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Yukio Masumoto(Graduate School of Science, The University of Tokyo), Swadhin Behera(Climate Variation Predictability and Applicability Research Group, Application Laboratory, JAMSTEC, 3173-25 Showa-machi, Yokohama 236-0001), Takanori Sasaki(Department of Astronomy, Kyoto University), Chairperson:Yosuke Yamashiki(GSAIS Kyoto University), Takanori Sasaki(Department of Astronomy, Kyoto University)

The main purpose of this session is to promote discussion on mutual interaction between Continental zone and Oceanic zone. The global-scale material circulation induced by River runoff through oceanic general circulation as major topic on Continental-Oceanic Interaction, where the ENSO / IOD influence into continental climate as major topics on Oceanic-Continental Interaction. Numerical simulation and field observation of radionuclide transport from continental zone into ocean and its potential impact is also important topics of this session. The session also extend discussion on planetary hydrology and oceanography focusing on subsurface ocean in Jupiter's moon & Ancient Martian Oceanography & Hydrology by possible application of terrestrial GCM into Ancient Mars.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS11-07] The Drivers of early Archean Earth’s Hydrology: Resolving the Faint Young Sun's Paradox

★Invited Papers

*Vladimir Airapetian[1], Guillaume Gronoff[2], Michael Way[3], Meng Jin[4] (1.NASA Goddard Space Flight Center/SEEC and American University, 2.NASA LaRC/SSAI, 3.NASA GISS/SEEC, 4.SETI)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS11-08] Experimental study on elementary hydrological process of rainfall in a forested continental hinterland

*Shigeki Murakami[1] (1.Kyushu Research Cente, Forestry and Forest Products Research Institute)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS11-09] Radiological Assessment of Martian and Terrestrial Surface during Young Sun

*Yosuke Alexandre Yamashiki[1], Hiroyuki Maehara[6], Yuta Notsu[3], Tatsuhiko Sato[2], Airapetian Vladimir[7], Shota Notsu[3], Ryusuke Kuroki[1], keiya murashima[5], Hiroaki Sato[4], Hina Bando[5], Kosuke Namekata[3], Takanori Sasaki[3], Scott Thomas[8], Nogami Daisaku[3], Kazunari Shibata[9] (1.Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2.Japan Atomic Energy Agency, 3.Graduate School of Science, Kyoto University, 4.School of Engineering, 5.School of Science, 6.National Astronomical Observatory of Japan, 7.NASA / Goddard Space Flight Center, 8.University of Bristol , 9.Kwasan Astronomical Observatory, Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS11-10] Evaluation of scintillator detection materials for application within environmental radiation monitoring

*Peter George Martin[1], D. Connor[1], M. Lowden[1], T. B. Scott[1] (1.School of Physics, University of Bristol, Bristol, UK)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS11-11] The important factors for future human space activity in terms of space medicine

*Masahiro Terada[1], Yosuke Yamashiki[1], Kenji Miki[1], Satoko Tsujihiro[1], Takao Doi[1] (1.Kyoto University, Unit of Synergetic Studies for Space)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS11-12] Storm Surge Response to Freshwater Outflow from Typhoons on the Ibaraki Coast

*Josko Troselj[1], Nobuhito Mori[1] (1.Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University)

The Drivers of early Archean Earth’ s Hydrology: Resolving the Faint Young Sun's Paradox

*Vladimir Airapetian[1], Guillaume Gronoff[2], Michael Way[3], Meng Jin[4]

1. NASA Goddard Space Flight Center/SEEC and American University, 2. NASA LaRC/SSAI, 3. NASA GISS/SEEC, 4. SETI

Understanding how the early Archean Earth supported standing bodies of liquid surface water under the faint young Sun is one of the greatest challenges of modern science. Can this problem be resolved as a part of the puzzle of understanding of the origin of building blocks of life on early Earth? Here, we present a new concept of how these two pieces of the mystery of life can be reconciled if we reconstruct the eruptive history of space weather from the young Sun at the time when life started on Earth. Our three-dimensional (3D) magnetohydrodynamic model of the young Sun suggests that energetic protons can be accelerated in shock waves driven by frequent and powerful Coronal Mass Ejection events and Corotating Interacting Regions produced by the young Sun's wind. Accelerated protons at energies > 300 MeV penetrated into the nitrogen-rich weakly reducing atmosphere and initiated the reactive chemistry by breaking molecular nitrogen, carbon dioxide, and methane, producing nitrous oxide, the potent greenhouse gas, and hydrogen cyanide, an essential feedstock molecule of life. Our Global Climate Model, ROCKE-3D, suggests that at 4(1000) ppmv of nitrous oxide produced in a 1(0.5) bar atmospheres outputs the mean annualized Earth’ s temperature of +16(5.2)C, and thus may provide a resolution of the FYS paradox and explain the presence of early oceans.

Keywords: Earth, Sun, climate, chemistry

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Experimental study on elementary hydrological process of rainfall in a forested continental hinterland

*Shigeki Murakami[1]

1. Kyushu Research Cente, Forestry and Forest Products Research Institute

There is an observational fact that a rainfall amount is constant or increases with increasing the distance from the coast (x) in a forest covered continent up to a few thousands kilometers, e.g. Amazon and Yenisei river basins. However, it contradicts the basic law of hydrology as shown in Fig 1a; rainfall (P) is partitioned into evapotranspiration (ET) and discharge (Q) that means P_0 at $x = x_0$ is larger than P_1 at $x = x_1$ ($x_0 < x_1$), because $P_0 = ET_0 + Q_0$ and $P_1 =< ET_0$. The contradiction is solved by Makarieva and Gorshkov (2007, hereafter refer to MG 2007) in which they proposed Biotic Pump of Atmospheric Moisture (BP) as illustrated in Fig. 1b. The principle of BP is that ET from forests (ET(F)) is greater than that from the ocean (ET(O)) that is the driving force to transport moisture from the ocean to a forested continental hinterland.

Nonetheless, MG (2007) and their series of studies did not explicitly mention the reason of large ET from forests. It is great in forests because evaporation of canopy interception (hereafter refer to interception; typically some 20% of rainfall) at the time of rainfall is larger than that from any other vegetative surfaces, though the amount of transpiration is similar independent of vegetation types under a certain climate condition.

Some studies showed that interception is proportional to the rainfall amount on an hourly basis. For example Hashino et al. (2012) observed evaporation rate of more than 10 mm/hour during rainfall that requires latent heat of five times as large as the solar constant. To explain such huge amount of evaporation during rainfall Murakami (2006) proposed splash droplet evaporation mechanism. I believe it is the only explanation of enormous evaporation because small droplets can evaporate and disappear quickly even under very high humidity based on the theory and experiments of cloud physics. On top of that, latent heat is supplied from clouds upon condensation of water vaper. However, splash droplet evaporation along with BP is still a hypothesis.

To prove the splash droplet evaporation hypothesis stable isotope of water is used. Over 1000 of rainwater samples were collected on an hourly basis both under the forest canopy and at the opening simultaneously (Fig. 2). The isotopic ratios are measured and are being analyzed in combine with the meteorological data. The outline of the methodology is presented at the meeting.

References

Hashino, M., Yao H., Tamura T. 2010 Micro-Droplet Flux in Forest and its Contribution to Interception Loss of Rainfall –Theoretical Study and Field Experiment. Journal of Water Resource and Protection, 2,

©2019. Japan Geoscience Union. All Right Reserved.

872-879. DOI: 10.4236/jwarp.2010.2101

Makarieva, A. M., Gorshkov V. G. 2007 Biotic pump of atmospheric moisture as driver of the hydrological cycle on land. 11, 1013–1033. DOI: 10.5194/hess-11-1013-2007

Murakami, S. 2006 A proposal for a new forest canopy interception mechanism: Splash droplet evaporation. Journal of Hydrology, 319, 72-82. DOI: 10.1016/j.jhydrol.2005.07.002

Keywords: Biotic Pump of Atmospheric Moisture, canopy interception, splash droplet evaporation, stable isotope of water

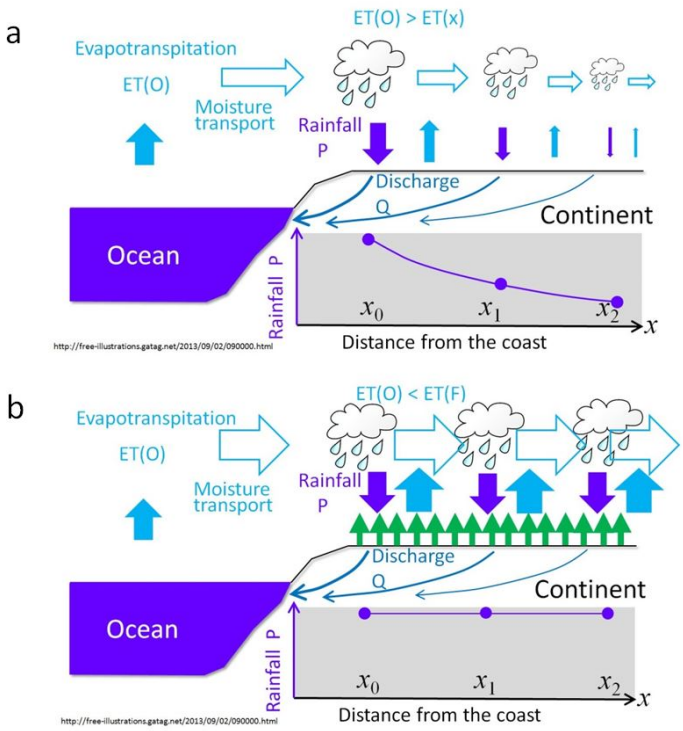


Fig. 1

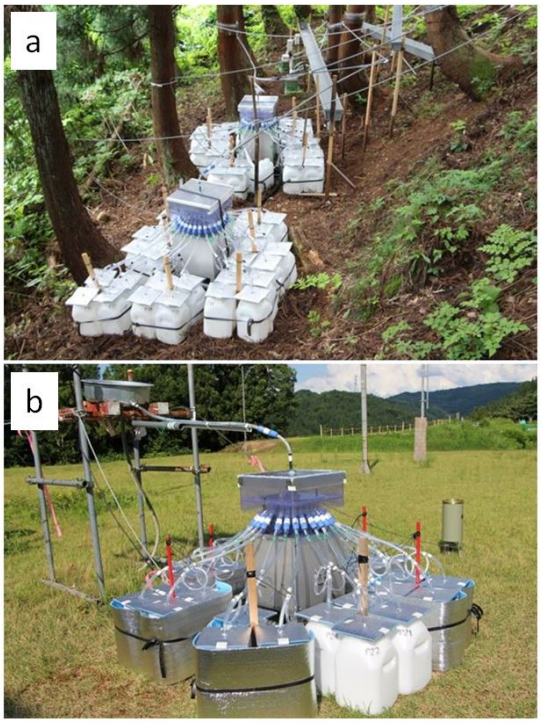


Fig. 2

©2019. Japan Geoscience Union. All Right Reserved.

Radiological Assessment of Martian and Terrestrial Surface during Young Sun

*Yosuke Alexandre Yamashiki[1], Hiroyuki Maehara[6], Yuta Notsu[3], Tatsuhiko Sato[2], Airapetian Vladimir[7], Shota Notsu[3], Ryusuke Kuroki[1], keiya murashima[5], Hiroaki Sato[4], Hina Bando[5], Kosuke Namekata[3], Takanori Sasaki[3], Scott Thomas[8], Nogami Daisaku[3], Kazunari Shibata[9]

1. Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2. Japan Atomic Energy Agency, 3. Graduate School of Science, Kyoto University, 4. School of Engineering, 5. School of Science, 6. National Astronomical Observatory of Japan, 7. NASA / Goddard Space Flight Center, 8. University of Bristol , 9. Kwasan Astronomical Observatory, Kyoto University

For a terrestrial planetary system, during the initiation period of planetary formation, the activity of a young Sun is extremely important in order to comprehend the atmospheric behavior of the planet. Relatively lower luminosity associated with lower surface temperature of the young Sun brings the planets a cooler surface environment. Terrestrial and Martian surfaces become icy cold in this environment without considering extensive GHG formation. Within such environments, the dose from SEP from a young Sun might play an important role in primordial atmospheric composition.

Here, we propose a reasonable radiological assssessment of the possible exposure intensity in SEP from a young Sun, by evaluating the possible magnitude and frequency of early solar flares by using possible star spot area, derived from their rotational period. We evaluated annual and maximum flare energy in different cases of solar spot areas for 3 %, 5 % ,and 10 % of solar surfaces. The maximum dose at the Martian TOA reaches 5.86 k Gy (265 Sv) when the solar spot area reaches 10 % of the solar surface. Such higher radiation dose may have influenced significantly atmospheric composition of Early Mars and Young Earth.

Keywords: Young Sun, Solar Flare, Radiological Condition

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of scintillator detection materials for application within environmental radiation monitoring

*Peter George Martin[1], D. Connor[1], M. Lowden[1], T. B. Scott[1]

1. School of Physics, University of Bristol, Bristol, UK

The last five years has seen the unabated growth in the number of airborne platforms performing radiation mapping –each using various iterations of low-altitude unmanned aerial vehicle (UAV). Alongside the associated advancements in the base airborne system transporting the radiation detection payload, from the earliest radiological analyses performed using gas-filled Geiger-Muller tube detectors, modern radiation mapping platforms are now based near-exclusively on solid-state scintillator (and to a lesser-extent semiconductor) detectors. With numerous types of these light-emitting crystalline materials now in existence, this combined desk and computational modelling study sought to evaluate the best-available detector material compatible with the requirements for low-altitude autonomous radiation mapping –of naturally-occurring but also anthropogenically-derived radionuclides.

Aside from ground-based radiation surveying undertaken by humans; environmental mapping of radiation distribution (resulting from both anthropogenic activities as well as from naturally-occurring radioactive material) has been performed historically using manned, fixed-wing aircraft. In contrast to the more limited detector volumes carried during on-ground operations (due to size and weight practicalities), the systems carried during these extensive spatial extent aerial surveys are typically not less than 33 litres in detector volume. For the gamma-ray measurements of naturally-occurring radionuclides, the key emission peaks are associated with the daughter products of the U (^{214}Bi) and Th (^{208}Tl) decay chains, alongside a strong contribution from radiogenic potassium (^{40}K). In contrast to the higher-energy (>1.0 MeV) gamma-ray emissions characteristic of the aforementioned naturally-occurring radionuclides, the primary anthropogenically-derived radionuclide released into the environment in extensive quantities during an emergency release event (such as at both Fukushima and Chernobyl) is radiocesium –specifically ^{137}Cs (half-life: 30.17 years), which emits a single gamma-ray photon at 0.662 MeV.

While the currently and widely-used NaI and CsI (both of which are Tl-doped) are the mainstays of radiation monitoring, during this study, LaBr scintillator detectors were determined to possess not only a greater sensitivity to incident gamma-radiation, but also a far superior spectral (energy) resolution over existing detector materials. Combined with their current competitive cost, an array of three such composition cylindrical detectors were determined to provide the best means of detecting and discriminating the various incident gamma-rays incident onto the detector owing to both naturally-occurring or anthropogenically-derived sources.
In this talk, we will present the results of multiple GEANT4 simulations that will inform the potential future development of the next generation of radiation detection materials and their optimal configurations for deployment.

©2019. Japan Geoscience Union. All Right Reserved.

The important factors for future human space activity in terms of space medicine

*Masahiro Terada[1], Yosuke Yamashiki[1], Kenji Miki[1], Satoko Tsujihiro[1], Takao Doi[1]

1. Kyoto University, Unit of Synergetic Studies for Space

When humans stay in space for long term, our body has various phyisiological effects by the specific space environments. Recently, space agency, such as NASA and JAXA, has the plan to send human to Moon or Mars. Therefore, it is very important to understand how we are effected during space staying. For example, our skeletal muscles on the leg become atrophy and bone volume decrease by spaceflight. And, astronauts must spend time in closed environment during human space mission. So, we need to know the mental or emotional changes during space mission.
Now, we have space camps which is simulated for future space misson. In this time, I will present the phyisiological data of mental factors in simulated space camps.

Keywords: Space medicine, Human space activity, Closed environment

©2019. Japan Geoscience Union. All Right Reserved.

Storm Surge Response to Freshwater Outflow from Typhoons on the Ibaraki Coast

*Josko Troselj[1], Nobuhito Mori[1]

1. Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University

Introduction and Objective

Collaborative results (Troselj et al., 2017) have permitted for the first time to quantitatively evaluate the influence of extreme freshwater outflow to the coastal ocean due to typhoon passage by combining river and ocean models using hourly time step data and remote-sensing technology. They found that projection of coastal Sea Surface Salinity was improved (up to 10 PSU difference) and became more realistic with included freshwater impact and concluded that extreme events freshwater outflows significantly decrease Sea Surface Salinity distribution in the coastal zone.

With the advance of weather forecasting systems and specific availability of forecasting typhoon trajectory and intensity, the research team aims to be able to apprehend freshwater impacts on the coastal marine environment in advance of typhoon events, and contribute to the comprehensive management and protection of coastal zones.

In our JpGU presentation (2018), we concluded that our findings that the freshwater outflow impact to the storm surge is negligible during the typhoon passage but is important to be considered in evaluating an after-runner storm surge mechanism should be further confirmed in future works by testing the applicability of using the same method with many other typhoon event cases.

A follow up of the previous studies is shown here. As parameters which affect the total sea level are storm surge, tides, waves and freshwater impact, the main objective of the study is to test dependence between storm surge heights and the freshwater impact before and after passing of several typhoons over the Ibaraki Coast, Japan.

Methods

We continued the study from Troselj et al. (2018) with improved downscaling model methodology and extended analyzed period into 7 years (2000-2006). We applied better vertical transformation equation (Vtransform=2, new formulation developed by A. Shchepetkin) and different vertical stretching function (Vstretching=4, where A. Shchepetkin improved double stretching) compared to Troselj et al. (2018). River forcing conditions were applied as observed river temperature and discharge (MLIT, 2017) with constant salinity of 0.5 PSU for Tone, Naka and Kuji rivers.

Discussions

We compared coastal storm surge heights for cases with and without freshwater outflow impact and discussed differences in results, for several typhoons passing over Ibaraki Coast during the analysed period. With new results, our conclusions from JpGU presentation (2018) cannot yet be certainly

©2019. Japan Geoscience Union. All Right Reserved.

confirmed. The mechanism which we found then, presence of so called after-runner storm surge occurring about 4 days after passage of the event, is occurring in some typhoon cases but not every time. Therefore, its occurrence is function of many parameters occurring simultaneously such as typhoon trajectory, intensity and central pressure, actual state of the ocean (tides, waves), river discharge magnitude and temporal distribution and model conditions.

Summary

Using dynamic downscaling for reanalysis of coastal current system in the Ibaraki Coast, our goal was to test dependence between storm surge heights and the freshwater impact before and after typhoon events. We found that the mechanism found in the previous study is not occurring every time on the same way but is rather function of many other dependent parameters.

References

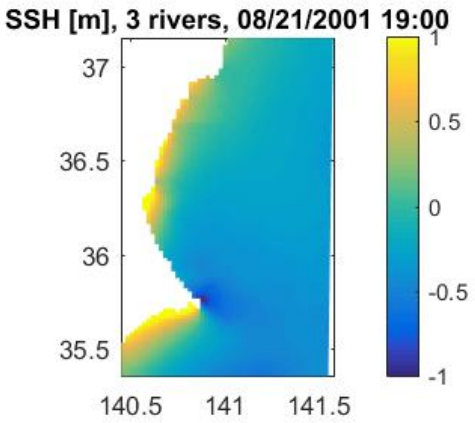
Troselj J, Sayama T, Varlamov SM, Sasaki T, Racault M-F, Takara K, Miyazawa Y, Kuroki R, Yamagata T, Yamashiki Y (2017). Modeling of extreme freshwater outflow from the north-eastern Japanese river basins to western Pacific Ocean, Journal of Hydrology, Vol. 555, pp. 956-970, doi:10.1016/j.jhydrol.2017.10.042.

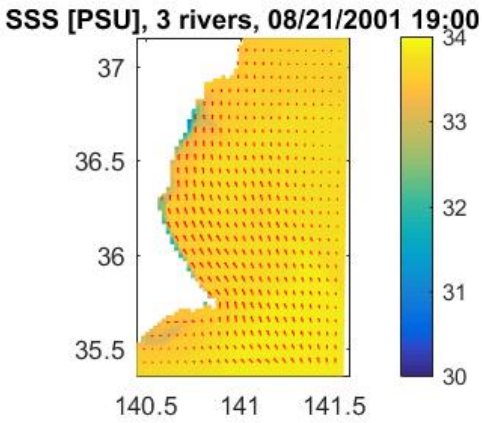
Troselj, J, Imai, Y, Ninomiya, J, Mori, N (2018). Coastal Current Downscaling Emphasizing Freshwater Impact on Ibaraki Coast, Journal of Japan Society of Civil Engineers, Ser. B2 (Coastal Engineering), vol.74, no.2, pp. 1357-1362.

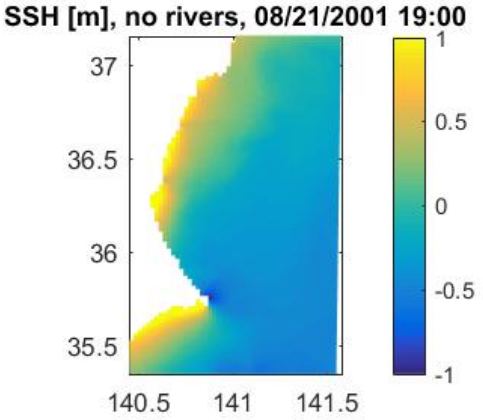
Keywords: storm surge, freshwater impact, typhoon events, downscaling, coastal current, COAWST

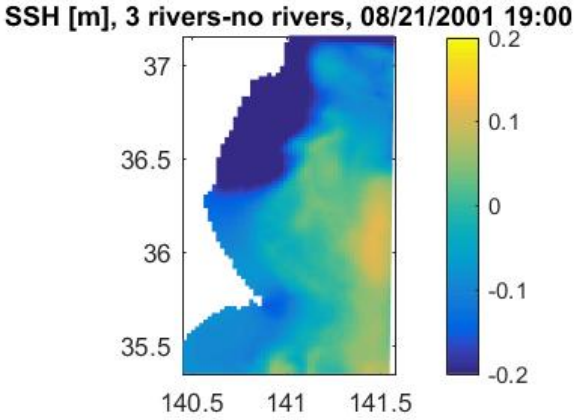
Keywords: storm surge, freshwater impact, typhoon events, downscaling, coastal current, COAWST

©2019. Japan Geoscience Union. All Right Reserved.









©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Noboru Okuda(Research Institute for Humanity and Nature)

This session aims to synthetize watershed sciences in order to understand dynamical processes of materials transport and nutrient cycles in watersheds from headwaters to coastal seas. The session will be integrating a variety of research disciplines including limnology, ground water hydrology, coastal oceanography, meteorology, pedology, sedimentology, forestry, agriculture, fishery, ecology, social science and more. This session calls for ideas on new methods for the watershed sciences, such as tracer and molecular technique, hydrological modeling, paleontological approaches, laboratory and field experiments, social-scientific evaluation of ecosystem services and social-ecological systems, and so on, in order to elucidate physical, chemical and biological mechanisms for shedding light on natural phenomena and their changes over time in complex and dynamic watershed systems under human and climate impacts. Through this session, we would like to facilitate interdisciplinary collaboration among participants to create new knowledge on watershed sciences.

3:30 PM - 3:40 PM JST | 6:30 AM - 6:40 AM UTC

Introduction

3:40 PM - 4:00 PM JST | 6:40 AM - 7:00 AM UTC

[AHW22-01] **Coral Skeleton $\delta^{15}N$ as a Tracer of Historic Nutrient Loading to a Coral Reef in Maui, Hawaii**

★Invited Papers

*Adina Paytan[1] (1.University of California Santa Cruz)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AHW22-02] **The Use of Ammonium and Trace Metals in Identifying Low Redox Environment Zone at Indonesian Coastal Alluvial Groundwater**

*Anna Fadliah Rusydi[1,4], Mitsuyo - Saito[2], Seiichiro - Ioka[3], Shin-ichi - Onodera[1] (1.Graduate School of Integrated Arts and Sciences, Hiroshima University, Japan, 2.Graduate School of Environmental and Life Sciences, Okayama University, Japan, 3.Institute of Regional Innovation, Hirosaki University, Japan, 4.Research Center for Geotechnology, Indonesian Institute of Sciences, Indonesia)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AHW22-03] Spatial and temporal variation in submarine groundwater discharge (SGD) on a beach scale in a temperate coastal island: a multi-tracer approach

*Mitsuyo Saito[1], Shin-ichi Onodera[2], Yusuke Tomozawa[2], Kazuyoshi Asai[3] (1.Graduate School of Environmental and Life Science, Okayama University, 2.Graduate School of Integrated Arts and Sciences, Hiroshima University, 3.Geo Science Laboratory)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AHW22-04] **Phosphorus discharge via groundwater into the lake, based on lacustrine groundwater discharge (LGD) and alluvial plain sediment**

*Shin-ichi Onodera[1], Mitsuyo Saito[2], Guangzhe Jin[3], Anna Fadliah Rusydi[1], Yusuke Tomozawa[1], Kunyang Wang[1], Syuhei Ban[4], Noboru Okuda[5] (1.Graduate School of Integrated and Arts Sciences, Hiroshima University, 2. Graduate School of Environmental and Life Science, Okayama University, 3.Guangdong Ocean University, 4.The University of Shiga Prefecture, 5.Research Institute for Humanity and Nature)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AHW22-05] **Geochemical controls and health implications of water chemistry in Benoue River Basin, North Cameroon: Insights from Major ions**

*Sharon Bih Kimbi[1,2], Wilson Y Fantong[3], Samuel N Ayonghe[2], Robert Kringel[4], Shin-ichi Onodera[1]
(1.Graduate School of Integrate Arts and Sciences, Hiroshima University, 2.Department of Environmental Science, Faculty of science, University of Buea, 3.Institute of Mining and Geological Research (IRGM), 4.Federal Institute for Geoscience and Natural Resources Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR) PRESS NO & SW)

Coral Skeleton $\delta^{15}N$ as a Tracer of Historic Nutrient Loading to a Coral Reef in Maui, Hawaii

*Adina Paytan[1]

1. University of California Santa Cruz

Excess nutrient loading to nearshore environments has been linked to declining water quality and ecosystem health. Macro-algal blooms, eutrophication, and reduction in coral cover have been observed in West Maui, Hawaii, and linked to nutrient inputs from coastal submarine groundwater seeps. Here, we present a forty-year record of nitrogen isotopes ($\delta^{15}N$) of intra-crystalline coral skeletal organic matter in three coral cores collected at this site and evaluate the record in terms of changes in nitrogen sources. Our results show a dramatic increase in coral $\delta^{15}N$ values after 1995, corresponding with the implementation of biological nutrient removal at the nearby Lahaina Wastewater Reclamation Facility (LWRF). High $\delta^{15}N$ values are known to be strongly indicative of denitrification and sewage effluent, corroborating a previously suggested link between local wastewater injection and degradation of the reef environment. This record demonstrates the power of coral skeletal $\delta^{15}N$ as a tool for evaluating nutrient dynamics within coral reef environments.

Keywords: Nitrogen Isotopes, Corals, Submarine Groundwater Discharge

©2019. Japan Geoscience Union. All Right Reserved.

The Use of Ammonium and Trace Metals in Identifying Low Redox Environment Zone at Indonesian Coastal Alluvial Groundwater

*Anna Fadliah Rusydi[1,4], Mitsuyo - Saito[2], Seiichiro - Ioka[3], Shin-ichi - Onodera[1]

1. Graduate School of Integrated Arts and Sciences, Hiroshima University, Japan, 2. Graduate School of Environmental and Life Sciences, Okayama University, Japan, 3. Institute of Regional Innovation, Hirosaki University, Japan, 4. Research Center for Geotechnology, Indonesian Institute of Sciences, Indonesia

Reduction and oxidation (redox) conditions in the aquifer are essential factors; those can determine the behavior of chemicals in the groundwater system. Nowadays, researches concerning the low redox (reduction) environment are growing significantly since some pollutions occur under this condition. The study was taken place in Indramayu, Indonesia. The area is an alluvial plain located on the North Coast of West Java Island. The groundwater in the alluvial area is compelling to study because it has a large aquifer storage capacity but unfortunately vulnerable to contamination. Moreover, the contamination will get severe under reduction environment. The primary objective of this study is to understand groundwater vulnerability by identifying the reduction environmental zone in the study site.

In this research, we used combined chemical parameters: ammonium (NH_4^+-N), dissolve manganese (Mn^{2+}) and ferrous (Fe^{2+}), to trace reduction condition in the groundwater. NH_4^+-N is one form of nitrogen compound that usually arise under reduction condition. Other parameters that arise with the reduction process are Mn^{2+} and Fe^{2+}. Therefore, in this investigation, we assumed the use of NH_4^+-N, combined with the concentrations of Mn^{2+} and Fe^{2+} elements, are able to identify groundwater reduction environment.

Totally, there was ten soil taken from 2 boreholes located at the south and north of the research site and 20 water samples collected from groundwater (18) and river (2). The soil samples were analyzed for NH_4^+-N and C/N ratio parameters. These data were used to explain further about NH_4^+-N presence in groundwater. Additionally, the water samples were analyzed for NH_4^+-N, $Mn^{2+,}$ and Fe^{2+} concentrations. The aquifer materials consist of sandstone, claystone, and sandy claystone. The NH_4^+-N concentrations were ranged from 0.82 until 3.37 mg / L. However; there was no clear relationship between the soil’s depth and compositions with NH_4^+-N concentrations. The soil samples had low C/N ratios, with values of 8.00 to 12.19. This is indicating that N-organic in the soil potentially experiences mineralization, one that produces NH_4^+-N. Furthermore, NH_4^+-N in water samples were detected as the dominant nitrogen form at most sites. Similarly, Mn^{2+} was detected at almost all locations. Moreover, the concentrations of Mn^{2+} were high (> 0.05 mg / L), around 0.07 - 12.8 mg / L, at 16 locations. High concentrations of Fe^{2+} (> 0.3 mg/L), were found in groundwater at 6 locations. The concentrations were ranged from 1.39 to 9.91 mg/L. The presence of NH_4^+-N along with high Mn^{2+} contents indicated that almost all locations experienced reduction condition at a zone of manganese reduction. Moreover, at 6 locations, the reduction process was stronger and lead to becoming ferrous zone. This was shown by NH_4^+-N existence as dominant nitrogen form and high concentrations of Fe^{2+} as well as Mn^{2+}.

Keywords: Ammonium, Manganese, Ferrous, Reduction, Coastal Groundwater, Indramayu

©2019. Japan Geoscience Union. All Right Reserved.

Spatial and temporal variation in submarine groundwater discharge (SGD) on a beach scale in a temperate coastal island: a multi-tracer approach

*Mitsuyo Saito[1], Shin-ichi Onodera[2], Yusuke Tomozawa[2], Kazuyoshi Asai[3]

1. Graduate School of Environmental and Life Science, Okayama University, 2. Graduate School of Integrated Arts and Sciences, Hiroshima University, 3. Geo Science Laboratory

Submarine groundwater discharge (SGD) is defined as subsurface water flow from the seabed to the coastal sea and ocean. Because groundwater often contains higher nutrients than river water, SGD delivers comparatively large quantities of nutrients to coastal ecosystems. However, there are few studies to examine the spatial relation between SGD and coastal ecosystem such as seagrasses and seaweeds. In the present research, we aimed to examine the spatial and temporal variation in SGD on a beach scale in a temperate coastal island.
The study areas are located on Ikuchijima Island in Seto Inland Sea, southern Japan. The regional climate is mild, with an annual mean precipitation of 1,100 mm and temperature of 15.6 ˚C. The whole island is characterized by steep slopes and is widely covered by citrus farms with more than 40% of the island. The previous researches confirmed that SGD can rival or even exceed surface runoff in this island. However, the spatial and temporal variation in SGD on a beach scale was not well examined. We installed piezometers in two beach sites (Gohonmatsu: IKG and Miyabara: IKM) and measured water pressure, water temperature, electric conductivity (EC), and radon (^{222}Rn) concentration in pore water in July and December 2018, and January 2019. In January 2019, SF6 (sulfur hexafluoride) concentration was measured to estimate residence time of pore water. Before the field campaign in July 2018, the study area had an extreme rainfall event. IKG has steeper backland topography than IKM. There is no surface water inflow to IKG, while a small channel inflow to IKM. Main bottom material is sand in both beaches, however, the western part of IKG is covered by coarse gravels. Large spatial variation in hydraulic potential, water temperature, EC and ^{222}Rn concentration in pore water were confirmed in both beaches, with larger variation range in IKG. EC was totally lower and ^{222}Rn was higher in IKG than IKM. These results suggest that higher rate in fresh-SGD in IKG than IKM. In addition, significant low EC and high ^{222}Rn concentration were confirmed in the western part of IKG in July 2018.

Keywords: Submarine groundwater discharge (SGD), Beach scale, Spatial and temporal variation

©2019. Japan Geoscience Union. All Right Reserved.

Phosphorus discharge via groundwater into the lake, based on lacustrine groundwater discharge (LGD) and alluvial plain sediment

*Shin-ichi Onodera[1], Mitsuyo Saito[2], Guangzhe Jin[3], Anna Fadliah Rusydi[1], Yusuke Tomozawa[1], Kunyang Wang[1], Syuhei Ban[4], Noboru Okuda[5]

1. Graduate School of Integrated and Arts Sciences, Hiroshima University, 2. Graduate School of Environmental and Life Science, Okayama University, 3. Guangdong Ocean University, 4. The University of Shiga Prefecture, 5. Research Institute for Humanity and Nature

Groundwater discharge and nutrient flux into a lake has not been confirmed enough in terms of spatial variation including those in deeper zone. Biwa Lake has different characteristics between in northern and southern. In northern, the water depth varies up to 100m, groundwater discharge is also expected not only in beach sides with shallower depth but in deeper zones. We examined to indicate spatial variation of Rn-222 and to compare with the results of seepage observations by Kobayashi (1993).

Radon radioisotope (Rn-222) concentrations were measured by a RAD7 at 500 m interval along the whole shoreline of the northern lake, and surface water samples were coincidently collected. Oxygen stable isotope ratio ($\delta^{18}O$), Chloride anion and nutrients (nitrogen, phosphorus, and silicon) concentrations were measured in the laboratory in order to evaluate inflow of the groundwater into the lake. Those dissolved materials were also measured from the groundwater samples were collected in ca. 20 wells situated along the shore of the lake as well as those in river waters. In the eastern coast (Hikone), artesian groundwater was also collected because of aquiclude at 10m deep under the ground. Lake waters at the surface, middle and bottom layers and interstitial waters in the bottom sediments were collected for measuring Rn-222 concentrations.

At the both sites of Yasu and Takashima, high pressures of groundwater indicated flow of the water to the lake under the ground. Spatial distributions in Rn-222, Cl^- and nutrient concentrations with those in $\delta^{18}O$ along the coasts also indicated discharges of groundwater into the lake. High concentrations of dissolved phosphorus phosphate (> 0.1ppm) were detected from several wells out of 15 ones investigated. Based on the comparative results with the seepage observations, we could confirm good correlation between Rn-222 concentration and seepage observation results.

In addition, Rn-222 concentrations in lake waters were measured in the surface and bottom layers at the 4 stations with different water depths (5m, 10m and 20m) in October 2015 and July 2016. The highest Rn-222 was observed in the bottom layer at 20m-deep site in both periods. The concentration was more than 2-fold of that in the littoral site. It suggests high possibility of deep-LGD from offshore lake floor.

Keywords: Phosphorus, groundwater, alluvial plain, semiment

©2019. Japan Geoscience Union. All Right Reserved.

Geochemical controls and health implications of water chemistry in Benoue River Basin, North Cameroon: Insights from Major ions

*Sharon Bih Kimbi[1,2], Wilson Y Fantong[3], Samuel N Ayonghe[2], Robert Kringel[4], Shin-ichi Onodera[1]

1. Graduate School of Integrate Arts and Sciences, Hiroshima University, 2. Department of Environmental Science, Faculty of science, University of Buea, 3. Institute of Mining and Geological Research (IRGM), 4. Federal Institute for Geoscience and Natural Resources Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR) PRESS NO & SW

Increase population growth in the north region of Cameroon coupled with rapid urbanisation has led to the widespread of informal settlements in urban areas. Multivariate statistics and hydrochemical diagrams were used to investigate the groundwater chemistry, usability and the impact of urbanisation on water resource quality. The purposive random technique was used to sample and collect 86 water samples from 34 boreholes, 37 wells, 14 rivers and 1spring during the month of January, 2017. Major ions were analyzed using an Ion Chromatography. The results revealed that, water pH ranged from slightly acidic to basic meanwhile the water types varied from Ca-Cl in wells, Na-HCO_3 in springs and CaMg-HCO_3 in boreholes and rivers. Water sources did not meet WHO, 2006 quality standard with respect to pH (60.5% <7 & >8.5), EC (58.1%>250 μS/cm) and NO_3^-(60.5%>10mg/l). The Wilcox and USSL diagrams for irrigational uses showed that the water sources are of low to moderate salinity and low alkalinity hazard and thus excellent for use in irrigation. Increase concentrations of NO_3^- and Cl^- from 8.0mg/l to 198.4mg/l and from 2.0mg/l to 59.4mg/l in 1997 and 2017 (20yrs) respectively could be linked to increase population, poor waste disposal and pollution from agricultural fields. While anthropogenic activities are main provenance of NO_3^- and Cl^-, the population is equally affected by fluorosis from lithogenic fluoride and is at risk to nitrate. It is recommended that a monitoring and evaluation system for ground water sources with respect to their quantity and quality be put in place to ensure sustainable management by policy makers.

Keywords: Hydrochemistry, Water resources, Fluorosis, Urbanization, Cameroon

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 103 1F

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Takeshi Hayashi(Faculty of Education and Human Studies, Akita University)

We focus on various issues of water cycle and environment and aim to answer questions of hydrological and earth system sciences including 1) surface, subsurface and evapotranspiration processes of water cycle; 2) natural and anthropogenic hydrothermal systems, 3) environments issues and studies on a watershed or global scale, 4) water-related issues with ecological, environmental, and geochemical aspects, and 5) other issues in hydrological sciences. This session welcomes presentations regarding various kinds of approaches and techniques such as field survey, remote sensing, isotope tracers, numerical simulation, and theoretical analysis.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AHW23-12] Drought Analysis based on Copulas and Poisson Process

*Pei-Yu Wu[1], Gene Jiing-yun You[1] (1.National Taiwan University, Department of Civil Engineering)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AHW23-13] **Snow melt dynamics in snowfall dominated mountain regions in Shonai**

*Alexander Brandt[1,3], Muhammad Fraz Ismail[2], Larry Maximo Lopez Caceres[1], Wolfgang Bogacki[2] (1.Yamagata University, 2.Hochschule Koblenz, 3.UGAS)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AHW23-14] Study on transport of particulate organic matter in a small river with forest and paddy filed by using carbon isotopes ($\delta^{13}C$ and $\Delta^{14}C$)

*Seiya Nagao[1], Ryunosuke Tahara[2], Shinya Ochiai[1], Akiko Goto[3], Takashi Hasegawa[3] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University, 3.Institute of Science and Engineering, Kanazawa University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AHW23-15] **Sources of Shallow Groundwater Salinity in the Ganges Delta of Bangladesh**

*Masudur Rahman[1,2], Tomochika Tokunaga[1] (1.Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo, 5-1-5, Kashiwa-no-ha, Kashiwa-shi, Chiba 277-8563, Japan, 2.Environmental Science Discipline, Life Science School, Khulna University, Khulna 9208, Bangladesh)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AHW23-16] **Groundwater chemistry in the Gunii Khooloi basin, Southern Gobi Region of Mongolia using multivariate analysis**

*Batdemberel BAYANZUL[1,2], Isao Machida[3], Kengo Nakamura[2], Noriaki Watanabe[2], Takeshi Komai[2] (1.School of Geology and Mining Engineering, Mongolian University of Science and Technology, 2.Graduate School of Environmental Studies, Tohoku University, 3.Groundwater research group, Advanced Industrial Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AHW23-17] **Temporal observation of molybdenum concentrations in rivers from Erdenet mining area, Mongolia**

*Solongo Tsetsgee[1], Keisuke Fukushi[1], Altansukh Ochir[2], Takahashi Yoshio[3], Ariuntungalag Yunden[2], Enkhjin Odgerel[2], Noriko Hasebe[1] (1.Kanazawa University, 2.National University of Mongolia, 3.The University of Toyko)

Drought Analysis based on Copulas and Poisson Process

*Pei-Yu Wu[1], Gene Jiing-yun You[1]

1. National Taiwan University, Department of Civil Engineering

Drought is a regular and recurring climatic phenomenon. Because of climate change and the increasing water demand, we have experienced higher drought deficit and severity in recent years. To evaluate the impact of the trend of drought, this study aims to develop an improved framework for streamflow drought analysis and simulation of the future conditions. Based on our proposed framework based on Copulas and Poisson process, this study firstly analyzes historical inflow data to estimate statistical parameters of drought. Secondly, we calculate three defined indices of the drought, drought duration, drought deficit, and interval time between droughts respectively. With statistical test, these three indices are found to be correlated. Following, the marginal distributions of these indices are estimated. Accordingly, this study constructs a stochastic model by three-dimensional Gaussian copulas to simulate the occurrence of drought events. In addition, to more appropriately simulate drought occurrences, a Poisson process is applied in this study to describe the occurrence between drought events. This simulation is based on the stationary assumption in current stage. In the future, we will consider the influence of climate change and simulate drought events under non-stationary condition. The results of this work can be utilized to support the decision or policy making processes in drought management.

Keywords: drought analysis, copulas, poisson process

©2019. Japan Geoscience Union. All Right Reserved.

Snow melt dynamics in snowfall dominated mountain regions in Shonai

*Alexander Brandt[1,3], Muhammad Fraz Ismail[2], Larry Maximo Lopez Caceres[1], Wolfgang Bogacki[2]

1. Yamagata University, 2. Hochschule Koblenz, 3. UGAS

With a total snowfall of 1500 mm, which is the half of the total annual precipitation, Shonai is one of the snowiest regions of the world (*Asaoka et al, 2013*). Snow depth can reach up to 5.2 meters in March before the snow melt finishes in May. The maximum snow depth as 50-year average is 2.7 m in the Yamagata University Research Forest (YURF), southern of the Shonai plains. The relatively warm air in winter (~ 0˚C) leads to several melting and refreezing processes within the snow column, increasing the snow density to 0.5 g/cm³. This huge amount of snow in Yamagata, Akita and Aomori prefecture is the dominating water source for plants in spring and a good thermal insulation for the soil, which is never freezing in YURF. A change of wind direction in winter is the reason for the high amount of snow. Cold air from Siberia is passing the warm Japanese Sea and faces the central mountains of Tohoku (*Asaoka et al., 2013*). These characteristics are very unique in the world leading to snow accumulations higher than in most areas of the world (*Krasting et al., 2013, Masiokas et al., 2006*).

The thick snow pack with high density results in a high Snow Water Equivalent (SWE). Monitoring and modelling of the snow melt period in spring is essential to confirm river discharges, water infiltration into the soil and to calculate the water balance of Japanese mountain forests. A modelling approach was done with the calculation of Degree-Day Factors (DDF) (*Ismail et al., 2015*). Measurements to determine the snow pack differences of forest covered sites and clear-cut sites are conducted this winter and will be intensified in the snow melting period. We expect results comparable to *Jost et al. (2009)* and *Schelker et al. (2013)*.

Automatic and manual measurements of snow density and snow depth were conducted intensively in the last 7 years in YURF. Together with the DDF we already discovered a significant trend of changing melt dynamics after half of the melting season. Results show furthermore, that the snow cover is not losing water, even in the warm periods during the winter. Soil moisture is measured to identify the start of the snow melt period, river flow discharge measurements will be introduced as soon as the snow melt starts. All these measurements together are parameters for the following calculations of snowmelt runoff. Melting dynamic related to temperature, snow cover and season was discovered and will be compared with river discharge measurements.

Literature:

Asaoka, Yoshihiro, Yuji Kominami (2013): Incorporation of satellite-derived snow-cover area in spatial snowmelt modeling for a large area: determination of a gridded degree-day factor

Ismail, Muhammad Fraz, Habib-ur-Rehman, Wolfgang Bogacki, Noor Muhammad (2015): Degree Day Factor models for forecasting the snowmelt runoff for Naran watershed

©2019. Japan Geoscience Union. All Right Reserved.

Jost, Georg, R. Dan Moore, Markus Weiler, David R. Gluns, Younes Alila (2009): Use of distributed snow measurements to test and improve a snowmelt model for predicting the effect of forest clear-cutting

Krasting, John P., Anthony J. Broccoli, Keith W. Dixon, John R. Lanzante (2013): Future Changes in Northern Hemisphere Snowfall

Masiokas, Mariano H., Ricardo Villalba, Brian H. Luckman, Carlos Le Quesne, Juan Carlos Aravena (2006): Snowpack Variations in the Central Andes of Argentina and Chile, 1951–2005: Large-Scale Atmospheric Influences and Implications for Water Resources in the Region

Schelker, J., L. Kuglerová, K. Eklöf, K. Bishop, H. Laudon (2013): Hydrological effects of clear-cutting in a boreal forest –Snowpack dynamics, snowmelt and streamflow responses

Keywords: Snow Water Equivalent, Degree-Day Factor, soil moisture, snowmelt, climate data, snow accumulation

©2019. Japan Geoscience Union. All Right Reserved.

Study on transport of particulate organic matter in a small river with forest and paddy filed by using carbon isotopes ($\delta^{13}C$ and $\Delta^{14}C$)

*Seiya Nagao[1], Ryunosuke Tahara[2], Shinya Ochiai[1], Akiko Goto[3], Takashi Hasegawa[3]

1. Institute of Nature and Environmental Technology, Kanazawa University, 2. Graduate School of Natural Science and Technology, Kanazawa University, 3. Institute of Science and Engineering, Kanazawa University

Radioactive and stable isotopes of carbon (^{14}C and ^{13}C) can serve as powerful tools for identifying sources and estimating turnover times of organic matter in aquatic systems. The present study aims to investigate variations in the characteristics of riverine particulate organic matter running through forests and paddy fields, corresponding to a typical Japanese river system. We selected the Kumaki River located in the central part of the Noto Peninsula in Ishikawa Prefecture, Japan. The river research was conducted at a fixed site of the midstream Kumaki River from April 2016 to March 2018.

Total organic carbon and nitrogen content was measured using the elemental analyzer after the 0.1 M HCl treatment to remove inorganic carbonates. ^{14}C measurements were performed by accelerator mass spectrometry. Final ^{14}C activities are reported in $\Delta^{14}C$. $\delta^{13}C$ values were determined for sub-samples of the CO_2 gas generated during graphite production, using an isotope ratio mass spectrometer.

$\delta^{13}C$ and $\Delta^{14}C$ values of organic matter in the riverine POC of Kumaki River show the range of −27.2‰ to −25.1‰, and −130 to +3 ‰, respectively. There are two negative correlations (correlation factor of 0.78) between the $\delta^{13}C$ and $\Delta^{14}C$ values at winter and the other season except for summer in July and August in 2017. The results indicate that particulate organic matter is mixed with two end-members such as surface forest soil and paddy field soil.

Keywords: Radiocarbon, stable carbon isotope ratio, Particulate organic matter

©2019. Japan Geoscience Union. All Right Reserved.

Sources of Shallow Groundwater Salinity in the Ganges Delta of Bangladesh

*Masudur Rahman[1,2], Tomochika Tokunaga[1]

1. Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo, 5-1-5, Kashiwa-no-ha, Kashiwa-shi, Chiba 277-8563, Japan, 2. Environmental Science Discipline, Life Science School, Khulna University, Khulna 9208, Bangladesh

In Bangladesh, unconsolidated fluvio-deltaic sediments host highly productive aquifer systems that are generally classified as shallow aquifers (depth less than 150 m below ground level, mbgl) and deep aquifers (depth more than 150 mbgl). Elevated groundwater salinity in shallow aquifers underlying the southern deltaic areas, in addition to mass poisoning of arsenic, aggravates freshwater scarcity in the country. However, little is known about the origin of salinity and mechanisms of salinization. Therefore, we analyzed both measured and previously published data on pH (n=585), electrical conductivity (EC, n=737), chloride and bromide (n=120 each), stable isotopes of water (oxygen-18 & deuterium, n=175 each), and radiogenic isotopes (C-14, n=18 & tritium, n=29) to discuss these issues for the upper shallow groundwater (depth around 60 mbgl) in the Ganges delta covering much of the coastal areas of Bangladesh. Stable isotope data from two GNIP (Global Network of Isotopes in Precipitation) stations in the delta were incorporated in this study. A paleo-shoreline, representing the maximum extent of last marine transgression at around 7 ka, was retrieved from a previous study and incorporated as well.
The upper shallow groundwater shows slightly acidic to alkaline in nature (6.1-8.5) over the delta. EC ranges from 210-29,400 microsimens/cm with lower salinity in fluvial area (210-2,000 microsimens/cm) than those in tidal domain (383-29,400 microsimens/cm). Cl^-/Br^- molar ratios are higher in tidal area (160-540,000) than those in fluvial setting (42-2,800). The cross plot between oxygen-18 and deuterium isotopes shows that groundwater data fall on or slightly below the local meteoric water line (Figure 1). Most of the brackish groundwater (n=43, EC>2,000-10,000 microsimens/cm) contains depleted isotope signatures. In EC vs oxygen-18 cross plot, EC mostly increases with almost constant isotopic signatures and this trend does not follow seawater mixing. Tritium concentrations are either low (0.1-2.9 TU, n=6) or below detection limit (<0.3 TU, n=9) in tidal domain, whereas around 57% of data show 0.2-7.2 TU in fluvial area. Radiocarbon (C-14) signatures are also higher in fluvial area (around 50-88 pMC) than those in tidal domain (around 36-86 pMC).
These results indicate that present-day seawater intrusion or connate seawater/estuarine water entrapped within sediments is not a major source of elevated salinity in groundwater. Current seawater intrusion is being occurred probably only in limited areas, i.e., near the coast. Also, it is hypothesized that groundwater salinity was possibly provided through the dissolution of soluble salts in paleosols by paleo-precipitation and concurrent infiltration to aquifers. During the transgression, intertidal environment was dominated in the study area, where evaporites and mud-cracks were likely to be developed during prolonged dry season. Subsequently, the monsoonal precipitation dissolved these evaporite minerals and vertically infiltrated into aquifers through mud-cracks or sediments. The future tasks should concentrate on analyzing whether these processes are occurring currently in the delta as well as reconstruction of paleo-geography for validating the hypothesis.

Keywords: Elevated salinity, Upper shallow groundwater, Electrical conductivity, Isotopes, Intertidal environment, Evaporite minerals

©2019. Japan Geoscience Union. All Right Reserved.

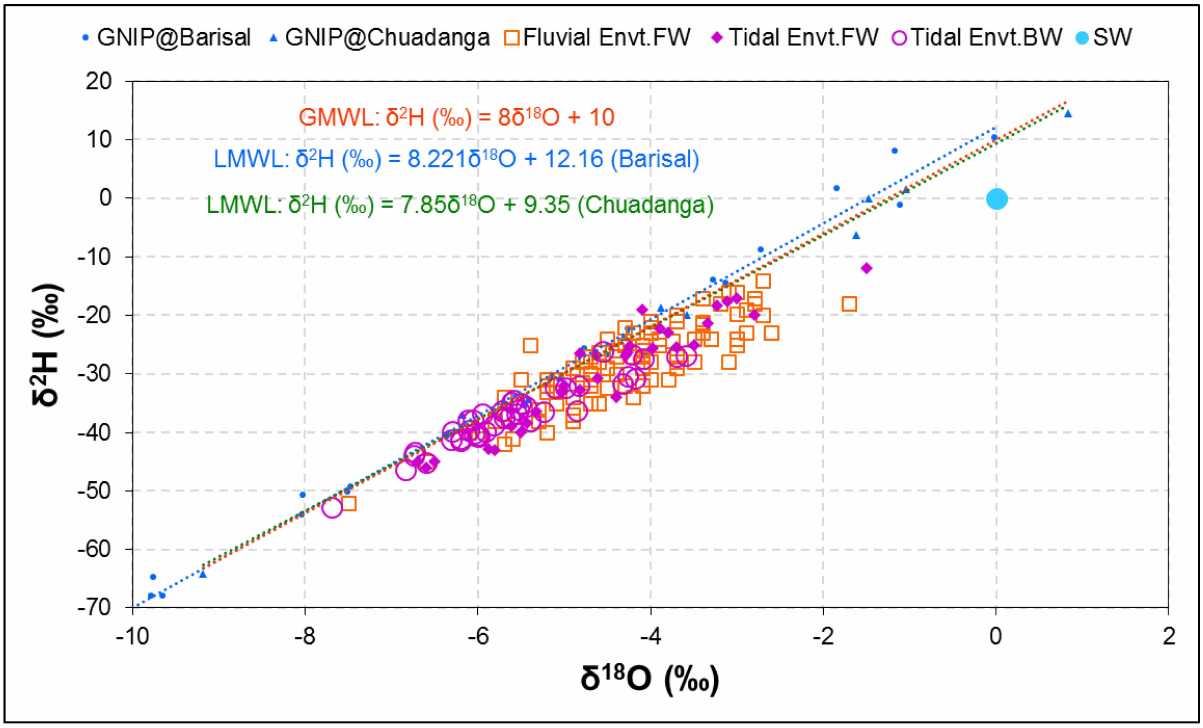


Figure 1: Cross plot between stable oxygen ($\delta^{18}O$) and deuterium ($\delta^{2}H$) isotopes

GNIP: Global Network of Isotopes in Precipitation, Envt.: Environment, FW: Freshwater (≤2000 µS/cm), BW: Brackish water (>2000 µS/cm), SW: Seawater

©2019. Japan Geoscience Union. All Right Reserved.

Groundwater chemistry in the Gunii Khooloi basin, Southern Gobi Region of Mongolia using multivariate analysis

*Batdemberel BAYANZUL[1,2], Isao Machida[3], Kengo Nakamura[2], Noriaki Watanabe[2], Takeshi Komai[2]

1. School of Geology and Mining Engineering, Mongolian University of Science and Technology, 2. Graduate School of Environmental Studies, Tohoku University, 3. Groundwater research group, Advanced Industrial Science and Technology

Water plays a vital role in the southern part of Mongolia where is climatically classified as an arid and semi-arid region, so called Southern Gobi Region of Mongolia (SGR). Groundwater serves as the only source of water supply and is largely utilized by mining companies such as the Tavan Tolgoi and Oyu Tolgoi Mine located in the SGR. The area is expected to face severe water shortages of mining and drinking water, which may be related to changes in groundwater recharge due to climate change. Understanding the geochemical evolution of groundwater and recharge mechanisms in the Gunii Khooloi basin is thus paramount for water resource management in this region. However, chemical compositions of groundwater in the SGR has not been studied so far.

In this study, the hydrogeochemical approaches have been introduced to characterize hydrogeochemical characteristics and its associated recharge processes in the Gunii Khooloi basin. To investigate this hydrogeochemical study, springs, groundwater in shallow wells and deep wells in the study area were sampled twice (in September 2016, and in June 2017). A total of 95 groundwater samples were collected within these two years for major chemical analysis in order to understand the general hydrogeochemical conditions of the Gunii Khooloi basin.

Here, we will present the groundwater chemical properties and relationship between shallow and deep groundwater in the Gunii Khooloi basin clarified by multivariate statistical analysis, such as principal component analysis (PCA) and hierarchical cluster analysis (HCA).

Keywords: Groundwater chemistry, Principal component analysis, Southern Gobi Region of Mongolia

©2019. Japan Geoscience Union. All Right Reserved.

Temporal observation of molybdenum concentrations in rivers from Erdenet mining area, Mongolia

*Solongo Tsetsgee[1], Keisuke Fukushi[1], Altansukh Ochir[2], Takahashi Yoshio[3], Ariuntungalag Yunden[2], Enkhjin Odgerel[2], Noriko Hasebe[1]

1. Kanazawa University, 2. National University of Mongolia, 3. The University of Toyko

Erdenet mine is one of the world’ s largest copper–molybdenum mine. This study is conducted the temporal observation of Mo concentrations in river waters. The waters were collected from three rivers, flowing thought Erdenet city, during 9 months in 2018 March to November.
During the summer Mo concentration was increasing with temperature and pH. On the other hand, When the winter was starting low concentration of Mo with low temperature and pH. The Mo concentration is positively correlated with pH and temperature. The tailing pond sample pH slightly lower than rivers due to it couldn’ t be increase of pH in river water. And also, sediment result showed that Mo concentration is lower than water. Therefore, another possibility of reason could be relating to the white dust and it can be increase pH of water.
A huge tailing pond is located in the north of the Erdenet area. It is recognized that the dried precipitates formed by the neutralization of the acidic mine water in the tailing ponds are dispersed widely in the Erdenet area by wind. The dried precipitates (so called white dust) are mainly composed with lime or carbonates containing high amount of Mo. It can be expected that the white dust may dissolve with rainwater. The increase of Mo concentrations associated with the increase of pH may be caused by the dissolution of the white dust at summer rainy season.

Keywords: Molybdenum , pH, Erdenet mine, River water, Temporal observation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 103 1F

[A-HW23] Hydrology & Water Environment

convener:Isao Machida(Geological Survey of Japan), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Takeshi Hayashi(Faculty of Education and Human Studies, Akita University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Keisuke Fukushi

We focus on various issues of water cycle and environment and aim to answer questions of hydrological and earth system sciences including 1) surface, subsurface and evapotranspiration processes of water cycle; 2) natural and anthropogenic hydrothermal systems, 3) environments issues and studies on a watershed or global scale, 4) water-related issues with ecological, environmental, and geochemical aspects, and 5) other issues in hydrological sciences. This session welcomes presentations regarding various kinds of approaches and techniques such as field survey, remote sensing, isotope tracers, numerical simulation, and theoretical analysis.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[AHW23-18] Solid-water interaction of Mn and As near the bottom of Lake Biwa. –Implications for the spatio-temporal change of these elements for past 40 years-

★Invited Papers

*TAKAAKI ITAI[1], SACHIKA NATORI[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AHW23-19] **Sources, pathways and treatment of contaminants in surface water: Applicability in developing countries**

*Mst. Shamsun Nahar[1] (1.Earth Consultant Co. Ltd, Toyama, Japan)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[AHW23-20] **Numerical simulations (COMSOL) of γ-Fe_2O_3 nanohybrids for transport (3D) and arsenic removal in homogeneous porous media**

*Ajay Kumar[1], Himanshu Joshi[1], Anil Kumar[1] (1.INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, INDIA)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[AHW23-21] **Transport processes of suspended solids in the Kumaki River inferred from atmospheric radionuclides**

*Shinya Ochiai[1], Ryunosuke Tahara[2], Tetsuya Matsunaka[1], Seiya Nagao[1] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[AHW23-22] Using tritium in Japanese precipitation for tritium-tracer transit time studies across Asia

*Maksym Gusyev[1], Yoshito Kikumori[1], Terumasa Nishihara[2], Takeshi Hayashi[3], Kimpei Ichiyanagi[4], Naofumi Akata[5], Tomoki Oda[6], Uwe Morgenstern[7], Michael Stewart[7] (1.International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), 2.Civil Engineering Research Institute for Cold Region, PWRI, 3.Akita University, 4.Kumamoto University, 5.National Institute for Fusion Science (NIFS), 6.University of Tokyo, 7.GNS Science, New Zealand)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

Discussion

Solid-water interaction of Mn and As near the bottom of Lake Biwa. –Implications for the spatio-temporal change of these elements for past 40 years-

*TAKAAKI ITAI[1], SACHIKA NATORI[1]

1. Department of Earth and Planetary Science, The University of Tokyo

Enrichment of Mn and As in the surface of sediment caused by diagenetic process has been reported from various lakes in the world. Lake Biwa is a typical example, in which clear enrichments of Mn (up to 5.7 wt%) and As (up to 900 mg/kg) within thin surface enriched layer (< 2 cm) of sediment were observed. This enrichment is caused by the accumulation of manganese oxide and arsenate both of which show lower mobility than these reducing chemical forms. However, decreasing trend of interannual minimum dissolved oxygen level reported from the lake-bottom can change redox behavior of these elements near the sediment-water interface (Itai et al. 2012, Sohrin et al. 2016, Fukushima et al. 2019). Through the geochemical survey after 2009, some specific scientific questions have been arisen.

(i) The degree of surface enrichment of Mn and As from 7 stations in northern lake were markedly increased in 2009 relative to 1977 (Itai et al., 2012). However, the source of them and process of this change are unclear.

(ii) The temporal increase of As in sediment is particularly significant in southern basin of northern lake (so called “first-basin”). The As accumulated on the surface of sediment is likely by scavenging from water column rather than upward diffusion from buried sediment. Nevertheless, difference between northern and southern basin (so called “second-basin”) is unclear.

(iii) Past study suggest that Mn and As level in sediment can be a unique indicator of palaeo water depth (Takamatsu, 1985). This is plausibly caused by higher enrichment of Mn and As toward deeper part of the lake. We confirmed this trend via measurement of 22 core sediments from northern lake. We hypothesize that this distribution is attributed to the geochemical focusing (Schaller et al., 1997), although scientific evidences are still not enough. Besides, there should be some specific mechanism to keep Mn and As enrichment after buried into deep sediment.

In order to answer these questions, we need comprehensive geochemical survey between water column and sediment with focusing speciation of these metals. In the presentation, we would like to present our dataset of lake water (3 stations, 10 m depth interval, 1 year), sediment core (30-40 cm depth, 22 stations), porewater (30 - 40 cm depth, 7 stations), filtered materials of 1, 3, 5, 7, 9 m from lake bottom (7 stations) characterized by X-ray absorption spectroscopy, micro beam chemical analysis, water chemistry analysis, porous diffusion model, and aqueous speciation calculation. Coupling with available monitoring data after 1950s, we make some constraints for the above questions.

Keywords: manganese, arsenic, speciation, redox environment, temporal change, lake sediment

©2019. Japan Geoscience Union. All Right Reserved.

Sources, pathways and treatment of contaminants in surface water: Applicability in developing countries

*Mst. Shamsun Nahar[1]

1. Earth Consultant Co. Ltd, Toyama, Japan

This report presents the contamination degree, occurrence, distribution characteristics in the surface water and sediments from Dhaka Rivers (Buriganga and Shitalakshya River) and the Bay of Bengal coast of Bangladesh. A model water treatment method is developing using Baburail Canal Water linked with Shitalakshya River, a World Bank supported project, under Narayanganj City Corporation, Bangladesh. By evaluating hypoxic to anoxic low dissolve oxygen (DO) (below the 0.85 mg/L critical level) associated with very high concentrations of biological oxygen demands (BOD) (5-10 mg/L) and toxic metals (Cr, As, Pb, Cd etc.) in surface water, a model treatment process is developing by using micro bubbling system for increasing the DO level, Neem leaves and bamboo powder are for heavy metals removal process and finally TiO_2 (P25)/ Fe^{+++} method is for the degradation and coagulation of organic content in treated water. The model method of this study should be applied to future water treatment focused on the potential to improve water quality in urban and surrounding areas in developing countries.

Keywords: Surface Water, Bay of Bengal, Dissolve Oxygen, Micro Bubbling System

©2019. Japan Geoscience Union. All Right Reserved.

Numerical simulations (COMSOL) of γ-Fe_2O_3 nanohybrids for transport (3D) and arsenic removal in homogeneous porous media

*Ajay Kumar[1], Himanshu Joshi[1], Anil Kumar[1]

1. INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, INDIA

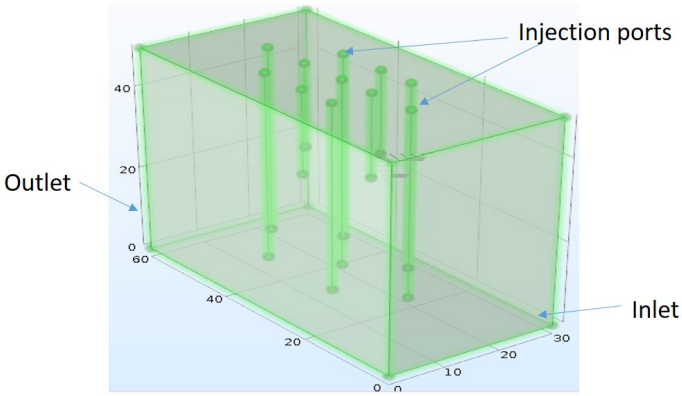
Worldwide, arsenic is a menace among the living communities due to its contamination in groundwater. It leaches moderately into groundwater from earth crust and bedrocks enriched with its ores. The countries like India and Bangladesh are being critically affected due to their densely populated areas. Several nanomaterials have been developed and examined as adsorbents for its removal, which are being utilized in *ex-situ* remediation technique. This technique has the disadvantages in terms of generating highly toxic waste, causes due to its easy mobilization in the living ecosystems. Nowadays, *in-situ* (subterranean) sequestration of arsenic is gaining considerable attention in respect to reduce the chance of its mobilization in living environment.

To this aim, the γ-Fe_2O_3 nanohybrids are developed using a novel approach of synthesis which include the usage of industry waste as one of precursor material. These nanoparticles have been found significantly stable in aqueous solutions representing real world groundwater conditions. The measured zeta (ζ)-potential value of -31.6 mV, indicated their significant colloidal stability. In respect to *in-situ* application, the understanding of transport modeling and retardation of nanomaterials in aquifer systems by simulating through numerical models in complex 3-dimensional scenario are necessary. Therefore, a modeling approach based on modified advection-dispersion-retardation equations has been investigated, considering the coupled influence of head difference and reaction rate of particle transport.

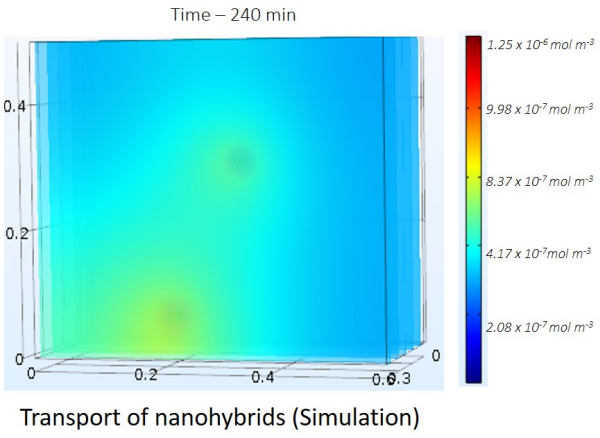
All the experiments were performed in a sand-tank set up (0.6 x 0.3 x 0.50 m) having several injection ports at variable depths. The tank was packed with the porous media (medium size sand) having the grain size (mm), grain density (g cm^{-3}), bulk density (g cm^{-3}) and effective porosity (%) values of 0.5-1.0, 2.33 ± 0.2, 1.55 ±0.09 and 0.34 ±0.1, respectively. The longitudinal and traverse dispersivity of consolidated media were calculated using NaCl as a tracer. The COMSOL Multiphysics model (subsurface module) was investigated for simulation of γ-Fe_2O_3 nanohybrids injection and their transport through porous media. Transport of arsenic and as-synthesized nanomaterial were modelled by considering these as solute and colloid, respectively, under fully saturated homogenous porous media and variable flow rate conditions. After simulation, the colloidal solution of nanoparticles was allowed to inject at the concentration of 1.25 x 10^{-4} mol m^{-3} and flow rate of 1.2 L h^{-1}. The simulation results were matched with the experimental observations which provided estimates of transport parameters. The retardation efficiency utilized to predict the γ-Fe_2O_3 nanohybrids in similar porous media, although the extend of injection pressure, colloid concentration and pumping rate may be underpredicted which require further investigations.

Keywords: Numerical modeling, In-situ arsenic sequestration, Groundwater

©2019. Japan Geoscience Union. All Right Reserved.



3-Dimesional view of Sand-Tank set up



Transport of nanohybrids (Simulation)

©2019. Japan Geoscience Union. All Right Reserved.

Transport processes of suspended solids in the Kumaki River inferred from atmospheric radionuclides

*Shinya Ochiai[1], Ryunosuke Tahara[2], Tetsuya Matsunaka[1], Seiya Nagao[1]

1. Institute of Nature and Environmental Technology, Kanazawa University, 2. Graduate School of Natural Science and Technology, Kanazawa University

The Kumaki River, which drains into the Nanao Bay, is in the central part of the Noto Peninsula. Over recent years, the vegetation in the catchment area of the Kumaki River has changed, and the areas of unmanaged forest and cultivated areas have progressively increased because of plantation activities and decreasing and aging population. These anthropogenic catchment environmental changes may affect the erosion and transport of clastic materials and particulate organic matter to the lower reaches and coastal areas. It is therefore important to clarify the transport processes of these materials to achieve proper management and prediction of environmental changes in river watersheds and coastal areas.
To investigate the transport processes of suspended solids (SS) in the Kumaki River, the atmospheric radionuclides ($^{210}Pb_{ex}$, ^{7}Be, and ^{137}Cs) of SS samples were observed. The SS samples were obtained with a continuous centrifuge of the river water (100 L) collected at the three sampling points (upstream, midstream, and downstream) in Kumaki River every month since April 2016. The concentrations of atmospheric radionuclides in SS samples were measured with a Ge detector. The water discharge was also measured based on cross-sectional profiles of water depth and the flow velocity with a leveling rod and a flow meter at each sampling point.
The $^{7}Be/^{210}Pb_{ex}$ activity ratio of SS sample, which is related to the residence time of these radionuclides in the catchment area, showed clear positive correlation with the water discharge and it was high during winter season with higher precipitation in each sampling point. This result indicates that SS was transported in a shorter time scale during rainfall event and winter season. On the other hand, $^{7}Be/^{210}Pb_{ex}$ ratio exceptionally decreased during heavy rainfall events with the higher water discharge over the threshold value, implying that older stored sediment and subsurface soil were eroded and transported under these conditions. Temporal and spatial changes in ^{137}Cs concentration and $^{137}Cs/^{210}Pb_{ex}$ ratio of SS sample showed different fluctuation in each sampling point, suggesting that changes in discharge amount and source of SS were affected by the subcatchment-scale local hydrological environments and land use conditions.

Keywords: suspended solids, river catchment area, atmospheric radionuclides

©2019. Japan Geoscience Union. All Right Reserved.

Using tritium in Japanese precipitation for tritium-tracer transit time studies across Asia

*Maksym Gusyev[1], Yoshito Kikumori[1], Terumasa Nishihara[2], Takeshi Hayashi[3], Kimpei Ichiyanagi[4], Naofumi Akata[5], Tomoki Oda[6], Uwe Morgenstern[7], Michael Stewart[7]

1. International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), 2. Civil Engineering Research Institute for Cold Region, PWRI, 3. Akita University, 4. Kumamoto University, 5. National Institute for Fusion Science (NIFS), 6. University of Tokyo, 7. GNS Science, New Zealand

In order to improve management of water resources, water circulation times are estimated with the use of tritium-tracer in catchments across Asia. As an environmental tracer generated in the upper atmosphere, tritium in precipitation is influenced by latitude, season and altitude, and understanding of tritium inputs in water cycle components is needed to estimate mean transit times (MTTs). For future studies, we established the latitude scaling factors to the north and south of the Tokyo area, which has the tritium measurements in monthly precipitation from 1961 to present, by investigating the latitude tritium effect at selected coastal stations in Asia (Gusyev et al., 2016; 2019). In Japan, higher spring tritium was confirmed with winter and spring precipitation samples in 2016 and we observed the altitude effect in March-April snowpack in Hokkaido. The importance of latitude and altitude effects is demonstrated with annual tritium in precipitation at Japanese meteorological stations compared to Tokyo tritium, and with estimated MTTs using 2016 tritium winter and summer baseflow samples at headwater catchments of the Tone and Ishikari River basins, Japan.

References:

Gusyev M.A., Morgenstern U., Nishihara T., Hayashi T., Akata N., Ichiyanagi K., Sugimoto A., Hasegawa A., Stewart, M.K. (2019). Evaluating anthropogenic and environmental tritium effects using precipitation and Hokkaido snowpack at selected coastal locations in Asia. Science of the Total Environment 659: 1307-1321, doi: 10.1016/j.scitotenv.2018.12.342

Gusyev M.A., Morgenstern U., Stewart M.K., Yamazaki Y., Kashiwaya K., Nishihara T., Kuribayashi D., Sawano H. and Y. Iwami (2016). Application of tritium in precipitation and baseflow in Japan: a case study of groundwater transit times and storage in Hokkaido watersheds. *Hydrol. Earth Syst. Sci.*, 20, 1-16, doi:10.5194/hess-20-1-2016

Keywords: tritium in precipitation, scaling factors, tritium input, mean transit times

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Misako Kachi(Earth Observation Research Center, Japan Aerospace Exploration Agency)

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick
up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG34-01] Current Status and Future Plan of the Global Change Observation Mission - Water (GCOM-W) and Advanced Microwave Scanning Radiometer 2 (AMSR2)

*Misako Kachi[1], Takashi Maeda[1], Nodoka Ono[1], Hideyuki Fujii[1], Marehito Kasahara[1], Naoto Ebuchi[1,2] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.Institute of Low Temperature Science, Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG34-02] Testing and Evaluation for JPSS-1 Algorithms using Algorithm Development Library Block 2.1

*Bigyani Das[1,2], Weizhong Chen[1,2], Thomas S King[1,2], Walter Wolf[2] (1.IMSG, 2.STAR/NESDIS/NOAA)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG34-03] Remote Sensing of Atmospheric and Surface Properties using Hyperspectral satellite Sensors

*Xu Liu[1] (1.NASA Langley Research Center)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG34-04] **RADIOMETRIC UNIFORMITY AND STABILITY OF GROUND SITE CHARACTERIZATION FOR INSAT-3D**

*Shailesh Parihar[1], R. Bhatla[1], A. K. Mitra[2] (1.Banaras Hindu University, Varanasi, India, 2.India Meteorological Department, New Delhi, India)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG34-05] Vicarious calibration activities of ASTER Thermal Infrared Radiometer (TIR) for Earth environmental observation

*Satoru Yamamoto[1], Hideyuki Tonooka[2], Soushi Kato[3], Kazuki Ayuzawa[2], Tsuneo Matsunaga[4] (1.Japan Space Systems, 2.Ibaraki University, 3.Remote Sensing Technology Center of Japan, 4.National Institute for Environmental Studies)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG34-06] **Overview of Vegetation Lidar MOLI**

★Invited Papers

*Haruhisa Shimoda[1], Toshiyoshi Kimura[2], Rei Mituhashi [2], Junpei Muruoka [2], Daisuke Sakaizawa[2], Tadashi Imai [2], Kazuhiro Asai[3] (1.Tokai University, 2.JAXA, 3.Tohoku Institute of Technology)

Current Status and Future Plan of the Global Change Observation Mission - Water (GCOM-W) and Advanced Microwave Scanning Radiometer 2 (AMSR2)

*Misako Kachi[1], Takashi Maeda[1], Nodoka Ono[1], Hideyuki Fujii[1], Marehito Kasahara[1], Naoto Ebuchi[1,2]

1. Earth Observation Research Center, Japan Aerospace Exploration Agency, 2. Institute of Low Temperature Science, Hokkaido University

The Global Change Observation Mission (GCOM) –Water (GCOM-W) is one of two medium sized satellites to provide comprehensive information of the Essential Climate Variables (ECV) of atmosphere, ocean, land, cryosphere, and ecosystem. The GCOM-W (Water) or “SHIZUKU” satellite that carries the Advanced Microwave Scanning Radiometer 2 (AMSR2), which was launched on May 2012; and GCOM-C (Climate) or “SHIKISAI” satellite that carries the Second-generation Global Imager (SGLI) and launched in December 2017. Both satellites are currently operating, and their data are distributed through the JAXA G-Portal (https://gportal.jaxa.jp/gpr/).

AMSR2 is multi-frequency, total-power microwave radiometer system with dual polarization channels for all frequency bands, and a successor of JAXA’s Advanced Microwave Scanning Radiometer for EOS (AMSR-E) on the NASA's Aqua satellite. Sensor specification of AMSR2 is almost identical to that of AMSR-E, except larger (2.0 m) antenna, additional 7.3 GHz channels to mitigate Radio Frequency Interference (RFI) and improved internal calibration. Due to its higher spatial resolution, all-weather capability, near-real-time availability and observation stability, AMSR2 data is routinely used in many operational and science applications. To provide consistent dataset between AMSR2 and AMSR-E for long-term water cycle monitoring and climate studies, we applied the latest AMSR2 algorithms and formats to AMSR-E data and have provided products through the G-Portal system. Level 1B and 1R (resampled L1B) products have been released since April 2018, and Level 2 products will be released early summer in 2019. We have also released new AMSR2 research products, Thin Ice Detection (sea ice thinner than 30 cm) and Total Precipitable Water over Land, since January 2019 through the GCOM-W Research Product Data Providing Service (https://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist.html).

The GCOM-W satellite has been in extended mission phase since 2017, and we expect to operate satellite and instrument as long as possible to reduce observation gaps between AMSR2 follow-on mission, which has been in Pre-project Phase (Phase A) since September 2018.

Keywords: satellite remote sensing, water cycle, microwave radiometer

©2019. Japan Geoscience Union. All Right Reserved.

Testing and Evaluation for JPSS-1 Algorithms using Algorithm Development Library Block 2.1

*Bigyani Das[1,2], Weizhong Chen[1,2], Thomas S King[1,2], Walter Wolf[2]

1. IMSG, 2. STAR/NESDIS/NOAA

The Joint Polar Satellite System 1 (JPSS-1) is the next generation polar-orbiting operational environmental satellite which was launched on November 18, 2017. It carries advanced versions of the instruments Advanced Technology Microwave Sounder (ATMS), Cross-track Infrared Sounder (CrIS), Ozone Mapping and Profiler Suite (OMPS) and Visible Infrared Imaging Radiometer Suite (VIIRS) that are on board of Suomi National Polar-Orbiting Partnership (S-NPP) satellite which was launched on October 28, 2011. All the Sensor Data Record (SDR) algorithms for the instruments are processed in the Interactive Data Processing Segment (IDPS) system designed and maintained by Raytheon. The Algorithm Development Library (ADL) Block 2.1 is an updated offline test system developed by Raytheon to mimic the operational system. Current version of the algorithm has gone through many recent code updates as well as Look-up-Table (LUT) updates for improving product quality. The center for Satellite Applications and Research (STAR) Algorithm Scientific Software Integration and System Transition Team (ASSISTT) uses ADL Block 2.1 to test and integrate updates to JPSS-1 algorithms, both code and the Lookup Tables (LUTs). Weekly updates are made to Dark tables for both OMPS Nadir Mapper (NM) and Nadir Profiler (NP) instruments and for both SNPP and JPSS-1 (J01) satellites. These are tested, integrated and submitted as packages with inputs, outputs and guide documents for further verification by the Data Products Engineering and Services (DPES) team and final integration by Raytheon in the operational system IDPS. Updates are also made to bi-weekly Wavelength and Solar tables for OMPS NP for SNPP satellite. They are tested and submitted in the package for operational implementation. We have created scripts to automate the staging and processing of weekly and bi-weekly updated LUTs in ADL Block 2.1. Details of the process of integration and application of the scripts for testing and integration of LUTs for OMPS as well as other instruments will be discussed.

Keywords: JPSS, Algorithm Integration, STAR ASSISTT, Algorithm Development Library

©2019. Japan Geoscience Union. All Right Reserved.

Remote Sensing of Atmospheric and Surface Properties using Hyperspectral satellite Sensors

*Xu Liu[1]

1. NASA Langley Research Center

Hyperspectral remote sensors from satellite platforms provide high information content on clouds, atmospheric temperatures, moisture, and trace gases profiles. They also provide surface information. In order to retrieve these information from hyperspectral remote sensing data, a fast and accurate radiative transfer model and a robust inversion algorithm are needed. We will describe a Principal Component-based Radiative Transfer Model (PCRTM) and an associated non-linear inversion algorithm. The PCRTM model can provide fast and accurate top of atmosphere high spectral resolution radiance or reflectance spectra from far infrared spectral region to UV-VIS spectral region. The forward model has been used to analyse hyperspectral data such as AIRS, CrIS, IASI, and SCIAMACHY. Examples of retrieval results from some of these satellite sensors will be given.

Keywords: remote sensing, atmospheric profiles, radiative transfer

©2019. Japan Geoscience Union. All Right Reserved.

RADIOMETRIC UNIFORMITY AND STABILITY OF GROUND SITE CHARACTERIZATION FOR INSAT-3D

*Shailesh Parihar[1], R. Bhatla[1], A. K. Mitra[2]

1. Banaras Hindu University, Varanasi, India, 2. India Meteorological Department, New Delhi, India

Radiometric phenomena of Earth Observation Satellite sensors vary between ground pre-launch calibration campaign, after launch and over satellite lifetime due to launching vibration, eventual optical element misalignments, generally space harsh environment. One of vicarious calibration methods is the reflectance-based approach that is applied here to radiometric calibration of INSAT-3D visible channel. In-situ vicarious calibration method for radiometric calibration of visible (VIS 550–750 nm) sensor onboard geostationary satellite INSAT-3D has been carried out for characterizing the radiometric uniformity of the site at Bhuj, Gujarat. The measurements of ground reflectance (spectral range of 350–2500 nm), aerosol optical depth (AOD), total column ozone from Spectroradiometer (spectral range of 350–2500 nm), Sunphotometer, Ozonometer respectively and other meteorological variables were obtained from site during the field campaigns and calibration coefficients with bias and relative error for optical sensor of the INSAT-3D satellite is presented. Based on these measurements, simulations of radiance reaching at top of the atmosphere (TOA) were carried out using radiative transfer model 6S (Second Simulation of the Satellite Signal in the Solar Spectrum). The computed TOA radiances when compared with the sensor measured radiances for various dates and sites show an over-estimation of TOA radiance. The analysis suggested that Bhuj site has been preferred for post launch vicarious calibration of optical sensor of INSAT-3D satellite as well as upcoming geostationary INSAT satellite series.

Keywords: INSAT-3D, vicarious calibration, radiative transfer model 6S

©2019. Japan Geoscience Union. All Right Reserved.

Vicarious calibration activities of ASTER Thermal Infrared Radiometer (TIR) for Earth environmental observation

*Satoru Yamamoto[1], Hideyuki Tonooka[2], Soushi Kato[3], Kazuki Ayuzawa[2], Tsuneo Matsunaga[4]

1. Japan Space Systems, 2. Ibaraki University, 3. Remote Sensing Technology Center of Japan, 4. National Institute for Environmental Studies

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on the Terra satellite has been retrieving multiband images with 14 spectral bands from the visible through thermal infrared and stereo images over the Earth's surface since 2000. The data set by ASTER has provided the composition and distribution of materials, temperature/emissivity map, and digital elevation topography models (DEM), contributing to a variety of Earth's science applications, i.e., natural resources, agricultural applications, natural disasters, geology, and urban development as well as monitoring global environmental change. In addition, the data of ASTER is being used for space business involved in space-enabled economic activity and service.

In order to establish the ASTER data for high-accuracy applications, radiometric calibration and atmospheric correction are highly important. Since any optical sensor is expected to degrade in space, we need to monitor the performance of the sensor over time based on onboard and vicarious calibrations. One of vicarious calibration approaches characterizes instrument performance based on comparison with the data measured by field campaigns at homogeneous ground areas such as lake and desert sites. The field campaigns for ASTER took place at various test sites such as Railroad Valley Playa, Lunar Lake, and Alkali Lake in Nevada and water sites such as Lake Kasumigaura in Japan during about two decades.

On 30 August through 1 September 2018, as part of annual vicarious calibrations for ASTER Thermal Infrared Radiometer (TIR), we conducted the field campaigns at Railroad Valley playa and Alkali Lake in Nevada. We also made the vicarious calibration at Lone Mountain playa in Nevada, which is a new test site discovered during this campaign. In this presentation, we will report the activity of the 2018's field campaigns at Nevada, and discuss how important the radiometric calibration after launch is to Earth's science applications including assessment of global environmental change based on satellites.

Keywords: multispectral data, remote-sensing, ASTER, Earth observation satellite, vicarious calibration

©2019. Japan Geoscience Union. All Right Reserved.

Overview of Vegetation Lidar MOLI

*Haruhisa Shimoda[1], Toshiyoshi Kimura[2], Rei Mituhashi [2], Junpei Muruoka [2], Daisuke Sakaizawa[2], Tadashi Imai [2], Kazuhiro Asai[3]

1. Tokai University, 2. JAXA, 3. Tohoku Institute of Technology

Under the PARIS AGREEMENT (Adopted at COP 21 in 2015), each country, including developing countries, is obliged to declare its emissions, but an objective verification method was considered necessary from the perspective of credibility and accuracy. It is said that one of the largest errors today is in the evaluation of CO_2 absorption by forests. Regarding the assessment of forests as a CO_2 absorption source, biomass and the change of biomass observed. We propose the use of airborne and satellite-mounted LIDAR as an effective method of directly measuring tree height. JAXA has begun studying the space vegetation LIDAR mission using the Multi-footprint Observation Lidar and Imager (MOLI) in collaboration with scientists. The main objective of this mission is to globally and precisely measure canopy height from space for improving biomass estimation. MOLI is designed to be mounted on the Exposed Facility (EF) of the Japanese Experiment Module on the International Space Station (ISS). The mission requirements for MOLI were set through discussions with scientists, and are listed as follows:

1. MOLI measures canopy height globally with accuracy of ±2 m (for canopy height less than 20 m) or ± 10% (for canopy height above 20 m) so as to generate map data of canopy heights and biomass, combined with imagery data from other satellites. The measurement data are also used as inputs or for validation in carbon cycle models.

2. Simultaneously, MOLI also measures the vegetation index and vegetation phenology for generating more accurate map data of canopy height and biomass.

3. MOLI measures the average amount of carbon per sub-national-scale area (80 km grid) to an uncertainty level of 20% or less (95% confidence interval).

The system requirements for MOLI are set based on the mission requirements. Regarding the waveform generated by the Geoscience Laser Altimeter System (GLAS) installed in the ICESat. However, waveforms with a lower S/N (less than 10) were excluded from analysis, as it greatly reduced the accuracy of canopy height measurement. Based on this result, the S/N requirement of MOLI was set to 10 or more, and the measurement precision of canopy height reached ±2 m or 10 %.

The tilted ground causes significant errors in measuring the canopy height due to the difference in height of the ground in the footprint. MOLI must be able to detect the inclination of the ground in order to estimate the difference in height of the footprint ground. Thus, MOLI must have a multi-footprint to estimate the tilt of the ground surface by detecting the time lag of each footprint.

Since MOLI needs to acquire data on vegetation phenology and vegetation index at the same time as the LIDAR observation to generate map data, it also has an optical imager with multiple bands. Using the imager, MOLI also measures the canopy height to identify the trees observed by MOLI for ground verification. The imager GSD is 5m. The imager also has green, red and NIR bands for measuring vegetation phenology and vegetation index.

©2019. Japan Geoscience Union. All Right Reserved.

To realize the sampling design, it is necessary to irradiate two laser beams and receive two reflection signals with the array detector. We considered dividing the laser beam into two laser beams by using an optical system. Based on this method, one laser transmitter is attached and the pulse energy is 40 mJ

Keywords: vegetation Lidar, MOLI, biomass

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 303 3F

[A-CG35] Projection and detection of global environmental change

convener:Michio Kawamiya(Japan Agency for Marine-Earth Science and Technology), Hiroaki Tatebe(Japan Agency for Marine-Earth Science and Technology), Kaoru Tachiiri(Japan Agency for Marine-Earth Science and Technology), Chairperson:Hiroaki Tatebe

Anthropogenic forcings on global environment are expected to cause intensification of extreme events, sea level rise, ocean acidification and deoxygenation, as well as large-scale ecosystem changes. The CMIP6 experimental protocol has been established based on which modeling groups across the world are starting to provide environmental projection data toward 6th IPCC assessment report due in 2021. Various new types of studies, such as event attribution and coupling of socio-economic processes and Earth system dynamics, are also emerging in the field of global change projection. In addition, observational studies are becoming increasingly more important for grasping changes in the global environment and evaluating model projections. Interactions and collaborations beyond boundaries of conventional scientific disciplines are desired for dealing with the issue of global changes. This session thus aims to deepen our understanding on global change, from both disciplinary and interdisciplinary viewpoints. This session is co-organized by AIMES - Future Earth project "Analysis, Integration and Modelling of the Earth System" (https://aimesproject.org/).

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[ACG35-01] Sour and anoxic Sea of Japan in the near future

*Chen-Tung Arthur Chen[1], Hon-Kit Lui[1], Masao Ishii[2] (1.National Sun Yat Sen University, 2.Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[ACG35-02] Decadal predictions of the variable ocean carbon uptake

★Invited Papers

*Hongmei Li[1], Tatiana Ilyina[1], Wolfgang A. Müller[1,2], Peter Landschützer[1] (1.Max Planck Institute for Meteorology, Bundesstraße 53, 20146 Hamburg, Germany, 2.Deutscher Wetterdienst, Bernhard-Nocht-Straße 76, 20359 Hamburg, Germany)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[ACG35-03] Air-sea CO_2 flux variations in the tropical Pacific simulated with two ESMs embedded an ocean data assimilation system

*Michio Watanabe[1], Hiroaki Tatebe[1], Hiroshi Koyama[1], Tomohiro Hajima[1], Masahiro Watanabe[2], Michio Kawamiya[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere and Ocean Research Institute, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[ACG35-04] A Study of Decadal Ocean Deoxygenation and Heat Uptake from a suite of OMIP Simulations

*Yohei Takano[1], Jerry Tjiputra[2], Jörg Schwinger[2], Matthias Gröger[3], Sarah Berthet[4], Roland Séférian[4], Andrew Yool[5], Julien Palmieri[5], Michio Watanabe[6], Irene Stemmler[1], Tatiana Ilyina[1] (1.Max Planck Institute for Meteorology, 2.Norwegian Research Centre, 3.Swedish Meteorological and Hydrological Institute, 4.Centre National de Recherche Météorologique, Unite mixte de recherche 3589 Météo-France/CNRS, 5. National Oceanography Centre, 6.Japan Agency for Marine-Earth Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACG35-05] Role of large-scale environmental variability in changing storm climate

*Nilima Aditya Natoo[1] (1.University of Bremen, Germany)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[ACG35-06] The forced response of the climate system: The case of climatic teleconnections

*Tamas Bodai[1], Matyas Herein[2], Gabor Drotos[3] (1.University of Reading, 2.Eotvos University Budapest, 3.Universitat de les Illes Balears)

Sour and anoxic Sea of Japan in the near future

*Chen-Tung Arthur Chen[1], Hon-Kit Lui[1], Masao Ishii[2]

1. National Sun Yat Sen University, 2. Japan Meteorological Agency

The ocean acidification is frequently related to hypoxia. In the paper "An anoxic Sea of Japan in 2200?" (Chen, Marine Chemistry, 1999) it was suggested that the sea is undergoing rapid de-oxygenation, and that the sea may become anoxic by the year 2200. But, a question mark was used in the title because of large uncertainties. In a recent Nature Climate Change paper (Chen et al., 2017), however, it was further concluded that the deep Sea of Japan has acidified at a faster rate than anywhere else in the world oceans. The conclusion of rapid acidification is in line with the conclusion of de-oxygenation. In addition, adding 20 years of new data confirms that the assessment of 1999 was correct. Likely the Sea of Japan would become sour and anoxic within the next two hundred years, if not sooner, based on nutrients, oxygen and pH data.

Keywords: Sea of Japan, acidification, hypoxia

©2019. Japan Geoscience Union. All Right Reserved.

Decadal predictions of the variable ocean carbon uptake

*Hongmei Li[1], Tatiana Ilyina[1], Wolfgang A. Müller[1,2], Peter Landschützer[1]

1. Max Planck Institute for Meteorology, Bundesstraße 53, 20146 Hamburg, Germany, 2. Deutscher Wetterdienst, Bernhard-Nocht-Straße 76, 20359 Hamburg, Germany

The global ocean, as a major carbon sink, absorbs about 25% of the contemporary anthropogenic CO_2 emissions; hence the carbon uptake by the ocean largely mitigates the CO_2concentration increase in the atmosphere and hence the global warming. Moreover, the strength of the carbon flux into the ocean, varies substantially from annual to decadal time-scale. Therefore, predicting the variable ocean carbon uptake and global carbon cycle is of essential value of tracing the fate of carbon and the corresponding climate and ecosystem changes.

By assimilating atmosphere and ocean physical observations into the decadal prediction system based on the Max Planck Institute Earth System Model (MPI-ESM), we reproduce the ocean carbon uptake variations in consistent with the data-based estimates. The retrospective predictions starting from the assimilation states show a predictive skill of 2 years in the ocean carbon uptake globally. Regionally the predictive skill is up to 5 years in the Southern Ocean and the North Pacific. To understand the mechanisms in maintaining the predictability of the ocean carbon uptake, we separate the ocean surface pCO_2, which is the main driver of the variability in carbon fluxes, into thermal and non-thermal components. The thermal component is affected by the solubility of CO_2via temperature variations, and the non-thermal component is affected by the ocean circulation and biology, i.e., is not first order affected by the temperature. We find that the thermal component contributes mainly to shorter-term (of <3 years) of predictive skill of the ocean carbon uptake, while the non-thermal component is responsible for longer-term (of >3 years) of predictive skill of the ocean carbon uptake.

Decadal prediction study of the global carbon cycle and corresponding ecosystem based on the ESMs is still at its early stage and facing a number of challenges arising from limited ocean biogeochemical observations and lack of proper initialization strategies. An extension of our predictions in the context of multi-model framework is in progress and this will facilitate deeper understanding of the mechanisms and further improvement of the predictive skill in the global carbon cycle.

Keywords: Decadal predictions, Ocean carbon uptake, Climate variability

©2019. Japan Geoscience Union. All Right Reserved.

Air-sea CO_2 flux variations in the tropical Pacific simulated with two ESMs embedded an ocean data assimilation system

*Michio Watanabe[1], Hiroaki Tatebe[1], Hiroshi Koyama[1], Tomohiro Hajima[1], Masahiro Watanabe[2], Michio Kawamiya[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Atmosphere and Ocean Research Institute, the University of Tokyo

Interannual-to-decadal fluctuations of the global-mean atmospheric CO_2 concentration are observed associated with internal climate variations, and these fluctuations sometimes cancel out and at other times support the centennial increasing trend of the global-mean atmospheric CO_2 concentration due to accumulation of anthropogenic CO_2 emissions. One direct cause of the fluctuations is the oceanic absorption or release of CO_2 through the global air-sea CO_2 flux variations which are mainly dominated by the tropical Pacific. Therefore, deeper understanding of the tropical oceanic processes and properly initializing oceanic states including marine ecosystem are of importance in future predictions of the global CO_2 concentration together with quantification of human-influences. In the present study, we examined the simulated air-sea CO_2 flux variations in the tropical Pacific in two ESMs (MIROC-ES2L and MIROC-ESM) with the same ocean data assimilation system. Although the assimilation procedures are the same, observed anti-correlated relationship between interannual variations of the upward air-sea CO_2 flux and the sea surface temperature (SST) in the tropical Pacific are well captured in MIROC-ES2L, but the relationship is reversed in MIROC-ESM. Tropical climatic-mean state of MIROC-ESM shows significant biases of weaker trade winds as well as more diffuse equatorial thermocline than observations, and simulated amplitude of interannual variations of NINO3-SST is about half as large as observations. When observations are assimilated into the model, these biases lead to non-negligible correction terms on the governing equations of ocean temperature and salinity, which induces an anomalous spurious equatorial upwelling during El-Niño events. The spurious upwelling brings dissolved inorganic carbon rich water in the subsurface layer to the surface mixed layer. Consequently, an anomalous upward air-sea CO_2 flux is occurred during El-Niño, as opposed to observations and MIROC-ES2L. Better modeling physical processes in the tropical climate system is suggested to be essential for better marine ecosystem modeling and reanalysis.

Keywords: Earth system model, data assimilation, air-sea CO2 flux, ENSO

©2019. Japan Geoscience Union. All Right Reserved.

A Study of Decadal Ocean Deoxygenation and Heat Uptake from a suite of OMIP Simulations

*Yohei Takano[1], Jerry Tjiputra[2], Jörg Schwinger[2], Matthias Gröger[3], Sarah Berthet[4], Roland Séférian[4], Andrew Yool[5], Julien Palmieri[5], Michio Watanabe[6], Irene Stemmler[1], Tatiana Ilyina[1]

1. Max Planck Institute for Meteorology, 2. Norwegian Research Centre, 3. Swedish Meteorological and Hydrological Institute, 4. Centre National de Recherche Météorologique, Unite mixte de recherche 3589 Météo-France/CNRS, 5. National Oceanography Centre, 6. Japan Agency for Marine-Earth Science and Technology

Observational studies reveal substantial ocean deoxygenation and increased heat uptake in the past decades. These two properties are known to be tightly connected. The Earth System Models (ESMs) struggle to simulate the observed trends in oxygen inventory (O_2-Inv) and the tight global O_2-heat relationship. One possible reason is the role of decadal climate variability.

The past decadal changes in oxygen inventory and tight global O_2-heat relationship cannot be fully explained by changes in solubility alone, indicating the important role of changes in ocean circulation and biology. Climate variability could modulate O_2-Inv and heat uptake on decadal timescales but the observed climate variability is not necessarily simulated in the ESMs historical simulations due to the fact that the models have their own internal climate variability, which vary in magnitude and phase, in the coupled climate system. Here we address the question how the observed decadal climate variability modulates O_2-Inv and heat uptake using a suite of OMIP simulations.

We will present results from the comparison of state-of-the-art ocean model simulations driven by the atmospheric reanalysis forcing. The main focus is to understand decadal changes in global and regional upper ocean O_2-Inv and OHC based on the results from six different model simulations (NorESM-OC, EC-EARTH3.3.0, CNRM-ESM2-1, UKESM1, MIROC-ES2L, and MPI-OM-HAMOCC), and observations. The model structural differences result in different physical and biogeochemical mean states, which lead to different decadal variability of O_2-Inv and OHC. The regional O_2-heat relationship among the models and observations would be presented to discern the biases in the simulated ocean circulations and biological processes. Our study will provide first indications of the importance of decadal climate variability on determining changes in O_2-Inv and OHC. Hence, it will also provide guidance on accuracy and uncertainty of future deoxygenation and warming projected in the ESMs. We aim on stimulating the discussion on near term strategy of how we analyze upcoming OMIP simulations within the context of climate variability and changes in ocean physics and biogeochemistry based on our multi-model analysis.

Keywords: Multi-model comparison, ocean deoxygenation, ocean heat uptake, decadal variability and trend

©2019. Japan Geoscience Union. All Right Reserved.

Role of large-scale environmental variability in changing storm climate

*Nilima Aditya Natoo[1]

1. University of Bremen, Germany

This paper focusses sequentially on two different aspects: (a) recent changes in observed storms, and (b) its linkages to the changes in large-scale environmental (LSE) variability. The analysis of observed storm show that in spite of an overall reduction in the Southwest Pacific (SWP) storminess over the past four decades, the number of extreme storms corresponding to the mean maximum sustained storm wind speed, has increased. At the same time, a slight reduction in the corresponding mean minimum central pressure is observed. The transition time from category 1 to 3 has also reduced substantially (by ~12 hours). Possible conditions for some of these observed behavioural change in terms of quick intensification and traveling longer distance towards south pole will be discussed.
The second aspect explores the linkages between above changes in storm indices and corresponding variability in LSE variability. The methodology uses multiple linear regression analysis to establish their relationship. This relationship is used to construct scenarios of likely change in future storminess using simulated (RCP8.5 minus historical) differences. The analysis will show how the role of some of the environmental indices when in combination can aid in modulating the Southwest Pacific change in storminess.

Keywords: Southwest Pacific, Storminess, Regression analysis

©2019. Japan Geoscience Union. All Right Reserved.

The forced response of the climate system: The case of climatic teleconnections

*Tamas Bodai[1], Matyas Herein[2], Gabor Drotos[3]

1. University of Reading, 2. Eotvos University Budapest, 3. Universitat de les Illes Balears

We frame the forced response of the climate system in terms of an ensemble that represents the so-called snapshot/pullback attractor, and explore the implications and power of this approach. Teleconnections as cross-correlations can be defined in the ensemble-based framework by evaluating the correlations over ensemble members. As a specific example, we studied the teleconnection between the El Niño–Southern Oscillation (ENSO) and the Indian summer monsoon in ensemble simulations from state-of-the-art climate models, the Max Planck Institute Earth System Model (MPI-ESM) and the Community Earth System Model (CESM). We detect an increase in the strength of the teleconnection in the MPI-ESM under historical forcing between 1890 and 2005, which is in contrast with scientific consensus. In the MPI-ESM no similar increase is present between 2006 and 2099 under the Representative Concentration Pathway 8.5 (RCP8.5), and in a 110-year-long 1-percent pure CO2 scenario; neither is in the CESM between 1960 and 2100 with historical forcing and RCP8.5. This is also a puzzling result inasmuch as the historical forcing is the weakest. Accordingly, we evaluated that the static susceptibility of the strength of the teleconnection with respect to radiative forcing (assuming an instantaneous and linear response) is at least three times larger in the historical MPI-ESM ensemble than in the others.

Keywords: teleconnection, ENSO, Indian monsoon, forced response, trajectory ensemble

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 303 3F

[A-CG35] Projection and detection of global environmental change

convener:Michio Kawamiya(Japan Agency for Marine-Earth Science and Technology), Hiroaki Tatebe(Japan Agency for Marine-Earth Science and Technology), Kaoru Tachiiri(Japan Agency for Marine-Earth Science and Technology), Chairperson:Kaoru Tachiiri(Japan Agency for Marine-Earth Science and Technology), Michio Kawamiya(JAMSTEC)

Anthropogenic forcings on global environment are expected to cause intensification of extreme events, sea level rise, ocean acidification and deoxygenation, as well as large-scale ecosystem changes. The CMIP6 experimental protocol has been established based on which modeling groups across the world are starting to provide environmental projection data toward 6th IPCC assessment report due in 2021. Various new types of studies, such as event attribution and coupling of socio-economic processes and Earth system dynamics, are also emerging in the field of global change projection. In addition, observational studies are becoming increasingly more important for grasping changes in the global environment and evaluating model projections. Interactions and collaborations beyond boundaries of conventional scientific disciplines are desired for dealing with the issue of global changes. This session thus aims to deepen our understanding on global change, from both disciplinary and interdisciplinary viewpoints. This session is co-organized by AIMES - Future Earth project "Analysis, Integration and Modelling of the Earth System" (https://aimesproject.org/).

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG35-07] Guiding Mother Earth: taking stock of progress to a long-term temperature goal

★Invited Papers

*Myles Robert Allen[1] (1.Environmental Change Institute, School of Geography and the Environment and Department of Physics, University of Oxford)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG35-08] Uneven distributions of four hazard indicators of climate change with the Paris Agreement's goals

*Hideo Shiogama[1] (1.Center for Global Environmental Research, National Institute for Environmental Studies)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG35-09] Understanding the centennial-scale human-natural interactions using an integrated terrestrial model MIROC-INTEG under ISIMIP2 project

*Yusuke Satoh[1], Julien Boulange[1], Naota Hanasaki[1], Kumiko Takata[1], Yadu Pokhrel[3], Ted Veldkamp[2,4], Peter Burek[2], Tokuta Yokohata[1] (1.National Institute for Environmental Studies, 2.International Institute for Applied Systems Analysis, 3.Department of Civil and Environmental Engineering, Michigan State University, 4.Institute for Environmental Studies (IVM), VU Amsterdam)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG35-10] Radiative forcing of the physiological CO_2 response

*Victor Brovkin[1], Veronika Gayler[1], Sonia I Seneviratne[2], Pierre Gentine[3] (1.Max Planck Institute for Meteorology, Hamburg, Germany, 2.ETH, Institute for Atmospheric and Climate Science, Zurich, Switzerland, 3.Columbia University, Earth and Environmental Engineering, New York, USA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG35-11] Progress of MIROC-ES2 simulations in CMIP6 and the analysis of the biogeochemical feedbacks

*Tomohiro Hajima[1], Shingo Watanabe[1], Michio Kawamiya[1], Kaoru Tachiiri[1], Hiroaki Tatebe[1], Akihiko Ito[2], Kumiko TAKATA[2], Michio Watanabe[1], Maki Noguchi[1], Akitomo Yamamoto[1], Akinori Ito[1], Manabu

Abe[1], Rumi Ohgaito[1], Dai Yamazaki[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Environmental Studies, 3.Institute of Industrial Science, the University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG35-12] The impact of long-term historical warming on the global terrestrial gross primary production

*Irina Melnikova[1], Takahiro Sasai[1] (1.Tohoku University)

Guiding Mother Earth: taking stock of progress to a long-term temperature goal

*Myles Robert Allen[1]

1. Environmental Change Institute, School of Geography and the Environment and Department of Physics, University of Oxford

The IPCC Special Report on 1.5˚C found that human-induced global warming had reached 1˚C ±0.2˚C, increasing at 0.2˚C per decade, leaving only a few decades for emissions to be reduced to net zero to limit warming to 1.5˚C. The Paris Climate Agreement introduced a regime of periodic stocktakes of progress to the long-term temperature goal of limiting warming to well below 2˚C, pursuing efforts to 1.5˚C. While there is general agreement that these stocktakes are to be informed by science, these is less consensus on how this will be done. I will explain how we can robustly estimate the level of human-induced warming to date, and how this information was used to support a revision in the remaining carbon budget for cumulative future CO_2 emissions consistent with limiting warming to 1.5˚C. CO_2 budgets in the IPCC Special Report were contingent on scenarios for non-CO_2 forcing, but the concept of a carbon budget can be generalised if we recognise how other anthropogenic forcing agents affect climate on different timescales, either expressing them as CO_2-forcing-equivalent emissions, or applying the traditional GWP_{100} metric in a new way. Taken together, these insights provide a simple, transparent, scenario-independent and model-independent method of assessing the implications of current and future emissions for progress towards a long-term temperature goal.

Keywords: Climate change, Greenhouse-gases, Stocktake, Attribution, Metrics, Forcing

©2019. Japan Geoscience Union. All Right Reserved.

Uneven distributions of four hazard indicators of climate change with the Paris Agreement's goals

*Hideo Shiogama[1]

1. Center for Global Environmental Research, National Institute for Environmental Studies

Clarifying characteristics of hazards and risks of climate change at 2ºC and 1.5ºC global warming is important for understanding the implications of the Paris Agreement. We perform and analyse large ensembles of 2ºC and 1.5ºC warming simulations. In the 2ºC runs, we find substantial increases in extreme hot days, heavy rainfalls, high streamflow and labor capacity reduction related to heat stress. For example, about half of the world's population will experience a present day 1-in-10 year hot day event every other year at 2ºC warming. The regions with largely increases of these four hazard indicators coincide with countries characterized by small CO_2 emissions, low-income and high vulnerability. Limiting global warming to 1.5ºC, compared to 2ºC, will lower increases in the four hazard indicators especially in those regions.

Keywords: Climate change, Paris Agreement

©2019. Japan Geoscience Union. All Right Reserved.

Understanding the centennial-scale human-natural interactions using an integrated terrestrial model MIROC-INTEG under ISIMIP2 project

*Yusuke Satoh[1], Julien Boulange[1], Naota Hanasaki[1], Kumiko Takata[1], Yadu Pokhrel[3], Ted Veldkamp[2,4], Peter Burek[2], Tokuta Yokohata[1]

1. National Institute for Environmental Studies, 2. International Institute for Applied Systems Analysis, 3. Department of Civil and Environmental Engineering, Michigan State University, 4. Institute for Environmental Studies (IVM), VU Amsterdam

Within the earth system, changing-climate, -human society, and -ecosystems interact mutually. It is crucial to better understand the interconnectedness among such human-natural systems in order to assess the potential impacts of climate and socioeconomic changes on each system and identify sustainable pathways. Although existing earth system models and integrated assessment models are applicable to explore this field, parts of their natural and/or human processes tend to be simplified depending on their scope. Therefore, it still remains a challenge to improve integrated modeling frameworks. For these reasons, a process-based integrated terrestrial model, MIROC INTEGrated terrestrial model (MIROC-INTEG), was developed. The modeling framework is composed of five natural/human subcomponents. At its core is a land surface model (MATSIRO), which is coupled to three human modules; water use (H08), food and biofuel crop production(PRYSBI2) and land use change (TELMO). An ecosystem model (VISIT) calculates the C and N cycles among atmosphere-vegetation-soil. While each sub-model can run independently, MIROC-INTEG dynamically simulates their interactions, embracing the water-food-energy nexus within a system.

The goal of this study is to improve our quantitative understanding on coupled terrestrial systems at the global scale for past and future time-scales. Hence, we have run MIROC-INTEG following the Inter-Sectoral Impact Model Inter-comparison Project phase 2a (ISIMIP2a) and 2b (ISIMIP2b) simulation protocols. Using 3 hourly climate forcing data and considering anthropogenic activities, MIROC-INTEG simulated agro-hydrological condition at a spatial resolution of 0.5˚, globally. As its inputs, ISIMIP2a makes use of three reanalysis-base metrological data for historical periods, and ISIMIP2b employs an ensemble of bias-corrected forcing data set of four general circulation models covering preindustrial, historical, and future time-periods under four representative concentration pathways. Furthermore, ISIMIP provides a unique opportunity for validation of simulation skill in comparison with other models' under consistent protocols.
Within this contribution we present the first results of MIROC-INTEG looking specifically at the centennial-scale human-natural interactions over the period 1851-2099 and its consequences for long-term changes in fundamental hydrological variables. The results are presented at global, regional and large-basin scale and are compared against existing ISIMIP runs of other hydrological and land surface models.

Keywords: Integrated terrestrial model, Human intervention, climate and socio-economic change, multi-forcing, model inter comparison

©2019. Japan Geoscience Union. All Right Reserved.

Radiative forcing of the physiological CO_2 response

*Victor Brovkin[1], Veronika Gayler[1], Sonia I Seneviratne[2], Pierre Gentine[3]

1. Max Planck Institute for Meteorology, Hamburg, Germany, 2. ETH, Institute for Atmospheric and Climate Science, Zurich, Switzerland, 3. Columbia University, Earth and Environmental Engineering, New York, USA

Theory and observations indicate that plant stomatal conductance decreases in response to increase in the atmospheric CO_2. This physiological CO_2 response causes reduction in the evapotranspiration and modification of the global hydrological cycle, affecting the global radiative fluxes and climate sensitivity. While this biogeophysical mechanism is included into all comprehensive Earth System Models, its radiative forcing has not been isolated from the other biospheric feedbacks. To evaluate the scale of its radiative forcing, we performed two sensitivity experiments with the CMIP6 version of the MPI Earth system model (MPI-ESM1.2-LR). In addition to the standard 4xCO_2 simulation, in which both climate and carbon cycle respond to an instantaneous 4-fold increase in CO_2, we performed the 4xCO_2rad simulation in which biogeochemistry and plants were not affected by elevated CO_2. We analyse changes in outgoing radiation and surface temperature using the Gregory et al. (2004) approach for radiative forcing, and compare results with- and without physiological CO_2 response. Rescaling to the doubling of the CO_2 concentration, stomatal conductance response increases equilibrium climate sensitivity of the model by ca. 10%, and its radiative feedback is estimated at 0.14 W/m^2/K. This suggest that the magnitude of this positive biogeophysical feedback is comparable with the magnitude of biogeochemical (climate-carbon) feedback.

Keywords: climate feedbacks, vegetation cover, radiative forcing

©2019. Japan Geoscience Union. All Right Reserved.

Progress of MIROC-ES2 simulations in CMIP6 and the analysis of the biogeochemical feedbacks

*Tomohiro Hajima[1], Shingo Watanabe[1], Michio Kawamiya[1], Kaoru Tachiiri[1], Hiroaki Tatebe[1], Akihiko Ito[2], Kumiko TAKATA[2], Michio Watanabe[1], Maki Noguchi[1], Akitomo Yamamoto[1], Akinori Ito[1], Manabu Abe[1], Rumi Ohgaito[1], Dai Yamazaki[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Institute for Environmental Studies, 3. Institute of Industrial Science, the University of Tokyo

In order to reveal how climate-biogeochemical system responds to anthropogenic forcing, a new Earth system model “MIROC-ES2L” has been developed for CMIP6. The physical core of the model is “MIROC5.2”, and the biogeochemical component are updated from that used for CMIP5: the new model has explicit CN interaction in land ecosystem, and ocean component has been improved to include P, Fe, and O in addition to C and N cycles that were already incorporated into that of CMIP5 ver. In the new model, ocean N cycle is opened to other subsystems: N input via biological fixation, deposition and riverine transport are considered, and denitrification process controls N loss from the ocean. This model is used for CMIP6 runs, by participating in endorsed MIPs such as C4MIP, PMIP, OMIP, LUMIP, CDRMIP, ScenarioMIP, VolMIP, etc.
A provisional historical simulation by MIROC-ES2L with CMIP6 official forcing (v6.2.1) clearly showed a global warming trend from 1970’s, which is consistent with observation (HadCRU4). Carbon stored in land ecosystem decreased by responding to the land-use change forcing, and started to increase around 1960 by responding to CO2 increase and increased N input into land (N deposition and fertilizer), in addition to the response to LUC. Ocean continuously store the anthropogenic CO2: the increase during 1850-2005 is about 150PgC, which is almost similar level to the number reported in Global Carbon Budget 2017. In addition to C cycle, the historical simulation showed drastic changes in global N budget, by directly responding to the anthropogenic forcing (LUC and agriculture), and indirectly affected by climate–carbon cycle change. Agriculture increased both land N2O emission (diagnosed) and N leaching, the latter of which impacted on ocean biogeochemistry near river mouths.

Keywords: Earth system model, Biogeochemistry, CMIP6, Carbon cycle, Feedback

©2019. Japan Geoscience Union. All Right Reserved.

The impact of long-term historical warming on the global terrestrial gross primary production

*Irina Melnikova[1], Takahiro Sasai[1]

1. Tohoku University

The recent increase of carbon dioxide in the atmosphere from anthropogenic emissions resulted in the increase of carbon uptake by the global biosphere. The most uncertain contributor to the interannual global uptake variability is land, and the largest and primary land carbon flux is gross primary production (GPP). In this study, we aim to estimate the impact of the long-term (1951–2010) historical warming on the global terrestrial GPP. We use the Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data (BEAMS ver.1.3) [*Sasai et al.*, 2016] forced by historical and nonwarming simulation climates of the Database for Policy Decision making for Future climate change (d4PDF) [*Mizuta et al.*, 2017]. This is a pioneer study to apply a diagnostic GPP estimation approach on the large-size ensembles climate data to simulate the long-term global GPP.

First, we evaluated the surface d4PDF climatology in comparison with existing modern datasets, including reanalyses, and discussed the benefits and limitations of the database in the studies of the terrestrial carbon fluxes. Second, we validated the BEAMS GPP forced by d4PDF data against observations and evaluated the BEAMS performance against existing GPP grid-datasets by other approaches (data-driven datasets and process-driven models). Finally, we discussed the impact of the long-term historical warming on the global GPP in terms of decadal trends and density histograms.

We confirmed that d4PDF surface climatology is appropriate for use in the studies of the terrestrial carbon fluxes, and d4PDF historical climate data is comparable to existing modern datasets. BEAMS estimated both the magnitude and decadal trends of the global terrestrial GPP realistically by using the benefits of the diagnostic approach. The global long-term (1951–2010) mean GPP equaled 144.0 ±2.3 GtC $year^{-1}$ for historical and 140.3 ±1.3 GtC $year^{-1}$ for nonwarming climates. The accumulated increase of the historical warming-induced GPP equaled 184.8 ±5.8 GtC for the period of 1951–2010 and accounted for nearly half of all anthropogenic emissions. The GPP increase intensified over time. The density histogram analyses showed that the global GPP distribution in the present (2001–2010) share neither the mean nor spread of GPP in the nonwarming climate.
This study provides the evidence of the impact of long-term historical warming on the global GPP by a novel approach using the benefits of the diagnostic model and large-size ensemble climate data.

Keywords: GPP, climate change, BEAMS, diagnostic approach, large-size ensemble, d4PDF

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-GM Geomorphology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 101 1F

[H-GM03] Geomorphology

convener:Tsuyoshi Hattanji(Faculty of Life and Environmental Sciences, University of Tsukuba), Masayuki Seto(Fukushima Future Center for Regional Revitalization, Fukushima University), Chairperson:Thomas Parkner, Tsuyoshi Hattanji

The main subject of this session is interdisciplinary discussion on the whole range of themes relating to geomorphology, especially geomorphic processes, landform development and its relation to environmental changes, geomorphological hazards and their mitigation, relationships among geomorphic processes, other natural phenomena and human activities, and various techniques of geomorphological measurements and landform classification. All presentations and discussion of this session are made in English.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HGM03-01] Surface structure as a control for gully complex development in the Mackey`s block, North Island, New Zealand

*Thomas Parkner[1] (1.University of Tsukuba, Graduate School of Life and Environmental Sciences)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HGM03-02] Model Linking Landslides and River Evolution of Incisional Channel Created by River Erosion

*Chia-Ting Kao[1], Gene Jiing-yun You[1] (1.National Taiwan University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HGM03-03] **A semi-automated method for extracting channels and channel profiles from LiDAR-derived digital elevation models**

*Pinliang Dong[1] (1.University of North Texas)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HGM03-04] Laboratory experiments on the landform development

*Shunji Ouchi[1] (1.Faculty of Science and Engineering, Chuo University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HGM03-05] Characteristics of lake sediment from southern part of Mongolia and comparison to meteorological data

*Uyangaa Udaanjargal[1], Noriko Hasebe[1], Keisuke Fukushi[1], Tanaka Yukiya[2], Davaadorj Davaasuren[4], Makoto Sambo[1], Baasansuren Gankhurel[1], Nagayoshi Katsuta[3], Shinya Ochiai[1], Tuvshin Gerelmaa[4] (1.Kanazawa University, 2.Kyunghee University, 3.Gifu University, 4.National University of Mongolia)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HGM03-06] **Evaluation of geomorphological changes on Kujukuri beach based on UAV SfM**

*Mergen Kungaa[1], Toshihiko Sugai[1], Natsuki Sasaki[1], Taiga Kimori[1], Taro Funatsu (1.Tokyo University, Graduate School of Frontier Sciences, Department of Natural Environmental Studies)

Surface structure as a control for gully complex development in the Mackey`s block, North Island, New Zealand

*Thomas Parkner[1]

1. University of Tsukuba, Graduate School of Life and Environmental Sciences

Gully erosion occurs on many steep, erosion-prone slopes. While most research focusses on gully formation by water erosion, gullies can also enlarge by mass movement processes. In New Zealand, such process combinations are named gully complexes. While concepts on gully complex development are available, material variability - other than lithology –is not included. In this study, development of gullies and gully complexes is analyzed by focusing on properties of the initial surface into with gullies and gully complexes erode to relate gully orientation and erosion intensity to surface structure.

The study area consists of 12 headwater catchments in the Mackey`s Block, North Island, New Zealand. Bedrock consists of Cretaceous-aged, highly crushed and sheared mudstones and sandstones. Deforestation by European settlers at the beginning of the 20th century for pastoral farming was followed by reforestation for wood production from the 1980s. Sequential aerial photographs from 1939 to 2005 were interpreted to map mass movements and the development of gullies. Digital elevation models were extracted from aerial photography from 1957 to 2002 using ERDAS to relate surface structure to gully orientation and erosion intensity.

Mapping results indicate that prior to a severe gully erosion phase, which started shortly before the first aerial photography in 1939, the surface structure is charaterized by (revegetated) small gullies, deep-seated landsliding with double ridges, and shallow flows. Deep (few meters to 15m) gullies complexes incised at the toe of mass movement bodies and eroded upslope. Such gullies developed oversteepened sidewalls, which in turn initiate extensive mass movements at the gully walls. Erosion intensity increased suddenly, where gullies destabilized mass movement deposits. Above the deep gully complexes, shallow (about 1 -2m deep), hundreds of meter long gully arms extended along boundaries of mass movements. These results indicate that next to morphometric parameters (slope, catchment size), material type, vegetation change, and moisture conditions, the development of gully complexes is also controlled by surface structure.

Keywords: gully, mass movement

©2019. Japan Geoscience Union. All Right Reserved.

Model Linking Landslides and River Evolution of Incisional Channel Created by River Erosion

*Chia-Ting Kao[1], Gene Jiing-yun You[1]

1. National Taiwan University

Landslides produce enormous volumes of sediment in mountainous watersheds. However, quantifying landslide-derived sediment transported downstream remains a challenge. This study makes effort in determine the amount of landslide-derived sediment that eroded by the water and the ratio of sediment yield of this problem. We try to use a coupled two-dimensional model to investigate the evolution of landslide aggregation influenced by the channel flow.In this study, the shallow water equations consider the two-dimensional distribution flow velocity to estimate the shear stress. In addition, the Exner equation is applied to calculate the sediment transport the landslide aggregation evolution. By assuming constant inflow, the Exner equation can be derived as a diffusion equation. Besides, both of the two equations under a horizontal 2D straight, non-erodible banks, and no secondary flow channel can be derived as our governing equation which has the nonlinear terms, and the analytical method may not work to solve the two equations under the 2D condition. As a result, this study adopts the finite volume method to proceed this work. This proposed model will be able to have a better presentation in estimating the landslide-derived sediment in channel, and these sequences are expected to be useful indicators in the watershed management according to the predicted the upstream of watershed sediment yield .

Keywords: Landslide aggregation, River erosion, Finite volume method, Exner equation, Shallow water equations, Numerical modeling

©2019. Japan Geoscience Union. All Right Reserved.

A semi-automated method for extracting channels and channel profiles from LiDAR-derived digital elevation models

*Pinliang Dong[1]

1. University of North Texas

Stream channels are an integral part of hydrology, alluvial geomorphology and tectonic geomorphology, and have long been studied qualitatively and quantitatively. With the advent of digital elevation models (DEMs) and geographic information systems (GIS), several methods have been proposed to extract channels from raster DEMs. This presentation introduces a semi-automated method for extracting stream channels from high resolution DEMs. The methodology flowchart includes the following major steps: (1) channel detection, (2) mathematical morphological operation, (3) vectorization, (4) profile generation, and (5) accuracy assessment. The method is implemented as an ArcGIS Python add-in toolbar. The application of the toolbar is demonstrated using a LiDAR-derived DEM in a study area along the San Andreas Fault in California, USA.

Keywords: Stream channel, Digital elevation model, Geographic information system, Light detection and ranging (LiDAR), Python

©2019. Japan Geoscience Union. All Right Reserved.

Laboratory experiments on the landform development

*Shunji Ouchi[1]

1. Faculty of Science and Engineering, Chuo University

Geomorphic experiments with uplift and rainfall erosion are expected to provide some important knowledge to interpret the development of landform, which has left only scarce and hard-to-find evidence. This type of experiments had not been conducted so often, probably because no one had a good idea to scale down the processes of landform development. In recent years, however, laboratory experiments on the development of landform were increasingly conducted for the purpose to verify numerical/analytical models, which have been promoted by the development of computer technology and the spread of DEM, while the fundamental problems of huge scale difference have not been solved yet. Some of these recent experiments demonstrated a certain mechanism or a law governing the experimental landform development, such as the self-organized criticality or the competition between diffusive hill slope transport and advective transport in channels, which was suggested by numerical analyses. This indicates the applicability of numerical models to the experimental landform, but not to the real landform yet, although the authors believed it. Real landforms we see today have developed in the geographical space through the historical time, and inevitably have infinite varieties. We can find landscapes similar to the experimentally formed landscapes somewhere in the world, but this does not mean that mechanisms or laws dominated in the experiment also work on the real landform. The experimental landform develops within a certain setting, which is restricted by the facilities and arranged for the purpose. We still have a lot to do before taking the experiments as a bridge between numerical models and natural landscapes. I have been conducting a series of geomorphic experiments with changing experimental settings (40 runs by now), and I here try to make clear the significance of experiments in the study of geomorphology on the basis of these experiments.
A mixture of fine sand and kaolinite (10:1 by weight) compacted in a square prism-shaped stainless container (ca. 60×60×40cm) is pushed up by the uplift-generating device put under the bottom plate of container. Mist-type rainfall is generated by a pump through spray nozzles. The results of experiments suggested the existence of two thresholds of uplift rate, which is the most important independent controlling factor. Below the lower threshold, fluvial erosion offsets the surface rising by slow uplift, and gentle landforms reflecting the mound erodibility and rainfall intensity appear (Characteristic relief phase). Above the upper threshold, uplift overwhelms and a massive mountain grows until it hits the limit of experimental facilities (Mountain building phase). When the uplift rate is between the lower and upper thresholds, average surface height stops increasing and changes around a certain height depending on the uplift rate, after valley systems develop and slopes grow enough to cause landslides (Steady state phase). This steady state phase is the most common condition through the series of experiments. Rainfall intensity is expected to affect the amount of surface flow; and therefore, the rate of erosion. Low rainfall generates less surface flow, and this reduces erosion and make the surface grow higher. Permeability of the sand mound is considered to have a similar effect concerning the surface flow. However, more permeable material, associated with lower sear strength, promotes slope failures even in the earlier stage. The surface, therefore, becomes lower even with less rainfall. These factors, which relate each other themselves, apparently have complex effects on the development of experimental landform. The relationships among these controlling factors can be compared to those concerning real landform. Revealing these relationships and their effects on the experimental landform is probably the key to make geomorphic experiments meaningful in the study of geomorphology.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: geomorphic experiment, uplift, rainfall intensity, fluvial erosion, landslide, permeability

©2019. Japan Geoscience Union. All Right Reserved.

Characteristics of lake sediment from southern part of Mongolia and comparison to meteorological data

*Uyangaa Udaanjargal[1], Noriko Hasebe[1], Keisuke Fukushi[1], Tanaka Yukiya[2], Davaadorj Davaasuren[4], Makoto Sambo[1], Baasansuren Gankhurel[1], Nagayoshi Katsuta[3], Shinya Ochiai[1], Tuvshin Gerelmaa[4]

1. Kanazawa University, 2. Kyunghee University, 3. Gifu University, 4. National University of Mongolia

Mongolia is located in center of the Central Asia and it provides an important key archive for the research of climate characteristics inside continents. Lake sediments are an excellent archive to study long-term fluctuations of environmental conditions (Gunten et al. 2009). Lake is the subject to a variety of extrinsic and intrinsic forcing variables that regulate the subsequent history of the lake, such as climate, watershed bedrock composition, tectonic and volcanic activity, vegetation, aquatic biota, and human activities (Gierlowski-Kordesch, 2004). To understand how climate system works in Mongolia and how we can extract information from the lake sediments, sediment cores of about 30 cm long from Boontsagaan, Orog and Olgoy lakes are analyzed and compared to the meteorological data (air temperature, precipitation and wind) of Galuut and Baatsagaan stations, Bayanhongor Province. The sedimentary features include whole and mineral grain size, grain density, water, organic matter, carbonate, and amorphous silica contents. Sedimentary ages were estimated by excess 210Pb measurement. According to the comparison between sediment characteristics and climate condition, temperature is correlated to whole grain size in three of lakes.

Further comparison reveals that calcium carbonate concentration, amorphous silica concentration, and mineral grain size correlate to temperature in Boontsagaan and Olgoy lakes. In Orog lake, wetter years with high wind and much rainfall result in fine grain size, while the high amount of $CaCO_3$and organic flux is found during the low precipitation. Some of the major fluctuations may indicate indirect consequence of climate change, for instance, some events such as the earthquake or a permafrost degradation.

Keywords: lakes , sediment characteristics, climate condition

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of geomorphological changes on Kujukuri beach based on UAV SfM

*Mergen Kungaa[1], Toshihiko Sugai[1], Natsuki Sasaki[1], Taiga Kimori[1], Taro Funatsu

1. Tokyo University, Graduate School of Frontier Sciences, Department of Natural Environmental Studies

Nowadays, structure from motion (SfM) photogrammetry became a powerful tool in the hands of coastal researchers. During 2018-2019 we conducted 4 aerial survey by UAV on the 4 km long stretch on Kujukuri beach between Nabakigawa and Horikawa rivers, Chiba Prefecture. These 2 rivers separate research area from rest of 60-km long Kujukuri beach, forming separate morpho- and lithodynamical unit. The results of the research were high-resolution digital elevation models (DEM) and orthomosaics for February 2018, June 2018, September 2018 and February 2019. Based on DEM and orhomosaics we were able evaluate geomorphological changes throughout the year. From February 2018 to September 2018 we recorded active accumulation along the entire length of the beach. But accumulation intensity varied in different zones of beach as if foreshore, backshore or dunes. Also, the accumulation processes did not occur evenly for 7 months, but mostly intensified in the summer. From September 2018 to February 2019 erosional processes prevailed having different intensity at various sites. Thus, we were able to record in high resolution the process of transition from the winter profile of the beach to the summer profile and back.

Keywords: Coastal geomorphology, UAV SfM, Kujukuri beach

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 304 3F

[H-DS10] Natural hazards impacts on human society, economics and technological systems

convener:ELENA PETROVA(Lomonosov Moscow State University, Faculty of Geography), Hajime Matsushima(Research Faculty of Agriculture, Hokkaido University), Chairperson:Elena Petrova, Hajime Matsushima

The last decade set a record for the number and scale of natural disasters and demonstrates high vulnerability of human society and technosphere to their impacts. The most serious consequences have the so-called natural-technological disasters in which natural hazards trigger accidents at technology and infrastructure such as nuclear power and chemical plants, oil refineries and pipelines, power supply systems, buildings, and roads. A distinctive feature of natural-technological events, such as of the 2011 Tohoku earthquake, is their multi-hazard and synergistic nature, which creates cascading impacts, resulting in simultaneous occurrences of myriad catastrophes. The main goal of this multidisciplinary session is to summarize case studies of relationships between natural hazards and technological disasters, their social and economic consequences; and to encourage a discussion about tools and methods to prevent disasters and to minimize their consequences, disaster reconstruction, and tourism for reconstruction, Eco-DRR, and green infrastructure.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HDS10-01] People's lives utilizing coastal dunes ecosystem service

★Invited Papers

*Kaneko Korehisa[1] (1.Hokuso Creature Association)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HDS10-02] Survey on the Impact of Sea wall on the Vegetation of Coastal sand dune

*XIANGMEI ZHONG[1], Hajime Matsushima[2], Akira Suzuki[3], Yoshihiko Hirabuki[4], Kouji Kimura[5] (1.Graduate school of Agriculture, Hokkaido University, 2.Research Faculty of Agriculture, Hokkaido University, 3.Kita-no-satohama Hana-no-kanehashi Network, 4.Faculty of Liberal Arts, Tohoku Gakuin University, 5.Snow Brand Seed Co., Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HDS10-03] Greening on the seawall: challenge to conversion from gray to green infrastructure.

★Invited Papers

*Hajime Matsushima[1], Akira Suzuki[2], Kouji Kimura[4], Xiangmei Zhong[5], Yoshihiko Hirabuki[3] (1.Research Faculty of Agriculture, Hokkaido University, 2.Kita-no-satohama Hana-no-kakehashi Network, 3.Faculty of Liberal Arts, Tohoku Gakuin University, 4.Snow Brand Seed Co., Ltd., 5.Graduate school of Agriculture, Hokkaido University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HDS10-04] Distribution Characteristics of Informal Green Space and Its Extension of perspective into Green Infrastructure

*minseo kim[1], Katsunori Furuya[1] (1.Chiba University Graduate School of Horticulture)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HDS10-05] DISASTER ANALYSIS OF LIGHTNING STRIKE DENSITY BASED ON LANDFORM FOR REDUCING VICTIMS IN WONOSOBO, INDONESIA

*Astry Zulky Permatasari[1], Gagad Nur Ridho[1], Yan Abdi Rahmanu[1], Emilya Nurjani[1] (1.Gadjah Mada University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HDS10-06] Development of Cost Competitive Unmanned Aerial Vehicle for Search and Rescue

*Aditya Keshav Natoo

People's lives utilizing coastal dunes ecosystem service

*Kaneko Korehisa[1]

1. Hokuso Creature Association

1. Introduction

The coastal sand system is a buffer zone between the sea and the land, and originally, it has a function to mitigate the natural disasters such as tsunamis and the formation of biodiversity. People form a settlement "town" in the coastal sand dunes for a long time. However, because natural coastal sand dunes have been destroyed due to the progress of development, opportunities to receive the benefits of nature have decreased since the period of high economic growth.
In this research, I evaluate the functions and ecosystem services from people's living in the coastal sand dunes before large-scale coastal development, we will also discuss about the regeneration of the coastal sand dunes in regard to social changes.

2. Method

The study sites are coastal cities in the coastal areas of Chiba Prefecture. In coastal area of Tokyo Bay side, large scale development has been conducted since the 1960’ s. Therefore, I judged it to be an effective place for evaluating coastal sand dunes before development. We investigated the environment of study sites, including the soil and groundwater. There were supported as necessities and luxury items in the area.

3. Results

In distance ratio of coastal type in Chiba Prefecture in 1993, natural coast was 23.5%, the artificial coast was 70.0%. The coastal cities of study site existed brewing industry such as soy sauce, miso, sake brewery. It was an industry that utilized ecosystem services such as the freshwater layer of the coastal dunes and the sea creatures. As a result investigated the location environment of the main coastal cities (soil, groundwater level, water quality), the coastal cities were often located on the geographical features consisting of sand, sandbanks and natural levees. The surface geology consisted of sand-rich sediments, including sand 1(i.e., exceedingly soft), the depth of the groundwater was 3-10 m. I believe that the coastal cities benefited from the proximity of the coast.

4. Themes for the future

The future prediction in Japanese society are ①progress of population decline, declining birthrate and aging population, ②economic decline, financial tightening, ③infrastructure (roads, railroads etc.) aging and the maintenance problem, the social situation change drastically. Moreover, in the coastal industrial area, the number of companies that suspended or stopped production facilities and the expansion of idle land have increased due to the shift of major manufacturing to overseas due to the shrinking domestic

©2019. Japan Geoscience Union. All Right Reserved.

demand over the medium to long term and intensified global competition. As a future task, it is important to work on the regeneration (green infrastructure) of the natural coast sand dune utilizing idle land while cooperating with the government, enterprises, local residents, and academics.

Keywords: Ecosystem Service, Coastal Sand System, Industry, Regeneration

©2019. Japan Geoscience Union. All Right Reserved.

Survey on the Impact of Sea wall on the Vegetation of Coastal sand dune

*XIANGMEI ZHONG[1], Hajime Matsushima[2], Akira Suzuki[3], Yoshihiko Hirabuki[4], Kouji Kimura[5]

1. Graduate school of Agriculture, Hokkaido University, 2. Research Faculty of Agriculture, Hokkaido University, 3. Kita-no-satohama Hana-no-kanehashi Network, 4. Faculty of Liberal Arts, Tohoku Gakuin University, 5. Snow Brand Seed Co., Ltd.

[Introduction]

In recent years, many extreme events have come out due to climate change such as heavy rain, typhoon, etc. Large amounts of expenses are required for disaster-management measures. However, with the declining of population, the government budget is gradually lessening. On the other hand, people’s interests about disasters risk reduction are increasing. Before the disaster in 2011, at Yuriage district in Miyagi prefecture, coastal sand dune, pine forest and backward wetlands can be seen from the shoreline to the landward. In 2011, it is clear that the tsunami disturbed the organisms that support the coastal ecosystem and the environment which is the foundation of its habitat on a large scale. Since the coastal sand dune ecosystem here was disturbed, it has been restored naturally over time and then as a tsunami protection measure, a large seawall was built. Later, on the land side of the Sea wall was reclaimed by the mountain soil. However, the impact of them on the coastal dune ecosystem is unclear. This study clarifies the ecological impact on coastal sand dune vegetation of the Sea wall and mountain soil. And if there is a negative effect, how can we reduce that effect? This study records it as a reference for future solutions.

Three sites at the Yuriage district were selected as survey targets(figure 1.). From the north to the south: the Yuriage area 1(Y1), the Yuriage area 2(Y2), and the Yuriage area 3(Y3). In Y1, the Sea wall was built about 2 years ago and the coastal ecology recovered in nature. In August 2017, plants (*Ixeris repens*) were planted on both sides of the Sea wall in Y2. In Y3, the Sea wall was built about 5 years ago, and the coastal ecology recovered naturally. Additionally, the land sides of the three survey areas were reclaimed with mountain soil.

[Methods]

A belt was set up from the coastal forest to the shoreline. Then, the terrain was recorded with Unmanned aerial vehicle(UAV). Vegetation surveys were conducted at 5m intervals and Plant species / Coverage(%) / Grass height(cm) were investigated. Furthermore, samples of sand were collected at intervals of 10m, and the particle diameter composition(mm) as well as Electrical Conductivity(mS / m)(EC) of each sample were measured. After that, the average plant volume(mm^3) was calculated. Based on the above data, the current status of the plants on both sides of the Sea wall and the physical environment were analyzed.

[Results&Discussion]

About the result of vegetation, there are three plant species on both sides of the Sea wall: *Imperata cylindrica, Digitaria ciliaris* and *Artemisia capillaris*. On the land side, *Artemisia capillaris,* and *Setaria viridis* are the dominant species. On the sea side, *Carex kobomugi, Glehnia littoralis, Calystegia soldanella* and *Ixeris repens* are the dominant species. It is obvious that the plant species on land side and sea side are different because of the separation by the sea wall. It can be seen that the distribution of plants on the

©2019. Japan Geoscience Union. All Right Reserved.

land side is significantly affected by the mountain soils, resulting in an increase in the number of inland plants, such as *Setaria viridis* and *Trifolium repens.* From the EC value, it is evident that the trend from the shoreline to the sea wall is gradually decreasing, and the trend from the sea wall to the inland is increasing. The phenomenon that the EC value increases inland can be considered as the impact of artificial coverage of mountain soil. About the result of particle diameter composition, it is obvious that the medium sand has a decreasing trend from the shoreline to the inland side. Closer to the shoreline, the proportion of the very fine sand is increasing. The closer to the inland, the greater the proportion of the very coarse sand and the coarse sand.

In general, the composition of particle diameter on both sides of the sea and land of the sea wall is of difference, and this phenomenon may be caused by the barrier effect of the sea wall. This phenomenon may become larger as time goes by.

Keywords: coastal plants, ecotone, green infrastructure, the sea wall

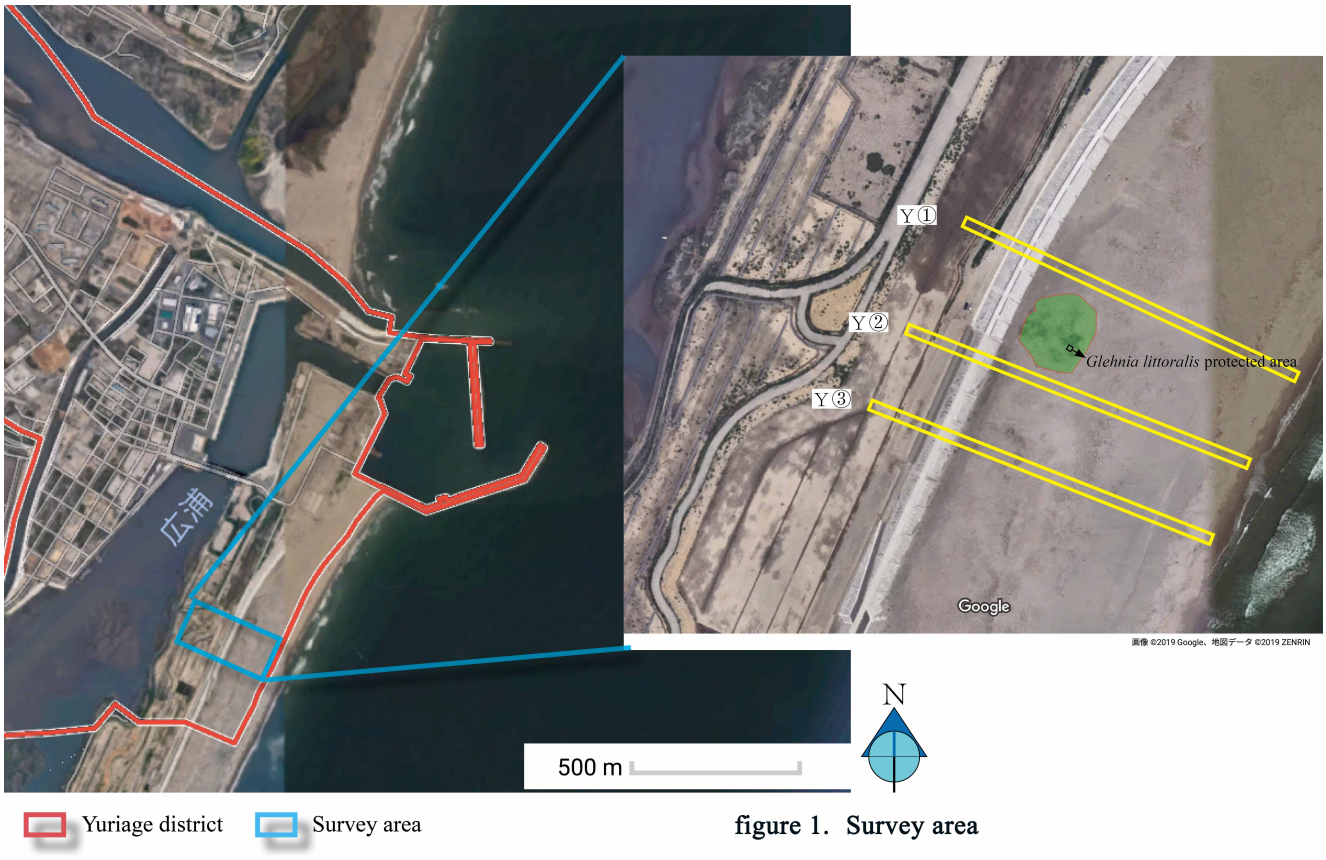


figure 1. Survey area

©2019. Japan Geoscience Union. All Right Reserved.

Greening on the seawall: challenge to conversion from gray to green infrastructure.

*Hajime Matsushima[1], Akira Suzuki[2], Kouji Kimura[4], Xiangmei Zhong[5], Yoshihiko Hirabuki[3]

1. Research Faculty of Agriculture, Hokkaido University, 2. Kita-no-satohama Hana-no-kakehashi Network, 3. Faculty of Liberal Arts, Tohoku Gakuin University, 4. Snow Brand Seed Co., Ltd., 5. Graduate school of Agriculture, Hokkaido University

After the Tsunami disaster in March 11th, 2011 at east Japan area, especially on the pacific side of Tohoku region, our government built huge seawalls along the coastline about 400 km long to protect inland area from Tsunami disaster. We aimed to regenerate the ecotone of coastal ecosystem using the dune plants by greening the seawall. We were planting the seven species of dune plants on the seawall in 2017. On this presentation we report the survival rate for a year of planted dune plants on the seawall.
As a result, most dune plants were survived around 80% or more on the seaside seawall. But the survival rates were decreased around 70% on the landside seawall because of dried out by soil loss. Comparison between natural recovered seaside seawall and planted seaside seawall, the dominant species *Ischaemum anthephoroides* were similar. But *Ixeris repens* were less survived on the planted seaside seawall, in spite of one of the dominant species on the natural recovered seaside seawall. On the other hand, species of landside seawall were completely different with natural recovered landside seawall. This results shows that the greening on the seawall, especially on the landside seawall, were important for regeneration of coastal dune ecotone.

Keywords: Green infrastructure, Ecotone, Coastal dune system, Dune plants, Seawall

©2019. Japan Geoscience Union. All Right Reserved.



Fig. 1 Planting of dune plants on the seawall with citizens

©2019. Japan Geoscience Union. All Right Reserved.

Distribution Characteristics of Informal Green Space and Its Extension of perspective into Green Infrastructure

*minseo kim[1], Katsunori Furuya[1]

1. Chiba University Graduate School of Horticulture

1. introduction

The issues of Green Infrastructure (GI) and urban natural disasters are being addressed around the world, not only in North America and Europe, where the discussion first began, but throughout Asia. GI is a planned network strategically between natural and semi-natural areas, along with environmental factors designed for overall ecosystem services. A well-connected network provides positive benefits for quality of life and biodiversity and can receive ecosystem services such as reduction of disaster risk, water purification, air quality, recreational space, and climate change mitigation and adaptation. GI is a widely applicable element that can effectively respond to the various damage caused by climate change. Examples include efficient use of water resources, water restoration, protection of plant species susceptible to disasters, implementation of water conservation measures, reduction of heat island phenomena. In the case of the U.S. and Europe, a network of natural or semi-natural spaces with multidisciplinary functions is defined with the aim of restoring the functions of the ecosystem, and the policy is to utilize the combined spatial plan of domestic or countries. However, in recent years, the decline of cities has increased and limitations have been considered to create new urban green space as GI. Accordingly, the interest in informal green space such as vacant lots, street verges, water verges, and brownfields is increasing as an open space that is abandoned or overlooked in interstices in a city. In particular, interest is growing in strategies to enhance the urban environment and the vitality of residents by converting the value of vacant properties in urban areas to GI. Therefore, this study aims to examine the potential of informal green space as GI, and to suggests a connection with natural disaster prevention.

2. method

Since informal green spaces do not have an officially documented database, fieldwork on the site should be involved to derive the implications of this study. Therefore, in this study, Ichikawa City was analyzed as a study site, and informal green space and urban structures were analyzed using the spatial information collected from the field and the official open data sources. The sampling strategy used in this study was to set a square sample site of 50 meters at the intersection of a grid 500m and collect site information in focusing on the sample site. The total number of sample sites set up is 229 and the total area is about 1% of the entire city area.

3. results

Informal green space was found on 106 sample sites out of 229 sample sites in this study area. The total area of collected informal green space is 26,458 m^2 and consists of 229 patches. The total area of the informal green space found accounts for about 4.62% of the entire sample sites area, with an average area of about 115 m^2. Informal green space was distributed 123 patches and 67.6 m^2 mean size in residential areas, 15 patches and 48 m^2 mean size in commercial area, 16 patches and 230 m^2 mean size in industrial area, and 75 patches and 183 m^2 mean size in the urbanization control area. In the residential and commercial area, where are population density, informal green spaces are frequently distributed with a small scale. On the other hand, the informal green space of the urbanization control area with low population density and high elderly density is relatively large scale compared to residential and commercial area.

©2019. Japan Geoscience Union. All Right Reserved.

4. discussion and conclusion

Informal green space is a secondary green space created by human activities. Therefore, the distribution characteristics of informal green space differ according to the land use patterns that are related to human activities. Given the accessibility according to the distribution characteristics of informal green space and the linkage with the surrounding natural environment, a supplementary system of urban green infrastructure can be proposed.

Keywords: vacant land, urban green space, green infrastructure policy , Asia

©2019. Japan Geoscience Union. All Right Reserved.

DISASTER ANALYSIS OF LIGHTNING STRIKE DENSITY BASED ON LANDFORM FOR REDUCING VICTIMS IN WONOSOBO, INDONESIA

*Astry Zulky Permatasari[1], Gagad Nur Ridho[1], Yan Abdi Rahmanu[1], Emilya Nurjani[1]

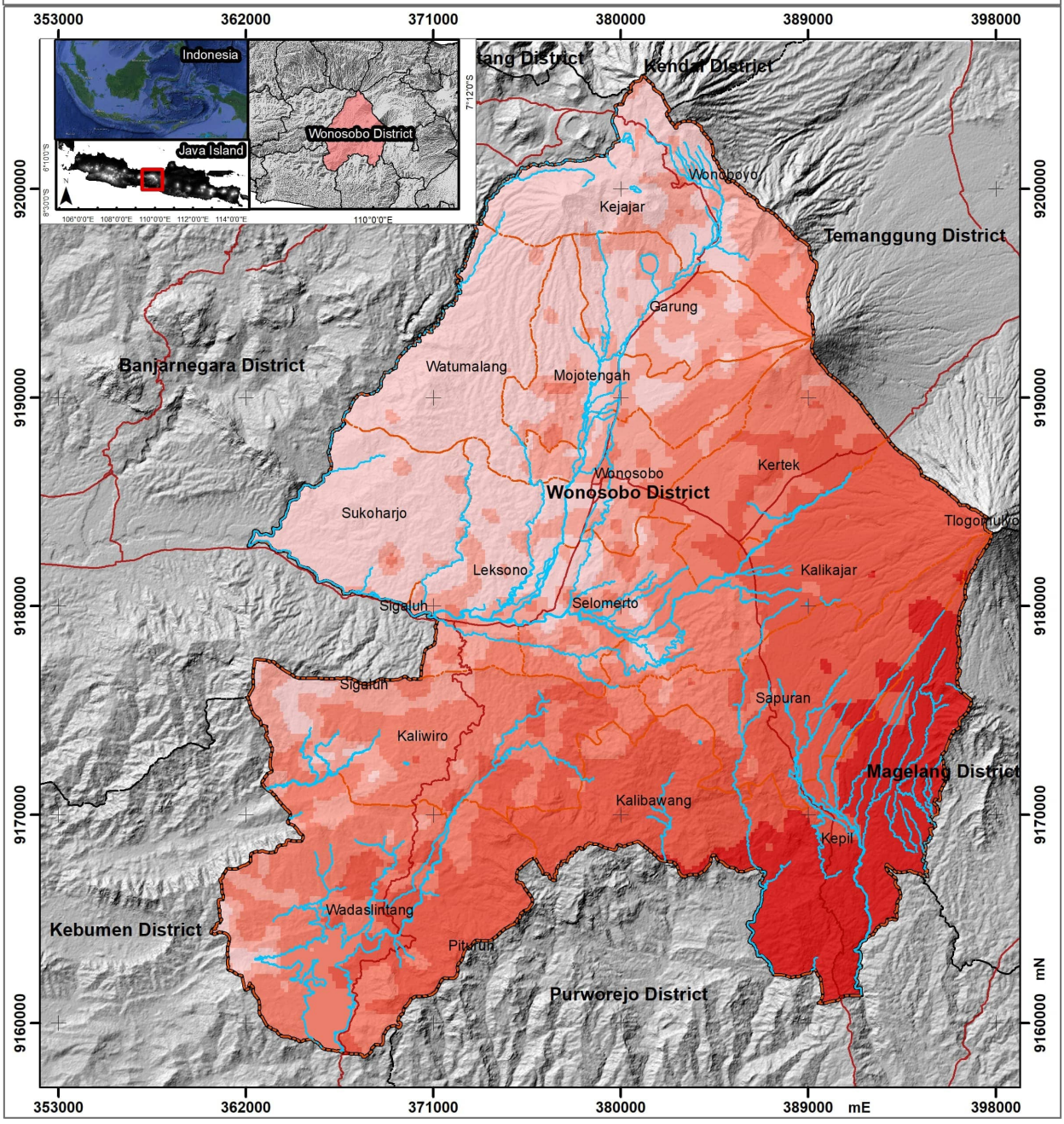
1. Gadjah Mada University

Wonosobo regency is a region with diverse configuration landforms. The morphological and material aspects of the landform different responses to the lightning strike density. The incident of lightning strikes in Wonosobo Regency has negative impacts on people, buildings, and environment. Therefore, a lightning strike density analysis is important to minimize the negative impact of lightning strikes. This study aims to determine the condition of landform, analyze the relationship of lightning strike density and the landform, to know the risk of a lightning strike and give a recommendation of mitigation to reduce the negative impacts caused lightning strike. The research was conducted in Wonosobo Regency, Central Java Province. The data used are lightning strike type Cloud to Ground (CG) on 2015 - 2017 obtained from BMKG Yogyakarta station. Data is processed using ArcGIS 10.3 software with Kernel Density modeling and analyzed quantitatively-qualitative. Lightning strike density in Wonosobo shows a lower pattern from the southeast to the northwest. Wonosobo's landforms are volcanic and structural. Structural landform in Wonosobo Regency is anticlinal mountains with a strong or moderate incision that has the highest lightning strike density. The condition of the lithology of Wonosobo Regency dominated by Breccia, Lava and Tuff rocks that effect on the number of lightning strikes, because it has a low resistivity value (conductor). Kepil District and Wonosobo District are areas that have the highest risk of lightning strikes. Some mitigation activities that can be applied to reduce the risk of losses and death are installing a lightning rod, unplug the cable of electronic device inside the house during a lightning strike and immediately ending the outdoor activities when Cumulonimbus clouds begin to appear, and protect yourself by going into permanent buildings.

Keywords: Landform, Cloud to Ground, Wonosobo Regency, Risk, Lightning Strikes

©2019. Japan Geoscience Union. All Right Reserved.

LIGHTNING STRIKE DENSITY MAP IN WONOSOBO DISTRICT 2017



Legend

- Road
- River
- Subdistrict Border
- District Border

N

0 2 4 Km

Scale 1: 250.000

Density Class (in hectar)

Very Low	< 4.020
Low	4.021 - 5.303
Medium	5.306 - 8.330
High	8.331 - 15.435
Very High	15.436 - 32.138

Projection System : Transvers Mercator
Coordinate System : UTM
Datum : WGS 1984 Zone 49S
Source : 1.Lightning Strike Data's in Wonosobo District 2017 (Yogyakarta BMKG Station)
Made By : PKM-PE UGM Sambaran Petir's Team 2018

Faculty of Geography
Gadjah Mada University
Yogyakarta
2018

©2019. Japan Geoscience Union. All Right Reserved.

Development of Cost Competitive Unmanned Aerial Vehicle for Search and Rescue

*Aditya Keshav Natoo

UAV Technology is progressing at a rapid pace around the world. Some organizations have tried to develop Enterprise class UAVs which aim to cater to large section of users.
A dedicated cost competitive UAV to be used during and after disaster and for search and rescue missions is currently not available.

An effort is made to develop quad/hexa copter based UAVs with thermal and/or regular video cameras alongwith a servo controlled arm for transporting objects during search and rescue mission.

The thermal camera can transmit video images to the UAV operator to check for presence of victims during floods, earthquakes, forest fires, landslides, avalanches, tsunamis and cyclones.
During the search and rescue operations, items like inflatable lifejackets, harness, food and water supply etc can be dropped to the victims as well as rescue teams.

Keywords: Cost Competitive, Unmanned Aerial Vehicle, Search and Rescue

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 301B 3F

[H-DS10] Natural hazards impacts on human society, economics and technological systems

convener:ELENA PETROVA(Lomonosov Moscow State University, Faculty of Geography), Hajime Matsushima(Research Faculty of Agriculture, Hokkaido University), Chairperson:Hajime Matsushima, Elena Petrova

The last decade set a record for the number and scale of natural disasters and demonstrates high vulnerability of human society and technosphere to their impacts. The most serious consequences have the so-called natural-technological disasters in which natural hazards trigger accidents at technology and infrastructure such as nuclear power and chemical plants, oil refineries and pipelines, power supply systems, buildings, and roads. A distinctive feature of natural-technological events, such as of the 2011 Tohoku earthquake, is their multi-hazard and synergistic nature, which creates cascading impacts, resulting in simultaneous occurrences of myriad catastrophes. The main goal of this multidisciplinary session is to summarize case studies of relationships between natural hazards and technological disasters, their social and economic consequences; and to encourage a discussion about tools and methods to prevent disasters and to minimize their consequences, disaster reconstruction, and tourism for reconstruction, Eco-DRR, and green infrastructure.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HDS10-07] **Seasonal variations of atmospheric hazard impacts on infrastructure**

★Invited Papers

*ELENA PETROVA[1] (1.Lomonosov Moscow State University, Faculty of Geography)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HDS10-08] Assessment of water supply function and measures for chemical release accidents triggered by major earthquakes

*Lisa Ito[1], Toyohiko Nakakubo[2], Naoya Kojima[1], Akihiro Tokai[1] (1.Graduate School of Engineering, Osaka University, 2.Faculty of Core Research, Ochanomizu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HDS10-09] Development of disaster risk management plan of a thermal power plant: Spearheading the paradigm shift from disaster management to disaster risk management of NATECH in India

*Repaul Kanji[1], Madan Mohan Rout[2], Ankur Srivastava[3] (1.Gujarat Institute of Disaster Management, Gandhinagar, Gujarat, India, 2.Institute of Seismological Research, Gandhinagar, India, 3.Indian Institute of Technology Delhi, India)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HDS10-10] **Applying Transfer Learning to Improve Machine Learning Impact Model at Extremes**

*Peter Lawrence Watson[1], Manos Anagnostou[1], David Wanik[1] (1.University of Connecticut)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HDS10-11] rescEU, the European Union Civil Protection System UCPM and the future role of Geosciences in natural disaster reduction

*Andreas Nikolaus Kueppers[1] (1.GFZ - Deutsches Geoforschungszentrum - Helmholtz Zentrum Potsdam)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HDS10-12] The Probability of Satellite Anomalies by a Disastrous Solar Flare

*Daikichi SEKI[1,2,3] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2.Centre for the Study of Existential Risk, University of Cambridge, 3.Astronomical

Observatory, Kyoto University)

Seasonal variations of atmospheric hazard impacts on infrastructure

*ELENA PETROVA[1]

1. Lomonosov Moscow State University, Faculty of Geography

Infrastructure facilities consist of power, heat and water supply systems, communication lines, transport infrastructure including roads and bridges, railways, airports, oil and gas pipelines, etc. Above-ground and ground infrastructure facilities are most affected by impacts of various natural hazards, especially those of atmospheric origin. More than 90% of all natural-technological accidents in infrastructure facilities of Russia are triggered by atmospheric hazards such as strong winds, heavy snowfalls and rainfalls, snowdrifts, torrents, thunderstorms and lightning, hailstorms, hard frost, icing, etc. Natural factors cause about 70 percent of “blackouts”, more than 10 percent of accidents at heat and water supply systems as well as water accidents; about four percent of air crashes, automobile and railway accidents, and about two percent of pipeline ruptures. Various atmospheric hazards can also cause long delays in automobile, railway and air transportation of passengers and goods. The majorities of these events are triggered by windstorms and hurricanes (37 percent), snowfalls and snowstorms (27 percent), rainfalls (16 percent), hard frost and icing (12 percent), thunderstorms and lightning (nearly 4 percent). All of these weather conditions are subject to seasonal variations. During the cold season, there are much more weather events influencing the growth in the number of accidents than in the warm season. The author created a database of natural-technological accidents occurring in Russia, including those in infrastructure facilities. More than 18.5 thousands events are registered in the database between 1991 and 2018. The collected information allows analyzing the main causes and triggers of accidents, their distribution within area of Russia, temporal variations, and revealing “weak spots” to cope with. The risk of natural-technological accidents in infrastructure facilities was assessed for Russian federal regions. The Far Eastern, South and North-Western parts of Russia are at the most risk of atmospheric hazard impacts. The risk of natural-technological accidents is highest in Sakhalin region, Krasnodarsky and Primorsky territories.

Keywords: infrastructure facilities , atmospheric hazards , risk assessment, seasonal variations

©2019. Japan Geoscience Union. All Right Reserved.

Assessment of water supply function and measures for chemical release accidents triggered by major earthquakes

*Lisa Ito[1], Toyohiko Nakakubo[2], Naoya Kojima[1], Akihiro Tokai[1]

1. Graduate School of Engineering, Osaka University, 2. Faculty of Core Research, Ochanomizu University

In recent years, natural disasters called Natech (Natural hazard triggered technological accident) has become a big issue around Europe. Also, in Japan, Natech becomes social issues by the recent major earthquake such as the Great East Japan Earthquake, in which highly concentrated toxic chemical substances was released due to tsunami or fire. Such an accident causes risks related to serious environmental contamination. However, chemical behaviors in the environments and degrees of the impact on the infrastructure after the accident have not been clarified especially under the unstable situation. In this research, we aimed i) to clarify the influence of toxic chemicals released into the environment due to the major earthquake and ii) to evaluate the efficiency of the countermeasure option, focusing on unintended releases of chemicals from manufacturing or on-site storage facilities to water.
As the research area, we selected Yodo River in Osaka, which is an essential water source that supports the infrastructure of Kansai area. On the other hand, there are growing concerns for the risks caused by seismic motion and liquefaction as there are many chemical factories with drainage pouring into Yodo River.
We selected 38 chemical substances with high risk such as acrylonitrile in addition to toluene and xylene that are used in large quantities. These chemicals are also included in Pollutant Release and Transfer Register (PRTR) which make it possible to grasp more actual discharge status. Among PRTR, these 38 substances have especially high toxicity for human (LD_{50} ≦300 mg/kg) (UN, 2015), and have difficulty to remove even in the water treatment process because of its high solubility in water (≧10,000 mg/L) and hydrophilic properties (octanol/water partition coefficients (Log Kow)≦ 1.5) (Ito et al., 2014). The prediction occurrence of chemical release accident caused by the earthquake was calculated as the expected value (Y) based on the statistical data in the world (Santella et al., 2011). Probability (P_n) of occurrence of the accident in Yodo basin area caused by Hanaore fault was calculated by the Poisson distribution. Subsequently, we calculated the maximum expected concentration of chemical substances at the water-intake points in the river after the accident using the hydrology-exposure analysis model (AIST-SHANEL ver. 3)(AIST, 2015). The accident date on the model was set for winter season since the streamflow is relatively low throughout the year from a factory which has the largest storage of target chemicals. Emergency shut-off valve was adopted as a countermeasure in this scenario. As judgement criteria for suspension of water supply, we evaluated subacute toxicity as a criterion ($JC_i^{subacute}$).
As a result of the model calculation, the concentration of acrylonitrile in the purified water was calculated to be 2.19×10^{-1} mg/L for a maximum. In this case, water supply system would stop, since it exceeds $JC_i^{subacute}$ ($=6.25\times10^{-2}$ mg/L) based on the no observable adverse effect level (NOAEL) (Ministry of the Environment, 2003) obtained from rats. Furthermore, as it exceeds the predicted no effect concentration (PNEC) of aquatic organisms, 7.6×10^{-3} mg/L (Ministry of the Environment, 2003), intake of the water would also stop. On the other hand, if the Emergency shut-off valve works properly, the outflow rate is 2% or less of the storage tank, calculating from the length of pipe and tube diameter outside the valve (Osaka, 2013). In that condition, the concentration of acrylonitrile in the river is less than $JC_i^{subacute}$ and PNEC, which suggested that outage of water supply function can be avoided. According to these analyses, we found that an emergency shut-off valve is a useful option as a countermeasure for an earthquake. Furthermore, it would be possible to implement more quick and proper responses applying the method of this study, even in the case that the released chemicals are not included in the criteria for tap water.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Chemical accidents, Water supply function, Major earthquake, Modeling, Natech

©2019. Japan Geoscience Union. All Right Reserved.

Development of disaster risk management plan of a thermal power plant: Spearheading the paradigm shift from disaster management to disaster risk management of NATECH in India

*Repaul Kanji[1], Madan Mohan Rout[2], Ankur Srivastava[3]

1. Gujarat Institute of Disaster Management, Gandhinagar, Gujarat, India, 2. Institute of Seismological Research, Gandhinagar, India, 3. Indian Institute of Technology Delhi, India

With global phenomenon like climate change looming large on the horizon, occurrences of extreme events are expected to rise eventually. Rapid urbanisation and the powerful want of globalisation does little to control the exposure of our ‘assets’ to such events, thereby increasing the disaster risks. The quantum of risk rises exponentially if the exposed asset is a critical infrastructure like a nuclear power plant or a thermal power plant which might lead to ‘natural hazard triggered technological disasters’ like that of Fukushima. The damage and loss in such cases is borne not only by the infrastructure in question but also by the community in its immediate surrounding. Management of disasters, which has long been the usual trend, has a very little effectiveness in such tragic scenarios, thus rather than managing disasters, one should manage the disaster risks. Even the Sendai Framework for Disaster Risk Reduction (SFDRR) talks about reduction of the acceptable risks and management of the residual risks. However, for all this to be implemented, one needs to understand and anticipate risks, which is way more than the current practice of risk identification.

The researchers, when provided with the opportunity to develop a disaster management plan for a thermal power plant in India, took cognisance of the priorities of SFDRR embarked on a strategy of disaster risk management and disaster risk reduction rather than mere disaster management. This study elaborates on the strategy adopted during the development of the plan. The first step was to conduct field survey and collect primary geo-technical and meteorological data. Content analysis of hazard maps were done to identify the possible hazards which can affect the critical infrastructure. Earthquake, cyclone and technological hazards were identified as the main probable hazards. The methodology developed by Cornell (1968) for Probabilistic Seismic Hazard Assessment (PSHA) was applied for the estimation of seismic hazard for 10% and 2% probability of exceedence in 50 years. In this method, seismogenic zones were delineated and then seismicity parameters were estimated using the decluttered earthquake catalog and finally the ground motion was estimated using different ground motion prediction equations (GMPE). In addition to this, probable intensities of earthquakes were evaluated according to the seismic zonation and the corresponding grade of damage was estimated, taking into account the typology of building construction. To elucidate assessment of cyclonic winds and rainfall over the critical infrastructure an experiment was designed in which 9 major cyclonic systems occurring in the region in last ten years were considered. These cyclonic events were numerically simulated around the geographical location of the infrastructure. Weather Research Forecasting (WRF) model was used to carry out the simulations. As a result, the maximum windspeed and the maximum rainfall was obtained. In addition to these natural hazards, content analysis was done to enumerate all the possible technological hazards and Maximum Credible Accident Analysis (MCAA) was performed. These steps were integral in assessing the hazards and the outputs of these simulations were fed as inputs of the Quick Risk Estimation (QRE) tool developed by UNISDR. Based on the outputs of the QRE tool, the disaster risk management plan was developed.

This particular study tries to identify and assess the hazards, vulnerabilities and capacities and estimates

©2019. Japan Geoscience Union. All Right Reserved.

the risks which is then used to develop risk management plans. Offcourse, management of extreme events through institutionalisation of Incident Response System (IRS) is a part of the plan but it forms only a part of it. Thus, in a way, this plan marks the first step taken towards disaster risk management of critical infrastructures in India; a step towards the management of risks of technological disasters due to natural hazards.

Keywords: Disaster risk management, Disaster risk reduction, Weather Research Forecasting, Ground Motion Prediction Equation, Quick Risk Estimation Tool

©2019. Japan Geoscience Union. All Right Reserved.

Applying Transfer Learning to Improve Machine Learning Impact Model at Extremes

*Peter Lawrence Watson[1], Manos Anagnostou[1], David Wanik[1]

1. University of Connecticut

Machine learning can be useful for modeling the impacts of natural hazards on infrastructural systems. By relying on empirical observations, these methods lack the prohibitive complexity of large-scale physical models, but can also operate in high-dimensional spaces: where a large number factors contribute to the observed damages to the system. However, modeling extreme events can be challenging with machine learning. Unlike parametric models, the dynamic range of these models is constrained to the training data, and the training data from extreme events is as rare as the events themselves. However, transfer learning, where a model trained on data from one system is retrained for another system, may enable the use of additional training data to improve the prediction of extreme events. This would allow for more examples of extreme events from more places to be included in the training data, and should improve the performance of machine learning based impact models at the extremes. In this study, we apply transfer learning methods to the University of Connecticut's Outage Prediction Model (OPM), a machine-learning based electrical power outage model. The OPM has a large domain that spans three states in the US: Connecticut, Massachusetts, and New Hampshire, and there is much more training data available for Connecticut than the other states. We investigate the effects of applying this additional data on the accuracy and dynamic range of models for the other states using transfer learning methods, in an effort to better predict the impacts of the most extreme weather events.

Keywords: Machine Learning, Impact Model, Transfer Learning, Extreme Events, Power Outage, Infrastructure

©2019. Japan Geoscience Union. All Right Reserved.

rescEU, the European Union Civil Protection System UCPM and the future role of Geosciences in natural disaster reduction

*Andreas Nikolaus Kueppers[1]

1. GFZ - Deutsches Geoforschungszentrum - Helmholtz Zentrum Potsdam

On February 12, 2019, the European Parliament in Strassbourg adopted the decision* for a substantial enhancement of the Union Civil Protection Mechanism which includes the 28 EU Member States plus a major number of affiliated nations. The actual legislational move had been directly instigated by the very serious impact of large wildfires in Europe with many fatalities in Portugal, Greece, Spain, Sweden, among others. It became clear in a dramatic way that sufficient technical resources for fire fighting, in particular aircraft, were neither available on a national nor an international base. The new and financially strengthened Mechanism embraces a large number of disaster types where geology based disasters like earthquakes, tsunami, volcanic eruptions including volcanic ash clouds and gravitational movements are among the most prominent. Expressis verbis, the decision calls for substantial foresight for the early discovery of future disasters which even may be not known to us today. While this without doubt means a great chance for broad geosciences to actively contribute from the start, the integration of more nations into the system and a possible globalisation constitute next stage challenges.

*Official text is expected to be published by the European Commission in due time.

Keywords: Earthquake, Tsunami, Volcanic Eruption, Landslide, European Civil Protection Mechanism, Globalisation

©2019. Japan Geoscience Union. All Right Reserved.

The Probability of Satellite Anomalies by a Disastrous Solar Flare

*Daikichi SEKI[1,2,3]

1. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2. Centre for the Study of Existential Risk, University of Cambridge, 3. Astronomical Observatory, Kyoto University

The Sun has a potential risk of various socioeconomic impacts on our human society. It often produces various eruptive phenomena such as a solar flare and a coronal mass ejection, which sometimes bring adverse effect to us like satellite anomalies, radiation exposure, and huge blackouts. For example, in 2003 October 28, X17-class flares (roughly once-in-10-year level severity) occurred and more than 60 % of NASA scientific satellites were affected.

Similar to other terrestrial disasters like an earthquake, the solar eruptive phenomena also follow the power-law distribution between frequency and severity, and low-frequency-high-impact solar disaster could also happen. Recently, it was revealed that a “super-flare”, a flare whose energy is 100 times larger than X10-class flare, can occur once in 1000 years from statistical and theoretical points of view [Maehara et al. 2012, Shibayama et al. 2013, Shibata et al. 2013].

However, though there are many assessment studies of “moderate” solar eruptive phenomena, the assessment of “disastrous” solar eruptive phenomena like a super-flare has been little conducted. For this reason, this research aims to evaluate the frequency (or probability) and the possible socioeconomic damage of a super-flare, especially focusing on satellite anomalies.

Using various data sets about satellites, their anomalies, flares, and plasma environment around the Earth*, 154 X-class flare events with 9 relating parameters (peak flux of X-ray (0.1–0.8 nm), integral fluxes of electron (> 2 MeV) and of proton (> 1, 5, 10, 30, 50, 60, 100 MeV)) were selected. To avoid multi-collinearity, Ridge regression model was used to compute the regression to the satellite anomaly rate (1/satellite/event). Also 10-fold cross validation was performed. After obtaining the model, the possible plasma parameters in case of X1000-class flare assumed by Takahashi et al. 2016 were input into the model.

As a result, we obtained the model with its coefficient of determination of 0.607 and its Pearson correlation coefficients of 0.691±0.212 (for 100 times randomly chosen dataset). Assuming that electron and proton follow the same scaling law, with applying scaling law by Takahashi et al. 2016, 0.573 satellite anomaly rate (57.3% per satellite per event) was obtained. It should be noted that the scaling law provided by Takahashi et al. 2016 is upper limit, so in the actual case, rate should be lower. The validity of assumption, the comparison between this research and others (Pilipenko et al. 2006; Iucci et al. 2005; Odenwald et al, 2006, 2007), and the possible socioeconomic loss will be also discussed.

* NOAA NGDC Spacecraft Anomaly Data, Satellite Catalogue (https://www.celestrak.com/satcat/search.php), NOAA GOES flare report (https://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-features/solar-flares/x-rays/goes/xrs/) , and OMNI 2 database

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Space weather disaster, satellite anomaly, super-flare

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 301B 3F

[H-DS10] Natural hazards impacts on human society, economics and technological systems

convener:ELENA PETROVA(Lomonosov Moscow State University, Faculty of Geography), Hajime Matsushima(Research Faculty of Agriculture, Hokkaido University), Chairperson:Elena Petrova, Hajime Matsushima

The last decade set a record for the number and scale of natural disasters and demonstrates high vulnerability of human society and technosphere to their impacts. The most serious consequences have the so-called natural-technological disasters in which natural hazards trigger accidents at technology and infrastructure such as nuclear power and chemical plants, oil refineries and pipelines, power supply systems, buildings, and roads. A distinctive feature of natural-technological events, such as of the 2011 Tohoku earthquake, is their multi-hazard and synergistic nature, which creates cascading impacts, resulting in simultaneous occurrences of myriad catastrophes. The main goal of this multidisciplinary session is to summarize case studies of relationships between natural hazards and technological disasters, their social and economic consequences; and to encourage a discussion about tools and methods to prevent disasters and to minimize their consequences, disaster reconstruction, and tourism for reconstruction, Eco-DRR, and green infrastructure.

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[HDS10-13] Management and Maintenance for Disaster prevention park in Tokyo Metropolitan Government

★Invited Papers

*Masayshi Kikuchi[1] (1.Tokyo Metropolitan Park Association)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[HDS10-14] Rebuilding Tourism after the Great East Japan Earthquake and Examining Post-Disaster Tourism in Kamaishi City

*Satoshi Sasaki[1], Kiyotatsu Yamamoto[2], Kaoruko Sasaki[3] (1.Iwate University, 2.The University of Tokyo, 3.Hokkaido University)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[HDS10-15] Population Change in Ishinomaki City, Miyagi Prefecture, with a Focus on the Area around the Earthquake Ruins

*Ryo Nishisaka[1], Katsunori Furuya[1] (1.Chiba University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[HDS10-16] The Way of Seeing the Atomic Bomb Dome and the Relationship with Viewers' Attributes

*yasuhara arisa[1], Kiyotatsu Yamamoto[1], Akio Shimomura[1] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[HDS10-17] Flood Disaster Risk Analysis at Ratnapura in Sri Lanka

*Tsuchida Ryo[1], Kaoru Takara[1] (1.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

Discussion

Management and Maintenance for Disaster prevention park in Tokyo Metropolitan Government

*Masayshi Kikuchi[1]

1. Tokyo Metropolitan Park Association

Tokyo has experienced great damage by many earthquakes since ancient times, has a history that has repeatedly been destroyed and reconstructed. Every time Tokyo suffered an earthquake disaster, the park has been required to have new functions. Every time Tokyo suffered an earthquake disaster, the park has been required to have new functions. The first is a role as evacuation site and the second is a role as Base for Large-scald and Life-saving Operations. Currently, there are 82 parks in metropolitan parks, but the 21 major parks are not only functions as evacuation places but also Base for Large-scald and Life-saving Operations when disasters such as large earthquakes occur in the capital Tokyo Function. We name them as disaster prevention parks and manage them. First, the function as an evacuation site is a function that all parks have and is to secure places where many citizens can escape as safe places in the event of a disaster. To that end, there are three distinctive park facilities. One is a "solar-type park light" so that you can check the location from anywhere even at the time of a power outage. The second type is "manhole type disaster prevention toilet" directly connected to the drain pipe so that many evacuees can use it even if they temporarily stay in the park. The third one is a normal bench in peacetime, but in the event of a disaster it is a "kamado bench" that can be used as a "kettle" that can be boiled. Next, the function as Base for Large-scald and Life-saving Operations is a function that serves as a helicopter departure station or a large emergency vehicle collecting base as an activity base of relief units, medical troops, etc. in the afflicted area. Therefore, although a park having a large-scale square is designated as a large-scale rescue and relief activity base, the characteristic maintenance is to expand and strengthen the school path so that large vehicles can pass, securing helicopter take-off and landing spots, etc. is there. What you need to fully demonstrate these functions is day-to-day disaster prevention drills. In the park, including citizens, police, fire fighting companies, companies, etc., training is conducted several times a year "Manhole type disaster prevention toilet" and "Kamado bench", and helicopter takeoff and landing training etc. are also carried out.

Keywords: disaster prevention park, evacuation site , Base for Large-scald and Life-saving Operations

©2019. Japan Geoscience Union. All Right Reserved.

Rebuilding Tourism after the Great East Japan Earthquake and Examining Post-Disaster Tourism in Kamaishi City

*Satoshi Sasaki[1], Kiyotatsu Yamamoto[2], Kaoruko Sasaki[3]

1. Iwate University, 2. The University of Tokyo, 3. Hokkaido University

1. Introduction

Natural hazards can have a devastating effect on tourism. In the case of the Great East Japan Earthquake (GEJE) of 2011, the tsunami caused damage to not only human lives but also to critical infrastructures in coastal areas in the Tohoku region. Tourist attractions and facilities were also damaged by the tsunami, and people who lived in the metropolitan and Kinki regions understood that they should avoid traveling to the Tohoku region (Yamamoto, 2013). Thus, a decrease in the number of visitors to the tsunami-hit area was reported in the Tohoku region immediately following the disaster (Igarashi et al., 2017). Fortunately, after suffering a drop in the number of tourists, the disaster area is experiencing a trend in recovery these days. “Disaster tourism”—defined as the practice of visiting natural or man-made environmental disaster sites (Amujo et al., 2012)—has succeeded in bringing visitors to the disaster area. However, eight years have already passed since the disaster, and the time lapse should be taken into account for promoting post-disaster tourism (Sasaki et al., 2018). From this viewpoint, the purposes of this study were established as follows: 1) to clarify the current situation of tourism after the GEJE of 2011 and 2) to examine post-disaster tourism in the Tohoku region.

2. Methods

The case study area for this study was Kamaishi City, which is located in Iwate Prefecture in northeast Japan; it was hit by the tsunami in 2011 and more than 1,000 lives were lost to the disaster. Thanks to disaster prevention efforts, however, almost all of the nearly 3,000 elementary and junior high school students miraculously survived (i.e., the “Miracle of Kamaishi”). Accordingly, many people have been infused with hope. To grasp the awareness and behaviors of visitors to the city, two post-recall questionnaires were distributed to Japanese people over age 17 from July to September in 2018. One was disseminated to visitors who participated in the guided tours conducted by storytellers with the Kamaishi Volunteer Guide Association. The other was given to tourists at the JR Kamaishi Station, Kamaishi Sennin-toge roadside rest area, and Hashino Iron Mining and Smelting Site (listed as a UNESCO World Heritage Site). The survey focused on the following aspects: (1) visitor attributes (e.g., age, gender), (2) characteristics of visits (e.g., number of visits, group size, objectives of trips, places visited), (3) familiarity with guided tours (e.g., expectations, sources of information), (4) changes in awareness after a visit, (5) appreciation for disaster lore, and (6) the satisfaction and intention to revisit.

3. Results and Conclusion

In total, 478 people (guided: N = 155, non-guided: N = 323) participated in the survey, representing a response rate of 22%. As a result, the largest proportion of respondents included people over age 59 (47%); further, the total number was almost equally divided between the two genders (male: 51%, female: 47%). The most frequent group size of visitors was two or three people (43%); moreover, approximately 50% of visitors used private cars. The most common trip type was the day trip (46%), and the majority of visitors were not there for the first time (32%). The most commonly mentioned trip objectives were engaging in tourism (46%), visiting the disaster area (29%), and eating delicious food (25%). Additionally, the degree to which visitors intended to join a tour guided by a storyteller was high (77%), with the most common contents of interest being stories recounted from the time of the disaster (77%) and lessons from

©2019. Japan Geoscience Union. All Right Reserved.

the disaster (68%). A few people acknowledged enjoying the storytelling tour locally (12%) and on the Web (6%). On the whole, the GEJE experience was regarded as worth handing down to future generations and sharing with the world (very valuable: 82%, somewhat valuable: 11%). Compared to non-guided visitors, guided visitors had a greater sense of being present during the disaster ($P < .01$, T-test) and were encouraged to change their attitudes toward disasters ($P < .01$, based on a single regression analysis). In conclusion, Kamaishi City still functions as a disaster tourism site but it is thought that efforts to increase the city’ s appeal in the future are necessary.

Keywords: tourism, Great East Japan Earthquake, storyteller, questionnaire



©2019. Japan Geoscience Union. All Right Reserved.

Population Change in Ishinomaki City, Miyagi Prefecture, with a Focus on the Area around the Earthquake Ruins

*Ryo Nishisaka[1], Katsunori Furuya[1]

1. Chiba University

1. Introduction

Eight years have passed since the Great East Japan Earthquake of 2011. There is a movement to preserve buildings and structures affected by the earthquake and resulting tsunami as earthquake ruins and to utilize them for storytelling and disaster prevention. In the Tohoku region, where the birthrate is declining and the population is aging, sustainable management of the earthquake ruins will be an issue.

So far, the bereaved families and storytellers (called the kataribe) who live around the earthquake ruins of Ishinomaki are known to have been working on the management of flowers from visitors, cleaning up the earthquake ruins, and improving the flowerbeds. At the same time, residents around the earthquake ruins might be affected by the increase in the number of visitors when the earthquake ruins are opened to the public, so consideration of them is necessary. Therefore, this paper aims to clarify the population change around the former Kadonowaki Elementary School and the former Okawa Elementary School, which are the two earthquake ruins in Ishinomaki.

2. Methods

We investigated mesh population data of 500-meter mesh areas from “Population Census,” published by the Statistics Bureau, Ministry of Internal Affairs and Communications, Japan, and analyzed the population change of Ishinomaki between 2010, before the earthquake, and 2015, after the earthquake, using Geographic Information Systems (GIS). We extracted the two earthquake ruins and created buffers of 2,000 meters. We considered the population change within 2,000 meters of the two earthquake ruins as well as the situation regarding Ishinomaki’s recovery.

3. Results

As a general overview of the population change in the whole city of Ishinomaki, we can confirm a large population decline in coastal areas that were reached by the tsunami, such as Kadonowaki-*cho*. In addition, large-scale temporary housing was constructed and a population migration to the inland area was confirmed.

Although the overall population decline was significant within 2,000 meters of the former Kadonowaki Elementary School, a population increase was confirmed in a small area near the temporary housing in Hiyorigaoka.

Even within 2,000 meters of the former Okawa Elementary School, the population was decreasing as a

©2019. Japan Geoscience Union. All Right Reserved.

whole, but we could confirm an area where the population increased slightly. There were no large temporary housing structures around the former Okawa Elementary School, and the population did not accumulate.

4. Discussion

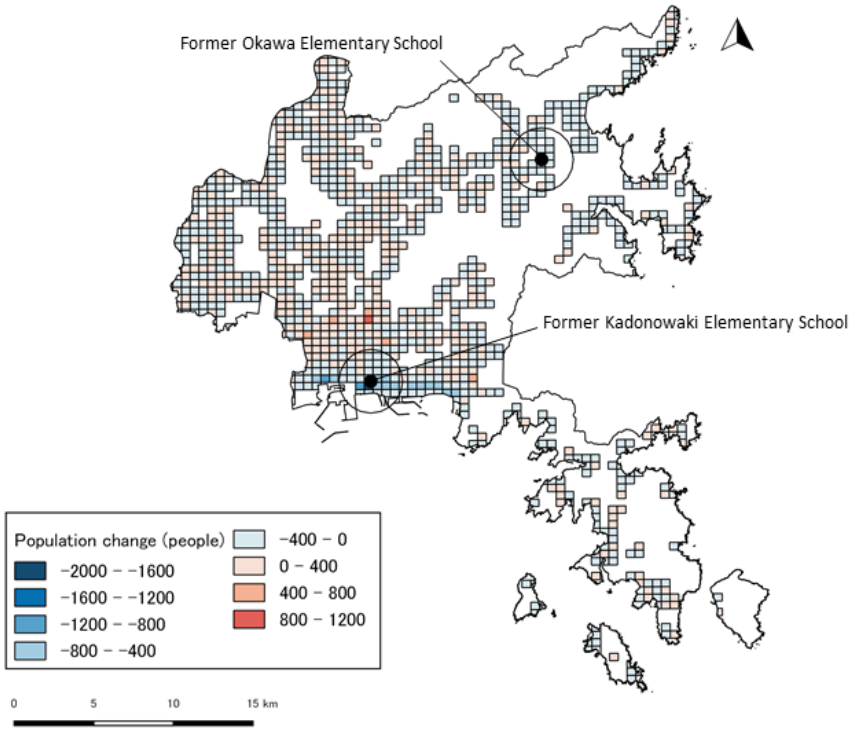
In Ishinomaki, after the Great East Japan Earthquake, the population of the coastal area drastically decreased, and population increase in the inland area was confirmed. Both the former Kadonowaki Elementary School and the former Okawa Elementary School had a drastic decrease in population within 2,000 meters. However, the existence of areas where the population was increasing even within 2,000 meters was confirmed. It seems that the presence of temporary housing greatly influenced the change in population.

The population changes around both earthquake ruins were large, so it is thought that there were many cases in which bereaved families and residents involved in the elementary schools had relocated. Particularly concerning the former Okawa Elementary School, there is a possibility that there was a large-scale relocation to the southwestern part of the city, where population increase advanced. In Ishinomaki, the situation with tenancy in temporary housing continues to change even after 2015, and now temporary housing is being demolished and residents are moving into public housing. In the future, it is necessary to track the population changes and consider how to support the activities in the earthquake ruins by residents who cannot easily get there.

Keywords: Earthquake Ruins, Ishinomaki, GIS, Population Change

©2019. Japan Geoscience Union. All Right Reserved.

Fig. Population change in Ishinomaki <2010-2015>



©2019. Japan Geoscience Union. All Right Reserved.

The Way of Seeing the Atomic Bomb Dome and the Relationship with Viewers' Attributes

*yasuhara arisa[1], Kiyotatsu Yamamoto[1], Akio Shimomura[1]

1. Graduate School of Agricultural and Life Sciences, The University of Tokyo

1. Introduction

The Atomic Bomb Dome (ABD) is one of the major atomic bombing sites in Hiroshima. In 1996, it was registered as an UNESCO World Heritage Site under the name "Hiroshima Peace Memorial," and its lasting preservation was secured. However, like other world heritage sites, its maintenance and management were not easy. Hiroshima City, taking charge of the management, established "Preservation and maintenance policies of peace memorial museums (2006)," in which the role of the ABD was specified as "The witness of history who suffered heavy damage by an atomic bomb" and "The symbol of hope for nuclear weapon extinction and lasting peace." This policy considered the mindset of the people who wished for peace, tried to preserve the history, and achieve World heritage-registration. This description meant regarding the ABD as the memory of Hiroshima. In other words, it was aimed to include not only the Dome's visual image (the visual aspect) but also the history of Hiroshima and people who had an emotional connection with the town (the semantic aspect), and to preserve both. To embody the idea in a preservation plan, it is necessary to clarify the history of Hiroshima as the background of the ABD and the mindset of people. This study analyzes the "way of seeing" to reveal "how" and "by whom" the ABD has been seen until today, and to understand the memory of Hiroshima.
In light of the above issues and viewpoints, the objectives of this study are 1) to classify the way of seeing the dome and 2) to address the meaning of the relationship between the landscape types and viewers' attributes.

2. Methods

Photographs were collected to understand how ABD is seen by a variety of viewers. Approximately 561 photographs in which the ABD appeared were found in 52 books at the Hiroshima City Central Library. These were selected as materials for analysis, excluding those wherein who took the photograph and when it was taken could not be identified. Time, locations, and photographers were identified, and the constituent elements of each scene were counted to understand the characteristics of the photographs. The attributes of photographing through identification are as follows: (1) time: year of photographing; (2) locations: 6 areas of photographing; and (3) photographers: 4 categories extracted by combining "people who visited Hiroshima," "people who were born or lived in Hiroshima," "photographers," and "amateur photographers." After this process, the sceneries were divided into typical patterns by using quantification method of the third type and cluster analysis. Finally, the relationship between the landscape types and the photographers' attributes was analyzed.

3. Results and Conclusion

The ways of seeing were classified into 6 types, which were related to photographers' attributes. These were: I) landscape hit by atomic bomb, II) landscape with low buildings, III) landscape viewed through the Hiroshima Peace Memorial Monument, IV) landscape of the ABD, V) landscape with plants, and VI) landscape with high buildings. Moreover, it was revealed that landscape I) was photographed more by "people who visited Hiroshima." Likewise, II), III), and IV) were related to "photographers who were born or lived in Hiroshima," "people who were born or lived in Hiroshima," and "photographers who visited Hiroshima," respectively. Additionally, the elements included in the photographs, the main period

©2019. Japan Geoscience Union. All Right Reserved.

of photographing, and the viewpoint of photographing differ according to the landscape types. In conclusion, it was suggested that the meaning of Hiroshima’ s memory as understood by the photographers was diverse and it was necessary to provide the visitors to ABD with various landscape experiences related to the ways of seeing the ABD.

Keywords: Atomic Bomb Dome, way of seeing, landscape, photograph, world heritage



©2019. Japan Geoscience Union. All Right Reserved.

Flood Disaster Risk Analysis at Ratnapura in Sri Lanka

*Tsuchida Ryo[1], Kaoru Takara[1]

1. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University

This paper describes disaster risk at a flood-prone area in southwest Sri Lanka where a severe flood disaster took place in May 2017. First, the author conducted frequency analysis at Ratunapura by using a 125-year annual maximum rainfall series to evaluate the probability of the 2017 event. Second, land use change was also detected by Landsat-8 images before and after the flood. Visiting Ratunapura a couple of times, the author interviewed people and the local government to understand the situation of the flood disaster and how they coped with the flood by utilizing a framework based on disaster ethnography. Results obtained from the interview survey showed that the residents, who acted on their own experience and knowledge, could not respond to disasters when enormous floods occurred, and the flood disaster brought them bad influences in many ways. In addition, external organizations including governments, UN agencies and Non Profits Organizations for disaster relief could not provide adequate supports to reflect the needs of residents worth covering vulnerabilities. Moreover, this survey found that the government’s assessment of the house and livelihood damage was delayed. Also, distribution of allowance and supplementary from the government was delayed. The research results in this paper would be useful for flood disaster risk reduction and for understanding recovery proesses in Sri Lanka.

Keywords: Flood Disaster, Frequent Analysis, Land Use Change, Recovery and Rehabilitation, Sri Lanka

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 101 1F

[H-TT21] Non-destructive techniques applied to stone cultural heritage

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Celine Elise Thomachot-Schneider(Groupe d'etude des environnements naturels, anthropiques et archeologiques - Universite de Reims-Champagne-Ardenne (France)), Wonsuh Song(Waseda University), Miguel Gomez-Heras(Universidad Autonoma de Madrid), Chairperson:Wonsuh Song, Chiaki Oguchi

Non-destructive and non-invasive techniques applying to cultural heritage made of stones, soils and earthen materials have been significantly developed over past years, and thus, the interest in such techniques has greatly increased. Here, we focus the session on new devices, new protocols and new data treatments that allow better understanding of weathering mechanisms, decay states and response to treatments.
A few topics would be listed as follows: 1) The development of new techniques and devices in cultural heritage and new protocols using non-destructive techniques; 2) The application of these techniques and protocols on indoor and outdoor case studies and laboratory studies; 3) The assessment of weathering mechanisms, weathering kinetics, decay state, and response to treatments; and 4) The modeling and simulation of decay processes.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HTT21-01] Study on creation of 3D model by SfM photogrammetry: An example of Taya Cave

Kisara Shimizu[1], *Chiaki T. Oguchi[1], Yasuhiko TAMURA[2], Yuichi S. Hayakawa[3], Takuro Ogura[4], OGATA KEISUKE[5] (1.Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University, 2.The Exective Committee for the Preservation of Taya Cavern, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Graduate School of Frontier Sciences, The University of Tokyo, 5.Tsurumi University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HTT21-02] TLS measurement data and 3D printing of an artificial cave for geotechnical and educational applications

*Yuichi S. Hayakawa[1,2], Takuro Ogura[4,5], Yasuhiko Tamura[2], Chiaki T. Oguchi[3], Kisara Shimizu[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Center for Spatial Information Science, The University of Tokyo, 3.Saitama University, 4.Graduate School of Frontier Science, The University of Tokyo, 5.Graduate School of Environmental Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HTT21-03] Conservation restoration of the world heritage of Okinawa Prefecture, Sonohyan-utaki Ishimon - Situation after 30 years since filling with mortar and applying silicone resin.

*Wonsuh Song[1], Tadateru Nishiura[2], Chiaki T. Oguchi[3] (1.Waseda University, 2.Kokushika Univeristy, 3.Saitama University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HTT21-04] Application of portable XRF analysis for provenance of seabed worked stone in coastal are of Kochi Prefecture

★Invited Papers

*Wataru Tanikawa[1], Go-Ichiro Uramoto[2], Masafumi MURAYAMA[2], Yohei Hamada[1], Yuhji Yamamoto[2], Osamu Tadai[3] (1.Japan Agency for Marine-Earth Science and Technology, Kochi Instutute for Core Sample Research, 2.Kochi University, Center for Advanced Marine Core Research, 3.Marine Works Japan LTD.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HTT21-05] pXRF analyses on Assyrain sculptures

★Invited Papers

*Ryo Anma[1], Ki-Cheol Shin[2], Chikako Watanabe[3], Akihiro Tuji[4] (1.Graduate School of Technology, Industrial and Social Sciences, Tokushima University, 2.Research Institute for Humanity and Nature,

3.Faculty of International Studies, Osaka Gakuin University, 4.National Museum of Nature and Science)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HTT21-06] Discussion

*Chiaki T. Oguchi[1] (1.Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University)

Study on creation of 3D model by SfM photogrammetry: An example of Taya Cave

Kisara Shimizu[1], *Chiaki T. Oguchi[1], Yasuhiko TAMURA[2], Yuichi S. Hayakawa[3], Takuro Ogura[4], OGATA KEISUKE[5]

1. Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University, 2. The Exective Committee for the Preservation of Taya Cavern, 3. Faculty of Environmental Earth Science, Hokkaido University, 4. Graduate School of Frontier Sciences, The University of Tokyo, 5. Tsurumi University

SfM (Structure-from-Motion) photogrammetry is one of the methods for creating 3D models of objects by extracting feature points in the images. Taya Cave, the investigation site of the present study, is a historical site of Yokohama City. It has about 200 base-reliefs on the surface of the cave tunnel walls, however, they are suffering from weathering and difficult to preserve from it in the future. The cave was excavated in Kamakura Era originally, and has a total length of 570 m with a three-layer structure. The present study tried to make a 3D model of this complicated, dark and narrow cave by SfM photogrammetry. The accuracy of the created 3D model were evaluated by comparing the values of distances between from the 3D model and from 2016 actual survey data.

Keywords: SfM, Taya Cave

©2019. Japan Geoscience Union. All Right Reserved.

TLS measurement data and 3D printing of an artificial cave for geotechnical and educational applications

*Yuichi S. Hayakawa[1,2], Takuro Ogura[4,5], Yasuhiko Tamura[2], Chiaki T. Oguchi[3], Kisara Shimizu[3]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Center for Spatial Information Science, The University of Tokyo, 3. Saitama University, 4. Graduate School of Frontier Science, The University of Tokyo, 5. Graduate School of Environmental Science, Hokkaido University

Conservation of an underground cultural heritage is often a controversial issue due partly to its invisibility and insufficient awareness in the local society. Also, the safety assessment is necessary to promote sustainable protection of an underground cultural heritage. The developments in high-definition topographic measurements enable to acquire detailed three-dimensional morphological data of a cave, which can be further utilized for the visualization and structural analyses. Regarding the measurements and visualization, we present a case study at the Taya Cave, a registered cultural heritage in Yokohama City, Kanagawa Prefecture in central Japan. The terrestrial laser scanning was performed from multiple scan positions throughout the cave, and the point clouds were registered using the feature-based iterated closest point algorithm. The registered point clouds were then converted into a mesh model, to which face error corrections and a solid filling were applied. After these processes, the mesh model can be printed out in three dimensions. The 3D print model of the cave is used for the class teaching in an elementary school in the local area, and such the visualization of the cave successfully enhanced the recognition by students regarding the underground cultural heritage. The 3D data can also be utilized for the structural assessment of the cave. Effective and sustainable protection of the cave will further be possible by integrating such geotechnical assessments and outreach activities in the local society.

Keywords: terrestrial laser scanning, point cloud, 3D printing, outreach, underground cultural heritage

©2019. Japan Geoscience Union. All Right Reserved.

Conservation restoration of the world heritage of Okinawa Prefecture, Sonohyan-utaki Ishimon - Situation after 30 years since filling with mortar and applying silicone resin.

*Wonsuh Song[1], Tadateru Nishiura[2], Chiaki T. Oguchi[3]

1. Waseda University, 2. Kokushika Univeristy, 3. Saitama University

Sonohyan-utaki Ishimon in the Shuri Castle Park has been registered as a World Heritage Site in 2000 as a place of "Gusuku and related heritage group of the Ryukyu Kingdom". The stone gate (Ishimon) and the forest behind it are called Sonohyan-utaki and used as a place of worship for praying for safety when the King of the Ryukyu Kingdom goes out. It was built with Ryukyu Limestone in 1519, was designated as the old national treasure in 1933 but was destroyed in the battle against Okinawa, was restored in 1957, and repaired in 1986. It became the national designated building in 1972. At the time of demolition repair, an old roof stone was used, but cleaning and water repellent silicone resin impregnation and surface filling were done at this time. Currently, as can be seen in Figure 1, the color of the entire stone gate becomes darker, the difference in color between the filling part of the roof and the original stone is becoming noticeable. The purpose of this study is to be used for the repair treatment in the future.
In order to understand the color of the surface of the repaired roof and the overall color of the stone gate, quantitative measurements were made using a spectroscopic colorimeter (Konica Minolta, CM-700d) at 51 locations on the surface of the stone gate. The proportion of blackened parts was determined from the front of the stone gate using Photoshop. To measure the surface temperature of the stone gate, we grasped the temperature distribution of the surface using the FLIR thermal camera.
We installed a button type temperature and humidity measuring instrument in the upper left side of the stone gate with the permission of Naha City to grasp the change of temperature and humidity in the year-round. As a result of the measurement by the spectrophotometer, the color of limestone was bright, and it was almost the same color as the repair material in the roof part. However, the discoloration rate and the situation were different after 30 years. The repair material was gray, and it was found that the original stone was darker. The average annual temperature observed under the roof of the stone gate was 24 ˚c, and the average humidity was 81.5%, and the characteristics of the hot and humid subtropical climate were observed. The average temperature in winter was 22.1 ˚c, and the humidity was 80% and the lowest temperature was 8.5 ˚c. Therefore, it seems that the growth of vegetation is very fast and it may affect the color of rock surface.

Keywords: Stone cultural heritage, Restoration, Okinawa , Limestone, Colorimeter

©2019. Japan Geoscience Union. All Right Reserved.



Fig. 1. After completing conservation restoration work of Sonohyan-utaki Ishimon (left) and situation of thirty years later (right).

©2019. Japan Geoscience Union. All Right Reserved.

Application of portable XRF analysis for provenance of seabed worked stone in coastal are of Kochi Prefecture

*Wataru Tanikawa[1], Go-Ichiro Uramoto[2], Masafumi MURAYAMA[2], Yohei Hamada[1], Yuhji Yamamoto[2], Osamu Tadai[3]

1. Japan Agency for Marine-Earth Science and Technology, Kochi Instutute for Core Sample Research, 2. Kochi University, Center for Advanced Marine Core Research, 3. Marine Works Japan LTD.

Many stone pillars around 1m long, which look like artifacts, lie on the seafloor in off Tsumajiro, Kochi Prefecture, Japan. Tsumajiro area has been repeatedly damaged by tsunami from Nankai earthquakes, and extreme rainfalls by typhoon events. Therefore, we suggest that a tsunami or river floods might have transported the pillars offshore, or coseismic land subsidence might have caused them to become submerged. To assess the origin of the submerged stone pillars in the Tsumajiro area (Tsumajiro pillars), we analyzed mineralogy, geochemistry and physical property of Tsumajiro pillars, of rocks from natural expores and quarries in Tsumajiro and neighboring areas, and of building stones in use in the Tsumajiro area. We analyzed concentrations of major and trace elements in samples using a portable X-ray fluorescence (pXRF) spectrometer, and estimated mineral composition of samples using powdered XRD analysis. Porosity and grain density were also measured on all samples.

In the XRF spectral data, we clearly recognized peaks for 12 elements (Mg, Si, S, K, Ca, Ti, Mn, Fe, Rb, Sr, Zr, and Pd) in all samples. Therefore, we selected these 12 elements for PCA. In the PCA results for all samples, we could clearly divide those into sandstone group and shale group from the first principle component, where components of Mg, Fe, and Ti strongly influenced. In PCA results for sandstone only, we could see the characteristics of each samples much more clearly. Submerged pillars showed similar characteristics, where a component of Zr was strongly contributed, with Tatsukushi formation in Misaki group (natural exposures and quarries) and foundation stones for main building at Tsumajiro area. Porosity, grain density, and mineral composition were also similar between Tsumajiro pillars, Tatsukushi formation, and a foundation stone.
Our results suggest that the submerged stone pillars were made from Tatsukushi sandstone and had been utilized as building stones for structures such as steps and foundations in Tsumajiro village.

Keywords: Principle Component Analysis (PCA), Provenance, pXRF, sedimentary rock, Nankai earthquake

©2019. Japan Geoscience Union. All Right Reserved.

pXRF analyses on Assyrain sculptures

*Ryo Anma[1], Ki-Cheol Shin[2], Chikako Watanabe[3], Akihiro Tuji[4]

1. Graduate School of Technology, Industrial and Social Sciences, Tokushima University, 2. Research Institute for Humanity and Nature, 3. Faculty of International Studies, Osaka Gakuin University, 4. National Museum of Nature and Science

To evaluate a possibility of reconstruction and understanding the provenance of stone materials used in the ancient cities of Western Asia, some of which have been destroyed and/or dismantled, and are moved to different places of the world, we characterized the bulk geochemical composition of gypsum-carbonate rocks, on which the Assyrians carved sculptures to decollate their palaces, using an Olympus VANTA portable X-ray fluorescence spectroscopy (pXRF). To establish the methodology, we started with the Assyrian sculptures with known provenance: i.e. the collections of the British Museum, the Ashmolean Museum, Magdalen College (Oxford), the Okayama Orient Museum and the MIHO museum.
The pXRF analysis was performed using a Rh target at 40 kV and 100 μA. Beam time was 20 seconds for Beam 1 and 15 and 30 seconds, in later sessions, for Beam 2. The accuracy and precision of the analyses were assessed by analyzing several powdered reference samples of igneous rocks (JB-2 basalt, JA-1, JA-2 andesites, JR-2 rhyolite JG1, JG2 granites and JGb-1 gabbro) and sedimentary rocks (JLk-1 lake sediment, JSd-1 and JSd-2 river sediments, JLs-1 limestone and JDo-1 dolomite) distributed by the Geological Survey of Japan, and gypsum samples (alabaster, selenite and satin spar) distributed by Nichika Inc. We performed the measurement three-times for each spot to assess repeatability of the measurement and/or inhomogeneity of the samples.
Our results showed that ~ 99% of the measured Assyrian sculptures were made of gypsum-anhydrate rocks. Although their distribution fields largely overlap, the gypsum sculptures from Nineveh tend to have more impurities when compared with those from Nimrud and Khorsabad. Visually, the stone materials used in the sculptures in Nimrud often have homogeneously distributed large gypsum crystals, whereas those from Nineveh are rather inhomogeneous and finer in grain size, and often exhibit developed bedding planes. Together with the textural changes, we provisionally conclude that degraded stone materials became used over time.
The Til-Tuba sculpture from Room 33 of the Southwest Palace of Nineveh has higher Ca and lower S contents compared with others. Visually, it contains numerous foraminifera shells of *Alveolinidae Sp*. The different chemical composition could be attributed to the amount of the included foraminifera shells. Stones from Room 36 of Nineveh Southwest Palace have slightly higher Al and Fe contents than others. Although, few such examples have somewhat different compositions, the exact provenance would not be able to identify from a single chemical data. More information obtained through destructive analyses would be necessary for the reconstruction and understanding the provenance of stone materials, such as textural and mineralogical information through thin-section observation, crystallographic information through XRD analysis and analyses of micro-fossils.
Nevertheless, our observation from a material science point of view can provide evidence to what Sennacherib (705-681 BCE) described in his text. The king states that he used “Na_4.^{d}Še.tir” stone from Nipur (Judi Dagh in SE Turkey) that looks like cucumber seeds to construct the statues of Aladlammû and *Apsātu*. Based on this, Mitchel and Middleton (2002) speculated that this same stone was used for the reliefs in Room 33 of the Southwest Palace, Nineveh. If their speculation is correct, evaporites of the middle to late Miocene Fars formation should have comprised the quarry.

Keywords: pXRF, Assyrian sculpture

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Discussion

*Chiaki T. Oguchi[1]

1. Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University

Discussion on non-destructive techniques for geoheritage.

Keywords: non-destructive techniques

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT26] New perspectives on the geodynamics of East Asia

convener:Timothy B Byrne(University of Connecticut), Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo), Jonny Wu(University of Houston), Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Jonny Wu, Okino Kyoko

The Pacific, Indo-Australia and Eurasian plates converge around the Philippine Sea plates in south and East Asia, resulting in one of the most tectonically active regions on earth. The area is also geologically and tectonically complex with numerous active tectonic environments, ranging from subduction to collision, and a long history of plate boundary interactions. The last decade has yielded a wide range of new observations, including detailed geologic data and high resolution crustal to mantle imaging. Here we seek oral and poster presentations that bear on the geologic history and geophysical character of modern and ancient plates in East Asia and their interactions since the Mesozoic. We also invite geodynamic models that integrate these diverse datasets into a more holistic view of this dynamic environment.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SIT26-01] How to solve controversies in Cenozoic tectonics in western Pacific margin

*Gaku Kimura[1] (1.Tokyo University of Marine Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SIT26-02] Plio-Pleistocene plate interactions associated the Philippine Sea Plate

*Timothy B Byrne[1], Gaku Kimura[3], Jonny Wu[2] (1.University of Connecticut, 2.University of Houston, 3.Tokyo University of Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SIT26-03] A regional mylonite zone between the Mesozoic metamorphic basement and the subducted Miocene covered schists in eastern Range of Taiwan: A possible Plio-Pleistocene transform fault between Eurasia and the Philippine Sea plate

*Gong-Ruei Ho[1], Jian-Cheng Lee[1], Timothy B Byrne[2], En-Chao Yeh[3] (1.Institute of Earth Sciences, Academia Sinica, 2.Department of Geography, University of Connecticut, 3.Department of Earth Sciences, National Taiwan Normal University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SIT26-04] **Coeval exhumation or subduction channel extrusion of the high pressure Yuli belt? Insights from the Shoufeng fault in eastern Taiwan**

*Jian-Cheng Lee[1,5], Gong-Ruei Ho[1,5], Timothy B Byrne[2], Yuan Hsi Lee[3,5], En-Chao Yeh[4,5] (1.Academia Sinica, 2.Univerity of Connecticut, 3.National Chung Cheng University, 4.National Taiwan Normal University, 5.The Yuli Exhumation Study team (YES Team))

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SIT26-05] Metamorphic temperature variation across the Yuli belt: a clue about exhumation of high-pressure rocks?

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Yui Kouketsu[2], Masaki Enami[3] (1.Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2.Department of Earth & Planetary Sciences, Nagoya Univ., 3.Institute for Space-Earth Environmental Research, Nagoya Univ.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SIT26-06] **Thermal state, slab metamorphism and interface seismicity in Mariana based on 3-D modeling**

*Yingfeng Ji[1,2,3], Shoichi Yoshioka[3,4] (1.Center of Excellence in Tibetan Plateau Earth Science, Chinese Academy of Sciences, 2.Key laboratory of continental collision and plateau uplift, Institute of Tibetan Plateau, Chinese Academy of Sciences, 3.Research Center for Urban Safety and Security, Kobe University, 4.Graduate School of Science, Kobe University)

How to solve controversies in Cenozoic tectonics in western Pacific margin

*Gaku Kimura[1]

1. Tokyo University of Marine Science and Technology

Tectonics and their geodynamic backgrounds are difficult theme and keep controversial. Cenozoic tectonics in the western Pacific margin are of them. 1) Oceanic ridge subduction, 2) Back-arc spreading, 3) interaction between the Philippine Sea Plate and SW Japan, 4) collision and bending of the Japanese islands, 5) onset of present tectonic and dynamic frameworks, and 6) dynamic background of the earthquakes and volcanic eruption are key events but controversial.

To solve these controversies, a classic geological philosophy of “uniformitarianism” is significant. It means “the present is the key to the past”.

1. To solve the controversy of the Izanagi-Pacific Ridge subduction in early Cenozoic, a comparative study with modern examples of the ridge subduction at the Chile triple junction, Woodlrack Basin and Middle America trench with a new data set and simlation is a key.
2. To solve the back arc spreading controversy of Kuril and Japan Basins and Okinawa Trough, the promotion of International collaboration to acquire a new data set is necessary together with a comparative study among the modern backarc spreading. A classic controversy of double door opening vs pull-apart spreading will be progressed by comparison with progressed modern examples. A large scale perspective beyond the back-arc basins themselves is also necessary for geodynamic solution for the back-arc spreading.
3. To solve the controversy of the interaction between the Philippine Sea Plate and SW Japan; switch from the Pacific plate to Philippine Sea Plate at ~15Ma vs ~12Ma- 6Ma, detailed tomographic study with new perspectives and data sets from on-and geology and geophysics is necessary with simulation.
4. To solve the controversy of the collision and bending of the Japanese islands, not only the geological data set but more comprehensive data set of geophysics and geochemistry with simulation are necessary. Differentiation between the hypothesis and fact promotes a constructive controversy. In geology, data reliability and re-productablity is the most significance part of science.
5. To solve the controversy of onset of present tectonic and dynamic frameworks is the most essential part of “uniformitarianism”. The definition of “present” depends on the scientific field even in geoscience, Seismological “present” is a moment to minutes, days and month scale, That of geodesy is ~10s to 100 years. Geomorphology combined with geology is 100s to 10^4 scale. That of most geology is beyond 10^4 scale. Establishment of seamless “uniformitarianism” with seamless space perspective is a key to understand this controversy.
6. To solve dynamic background of the earthquakes and volcanic eruption, I like to emphasize the viewpoint of evolving effect of hysteresis. A final trigger of earthquakes and volcanic eruption is no doubt of physical consequence resulted from long and short term hysteresis.

Keywords: western Pacific, ridge subduction, back-arc spreading, collision, subduction, Japanese islands

©2019. Japan Geoscience Union. All Right Reserved.

Plio-Pleistocene plate interactions associated the Philippine Sea Plate

*Timothy B Byrne[1], Gaku Kimura[3], Jonny Wu[2]

1. University of Connecticut, 2. University of Houston, 3. Tokyo University of Science and Technology

Geologists have long recognized the possible significance of a change in motion of the Philippine Sea Plate (PSP) in the middle to late Cenozoic (Huchon, 1983; Seno and Maruyama, 1984), although the detailed timing and kinematics have remained elusive. The most recent reconstructions suggest a ~50° counterclockwise rotation of the plate motion vector relative to Eurasia possibly as recently as 2 Ma (Wu et al., 2015), which would have significant implications for the tectonics of east-central Asia. In southern Japan, for example, CCW rotation of the plate motion vector predicts a change from generally orthogonal plate convergence to the present NW-directed and oblique motion. In Taiwan, in contrast, plate convergence obliquity would decrease significantly. To better understand and possibly better constrain the geometry, kinematics and timing of this change in motion, we review the geologic histories of different geologic units and terranes along the boundary of the PSP, including: the Okinawa Trough, Kyushu and Shikoku Islands, Kumano Basin, Boso and Miura Peninsulas, the southern Marianas, the Philippines and Taiwan. Several areas in southern Japan also appear to provide critical constraints on the kinematics and timing of a possible change in motion. For example, geological and geophysical studies of the accretionary prism in SW Japan show a transition from shortening perpendicular to the plate boundary to extension perpendicular to the boundary <1.0 Ma (Gulick et al., 2010, and Sacks et al., 2013). Although these authors suggest that this change reflects changes in subduction zone dynamics, we propose that the change to extension relates to the decrease in the rate of convergence across the prism as the plate motion changed from nearly orthogonal to more oblique at ~1.0 Ma. Hayman et al. (2012) also documented a CCW rotation in the shortening direction deep in the Nankai accretionary prism just south of Shikoku Island, although the timing of this rotation was only constrained to be younger than ~5 Ma (the age of the youngest deformed sediments). In the eastern Nankai, Yamaji et al. (2003) interpreted a similar suite of faults to be related to a similar change in plate motion at ~1 Ma. Further landward, studies of the Median Tectonic Line on Shikoku Island document a change from thrusting to right-lateral strike-slip faulting at about ~0.8 Ma (Mizuno, 1999; Sato et al., 2015). This change in kinematics and timing is consistent with previous ideas on the age of formation of the Nankai forearc sliver (~0.8 Ma) based primarily on geologic and geomorphic data from Shikoku Island (Ohmori, 1978; Saito, 1999; Okamura, 1990). Finally, in Taiwan, Hsu et al. (2016) have proposed an acceleration in rock uplift at ~0.8 Ma based on low-temperature thermochronology data that may reflect an acceleration in plate convergence related to changing plate motions. Taken together, these observations suggest that a significant change in the plate motion vector (i.e., CCW rotation) occurred relatively recently and probably < 1 Ma.

Keywords: plate tectonics, philippine sea plate

©2019. Japan Geoscience Union. All Right Reserved.

A regional mylonite zone between the Mesozoic metamorphic basement and the subducted Miocene covered schists in eastern Range of Taiwan: A possible Plio-Pleistocene transform fault between Eurasia and the Philippine Sea plate

*Gong-Ruei Ho[1], Jian-Cheng Lee[1], Timothy B Byrne[2], En-Chao Yeh[3]

1. Institute of Earth Sciences, Academia Sinica, 2. Department of Geography, University of Connecticut, 3. Department of Earth Sciences, National Taiwan Normal University

As one of the youngest orogenic belts, Taiwan offers insights into mountain building processes operating from the Earth’ s surface. In the eastern Central Range of the Taiwan mountain belt, the Tananao metamorphic belt, comprising the Tailuko Belt, high temperature/low pressure Mesozoic basement, was attached by the Yuli belt, a Miocene pelitic quartz-mica schist with high-pressure exotic mafic to ultra-mafic blocks (Yen, 1960; Tsai et al., 2013). Observations of meso- and microscopic structures show predominant asymmetric folds with top-to-east S2/S3 on the eastern Yuli belt and isoclinal folds with west dipping S2 on the western Tailuko belt. In the boundary between these two geological rock units, we observed a mylonite zone distributed about 2 kilometers wide, which has been called the Shoufeng Fault, which indicated sinistral sense of shear and shallow stretching lineation within the mylonite zone. The structural style of other area is relatively irregular and disordered (Stanley et al., 1981; Lu and Wang Lee, 1986; Pulver et al., 2002; Ho, 2007; Liao, 2011; Ji, 2011). This pattern was found from north to south in a distance of 100 km along the Yuli belt along the Mugua, Shoufeng, Wanliqiao, and Chinshui Rivers to the Southern Cross island highway and the Dawushan map (Usami, 1940). The above observations pointed out an apparently down-dip folding coupled with a dominant orogen-parallel lineation pattern around the Shoufeng mylonite zone between the Miocene Yuli belt and the Mesozoic Tananao complex. It provides structural constraints on the deformation associated with ductile metamorphism of the high-pressure Yuli belt terrane while attached against the much older continental crust of the Tananao complex as well as during the subsequent rapid exhumation processes.

Keywords: Tananao metamorphic belt, mylonite zone, left-lateral strike slip motion

©2019. Japan Geoscience Union. All Right Reserved.

Coeval exhumation or subduction channel extrusion of the high pressure Yuli belt? Insights from the Shoufeng fault in eastern Taiwan

*Jian-Cheng Lee[1,5], Gong-Ruei Ho[1,5], Timothy B Byrne[2], Yuan Hsi Lee[3,5], En-Chao Yeh[4,5]

1. Academia Sinica, 2. Univerity of Connecticut, 3. National Chung Cheng University, 4. National Taiwan Normal University, 5. The Yuli Exhumation Study team (YES Team)

Based on field investigations, microscopic observations, and available geophysical, geochemical and geochronological data, this study intends to better understand the structural characteristics of the Eurasian continental margin (e.g., the eastern Central Range in Taiwan) during subduction and exhumation while the Philippine Sea plate has been approaching in the vicinity of Taiwan since the Miocene time. The eastern Central Range is composed of two major geological units: 1) the Tailuko belt, the Mesozoic metamorphic subduction complex, retro-metamorphosed in green schist facies and exhumed since late Miocene, and 2) the Yuli belt, continental margin rocks that contain high-pressure minerals (omphacite, glaucophane, garnet) with Miocene-Pliocene ages suggesting rapid exhumation from mantle depths of 40-50 km.

We conducted detailed field surveys around the Shoufeng fault which represents the boundary between the Tailuko belt and the Yuli belt. We found a mylonite zone of several kilometers wide in the boundary of these two belts. Based on the meso- and microscopic scale observations we define the boundary as ultra-mylonite, mylonite, and proto-mylonite zones. Within the ultra-mylonite and mylonite zones, rocks from two belts are intercalated each other in varied widths. The main dominant schistosity/cleavage in the mylonite zones (Sm/S3) remains the same orientation of striking in NE/NNE and dipping to the west. Also, the main composition layers, which we tentatively called S2 for the sake of field investigations, were more intensively deformed (i.e., crenulated, folded, etc.) from outside toward the core of the mylonite zones. As a result, the Sm/S3 becomes less persistent outside of the mylonite zones in the Yuli belt.
The mylonite zones exhibit left-lateral Sm/S3-related shearing without significant down-dip component. We also observed a general S2/S3-related top-to-west sense of shear across the two belts. As a consequence, we tend to interpret that the Yuli belt and the Tailuko belt have been mylonitically sheared (Sm/S3) in a left-lateral movement at the depth and that they exhumed coevally up to the surface level. The schistosity of the main composition layers S2 probably occurred before the mylonization during the transition from subduction to exhumation. The shallow dipping and less dominant S3 outside the mylonite zone might imply a upward and unroofing process during the rapid exhumation of the eastern Central Range of Taiwan.

Keywords: Mylonite, Exhumation, Shoufeng fault, Yuli belt, Taiwan

©2019. Japan Geoscience Union. All Right Reserved.

Metamorphic temperature variation across the Yuli belt: a clue about exhumation of high-pressure rocks?

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Yui Kouketsu[2], Masaki Enami[3]

1. Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2. Department of Earth & Planetary Sciences, Nagoya Univ., 3. Institute for Space-Earth Environmental Research, Nagoya Univ.

We applied Raman spectra of carbonaceous material (RSCM) geothermometer to estimate peak metamorphic temperatures of pelitic and psammitic schists across the Yuli belt, eastern Taiwan. The analyzed samples mainly consist of phengitic mica, quartz, chlorite, and albite, with accessory graphitic carbonaceous material, titanite, zircon, and tourmaline. In samples from the Juisui Schist and Chinshuichi Plantation units (both containing high-pressure allochthonous blocks), garnet, ilmenite, and paragonite may occur and albite tends to be porphyroblastic. Serpentinite and metabasite pods occur in these units, whereas the neighboring metasedimentary units lack such rocks and porphyroblastic phases. The yielded metamorphic temperatures reveal a systematic variation in spatial distribution across the Yuli belt. In the Wanjung and Juisui areas, peak temperatures of the four schist units are in the range of 430-510˚C, 410-470˚C, 560-620˚C and 420-450˚C, from west (structurally upper) to east (lower), respectively. In the Chinshuichi area, temperatures of the two units are in the range of 540-560˚C (structurally lower) and 400-450˚C (higher), whereas the temperatures of the low-grade Slate unit (Chulai Formation) bordering the Yuli belt in the east are 330-340˚C. The high-pressure Juisui Schist and Chinshuichi Plantation are apparently warmer than their neighboring units in each area, although boundaries of the units are poorly exposed or characterized. The spatial distribution of metamorphic temperatures requires a structural explanation. Possible interpretations include doming, extension, or extrusion, and the inferred structures and processes may shed new lights on the exhumation of high-pressure metamorphic rocks in the Yuli belt.

Keywords: metasedimentary rocks, thermobarometry, carbonaceous material, exhumation, high-pressure metamorphism

©2019. Japan Geoscience Union. All Right Reserved.

Thermal state, slab metamorphism and interface seismicity in Mariana based on 3-D modeling

*Yingfeng Ji[1,2,3], Shoichi Yoshioka[3,4]

1. Center of Excellence in Tibetan Plateau Earth Science, Chinese Academy of Sciences, 2. Key laboratory of continental collision and plateau uplift, Institute of Tibetan Plateau, Chinese Academy of Sciences, 3. Research Center for Urban Safety and Security, Kobe University, 4. Graduate School of Science, Kobe University

The Marina arc system represents a typical mode of intra-oceanic convergent boundary characterizing circum-Pacific subduction zones, together with the Izu-Bonin, Kuril and Tonga-Kermadec margins well known for the tectonically formed deep trenches. Active back-arc extension driven by hydrothermal mantle upwell comprises one of the significant features of Mariana caused by steep subduction. Previous studies document that the narrow subduction constrains the seismicity in Mariana to be less than M7. However, the subduction thermal regime remains still unclear in detail. Based on the 3-D thermal model constructed for Mariana, we found that the highly curved Mariana arc presenting such a particular tectonic setting caused by trench retreat produces a cold thermal structure beneath the central and northern Mariana influenced by an oblique subduction. The deep earthquakes (>100 km) are therefore frequently detected compared with the southern Mariana. The subducted Pacific plate entraining the oceanic crust components is calculated to obtain their pressure-temperature conditions for different petrological faces undergoing multiple phase transition including the paths from amphibolite to eclogite or harzburgite at a high temperature of >500 degrees in Celsius which is conjectured to facilitate the deep earthquakes at Mariana. The dewatered oceanic plate is expected to releases ample fluids for the backarc volcanism and hydrous circulation at Mariana mantle wedge. The 3-D temperature structure of Mariana obtained in this study sheds lights on regional earthquake genesis and slab metamorphism in such an intro-oceanic subduction system featured by deep events.

Keywords: Thermal state, slab metamorphism , interface seismicity, Mariana, 3-D modeling

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT26] New perspectives on the geodynamics of East Asia

convener:Timothy B Byrne(University of Connecticut), Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo), Jonny Wu(University of Houston), Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo), Tim Byrne

The Pacific, Indo-Australia and Eurasian plates converge around the Philippine Sea plates in south and East Asia, resulting in one of the most tectonically active regions on earth. The area is also geologically and tectonically complex with numerous active tectonic environments, ranging from subduction to collision, and a long history of plate boundary interactions. The last decade has yielded a wide range of new observations, including detailed geologic data and high resolution crustal to mantle imaging. Here we seek oral and poster presentations that bear on the geologic history and geophysical character of modern and ancient plates in East Asia and their interactions since the Mesozoic. We also invite geodynamic models that integrate these diverse datasets into a more holistic view of this dynamic environment.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SIT26-07] **A tomography-led plate reconstruction of NE Asia during the late Cretaceous**

*Jonny Wu[1], Yi-An Lin[1], Nicolas Flament[2], Tsung-Jui Wu[1], Yiduo Liu[1] (1.University of Houston, 2.University of Wollongong)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SIT26-08] Geodynamic models of late Mesozoic intraoceanic subduction offshore NE Asia caused by growing Izanagi plate

*Lorenzo Colli[1], Jonny Wu[1], Yi-An Lin[1] (1.University of Houston)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SIT26-09] **Early Cretaceous to Paleocene magmatism in the Sikhote-Alin area and their implications for Paleo-Pacific plate subduction and continental evolution**

*Tsung-Jui Wu[1], Jonny Wu[1], Igor Alexandrov[2], Thomas Lapen[1] (1.Department of Earth and Atmospheric sciences, University of Houston, Houston, U.S., 2.Far East Geological Institute, Russian Academy of Sciences, Vladivostok, Russia)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SIT26-10] Processes of subduction initiation revealed by P-T paths of amphibolite and blueschist tectonic blocks in serpentinite mélange: An example from the Kamuikotan high-P/T metamorphic rocks in Hokkaido, northern Japan

*Toru Takeshita[1], Ayumi S. Okamoto, Wonji Shin[1], Mizuho Ando[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University)

4:30 PM - 4:50 PM JST | 7:30 AM - 7:50 AM UTC

[SIT26-11] Metamorphism in the Sanbagawa belt of SW Japan as a record of subduction processes

★Invited Papers

*Simon Richard Wallis[1] (1.University of Tokyo)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[SIT26-12] Subduction and exhumation of the high pressure metamorphic rocks: What we know and what we need to know.

*Timothy B Byrne[1] (1.University of Connecticut)

A tomography-led plate reconstruction of NE Asia during the late Cretaceous

*Jonny Wu[1], Yi-An Lin[1], Nicolas Flament[2], Tsung-Jui Wu[1], Yiduo Liu[1]

1. University of Houston, 2. University of Wollongong

Contrasted plate tectonic reconstructions have been proposed for the northeast Asian margin during the late Cretaceous, including: an Andean-type subduction margin, the existence of marginal seas, the subduction of a spreading ridge, the subduction of remnant arcs, or continental block collision and continental subduction. Here we investigate which scenarios are consistent with tomography models by mapping and unsubducting the vanished western Pacific slabs along the Kurile-Kamchatka, Japan, and Izu-Bonin-Marianas trenches from global tomography models. We show that a mapped 4,000 km-long slab gap within the East Asian lower mantle is the tomographic signature of the subducted Izanagi-Pacific spreading ridge based on a comparison to global mantle flow models. We reconstruct the size of the lost Izanagi conjugate from the geometry of the unsubducted western Pacific slabs, the age of Pacific oceanic crust, and published synthetic seafloor isochrons.

Our tomography-based plate reconstruction implies that: (1) the Izanagi ocean basin crust (i.e. formed by Pacific MORB) first reached and subducted along Sikhote-Alin and northern Japan around ~100 Ma; (2) subduction of the Izanagi plate along northeast Asia during the late Cretaceous ~75 Ma was limited to north of southernmost Korea and Bohai Bay, China, and west of westernmost Alaska; and, (3) the Izanagi-Pacific ridge intersected with the northeast Asian margin at a low angle in the early Cenozoic. We discuss our plate model against proposed northeast Asian margin plate tectonics during the Cretaceous.

Keywords: NW Pacific Ocean, Izanagi plate, NE Asia

©2019. Japan Geoscience Union. All Right Reserved.

Geodynamic models of late Mesozoic intraoceanic subduction offshore NE Asia caused by growing Izanagi plate

*Lorenzo Colli[1], Jonny Wu[1], Yi-An Lin[1]

1. University of Houston

The existence of the Izanagi plate is well established both from magnetic lineations and fracture zones in the western Pacific and from tomographic imaging of the deep mantle underneath East Asia. But its spatial extent, position and motion through time remain poorly known.

A common scenario envisages the Izanagi as a large and long-lived plate extending from central Panthalassa to the eastern margin of Eurasia. In this scenario the Izanagi plate is conjugate to the Farallon and Phoenix plates before the inception of the Pacific plate and it subducts continuously beneath East Asia during the Mesozoic (e.g. Müller et al., 2016).

A conservative choice for the spatial and temporal extent of the Izanagi plate, limiting it to what can be extrapolated using the conjugate Pacific plate, leads to a very different scenario: in this case the Izanagi plate is born together with the Pacific plate around 190 Ma and grows triangular in shape. It overrides preexisting oceanic lithosphere causing extended intraoceanic subduction in western Panthalassa characterized by fast trench retreat towards the Eurasian margin. The tip of the Izanagi plate reaches the Eurasian continental margin near Japan and Sikhote-Alin around 100 Ma.

Here we assimilate these two scenarios in geodynamic models of global mantle convection in the form of time-dependent velocity boundary condition at the Earth’ s surface. Their implications for the evolution of mantle structure in East Asia during Mesozoic time up to present-day are presented and discussed.

Keywords: Izanagi plate, intraoceanic subduction, Panthalassa, East Asia, Mesozoic, Numerical model

©2019. Japan Geoscience Union. All Right Reserved.

Early Cretaceous to Paleocene magmatism in the Sikhote-Alin area and their implications for Paleo-Pacific plate subduction and continental evolution

*Tsung-Jui Wu[1], Jonny Wu[1], Igor Alexandrov[2], Thomas Lapen[1]

1. Department of Earth and Atmospheric sciences, University of Houston, Houston, U.S., 2. Far East Geological Institute, Russian Academy of Sciences, Vladivostok, Russia

The Sikhote-Alin area in southern Russian Far East is one of the few places in the East Asian margin that has extensively exposed Mesozoic geological units. In particular, Cretaceous to Cenozoic igneous rocks are abundant and formed in response to periodic subduction of Paleo-Pacific plates. Previous geochemical studies of igneous rocks, mainly from southern Sikhote-Alin, resulted in significant insights into the continental evolution of East Aisan margin and subduction history of Paleo-Pacific plates (Kruk et al., 2014; Jahn et al., 2015; Grebennikov et al., 2016). In this study, we present new zircon U-Pb chronology and geochemical data from ~50 samples in across the entire Sikhote-Alin area. We combine our new results with published data to discuss the history of arc magmatic evolution in the region.

In general, the data show a cycle of arc magmatism that started from the early Cretaceous to Paleocene in Sikhote-Alin. Zircon U-Pb geochronology of igneous rocks indicate a major population of granitoids that had ages of 135-57 Ma; a small population of volcaniclastic rocks were dated at 55-53 Ma. Three magmatic episodes with distinct geochemical characteristics were recognized: 135-120 Ma, 110-100 Ma and 100-57 Ma. The 135-120 Ma granitoids are dominated by S-type granites; zircons with inherited cores were frequently observed in this episode. The 110-100 Ma episode has mostly I-type granites, whereas the 100-57 Ma magmatism had I-type granites that show greater degrees at fractional crystallization than the other groups. Some magmatic rocks with 67-57 Ma and ~100 Ma were A2 type granites, suggesting that two periods of intraplate magmatism could had occurred within this subduction setting. The La/Yb ratio and Nd isotopic ratios of the granitoids remained relatively similar during the Cretaceous and even showed a La/Yb ratio decrease in the late Cretaceous, implying that the Andean subduction margin crustal thickening model (Haschke et al., 2002) may not applicable to the Sikhote-Alin area.

Keywords: continental arc, paleo-pacific plate subduction, Northeast Aisa, Sikhote-Alin, continental evolution

©2019. Japan Geoscience Union. All Right Reserved.

Processes of subduction initiation revealed by P-T paths of amphibolite and blueschist tectonic blocks in serpentinite mélange: An example from the Kamuikotan high-P/T metamorphic rocks in Hokkaido, northern Japan

*Toru Takeshita[1], Ayumi S. Okamoto, Wonji Shin[1], Mizuho Ando[1]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University

It has been recently noted that serpentinite mélange which contains tectonic blocks of high-*P/T* type metamorphic rocks such as blueschist and eclogite and their counterclockwise P-T paths could indicate the subduction initiation (e.g. Willner et al., 2004; Escuder-Viruete et al., 2011; Agard et al., 2016; Bhowmik and Ao, 2016; Hunziker et al., 2017). We investigated tectonics in amphibolite and blueschist tectonic blocks in mélange, which are distributed at the highest structural level of the high-*P/T* type Kamuikotan metamorphic rocks in Hokkaido, northern Japan. We reconstructed their individual pressure-temperature (*P-T*) paths based on petrography, mineral chemistry and phase equilibria modeling. As a result, tectonic blocks in this study area are divided into six rock types: garnet-epidote amphibolite, epidote amphibolite, amphibolite, plagioclase-poor amphibolite, blueschist and quartz-rich blueschist. From the reconstruction of *P-T* paths, it is found that most of the tectonic blocks experienced blueschist facies metamorphism probably at the maximum depth, while the initial paths vary from a counterclockwise *P-T* path shown by different kinds of amphibolite to a prograde *P-T* path shown by blueschist and quartz-rich blueschist. We have concluded that these *P-T* paths, on the whole, could have reflected the cooling history of subduction channel from the beginning to steady state of subduction. The geothermal gradient could have been changed from ~25 ˚C/km to ~10 ˚C/km within *c.* 25 myr estimated by previously reported radiometric ages. These tectonic blocks could have started to subduct at a different timing to show the different *P-T* paths, and juxtaposed against each other at a certain depth in the subduction channel. Since these tectonic blocks show little deformation structures formed during exhumation stage, they might have behaved as a rigid body in serpentinite (i.e. mélange matrix) after they were incorporated in it during subduction stage.

Keywords: Kamuikotan high-P/T type metamorrphic rocks, amphibolite and blueschist tectonic blocks in serpentinite mélange, counterclockwise P-T paths, subduction initiation

©2019. Japan Geoscience Union. All Right Reserved.

Metamorphism in the Sanbagawa belt of SW Japan as a record of subduction processes

*Simon Richard Wallis[1]

1. University of Tokyo

The Sanbagawa belt of SW Japan records Cretaceous suduction processes off the eastern Asian margin. The Sanbagawa belt can be traced for around 800 km throughout SW Japan, but the main exposure is found in Shikoku. The main constituent rock types are pelitic, quartz and mafic schists which were derived from the subducted oceanic slab. These are associated with widespread blocks and lenses of serpentinite and related rocks types derived from the mantle wedge.

A long running dispute about the age of peak metamorphism has recently been resolved. Evidence for an early stage of subduction associated at around 115 Ma is locally preserved with anticlockwise P-T paths. This is followed at around 90 Ma by the main been long disputed with estimates of the peak

Keywords: Tectonics, Sanbagawa belt, subduction

©2019. Japan Geoscience Union. All Right Reserved.

Subduction and exhumation of the high pressure metamorphic rocks: What we know and what we need to know.

*Timothy B Byrne[1]

1. University of Connecticut

Although great strides have been made in understanding the subduction and, to a lesser extent the exhumation, of high pressure rocks, the links between these two processes is much less clear. As a result, many of the regional-scale models of these processes are poorly constrained and weakly supported by data. In this discussion session, we would like to better understand the data and observations that provide evidence for exhumation of high pressure rocks and, in areas were data gaps remain, what data are necessary to advance our understanding.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-GC Geochemistry

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GC40] Volatile Cycles in the Deep Earth - from Subduction Zone to Hot Spot

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Takeshi Hanyu(Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Gray E Bebout(Lehigh University), Chairperson:Takeshi Hanyu, Gray Bebout(Lehigh University), Yuji Sano, Hirochika Sumino

Volatiles play an important role in the geodynamics and chemical differentiation in the mantle and crust by drastically changing mineral stability and rheological behavior. Fractionation-processes such as partial melting, hydration, and dehydration are all controlled by volatiles in the rocks. A significant portion of the volatiles in the Earth has been thought to be present in the atmosphere and oceans as a consequence of extensive degassing during accretion and subsequent mantle degassing. On the other hand, it has been recently recognized that substantial amounts of volatiles are recycled back into the mantle at subduction zones, where intensive devolatilization of descended materials during arc magma generation was once thought to act as an effective "subduction barrier". However, fundamental questions still remain, such as: how are volatiles species distributed throughout the early and present Earth? What are the mechanisms for, and rate at which, volatiles are fluxed between the atmosphere, crust, and mantle? And what role have volatiles played in driving the evolution of the Earth? The possible role of the core in storing primordial volatiles is also poorly constrained. We therefore welcome contributions from experimental, observational, and modeling studies that help shed light on the deep cycles of volatiles, such as hydrogen, carbon, nitrogen, noble gases, halogens and sulfur. We particularly encourage studies linking the behavior of multiple volatile elements and their isotopic compositions. Studies investigating the linkage between volatile and solid geochemical tracers, the phase equilibria of volatile-bearing mantle assemblages, and the effect of volatiles on the physical properties of the mantle are also welcome.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[SGC40-01] Continental growth, crustal recycling, and global water cycle

★Invited Papers

*Jun Korenaga[1] (1.Department of Geology and Geophysics, Yale University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SGC40-02] Role of volatiles in magma genesis of ascending mantle plume

*Eiichi Takahashi[1], Jintuan Wang[1], Li Li[1] (1.Guangzhou Institute of Geochemistry, Chinese Academy of Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SGC40-03] DH partitioning experiment among high-pressure polymorph of olivine

*Asami Sano-Furukawa[1], Shoichi Itoh[2], Toru Inoue[3], Masamichi Noda[3] (1.J-PARC center, Japan Atomic Energy Agency, 2.Kyoto University, 3.Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SGC40-04] **Formation of Fe-rich volatile-bearing phases in the deep lower mantle and the implications for deep Earth volatile cycles**

*Li Zhang[1], Hongsheng Yuan[1], Eiji Ohtani[2], Lianjie Man[1], Duck Young Kim[1], Dmitry Popov[3], Yue Meng[3], Eran Greenberg[4], Vitali Prakapenka[4] (1.Center for High Pressure Science and Technology Advanced Research (HPSTAR), 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.HPCAT, X-ray Science Division, Argonne National Laboratory, 4.GeoSoilEnviroCARS, University of Chicago)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SGC40-05] Estimation of the origin of Pitcairn Island OIB by Independent Component Analysis

*Takahiro Ozawa[1], Hikaru Iwamori[1,2,3], Takeshi Hanyu[2], Morihisa Hamada[2], Kenji Shimizu[4], Ushikubo Takayuki[4], Jun-Ichi Kimura[2], Q. Chang[2], Hitomi Nakamura[5], Motoo Ito[4] (1.Tokyo Institute of Tokyo, 2.Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology, 3.Earthquake Research Institute, The University Tokyo, 4.Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 5.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

Continental growth, crustal recycling, and global water cycle

*Jun Korenaga[1]

1. Department of Geology and Geophysics, Yale University

The evolution of continental crust provides first-order control on Earth’ s surface environment, but relevant studies on this important issue have long been in a confused state since 1990s. There are mainly two reasons for this situation. First, the volume of the global database of detrital zircons has been continuously growing in the last three decades, and as a result, the most of new crustal growth models have been built solely on such a zircon database. Zircons that have survived to the present day, however, do not constrain the amount of crust that has been lost to the mantle by subduction, so there is no way to reconstruct net crustal growth from zircon data. Second, this situation further deteriorated by two influential papers, Belousova et al. (2010) and Dhuime et al. (2012), with the former introducing an illogical method of using zircon age data to construct a growth model, and the latter claiming falsely that this method can actually reconstruct net crustal growth. The situation has recently been rescued by the development of a sensible method of utilizing zircon age data as well as a new geochemical box modeling of Nd isotope data. These new studies point to the possibility of rapid crustal growth and efficient crustal recycling in early Earth, and such crustal evolution is consistent with the operation of plate tectonics throughout Earth history. In particular, the secular evolution of crustal recycling, when considered jointly with the constancy of continental freeboard, indicates a novel connection between global water cycle and the stability of continental crust, which can naturally explain both the Hadean/Archean and Archean/Proterozoic transitions.

Keywords: Plate tectonics, Continental crust, Origin of geologic eons

©2019. Japan Geoscience Union. All Right Reserved.

Role of volatiles in magma genesis of ascending mantle plume

*Eiichi Takahashi[1], Jintuan Wang[1], Li Li[1]

1. Guangzhou Institute of Geochemistry, Chinese Academy of Science

It is now widely accepted that recycled former oceanic crust component (eclogite) plays a great role in magma genesis of OIBs and flood basalts (Hauri, 1996; Takahashi et al, 1998; Sobolev et al, 2005). In this study we investigated the effect of H_2O and K_2O in magma genesis of heterogeneous mantle plume that contains large amount of recycled eclogite component. K_2O was studied as a group of volatile component, because it is incompatible to most mantle minerals at P<7 GPa (Tsuruta and Takahashi, 1998) and it drops the solidus of both peridotite and eclogite dramatically (Wang and Takahashi, 1999, 2000).

High-pressure melting experiments were carried out using a piston-cylinder and a 2500 ton cubic-type multi-anvil that have been moved from Tokyo Institute of Technology to Guangzhou Institute of Geochemistry in 2017. In order to understand the melting reaction between recycled eclogite and surrounding peridotite, we investigated melting of layered eclogite/peridotite starting materials both under dry and wet conditions. Spinel lherzolite KLB-1 (Takahashi 1986) was employed as peridotite component in this study. Two basalt components were used as recycled crust component: 1) Columbia River basalt (CRB72-180, Takahashi et al., 1998) which is relatively enriched in K, Ti and LREE (K_2O=1wt%, TiO_2=3.2wt%), N-type MORB (NAM-7, Yasuda et al., 1994). The 2.9GPa experiments (corresponding to about 80km depth which is the top most horizon of the Hawaiian plume head) were carried out with Boyd-England type piston-cylinder apparatus at (1460~1540˚C for dry experiments; 1400~1500˚C for hydrous experiments), The 5GPa and 8 GPa experiments (corresponding to about 150km and 200km depth on the plume axis) were conducted cubic-type multi-anvil apparatus (1550~1650˚C for dry experiments; 1350~1550˚C for hydrous experiments).

Melts formed by reactive melting of dry eclogite and peridotite changes dramatically in the temperature range across the solidus of peridotite KLB-1 from basalt (below dry solidus) to picrite (20-40˚C above dry solidus). Basaltic melts are not saturated with olivine both at 2.9 and 5 GPa and therefore they are separated by peridotite matrix by Opx film. Chemical reaction between the basalt melt and the peridotite matrix proceeds only slowly by solid-diffusion across the Opx film. In hydrous experiments, solidus of peridotite decreases significantly, Opx film was not formed, therefore, the reaction between hydrous melt and the partially molten peridotite matrix proceeds significantly even at temperatures much below peridotite dry solidus.

Melt composition produced by reactive melting of dry basalt and peridotite are similar to basaltic andesite (below peridotite solidus), Hawaiian tholeiite (slightly below peridotite solidus) to picrite (above peridotite dry solidus). On the other hand, melt compositions formed by reactive melting between hydrous basalt and peridotite show a great diversity depending on the amount of H_2O and K_2O. At H_2O-rich conditions (3 to 5 wt.% in bulk), melting took place both in peridotite and eclogite layers and composition of partial melts are similar to silica-deficient basanite and nephelinite at temperatures 1300-1400˚C both at 3 and 5 GPa. At low H_2O conditions (1 wt.% in bulk) partial melts formed in the MORB layer at 1300˚C are similar to silica-rich dacite both at 3 and 5 GPa. On the other hand, partial melts formed in the CRB72-180 layer with 1 wt.% H_2O at 3 and 5 GPa are similar to K-rich alkali acidic magma (phonolite, tracyte, hawaiite).

©2019. Japan Geoscience Union. All Right Reserved.

Post shield stage phonolite and hawaiite magmas in Hawaii were considered to be fractionation product of alkali basalts under crustal magma chambers (e.g., Frey et al, 1990). However, our experimental results demonstrated an alternative scenario that phonolite and hawaiite magma were derived from partial melting of alkali basaltic blocks at deeper part (150-200km) of the plume. On the other hand, basanite and nephelinite which appears in rejuvenated stage in Oahu and Kawai may represent partial melts of peridotite portion of the plume beneath Pacific plate. Volatiles control the solidus and the depth of melting as well as enhancing chemical interaction between the peridotite and entrained eclogite component in the ascending plume. In this presentation, we discuss the role of volatile and K_2O in magma genesis in ascending plume based on our melting experiments and field occurrence of diverse magma types both geographically and in growth history of given shield volcanoes in Hawaii.

Keywords: magma genesis, effect of volatile, mantle plume, Hawaii hot spot

©2019. Japan Geoscience Union. All Right Reserved.

DH partitioning experiment among high-pressure polymorph of olivine

*Asami Sano-Furukawa[1], Shoichi Itoh[2], Toru Inoue[3], Masamichi Noda[3]

1. J-PARC center, Japan Atomic Energy Agency, 2. Kyoto University, 3. Hiroshima University

Mantle is known to have homogeneous hydrogen isotope composition with δD = -80 ~ -60 ‰based on the analysis of MORB and OIB [1, 2]. The reason of the depletion of deuterium compared to the present ocean has been explained by the existence of isolated primordial reservoir in the mantle [1], evolution by the subduction of deuterium-poor hydrous mineral through the geological timescale [3], and addition of cometary water after the formation of ocean [4]. Hydrogen isotope partitioning factor among minerals is a key in these discussions, but little is known under high pressure and high temperature of mantle conditions. In this study we focused on DH partitioning between olivine and wadsleyite, which is a main constituent of upper mantle and mantle transition zone (MTZ). High pressure experiments suggest that wadsleyite and its high pressure polymorph of ringwoodite can contain significant amount of water up to 3.3 wt.% thus MTZ has an ability to keep water up to several times of ocean [5]. Finding of Ringwoodite with 1.4 wt.% H_2O in a diamond inclusion also reveals hydrated MTZ at least locally [6].

The partitioning experiment was conducted using Kawai-type multianvil press at GRC, Ehime University. Powder of $Mg(OH)_2$ and $Mg(OD)_2$ was mixed with synthetic olivine so that the starting composition is equivalent to $Mg_{1.8}Fe_{0.2}SiO_4$ + 1.0 wt.% HDO. The sample was sealed in the Au75Pd25 capsule and kept at 1300 ˚C and around 13 GPa, which is the condition of olivine and wadsleyite coexist. The recovered sample was polished and analyzed by micro-focused X-ray diffractometer, Raman spectroscopy and EPMA. Hydrogen isotope composition was determined using SIMS at Kyoto University.

To test for equilibrium, partitioning experiments are made with changing duration times from 1 h to 72 h. The fractionation factor decreases with increasing of duration time. After keeping for 30 h, $1000\ln\alpha_{\text{Olivine-Wadsleyite}}$ seems to reach almost equilibrium around -60 ‰. Assuming that the δD of olivine of upper mantle to -80, the δD of wadsleyite at MTZ become -20 to 0, which is more comparable to the composition of the ocean. The present result shows that the depletion of deuterium of upper mantle can be explained as a result of DH fractionation between upper mantle and MTZ.

[1] Kyser and O’ Neil, 1984, *Geochim Cosmochim. Acta.* [2] Clog et al., 2013, *Earth Planet. Sci. Lett.* [3] Kurokawa et al., 2018, *Earth Planet. Sci. Lett.* [4] Kokubu et al., 1961, *Geochim. Cosmochim. Acta* [5] Smyth et al., 1987, *Am. Mineral.* [6] Pearson et al., 2014, *Nature.*

Keywords: mantle transition zone, olivine, wadsleyite, hydrogen isotope

©2019. Japan Geoscience Union. All Right Reserved.

Formation of Fe-rich volatile-bearing phases in the deep lower mantle and the implications for deep Earth volatile cycles

*Li Zhang[1], Hongsheng Yuan[1], Eiji Ohtani[2], Lianjie Man[1], Duck Young Kim[1], Dmitry Popov[3], Yue Meng[3], Eran Greenberg[4], Vitali Prakapenka[4]

1. Center for High Pressure Science and Technology Advanced Research (HPSTAR), 2. Department of Earth Science, Graduate School of Science, Tohoku University, 3. HPCAT, X-ray Science Division, Argonne National Laboratory, 4. GeoSoilEnviroCARS, University of Chicago

Inclusions in deep diamonds provide a window to the actual deep mantle processes. The observation of hydrous ringwoodite with ~1 wt.% H_2O as a diamond inclusion indicates the transition zone is, at least locally, very wet [1]. Furthermore, the recent discovery of Ice-VII and halite inclusions at pressures as high as 24 GPa in diamonds provides direct evidence for the existence of saline fluid at least down to the shallow lower mantle [2]. To understand the interaction of water and Cl with the Fe-bearing lower mantle, we performed experiments to simulate the behavior of volatile-bearing systems in laser-heated diamond anvil cells (DACs) under high pressure-temperature (*P-T*) conditions corresponding to the deep lower mantle. The phase assemblages were determined by a combination of *in-situ* synchrotron-based X-ray diffraction (XRD) and *ex situ* transmission electron microscope (TEM) analysis. In the system MgO-Al_2O_3-Fe_2O_3-SiO_2-H_2O containing ~7 wt.% water, the hydrous Fe-bearing δ-phase coexists with both bridgmanite (Bdg) and post-perovskite (pPv) in a broad *P-T* range of 104-126 GPa and 1900-2500 K, whereas the pyrite-type (py) FeOOH phase was observed coexisting with the pPv phase. *In situ* XRD data further revealed that saline fluid reacts with Fe-bearing pPv to form a previously unknown cubic phase of $FeCl_2$ that adopts the identical space group of *Pa3* with the py-phase FeOOH. The TEM chemical analysis revealed that the composition of the pPv phase contains 3.5 wt.% Na_2O and 16.5 wt.% FeO after the reaction with the oversaturated saline fluid. Formation of the very dense Fe-rich volatile-bearing phases in the lowermost mantle provides clues for the deep storage of water and Cl and may contribute to the chemical heterogeneities in this region.

[1] D. G. Pearson *et al.*, Nature **507** (2014).
[2] O. Tschauner *et al.*, Science **359** (2018).

Keywords: deep lower mantle, volatile cycle, post-perovskite, synchrotron X-ray diffraction

©2019. Japan Geoscience Union. All Right Reserved.

Estimation of the origin of Pitcairn Island OIB by Independent Component Analysis

*Takahiro Ozawa[1], Hikaru Iwamori[1,2,3], Takeshi Hanyu[2], Morihisa Hamada[2], Kenji Shimizu[4], Ushikubo Takayuki[4], Jun-Ichi Kimura[2], Q. Chang[2], Hitomi Nakamura[5], Motoo Ito[4]

1. Tokyo Institute of Tokyo, 2. Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology, 3. Earthquake Research Institute, The University Tokyo, 4. Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 5. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

Ocean island basalts (OIB) are thought to bring information concerning geochemistry and material cycling of the deep mantle. For this reason, OIB have been studied extensively, among which Pitcairn Island in the South Pacific is regarded as a unique and important location as a hotspot volcano. Previous studies reported that the lavas in Pitcairn involve multiple components from DM (depleted mantle) to EM1 (enriched mantle) (Woodhead & McCulloch, 1989), of which EM1 component has been argued to originate from recycling oceanic plate, delaminated lower crust, continental marine sediment and others (Eisele et al., 2002; Garapic et al., 2015). The mechanism to produce the specific isotopic composition of EM1 is still under extensive debate.

We analyzed concentrations of major elements, volatile elements (CO_2, H_2O, F, S, and Cl), and trace elements, as well as lead isotopic ratios, by using SIMS, EPMA and LA - ICP - MS for melt inclusions contained in olivine from basalt and pyroclastic rock in Pitcairn Island. Melt inclusions are thought to retain the volatile elements without losing them upon eruption, which is suitable for discussing the origin of the EM1 component. In this study, four lavas (PC-2, PC-16, PC-38, and PC-40) and a pyroclastic rock collected from the Tedside formation of Pitcairn Island were analyzed. The whole-rock composition of these lavas show EM1 signatures. Melt inclusions in olivine are crystallized, but those of pyroclastic rock are all glassy and homogeneous as they are. The crystalized melt inclusion samples from the four lavas were homogenized at the individual liquidus temperatures (1150 degrees and 1175 degrees). A small amount of H2O loss was found for 10 min heating for homogenization, by comparing the analyses of both melt inclusion with/without reheating of the pyroclastic rock samples. On the other hand, virtually no effect was seen for F and Cl.

Multivariate statistical analysis is useful to extract the geochemical features from these data set. McKenzie et al. (2004) identified the coherence between the trace element concentrations and the isotopic ratios, and argued that such coherence must indicate multiple sources of different origin. Instead of Principal Component Analysis (PCA) as used by McKenzie et al. (2004), we utilize Independent Component Analysis (ICA) to extract geochemically independent features. At the same time, we also performed k-means cluster analysis on the whitened data set (Iwamori et al., 2017) to clarify the multiple sources hidden in the lavas from a small area within the Pitcairn Island. In this paper, we will present the results of the geochemical analyses and statistical analyses to identify and discuss the nature of the sources involved in the Pitcairn volcanism.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-GC Geochemistry

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GC40] Volatile Cycles in the Deep Earth - from Subduction Zone to Hot Spot

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Takeshi Hanyu(Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Gray E Bebout(Lehigh University), Chairperson:Takeshi Hanyu, Gray Bebout(Lehigh University), Yuji Sano, Hirochika Sumino

Volatiles play an important role in the geodynamics and chemical differentiation in the mantle and crust by drastically changing mineral stability and rheological behavior. Fractionation-processes such as partial melting, hydration, and dehydration are all controlled by volatiles in the rocks. A significant portion of the volatiles in the Earth has been thought to be present in the atmosphere and oceans as a consequence of extensive degassing during accretion and subsequent mantle degassing. On the other hand, it has been recently recognized that substantial amounts of volatiles are recycled back into the mantle at subduction zones, where intensive devolatilization of descended materials during arc magma generation was once thought to act as an effective "subduction barrier". However, fundamental questions still remain, such as: how are volatiles species distributed throughout the early and present Earth? What are the mechanisms for, and rate at which, volatiles are fluxed between the atmosphere, crust, and mantle? And what role have volatiles played in driving the evolution of the Earth? The possible role of the core in storing primordial volatiles is also poorly constrained. We therefore welcome contributions from experimental, observational, and modeling studies that help shed light on the deep cycles of volatiles, such as hydrogen, carbon, nitrogen, noble gases, halogens and sulfur. We particularly encourage studies linking the behavior of multiple volatile elements and their isotopic compositions. Studies investigating the linkage between volatile and solid geochemical tracers, the phase equilibria of volatile-bearing mantle assemblages, and the effect of volatiles on the physical properties of the mantle are also welcome.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SGC40-06] Tracing recycled volatiles in MORB with halogens

★Invited Papers

*Ray Burgess[1], Lorraine Ruzie-Hamilton[1], Patricia Clay[1], Bastian Joachim[2], Christopher Ballentine[3] (1.School of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL UK, 2.Institute for Mineralogy and Petrography, University of Innsbruck, Innrain, 52A-6020, Innsbruck, Austria, 3.Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN UK)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SGC40-07] Volatile composition in ocean island basalts

*Takeshi Hanyu[1] (1.Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SGC40-08] Halogen heterogeneity in the subcontinental lithospheric mantle

*Hirochika Sumino[1], Masahiro Kobayashi[2], Ray Burgess[3], Chris J Ballentine[4] (1.Department of Basic Science, Graduate School of Arts and Sciences, University of Tokyo, 2.Tokyo Metropolitan Industrial Technology Research Institute, 3.School of Earth and Environmental Sciences, University of Manchester, 4.Department of Earth Sciences, University of Oxford)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SGC40-09] Efficiency of Deep Carbon Subduction: Input, Metamorphic Records, and Bearing on Estimated Sources of Arc Volcanic Gases

*Gray E Bebout[1,2], Gabe S Epstein[2], Brian M House[3] (1.Institute for Planetary Materials, Okayama University, 2.Lehigh University, 3.University of California, San Diego)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SGC40-10] Helium isotope variations in subduction-type volcanic hydrothermal systems

*Yuji Sano[1], Takanori Kagoshima[1], Naoto Takahata[1], Tetsuji Onoue[2], Tomo Shibata[3], Tobias P Fischer[4]
(1.Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Earth and Environmental Sciences, Kumamoto University, 3.Institute for Geothermal Sciences, Kyoto University, 4.Department of Earth and Planetary Sciences, University of New Mexico)

Tracing recycled volatiles in MORB with halogens

*Ray Burgess[1], Lorraine Ruzie-Hamilton[1], Patricia Clay[1], Bastian Joachim[2], Christopher Ballentine[3]

1. School of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL UK, 2. Institute for Mineralogy and Petrography, University of Innsbruck, Innrain, 52A-6020, Innsbruck, Austria, 3. Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN UK

Interactions between the Earth’ s mantle and the surface have controlled the evolution of the crust, the oceans, and the atmosphere. The mantle is by many orders of magnitude the largest silicate reservoir for volatiles, and volcanic release of these species has played a major role throughout Earth history in global chemical cycles. Understanding the distribution and geochemical evolution of volatiles in the terrestrial mantle is therefore central to understanding the unique planetary history of Earth. The input and output of volatiles at plate boundaries provides major controls on the cycles of many important elements and exerts long-term controls on habitibale conditions at the surface.

Noble gases have provided key insight into the processes controlling the mantle system. Primordial heavy noble gases in the MORB-source mantle are accompanied by atmosphere noble gases with an elemental composition consistent with subduction of an ocean/pore-fluid signature into the mantle (1). Pore fluid subduction represents an important opportunity to use halogens, in particualr iodine which is highly enriched in marine pore fluids, in conjunction with noble gases as sensitive tracers of water and volatile enrichment processes in the mantle.

To assess the control of subduction zones on the mantle halogen budget we have investigated basaltic glass samples from the Manus Back-Arc Basin as some of the volatiles may survive forearc to subarc devolatilization to depths beyond arcs/back-arcs and contribute to the long term volatile budget of the mantle. We also investigated two sets of samples: one from the Central Indian Ridge (2) containing D(epleted)-MORB, N(ormal)-MORB and E(nriched)-MORB and one from the Siqueiros Transform Fault (STF) known for sampling the depleted upper mantle (3). In contrast to axial MORB, lavas from STF are tapping smaller mantle melt without mixing in large magmatic chambers. These melts provide better estimates of the volatile contents of the potential mantle sources.

Based on new halogen determinations, we show that the volatile budget in the mantle sampled by the mid oceanic ridge basalts is a mixture between the depleted upper mantle and a fluid-modified mantle enriched during its residency in subduction zone. This enables us to revisit the global halogen budget and assess how subduction of halogens has affected the habitability of our planet.

1. Holland & Ballentine, Nature 441, 186-191, 2006.

2. Nauret et al. Earth Planet. Sci Lett. 245, 137-152, 2006.

3. Saal et al., Nature 419, 451-455, 2002.

Keywords: Halogens, Recycling, Mantle, Volatiles

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Volatile composition in ocean island basalts

*Takeshi Hanyu[1]

1. Japan Agency for Marine-Earth Science and Technology, Department of Solid Earth Geochemistry

Volatile reservoirs and transport mechanisms in the mantle are one of fundamental questions in mantle geochemistry. The atmosphere and hydrosphere are major volatile reservoirs in the Earth. Portions of volatiles in the surface layers can be incorporated into oceanic crust and sediment by fluidal reaction and organic and inorganic sedimentation, and then they are delivered to the mantle via slab subduction. However, the efficiency of volatile transport against subduction barrier is poorly constrained. Studies of volatiles in ocean island basalts (OIBs) should document the origin and distribution of volatiles in the deep mantle. This presentation provides an overview of previous studies of volatiles on OIBs using submarine quenched glasses and olivine-hosted melt inclusions.

Whether the mantle source of OIBs is enriched in H_2O is measured by taking H_2O/Ce ratio, where Ce is a lithophile element that has similar incompatibility to H_2O during partial melting. While many OIBs exhibit H_2O/Ce that overlap with the MORB range, OIBs with robust EM1, EM2, and HIMU signatures have significantly lower H_2O/Ce. The fact that H_2O/Ce decreases proportionately with increasing $^{87}Sr/^{86}Sr$ for Pitcairn, Kerguelen (EM1), and Society (EM2), and with decreasing $^{207}Pb/^{206}Pb$ for Tuvalu (HIMU) documents that the mantle components with robust EM1, EM2, and HIMU signatures are commonly depleted in H_2O relative to Ce [1-3]. If their precursor was any type of subducted material, fluid or hydrous melt extraction from the subducted slab reasonably explains the low H_2O/Ce. However, an alternative explanation is a contribution from pyroxenite components in the magma sources, where Ce is more efficiently partitioned into pyroxene than H [4].

Enrichment in F (i.e., F/Nd) in the EM1 and EM2 OIBs from Pitcairn and Samoa is equivocal [2,5]. In contrast, melt inclusions from Mangaia HIMU basalts have high F/Nd (~30) as a group relative to the average MORB value (~21) [1,6], which is best explained by the efficient transfer of F to the mantle by F-bearing minerals such as amphibole, serpentinite, mica, and clinohumite in subducted slabs [7]. Detecting Cl enrichment is not always straightforward because shallow-level magma assimilation with seawater, brines, and altered oceanic crust easily alter the Cl composition [8]. Submarine glasses from Pitcairn and Society exhibit decreasing Cl/K with increasing $^{87}Sr/^{86}Sr$ [2]. Such covariation precludes assimilation as the principal cause of Cl/K variation, and therefore low Cl/K is the source feature of EM1 and EM2. Chlorine loss from subducted components due to fluid release or hydrous melt extraction accounts for low Cl/K. In contrast, HIMU OIBs show increase of Cl/K and Cl/Nb along with decreasing $^{207}Pb/^{206}Pb$ (more robust HIMU signature from ancient altered oceanic crust) as observed in olivine-hosted melt inclusions in Raivavae basalts from Austral Islands [9]. Because such correlation is not ascribed to shallow-level assimilation, this fact requires a mechanism to return Cl from the hydrosphere to the HIMU mantle source via altered oceanic crust against subduction dehydration. Although Cl-hosting minerals beyond the sub-arc depth have not been thus far identified, the lattice defects in major minerals or mineral grain boundaries may be a carrier of small amounts of Cl in subducted oceanic crust. Subduction of altered oceanic crust would transfer Cl from seawater to the deep mantle, forming Cl-rich HIMU mantle reservoir in the deep mantle.

©2019. Japan Geoscience Union. All Right Reserved.

[1] Jackson et al., Geochem. Geophys. Geosyst. 16, 3210-3234 (2015).

[2] Kendrick et al., Chem. Geol. 370, 69-81 (2014).

[3] Wallace, J. Petrol. 43, 1311-1326 (2002).

[4] Bizimis & Peslier, Chem. Geol. 397, 61-75 (2015).

[5] Kendrick et al., Earth Planet. Sci. Lett. 410, 197-209 (2015).

[6] Cabral et al., Geochem. Geophys. Geosyst. 15, 4445-4467 (2014).

[7] Grützner et al., Geology 45, 443-446 (2017).

[8] Stroncik & Haase, Geology 32, 945-948 (2004).

[9] Hanyu et al., Nat. Commun. 10, 60 (2019).

Keywords: volatile, recycle, mantle

©2019. Japan Geoscience Union. All Right Reserved.

Halogen heterogeneity in the subcontinental lithospheric mantle

*Hirochika Sumino[1], Masahiro Kobayashi[2], Ray Burgess[3], Chris J Ballentine[4]

1. Department of Basic Science, Graduate School of Arts and Sciences, University of Tokyo, 2. Tokyo Metropolitan Industrial Technology Research Institute, 3. School of Earth and Environmental Sciences, University of Manchester, 4. Department of Earth Sciences, University of Oxford

Volatile recycling back to the Earth’ s mantle at subduction zones has a significant, yet poorly constrained impact to the volatile budget in the mantle. Halogen and noble gas systematics are powerful tracers of volatile recycling. The presence of noble gases and halogens with seawater and sedimentary pore-fluid signatures in exhumed mantle wedge peridotites from the Sanbagawa-metamorphic belt, southwest Japan [1], and in forearc serpentinites [2] along with seawater-like heavy noble gases (Ar, Kr, and Xe) in the convecting mantle [3] strongly suggest the subduction of sedimentary-pore-fluid-like noble gases and halogens. In order to better constrain how such subduction fluids may modify the halogen composition of subcontinental lithospheric mantle, we have analyzed halogens in mantle-derived xenoliths from volcanic front and back-arc regions of subduction zones, and intraplate continental settings.

In addition to a MORB-like halogen component observed in most of the samples, three other distinct components were identified: (A) a marine-pore-fluid-like component with high Br/Cl and I/Cl ratios similar to mantle wedge peridotites [1], (B) a Cl-enriched component relative to MORB, similar to bulk altered oceanic crust [4]; and (C) a component enriched in Br and moderately in I compared to MORB, which resembles to fluid components in altered oceanic crust and diamonds [4,5].

The component (A) is typically observed in the volcanic front samples containing abundant H_2O-rich fluid inclusions. This suggests that marine pore fluids in deep-sea sediments are carried by serpentine and supplied to the mantle wedge, preserving their original halogen and noble gas compositions. However, the measured Cl/H_2O and $^{36}Ar/H_2O$ in the peridotites are higher than those in sedimentary pore fluids and serpentine in oceanic plates [2]. The halogen/noble gas/H_2O systematics are interpreted within a model where water is incorporated into serpentine in a closed system formed along fracture zones developed at the outer rise, where oceanic plates bend prior to entering subduction zones, preserving Cl/H_2O and $^{36}Ar/H_2O$ values of sedimentary pore fluids. Dehydration-hydration process within the oceanic lithospheric mantle maintains the closed system until the final stage of serpentine dehydration. The sedimentary pore fluid-like halogen and noble gas signatures in fluids released at the final stage of serpentine dehydration are preserved due to highly channelized flow [6].

The samples involving the component (B) have higher Cl concentration and trace elements ratios, whereas the samples involving the component (C) have relatively low Cl concentration and low ratios of highly incompatible elements relative to heavy rare earth elements. Considering that these two components are observed in some back-arc samples having radiogenic/nucleogenic noble gases [7], they could be remnants of metasomatic agents derived from subducted altered oceanic crust, or could result from secondary processes of volatile loss during partial melting and secondary phase formation during interaction with melts [8].

The common primary MORB-like halogen ratios in mantle xenoliths from different parts of the globe indicate that the mantle itself must have a relatively uniform composition over a wide scale. The mantle has maintained its halogen composition over billion year timescales without being affected by I-rich

©2019. Japan Geoscience Union. All Right Reserved.

halogens being transported into the mantle. Mass balance calculations suggest that, in order to maintain the I/Cl ratio of the convecting mantle over 2 Gyr, the I/Cl ratio of the subducted halogens must be no more than several times higher than the present-day mantle value [8].

[1] Sumino *et al. EPSL* 2010. [2] Kendrick *et al. EPSL* 2013. [3] Holland & Ballentine *Nature* 2006. [4] Chavrit *et al.*, *GCA* 2016. [5] Burgess *et al.*, *GCA* 2009. [6] Kobayashi *et al. EPSL* 2017. [7] Jalowizki *et al.*, *EPSL* 2016. [8] Kobayashi *et al.*, *G-cubed* 2019.

Keywords: halogen , subcontinental mantle, noble gas, subduction, volatile recycling

©2019. Japan Geoscience Union. All Right Reserved.

Efficiency of Deep Carbon Subduction: Input, Metamorphic Records, and Bearing on Estimated Sources of Arc Volcanic Gases

*Gray E Bebout[1,2], Gabe S Epstein[2], Brian M House[3]

1. Institute for Planetary Materials, Okayama University, 2. Lehigh University, 3. University of California, San Diego

Circum-Pacific and Italian Alps high- and ultrahigh-pressure metasedimentary rocks record the subduction of organic (reduced) and carbonate (oxidized) C through forearcs (10-70 km) to depths approaching those beneath volcanic fronts. Still uncertain are the efficiency of delivery of such sections to subarc depths, as related to varying degrees of accretion and underplating, the mobilization of C during prograde metamorphism and fluid-rock interactions, and the fractions of C recycled in arcs, stored in forearc reservoirs (e.g., the mantle wedge), or added to the deeper mantle.

Franciscan Complex (FC) blueschist-facies rocks, and lower-grade units (lawsonite-albite and lawsonite-blueschist) of the carbonate-poor Catalina Schist (CS), preserve reduced C (RC) concentrations and $\delta^{13}C$, and C:N, similar to those of sediment protoliths, as does the lowest-grade unit of the Schistes Lustres (SL) exposed in the Alps (regardless of carbonate content). In CS units that experienced warmer prograde *P-T* paths (epidote-blueschist grade and higher), RC is shifted in $\delta^{13}C_{VPDB}$ from -25 per mil to as high as -19 per mil, seemingly related to minor loss of C as CH_4 during prograde devolatilization. The higher-grade units of the SL extend, to depths of ~70km, the extremely low-*P/T* trajectory represented by the FC and low-grade CS. Across this range of grade, RC shows little evidence of loss but considerable increase in $\delta^{13}C$ toward mantle values (-5 to -6 per mil) related to isotopic exchange with coexisting carbonate. In SL metashales, RC preserves protolith $\delta^{13}C$ of -24 to -21 per mil independent of grade and degrees of devolatilization. Reduced C occurs as amorphous carbonaceous matter at low grades, and its transformation to graphite at higher grades presumably enhances isotopic exchange with carbonate. This work implies that much of the RC reservoir is retained to depths beneath volcanic fronts and could be available for transfer into the sub-arc mantle wedge, likely via partial melting (K. Kraft, Lehigh Univ. M.S. thesis, 2018).

The blueschist to eclogite facies SL contains carbonate-rich flysch formed prior to and during Eocene subduction of the Piemonte-Liguria Ocean and underplated at 40-70 km depths. We analyzed $\delta^{13}C$ and $\delta^{18}O$ of carbonate in this unit, over a regional scale, and made field and petrographic observations bearing on mechanisms of C mobilization. A study of decarbonation history by Cook-Kollars et al. (2014) for the same suite demonstrated that, depending on extents of open-system infiltration by H_2O-rich fluid, large fractions of initially subducted carbonate could be retained in such rocks to at least 70 km depths. Assessing the magnitude of removal of carbonate via dissolution, at the whole-unit scale, has proven difficult. Isotopic exchange between the reduced and oxidized C reservoirs, and any fractionation during sub-arc mobilization and delivery into the mantle wedge, would have implications for the approach of Sano and Marty (1995) used to estimate proportions of gas from mantle and disparate sediment sources.

Study of along-margin C input flux at the Sunda margin (House et al., 2016; Fall AGU) emphasizes the role of sediment composition, source, and degree of accretion on the nature and size of the deeply subducted C reservoir. Ongoing NSF-funded work on the Hikurangi margin, New Zealand (collaborative with Bruce Christenson-GNS-NZ, Hirochika Sumino-Univ. Tokyo, and Ikuko Wada-Univ. Minnesota), is aimed at resolving C inputs vs. outputs in arc volcanoes and associated hydrothermal systems, in part considering the makeup of the incoming sediment section (based on drilling by IODP Exp. 375), extents of accretion,

©2019. Japan Geoscience Union. All Right Reserved.

along-margin thermal structure, and calculated extents of devolatilization. Studies of the Schistes Lustrés and other HP and UHP suites provide insight regarding the structural and geochemical evolution of sediments similar in composition to those subducting at modern margins (e.g., Sunda).

Keywords: carbon, subduction, arc volcanism, metamorphism

©2019. Japan Geoscience Union. All Right Reserved.

Helium isotope variations in subduction-type volcanic hydrothermal systems

*Yuji Sano[1], Takanori Kagoshima[1], Naoto Takahata[1], Tetsuji Onoue[2], Tomo Shibata[3], Tobias P Fischer[4]

1. Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo, 2. Department of Earth and Environmental Sciences, Kumamoto University, 3. Institute for Geothermal Sciences, Kyoto University, 4. Department of Earth and Planetary Sciences, University of New Mexico

Large variations of $^{3}He/^{4}He$ ratios of gas and fluid samples were observed in subduction-type modern hydrothermal systems (0.3Ra −8Ra where Ra is the atmospheric ratio of $1.38x10^{-6}$) compared with those of mid-ocean ridge basalt (MORB) glasses (7.5Ra −9.5Ra). These variations are principally attributable to binary mixing of two components: mantle He (8Ra) and crustal helium (0.1Ra). Major source of the latter component could be due to radiogenic helium in the subsurface crustal material. Thus, shallow assimilation would result in helium isotope variations around an isolated volcano. Early case study on the Ontake volcanic hydrothermal system showed that high-Ra was located in hot spring close to the central cone and decreased with distance from the volcano. Subsequent studies around Mt Nevado del Ruiz and Mt Kusatsu-Shirane confirmed the negative correlation between the $^{3}He/^{4}He$ ratio and the distance. There may be three necessary conditions to produce such a tendency. First, the volcano is independent strato-type and there is no other volcano close to the subject. Second, the magma chamber is located just beneath the volcano so that the conduit is not inclined significantly. Third, the hydrothermal system is well developed and the emission of mantle helium is stable for a long time. In order to apply these hypothetical conditions to a caldera volcano, we have carried out helium isotope survey around Aso volcano in Southwest Japan. Mt Aso is the largest active volcano in Japan with a caldera 25 km north-south and 18 km east-west. Post caldera activity is currently observed in central cone at Mt Nakadake. We have collected hot spring gas and fluid samples within the Aso caldera together with the outside and measured $^{3}He/^{4}He$ and $^{4}He/^{20}Ne$ ratios by a noble gas mass spectrometer. The helium isotopes, after correction of air contribution, decrease with the distance from the central cone in the region. The tendency is consistent with those of strato-volcanoes reported in literatures.

Keywords: helium, isotopes

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | IC 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Hitoshi Hirose, Yoshiyuki Tanaka

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[SCG48-01] Variability of the space-time evolution of slow slip events off the Boso Peninsula, central Japan, from 1996 to 2018

★Invited Papers

*Jun'ichi Fukuda[1] (1.Earthquake Research Institute, University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG48-02] Cumulative slip distribution of short-term slow slip events in the western Shikoku area, southwest Japan based on tilt change measurements

*Hitoshi Hirose[1,2], Wakako Tamura[2], Takeshi Kimura[3] (1.Research Center for Urban Safety and Security, Kobe University, 2.Graduate School of Science, Kobe University, 3.National Research Institute for Earth Science and Disaster Resilience)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG48-03] Shallow undersea SSEs off the western Japan monitored by the GNSS-A

*Yusuke Yokota[1], Tadashi Ishikawa[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Hydrographic and Oceanographic department, Japan Coast Guard)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG48-04] Co- and Post-seismic deformation due to the 2016 moderate earthquake sequence at the Chaman fault

*Fumiko Matsumoto[1], Masato Furuya[1] (1.Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG48-05] An attempt to quantify transient fluid flow during slow slip event using GNSS and gravity data-1st report

*Yusuke Umemiya[1], Yoshiyuki Tanaka[1] (1.The University of Tokyo)

Variability of the space-time evolution of slow slip events off the Boso Peninsula, central Japan, from 1996 to 2018

*Jun'ichi Fukuda[1]

1. Earthquake Research Institute, University of Tokyo

Continuous geodetic measurements over the past two decades have identified numerous recurrent slow slip events (SSEs) in subduction zones and other tectonic settings. Many previous studies revealed static source characteristics of SSEs, including the magnitudes, durations, recurrence intervals, and spatial slip distributions. However, our current knowledge of the time-dependent evolution of SSEs and their variability is much more limited.

In this study, we focus on a series of SSEs that occurred off the Boso Peninsula, central Japan. Since the installation of a dense GNSS network in Japan in the early 1990s, six Mw 6.6-6.7 SSEs, accompanied by swarms of regular earthquakes, have been identified on the subducting Philippine Sea Plate interface offshore of the Boso Peninsula in 1996, 2002, 2007, 2011, 2013-2014, and 2018. We invert GNSS time series to estimate the space-time evolution of the six SSEs using a modified version of the Network Inversion Filter (NIF) [Fukuda et al., 2008]. Our analyses reveal the similarities and differences in the time-dependent evolution of the six SSEs. We find that the nucleation style and space-time evolution of slip vary among the SSEs. The 2002, 2007, and 2011 SSEs nucleated more rapidly, with slip accelerations significantly higher than those of the 1996 and 2013-2014 SSEs. Furthermore, the 2002, 2007, and 2011 SSEs exhibited more rapid temporal variations in their slip and slip rates, and showed larger seismic moments and higher maximum slip rates than the 1996 and 2013-2014 SSEs. The along-strike expansion/propagation of slip is identified for the SSEs, revealing that the expansion/propagation patterns vary from event to event. Our results also show that the swarm seismicity accompanying the SSEs is highly correlated in space and time with slip rate, and seismicity only occurred after the slip rate exceeded ~4 m/yr, suggesting that the evolution of seismicity is controlled by the instantaneous stressing rate determined by slip rate.

Finally, we show that the space-time evolution of slow slip obtained here can potentially be used to study mechanisms governing the SSEs. We model the spatiotemporal evolution of shear stress on the plate interface due to slow slip obtained in the NIF analysis using the rate-and-state friction law. The rate-and-state friction parameters and initial state variable are adjusted to reproduce the stress histories. Results show that the rate-and-state friction law well reproduces the spatiotemporal evolution of stress on the plate interface during the SSEs. The critical fault size calculated from the estimated friction parameters is similar to the size of the SSE region, suggesting that the evolution of slow slip is governed by frictional properties near the stability boundary between stable and unstable slip.

Keywords: slow slip event, GNSS, crustal deformation

©2019. Japan Geoscience Union. All Right Reserved.

Cumulative slip distribution of short-term slow slip events in the western Shikoku area, southwest Japan based on tilt change measurements

*Hitoshi Hirose[1,2], Wakako Tamura[2], Takeshi Kimura[3]

1. Research Center for Urban Safety and Security, Kobe University, 2. Graduate School of Science, Kobe University, 3. National Research Institute for Earth Science and Disaster Resilience

In the western Shikoku area, southwest Japan, so-called short-term slow slip events (SSE) accompanying tremor activities repeatedly occur with an average recurrence interval of about six months (e.g., Obara et al., 2004; Sekine et al., 2010). This activity has been detected by high-sensitivity accelerometers (tiltmeters) equipped at NIED Hi-net stations (Obara et al., 2005). Using the observed tilt records, Sekine et al. (2010) estimated a history of released seismic moment by short-term SSEs and reported that about 65\% of the accumulated moment by the relative plate convergence is released as short-term SSEs in the western Shikoku area. Because this estimation is based on a fault model such that slip is uniform on a plane rectangular fault and a location of the fault, especially a depth of the fault, is an unknown (nonlinear) parameter in their inversion, it is possible that an estimated seismic moment of an SSE could be biased.

In this study, we apply an inversion method that can express a spatial fault slip distribution assuming the slip is on the plate interface to the same tilt change data set that were detected in Sekine et al. (2010). They measured a tilt change caused by a short-term SSE as a difference between two averages of tilt values in one-day-long time interval (this can vary on a case-by-case basis) just before and after the SSE episode. We estimated each slip distribution of 18 short-term SSEs in western Shikoku between January 2001 and March 2008 although a reliable slip distribution is not estimated in a couple of episodes because of the limited number of available stations.

A cumulative slip distribution of the 18 SSEs shows that (1) slip area is localized within a narrow zone with its width of about 30-40~km in dip direction and about 70~km in strike direction of the subducting plate; (2) accumulated moment by the plate subduction is considered as fully released by SSEs at an area with larger cumulative slip; (3) the width of the slip zone is wider in the western part and narrower in the eastern part. The last characteristics is in agreement with the tremor epicenter distribution in this area (e.g., Obara et al., 2010). This suggests that there is a segment boundary that separates the western and eastern part of the SSE area in the western Shikoku region, and these segments likely have different frictional property and/or different pore fluid distribution.

Acknowledgments: This work was supported by JSPS KAKENHI Grant Number JP16H06474.

Keywords: subduction zone, slow earthquakes, tilt changes, earthquake cycle

©2019. Japan Geoscience Union. All Right Reserved.

Shallow undersea SSEs off the western Japan monitored by the GNSS-A

*Yusuke Yokota[1], Tadashi Ishikawa[2]

1. Institute of Industrial Science, The University of Tokyo, 2. Hydrographic and Oceanographic department, Japan Coast Guard

In the last two decades, many kinds of SEQs including non-seismic SSE have been detected using the onshore high-precision seismometer and GNSS networks. Along the Nankai Trough having dense seismic and geodetic monitoring network, their relationships were discussed and compared in detail [e.g., Hirose et al., 2010, Science; Obara and Kato, 2016, Science]. Observation of deep and shallow SEQ analogies and differences has multidisciplinary value for the physical properties of the plate boundary, submarine geology and earthquake disaster research. However, comparison between deep underground SEQs and shallow undersea SEQs cannot easily be performed due to the undersea observation technical constraint.

In these several years that the technology has been upgraded, shallow SEQs (tremor, LFE, VLF and short-term SSE) have been detected along the pan-Pacific subduction zones in high-precision onshore seismometers, seafloor seismometers, ocean bottom pressure gauges and submarine borehole strainmeters [e.g., Wallace et al., 2016, Science; Araki et al., 2017, Science]. However, there was no geodetic monitoring technology for detecting undersea longer sequence of SSE than week-scale. Longer-term SSE than week-scale cannot be monitored except for the GNSS-A technique.

Recently, we improved the GNSS-A technology and upgraded observation frequency and precision [Yokota et al., 2017, Rep. Hydro. Ocean. Res; Yokota et al., 2018, MGR]. With the present observation capability, yearly time change of the amount of undersea crustal deformation was newly unclosed. Then, the GNSS-A monitoring uncloses the occurrence situation of undersea SSE which could not be observed by the onshore geodetic network.

We detected SSE signals in the GNSS-A data using c-AIC detection process based on the method of Nishimura et al. [2013, JGR]. Then, SSE rectangle models were estimated by the grid search process using the GNSS-A signals and the onshore GEONET data. The detected models are located off the Kii channel and the Bungo channel at shallow side around the Nankai Trough historical seismogenic zone and strong coupling regions estimated by Yokota et al. [2016, Nature] and Nishimura et al. [2018, Geosphere]. We detected about M_w 6.0 and 6.5 events off the Kii channel and a migration of about M_w 6.1 ~ 6.2 events off the Bungo channel.

Shallow VLF events [NIED and Asano et al., 2008, EPS] were also activated simultaneously with these undersea SSEs. Off the Kii channel, VLF activity in 2009 was a little closer to the western side than 2018. Off the Bungo channel, VLF activity after 2015 was synchronized with the undersea SSEs. These suggest the temporal synchronization and the spatial relationship between SSE and VLF in these regions.

Keywords: SSE, GNSS-A, Nankai Trough

©2019. Japan Geoscience Union. All Right Reserved.

Co- and Post-seismic deformation due to the 2016 moderate earthquake sequence at the Chaman fault

*Fumiko Matsumoto[1], Masato Furuya[1]

1. Hokkaido University

Chaman fault system, located in Pakistan and Afghanistan, forms a transform boundary between Indian and Eurasian plates. Previous geological survey found the relative velocity of the Indian plate to the Eurasian at ~36mm/yr. Chaman fault is the major sinistral strike-slip fault which has ~900km long in the system. However, no large earthquakes (M>7) have been documented on the Chaman fault. Low seismicity results from either a long recurrence interval or aseismic creeping. Recent studies indicate a heterogeneous distribution of locked and creeping segments along the fault. In previous work, Furuya and Satyabala(2008) revealed a long lasted afterslip following a moderate earthquake (M5) in 2005 on the Chaman fault. We examine other earthquakes on the Chaman fault and their behavior comparing with the results in Furuya and Satyabala(2008). We find two moderate events occurred on May 13 and July 10 in 2016, first events larger than M5 on the Chaman fault after the M5 earthquake in 2005. The first event on May 13 was the largest M5-class earthquake since the 2005 M5 event examined by Furuya and Satyabala (2008). According to USGS catalogue, this May 13 event has three earthquakes observed within a few kilometers every minute in a row. We use ascending Sentinel-1 SAR data from March 31, 2016 to January 13, 2017. We generate InSAR images that suggest that the co- and post-seismic deformation of left-lateral strike-slip. Especially the second July 10 event almost implies the same behavior with the results in Furuya and Satyabala(2008). We must pick up real deformation except atmospheric trend, so we stack five InSAR images using different master date for each events before estimation of fault source model.

Keywords: InSAR, Slow slip, Crustal deformation

©2019. Japan Geoscience Union. All Right Reserved.

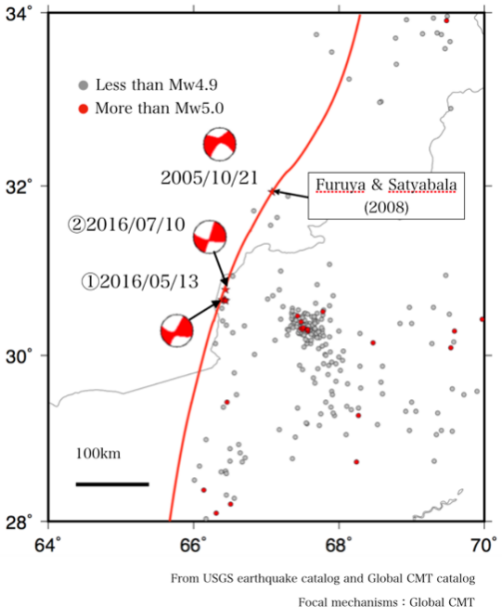


Figure1. Location map of Chaman fault and earthquakes after 2005/10/21. Gray dots show events less than Mw4.9 while red dots show more than Mw5.0. We pick up two events from more than Mw5.0 along the fault.

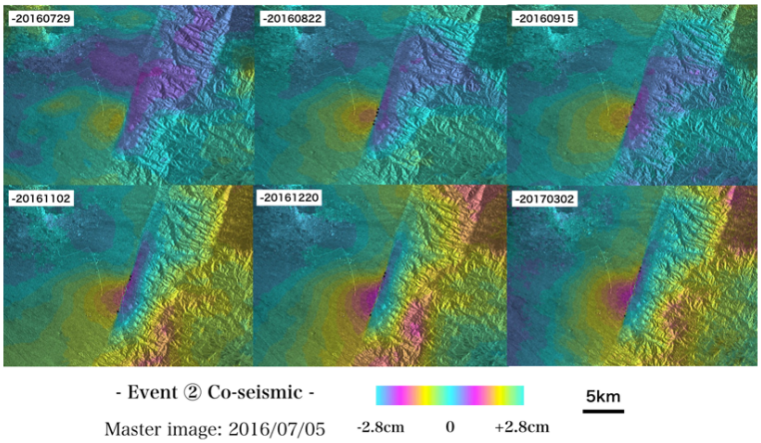


Figure2. Co-seismic deformation regarding the second event on 2016/07/10. There are six interferograms using same master image on 2016/07/05. These patterns are consistent with left lateral deformation. The phase and extent of deformation area gradually become larger.

©2019. Japan Geoscience Union. All Right Reserved.

An attempt to quantify transient fluid flow during slow slip event using GNSS and gravity data-1st report

*Yusuke Umemiya[1], Yoshiyuki Tanaka[1]

1. The University of Tokyo

Slow slip events (SSEs) cause crustal deformation. The observed deformations are usually explained with a fault model based on elasticity dislocation theory and fault slip distributions on plate interfaces have been inferred. On the other hand, a recent study analyzing the temporal gravity change which was obtained in the Tokai area indicates that long-term SSEs could cause transient fluid flow within the fault fracture zone. According to their study, fault slip cannot explain the observed negative gravity anomalies because the density redistribution which is expected from a dislocation theory is too small. However, their fluid-flow model neglects the deformation outside the fault fracture zone for simplicity. Therefore, how large surface deformation occurs due to such fluid flow (if it exists) has not yet been estimated. In this study, we propose a model which can consider the crustal deformation outside the fault fracture zone, which is induced by fluid flow. Instead of poroelasticity theories, we combine Mogi model with an ordinary dislocation model. Our model does not include a physical mechanism to drive the fluid flow itself. However, the kinematic approach allows us to quantify the fluid volume which is injected within the fault fracture zone during the SSEs in a very simple manner, using crustal deformation and gravity anomaly data. A preliminary result indicates that the injected fluid volume is approximately 0.01% if assuming that the thickness of the fault fracture zone is 200 m and the length and the width of the area where the fluid flow occurs are of the fault model of the SSE. For this volume change, our model can explain the crustal deformation and the gravity anomaly simultaneously.

Keywords: slow slip, fluid flow, GNSS, Gravity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Kazushige Obara(Earthquake Research Institute, University of Tokyo), Aitaro Kato(Earthquake Research Institute, University of Tokyo)

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG48-06] Interplay between long-term SSE and ETS facilitated by different underground environment

*Kazushige Obara[1] (1.Earthquake Research Institute, The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG48-07] **Determination of sVLFE epicenters around the subducted Kyushu-Palau Ridge from coda interferometry**

*Takashi Tonegawa[1], Yusuke Yamashita[2], Aki Ito[1], Masanao Shinohara[3], Daisuke Suetsugu[1], Tsutomu Takahashi[1], Yasushi Ishihara[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[4] (1.JAMSTEC, 2.DPRI, Kyoto University, 3.ERI, The University of Tokyo, 4.Kagawa University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG48-08] Detection of slow earthquakes in the microseism frequency band (0.05–1.0 Hz) by large-scale waveform stacking

*Koki Masuda[1], Satoshi Ide[1], Kazuaki Ohta[2] (1.Department of Earth an Planetary Science, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG48-09] Source characteristics of low-frequency earthquakes in Nankai subduction zone inferred from analysis of large event dataset

*Natalia Poiata[1], Mariano Supino[1,2], Gaetano Festa[2], Jean-Pierre Vilotte[1], Kazushige Obara[3] (1.Institut de Physique du Globe de Paris, 2.Università degli Studi di Napoli “ Federico II ”, Napoli, Italy, 3.Earthquake Research Institute, University of Tokyo, Japan)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG48-10] **High-frequency radiation prior to semi-volcanic low-frequency earthquake in Eastern Shimane, SW Japan, illuminated by “0.1 manten” Hyper Dense Seismic Observation**

*Aitaro Kato[1], Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3] (1.Earthquake Research Institute, the University of Tokyo, 2.Kyushu University, 3.Kyoto University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG48-11] Variation of Focal Mechanisms of Low Frequency Earthquakes in Parkfield

*Miki Aso[1,3], Naofumi Aso[2], Satoshi Ide[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Tokyo Institute of Technology, School of Science , 3.OYO RMS Corporation)

Interplay between long-term SSE and ETS facilitated by different underground environment

*Kazushige Obara[1]

1. Earthquake Research Institute, The University of Tokyo

Slow earthquakes consist of fault slip phenomena with various characteristic times. Geodetically detected slow earthquakes are mainly classified into two types; short-term and long-term slow slip events (SSEs) with duration from days to weeks and from months to years, respectively. In southwest Japan, at the deeper part from the seismogenic zone along the subducting plate interface, long-term and short-term SSEs are adjacently distributed and they indicate interaction. Because the short-term SSE usually occurs as an Episodic Tremor and Slip (ETS) associated with low-frequency tremor and very-low-frequency earthquake, the interaction is usually observed clearly in ETS tremor seismicity.
In Bungo channel, the long-term SSE is well known to occur at interval of 6-7 years. After the deployment of dense high-sensitivity seismograph network, major long-term SSEs in 2003 and 2010 were accompanied by activation of tremor seismicity. The activated tremor region is limited within a narrow width of 10 km from the updip edge of ETS zone and the tremor activity of the rest downdip part is constant irrespective to the occurrence of the long-term SSE.
In this region, two small long-term SSEs were detected by GNSS in 2014 and 2016; however, the interaction to ETS tremor were different from cases in 2003 and 2010. In 2014, activated tremor was smaller than that in 2010 according to the difference in the magnitude of SSE. On the other hand, there was no tremor activity associated with 2016 SSE. This is because the slip region of SSE was located southward apart from the tremor zone. By the way, a long-term SSE from the end of 2018 continues associated with activation of tremor lasting for several months. This SSE might be expected as a major SSE since 2010.
The main difference between long-term and short-term SSEs is slip rate. The difference in the slip rate may affect to the tremor rate. During the long-term SSE in 2003 and 2010, the temporal change in cumulative number of tremor increased smoothly similar to the GNSS displacement. However, the gradual increase of tremor number was actually composed of superposition of small bursts corresponding to the faster speed slip compared to the long-term SSE. This suggests that the ETS region has a characteristic slip and frictional property different from the long-term SSE region.
A recent receiver function study conducted along a linear seismic array installed at the west of Shikoku besides from Bungo channel has revealed a low velocity oceanic crust and a continental Moho discontinuity just above ETS activity. This indicates that the ETS occur at the boundary between the subducting oceanic plate and the overlying mantle wedge, whereas that long-term SSE occurs at the boundary between oceanic plate and the continental lower crust. The difference of slow earthquake behavior controlled by the structure in the hanging wall is very similar to the Tokai region (Kato et al., 2010). Therefore, the different environment at the plate interface facilitates these SSEs with different characteristic times.

Keywords: slow earthquake, low frequency tremor, slow slip event, subduction zone

©2019. Japan Geoscience Union. All Right Reserved.

Determination of sVLFE epicenters around the subducted Kyushu-Palau Ridge from coda interferometry

*Takashi Tonegawa[1], Yusuke Yamashita[2], Aki Ito[1], Masanao Shinohara[3], Daisuke Suetsugu[1], Tsutomu Takahashi[1], Yasushi Ishihara[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[4]

1. JAMSTEC, 2. DPRI, Kyoto University, 3. ERI, The University of Tokyo, 4. Kagawa University

Shallow very low frequency earthquakes (sVLFEs) occur at the shallow portion of the plate boundary. The Rayleigh waves at a frequency of 0.03–0.2 Hz radiated from their sources are observed in land and seafloor seismic records. Although sVLFE locations have been estimated from land records, there is a possibility to determine them more precisely if seafloor records near the epicenters are available. In the Hyuga-nada region and off Nansei Islands, ocean bottom seismometer (OBS) arrays were deployed 4 times during 4 years, each of which contained 5–13 OBSs and could observe at least one episode of sVLFE activity. In this study, we estimated the group velocity of the Rayleigh wave in the OBS arrays from coda interferometry, and applied it to the envelope correlation method (ECM) using seafloor seismic records for determining sVLFE epicenters.

As a result, the locations of sVLFE during 2014 and 2016 were determined at the northern edge of the Kyushu-Palau Ridge (KPR) (Yamamoto et al. 2013), while those on 2017 and 2018 were estimated to be the southern edge of the KPR. In particular, the sVLFEs on 2015 firstly occurred at the northern edge of the KPR, but occurred near the trough afterwards. Also, comparing the area of slow slip event (SSE) in the Hyuga-nada region (Ozawa 2017), sVLFE region at the northern part of KPR directly connects to the SSE region, indicating that slow earthquakes potentially occur from deep to shallow plate interface around the KPR.

Acknowledgement
This study was supported by “Research Project for Compound Disaster Mitigation on the Great Earthquakes and Tsunamis around the Nankai Trough Region” of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. We thank Shinzaburo Ozawa and Yojiro Yamamoto for providing us SSE and KPR data.

Keywords: shallow very low frequency earthquake, Hyuga-nada region, Kyushu-Palau Ridge

©2019. Japan Geoscience Union. All Right Reserved.

Detection of slow earthquakes in the microseism frequency band (0.05–1.0 Hz) by large-scale waveform stacking

*Koki Masuda[1], Satoshi Ide[1], Kazuaki Ohta[2]

1. Department of Earth an Planetary Science, University of Tokyo, 2. Disaster Prevention Research Institute, Kyoto University

Slow earthquakes have been intensively studied because of the proximity of their source area to that of megathrust earthquakes and their high sensitivity to regional stress change. They have been classified according to their characteristic time scale into tremors and low frequency earthquake (LFE; >1 Hz), very low frequency earthquake (VLFE; 20-100 sec), and slow slip event (SSE; > 1 day). Microseism noise is dominant in the frequency band between LFE and VLFE, which we call the microseism frequency band, and it is difficult to detect signals of slow earthquakes in this band. As a rare exception, signals in this band accompanied with LFEs and VLFEs were detected on the shallow subduction interface by near-field ocean bottom broadband seismometers with fortuitously low microseism noise (Kaneko et al., 2018). The characteristics of signals in this band are totally unknown for deep slow earthquakes.

In this study, we first report the observation of slow earthquake signals in the microseism frequency band in the western Shikoku region of the Nankai subduction zone, Japan, by stacking a lot of seismograms relative to the timing of high-frequency signals. First, we made synthetic template waveforms and conducted a matched filter analysis using these template waveforms (Ohta & Ide, 2017). Utilizing GPU, we detected about 700,000 events in continuous records at 9 Hi-net stations, operated by National Research Institute for Earth Science and Disaster Resilience, from 2005 to 2015. Their temporal distribution suggests that LFEs are episodic phenomena and their spatial distribution indicates the sources are concentrated in several patches, as reported by previous researches (e.g., Ohta & Ide, 2017). Then we stacked seismograms at the timing of these detected events, after band-pass filtering in different frequency bands (4-8 Hz, 2-4 Hz, 1-2 Hz, 0.5-1 Hz, 0.25-0.5 Hz, and 0.125-0.25 Hz). In-phase waveforms are confirmed in all frequency bands, despite low sensitivity of Hi-net seismometers in lower frequencies than 1 Hz. This result suggests that slow earthquakes radiate broadband signals without characteristic frequencies from 0.125 to 8 Hz.

Keywords: slow earthquakes, LFE, microseism, matched filter, Nankai subduction zone

©2019. Japan Geoscience Union. All Right Reserved.

Source characteristics of low-frequency earthquakes in Nankai subduction zone inferred from analysis of large event dataset

*Natalia Poiata[1], Mariano Supino[1,2], Gaetano Festa[2], Jean-Pierre Vilotte[1], Kazushige Obara[3]

1. Institut de Physique du Globe de Paris, 2. Università degli Studi di Napoli “Federico II”, Napoli, Italy, 3. Earthquake Research Institute, University of Tokyo, Japan

Application of advanced detection and location methods to the analysis of low-frequency earthquakes (LFE) allows building large event catalogues rich in information that can provide a better understanding of their source characteristics. Up to now, LFE characterization in terms of size, stress drop and rupture propagation still remains uncertain, the main difficulty owing to the low signal-to noise ratio of corresponding records.

We present a catalog of LFE in western part of Nankai subduction zone derived by applying a full waveform-based detection and location scheme of Poiata et. al. (2016) to the continuous records form Hi-net seismic stations covering a 3-year period from 2013-2016. The applied method is based on the frequency-selective coherence of signals’ statistical features recorded across the stations of seismic network, not requiring a prior assumption about the event source (i.e., template event). The derived catalog (~ 40000 events) allows to look into the details of LFE space-time activity (i.e., clustering and migration patterns) during the energetic tectonic tremor sequences as well as inter-sequence periods as well as characterize source properties of these events.

We derive source parameters of LFEs extracted from this 3-year catalog by applying the probabilistic approach of Supino et al. (2019) based on the conjunction of states of information between data and model and estimating the joint probability density function of the parameters. The events S-wave displacement amplitude spectrum is described by a circular source model, characterized by a plateau at low frequencies and a coherent decay at high frequencies; the frequency of transition between these two regimes is the corner frequency. Processing of this large LFE data set is performed using accurate quality criteria, allowing to automatically reject noisy data and unconstrained solutions.

The resulted moment magnitudes, estimated from low-frequency plateau, range between Mw 0.9 and 2.2, while corner frequencies vary between 0.8 and 12 Hz, being lower than expected for ordinary earthquakes, as already observed for LFEs. We found that LFE sources exhibit a power-law scaling between corner frequency and seismic moment, with an exponent of -3.5, very similar to the scaling observed for classical earthquakes.

Keywords: low-frequency earthquakes, source characteriziation, continuous data analysis, event detection and location

©2019. Japan Geoscience Union. All Right Reserved.

High-frequency radiation prior to semi-volcanic low-frequency earthquake in Eastern Shimane, SW Japan, illuminated by “0.1 manten” Hyper Dense Seismic Observation

*Aitaro Kato[1], Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3]

1. Earthquake Research Institute, the University of Tokyo, 2. Kyushu University, 3. Kyoto University

Semi-volcanic deep low-frequency earthquake (LFE) that occurs distant from active volcanoes has been investigated by previous several studies [Ohmi and Obara, 2002; Aso et al., 2013]. In eastern Shimane of SW Japan, there is a spot hosting frequent semi-volcanic LFE activity for over 20 years. Above this source area, we installed a thousand of seismic stations from March 2017 to March 2018, which covers an entire aftershock zone of the 2000 Western-Tottori earthquake (Mw 6.7). The spatial interval of each seismic station ranges from 1 to 2 km.

We found out clear arrivals of high-frequency waveforms prior to arrivals of low-frequency signals by a hundred of the dense seismic stations. The differential arrival times between the high- and low-frequency waveforms are approximately 1.5 s. The high-frequency radiation has the strongest amplitude at 28 Hz and 16 Hz and is characterized by stronger P-wave amplitude than faint S-wave. In contrast, the low-frequency component is predominant from 1 to 6 Hz and shows variation of the ratio of P-wave to S-wave with epicentral distance. This observation clarifies that different excitation mechanisms are needed to explain bimodal radiations at the high- and low-frequency bands.

We relocated the high- and low-radiation sources by both visually picked arrival times and Source Scanning Algorithm. Then, each radiation source is located within a cloud of LEFs determined by the JMA. The depth of the high- and low-frequency sources are imaged around the depth of 30 km, namely around Moho discontinuity. But, the high-frequency radiation is slightly deeper than that of the low-frequency with a few km horizontal offset. The origin time of the high-frequency radiation is by 1.5 ~ 2 seconds earlier than that of the low-frequency. This slight spatial gap indicates that the two sources appear to be not collocated, while the spatial separation between the two sources is not so large in terms of the hypocenter accuracy. The present study first shows that the high- and low-frequency radiation sources are close to each other around Moho discontinuity.

Combined with these observations, we interpret that the early high-frequency radiation is derived from brittle breakage of low-permeability seal may arise from hydrothermal cementation. Infiltration of high-pressurized fluids into the bottom of lower crust may trigger slow shear slip or resonance of crustal fluids along a pre-existing fracture.

©2019. Japan Geoscience Union. All Right Reserved.

Variation of Focal Mechanisms of Low Frequency Earthquakes in Parkfield

*Miki Aso[1,3], Naofumi Aso[2], Satoshi Ide[1]

1. Department of Earth and Planetary Science, The University of Tokyo, 2. Tokyo Institute of Technology, School of Science , 3. OYO RMS Corporation

Tectonic low frequency earthquakes (LFEs) occur at plate boundaries around the world, and considered as local slow deformation. LFEs in subduction zones are found to have low-angle thrust fault mechanisms in southwest Japan [Ide et al., 2007], Mexico [Frank et al., 2013], and Cascadia [Royer and Bostock, 2014]. LFEs along Alpine fault, a transform fault in New Zealand, are known to have right-lateral strike slip mechanism [Baratin et al., 2018]. However, the focal mechanisms of LFEs at Parkfield along the San Andreas Fault zone have not been revealed yet, regardless of the frequent activities. The San Andreas Fault is one of the most matured active faults in the world, especially at Parkfield, and large damaging earthquakes also repeatedly occurred in history. Therefore, many seismologists and geologists have been challenging to reveal the cause of earthquakes and LFEs.
In this study, we estimate the focal mechanisms of 88 LFE families in the catalog of Shelly [2017]. We first stack seismograms of over one million events in the catalog to improve the signal-to-noise (S/N) ratio. P-wave polarities of the stacked waveforms suggest the existence of variations in focal mechanisms of the LFE families.
Then, we evaluate the absolute amplitudes of original seismograms using the stacked waveforms. The SH wave amplitudes are inverted to the focal mechanisms for each LFE family. Specifically, the contributions from source radiation, path attenuation, and site amplification are represented by independent terms based on the assumption of simple ray theory, and estimated by solving a two-step inversion problem. The source terms are utilized to determine focal mechanisms. While most of the focal mechanisms are strike-slip consistent with the San Andreas Fault motion, those for families near the central Parkfield and the family off the surface trace contain large dip-slip (Figure 1 and 2). These variations are consistent with tidal sensitivities of LFEs in Parkfield [Thomas et al., 2012]. Our study reveals regional dip-slip focal mechanisms at first glance to be strike-slip along matured San Andreas Fault.

Keywords: San Andreas Fault, Parkfield, focal mechanism inversion, waveform stacking, low frequency earthquake, amplitude evaluation

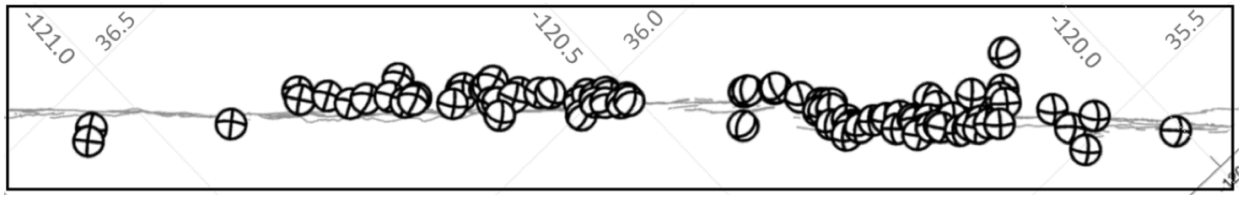


Figure 1. The focal mechanisms of LFE families

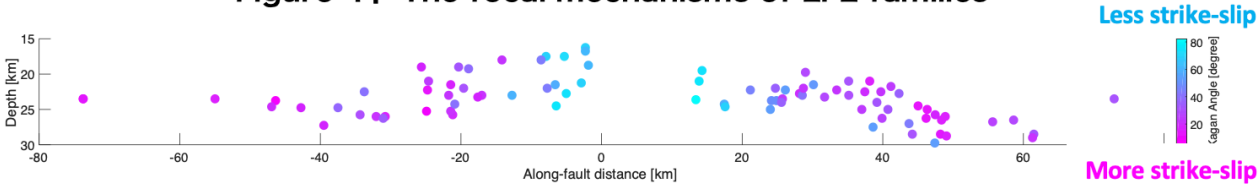


Figure 2. The difference from strike-slip focal mechanism of ordinary earthquake

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Satoshi Ide(Graduate School of Science, University of Tokyo), Kazuaki Ohta

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SCG48-12] Mapping seismic data to slow slip using machine learning

★Invited Papers

*Bertrand Rouet-Leduc[1], Claudia Hulbert[2], Ian McBrearty[1], Paul Johnson[1] (1.Los Alamos National Laboratory, USA, 2.Ecole Normale Superieure, France)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG48-13] Revealing the slow earthquake activity in the Japan Trench and its relation to the 2011 Tohoku-Oki earthquake

*Tomoaki Nishikawa[1], Takanori Matsuzawa[2], Kazuaki Ohta[1], 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, Tohoku University, 4.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG48-14] Tremor and slow slip associated with afterslip of the 2011 Tohoku earthquake

*Kazuaki Ohta[1], Yoshihiro Ito[1], Ryota Hino[2], Shukei Ohyanagi[1], Takanori Matsuzawa[3], Masanao Shinohara[4], Hajime Shiobara[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Science, Tohoku University, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Earthquake Research Institute, the University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG48-15] High definition imaging of the Japan Trench by OBS Array of Arrays: Does shallow tectonic tremor occur in the plate interface?

*Shukei Ohyanagi[1], Kazuaki Ohta[2], Yoshihiro Ito[2], Ryota Hino[3], Yusaku Ohta[3], Ryosuke Azuma[3], Masanao Shinohara[4], Kimihiro Mochizuki[4], Toshinori Sato[5], Yoshio Murai[6] (1.Kyoto University, Graduate School of Science, 2.Kyoto University, Disaster Prevention Research Institute, 3.Tohoku University, 4.Tokyo University, Earthquake Research Institute, 5.Chiba University, 6.Hokkaido University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG48-16] The activity of small repeating earthquakes after the 2011 Tohoku-oki earthquake: an examination based on the S-net and land networks

*Naoki Uchida[1], Ryota Takagi[1], Satoshi Hirahara[1], Takashi NAKAYAMA[1], Toru Matsuzawa[1], Sachiko Tanaka[2], Youichi Asano[2] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2.National Research Institute for Earth Science and Disaster Resilience)

Mapping seismic data to slow slip using machine learning

*Bertrand Rouet-Leduc[1], Claudia Hulbert[2], Ian McBrearty[1], Paul Johnson[1]

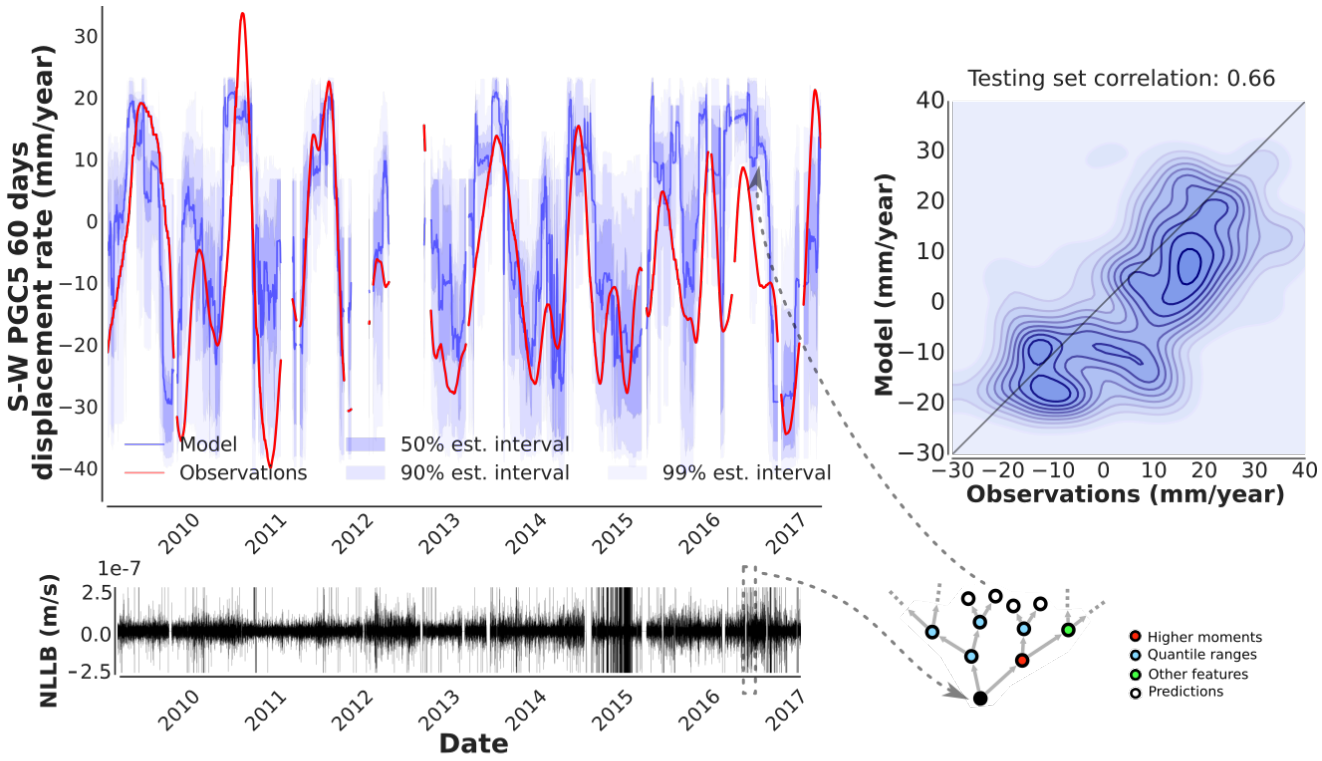
1. Los Alamos National Laboratory, USA, 2. Ecole Normale Superieure, France

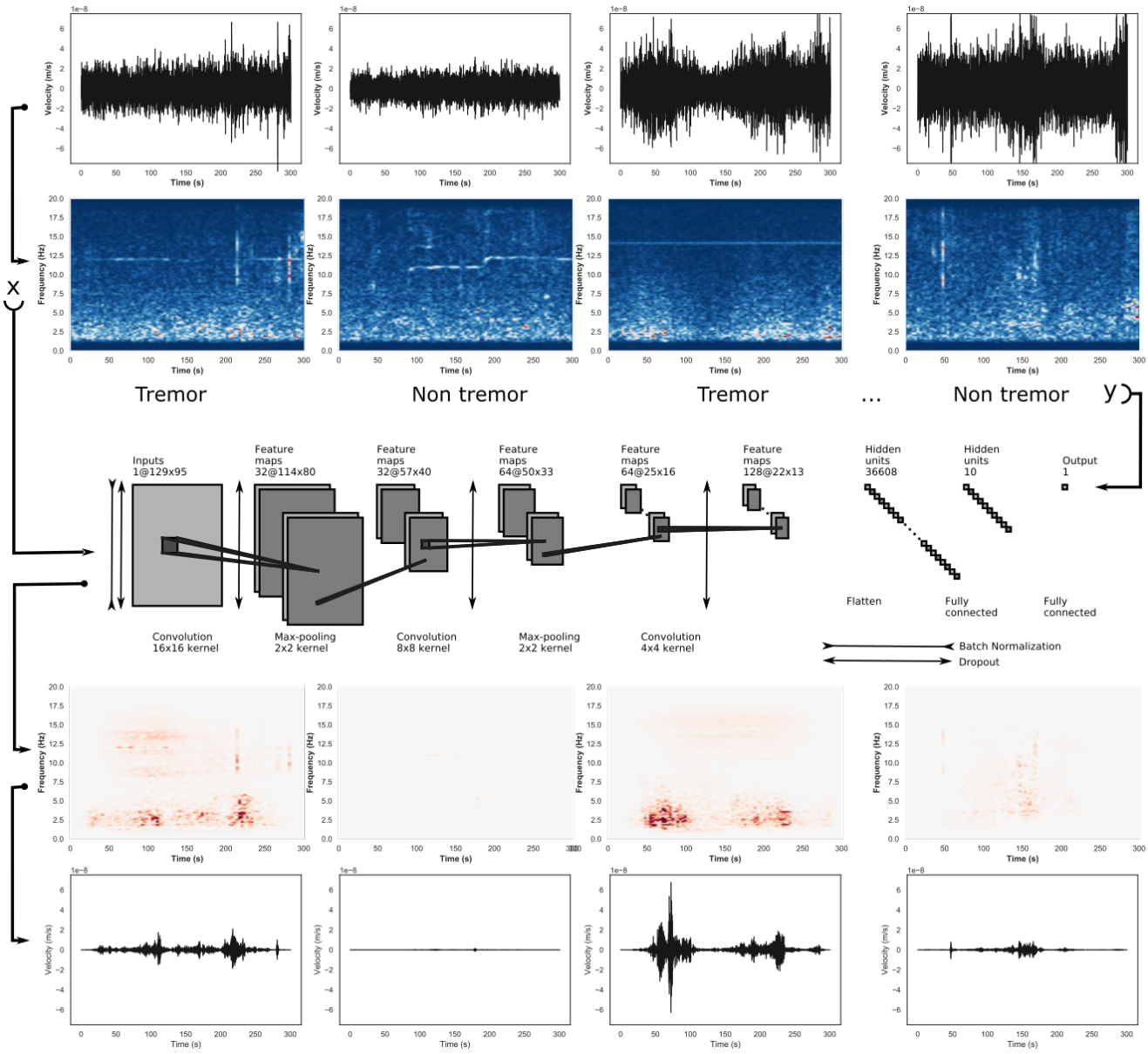
We show that the Cascadia subduction zone is apparently continuously broadcasting a low-amplitude, tremor-like signal that precisely informs of the fault displacement rate throughout the slow slip cycle. Using a method based on machine learning previously developed in the laboratory, we analysed large amounts of raw seismic data from Vancouver Island to separate this signal from the background seismic noise. We posit that this provides indirect real-time access to fault physics on the down-dip portion of the megathrust, and thus may prove useful in determining if and how a slow slip may couple to or evolve into a major earthquake.

In a parallel approach, we show that tremor can be accurately detected on a single seismic station by a deep convolutional neural network. Seismic tremor is posited to provide information on the physical state of the slowly slipping portion of the megathrust, and a single station tremor detector gives a direct access to the tremor signal and its physical characteristics. A deep learning model trained to detect tremor in Cascadia recognizes catalogued tremor in other subduction zones, arguing for the universality of tremor and slow slip characteristics. The detection rate of a deep learning model trained to recognize tremor in Cascadia and applied on waveforms from Northern Chile shows strong correlation with surface displacement rate, arguing for episodic tremor and slip detection where slow earthquakes and associated tremor had not been seen so far, presumably taking place too deep to have been detected using conventional multi-station methods.

Keywords: Tremor, Slow earthquake, Machine learning, Deep learning

©2019. Japan Geoscience Union. All Right Reserved.





©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Revealing the slow earthquake activity in the Japan Trench and its relation to the 2011 Tohoku-Oki earthquake

*Tomoaki Nishikawa[1], Takanori Matsuzawa[2], Kazuaki Ohta[1], Naoki Uchida[3], Takuya NISHIMURA[1], Satoshi Ide[4]

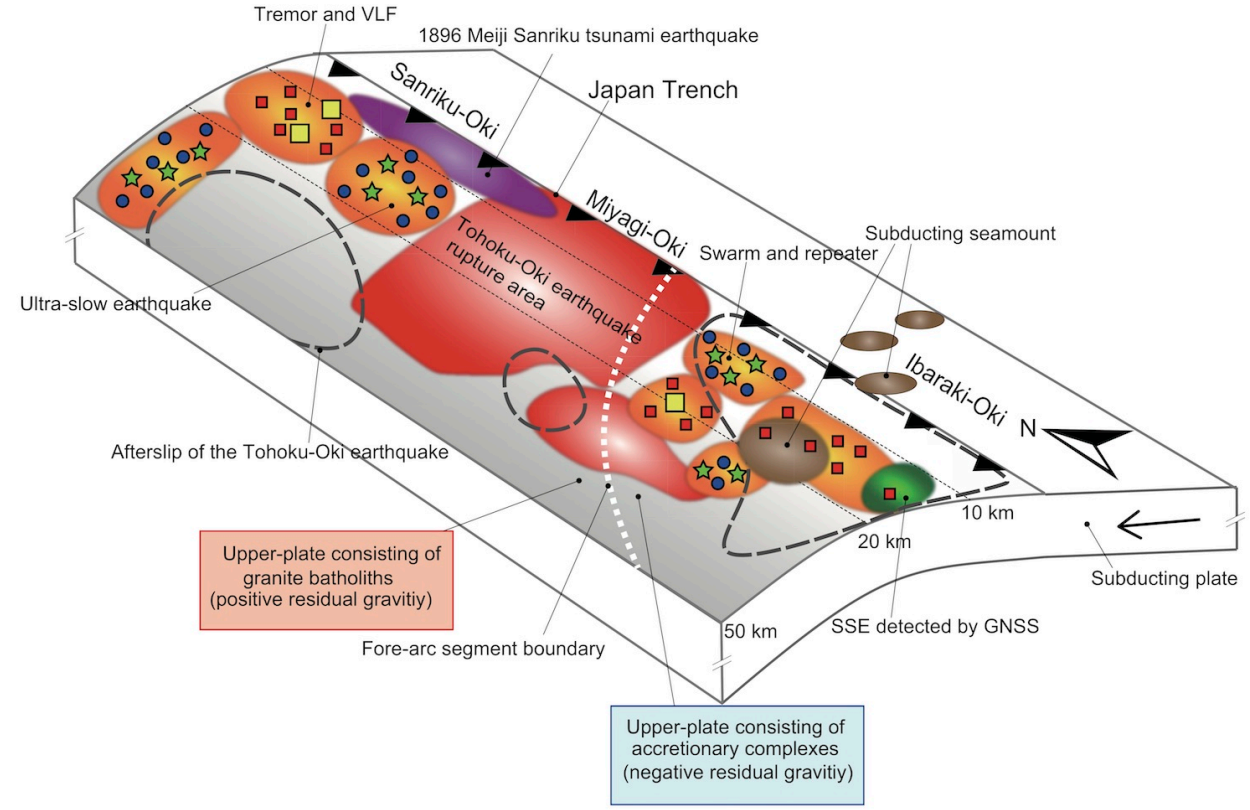
1. Disaster Prevention Research Institute, Kyoto University, 2. National Research Institute for Earth Science and Disaster Resilience, 3. Graduate School of Science, Tohoku University, 4. Graduate School of Science, The University of Tokyo

Subduction zone megathrust earthquakes result from the interplay between fast dynamic rupture and slow deformation processes, which are directly observed as various slow earthquakes, including tectonic tremors, very low-frequency earthquake (VLFs) and slow slip events (SSEs), and indirectly suggested by a temporal change in the frequency of repeating earthquakes and the occurrence of episodic earthquake swarms. Some megathrust earthquakes have been preceded by slow earthquakes and terminated near the areas where slow earthquakes were frequently observed. While capturing the entire spectrum of slow earthquake activity is crucial for estimating the occurrence time and rupture extent of future megathrust earthquakes in a given subduction zone, such an observation is generally difficult, and slow earthquake activity is poorly understood in most subduction zones, including the Japan Trench, which hosted the 2011 M_w9.0 Tohoku-Oki earthquake. Here we reveal the slow earthquake activity in the Japan Trench in detail using tectonic tremors, which we detected in the seismograms of a new ocean-bottom seismograph network, VLFs, SSEs, repeating earthquakes, and earthquake swarms. We show that the slow earthquake distribution is complementary to the rupture area of the Tohoku-Oki earthquake and correlates with the structural heterogeneity along the Japan Trench. Concentrated slow earthquake activities were observed in the afterslip area of the Tohoku-Oki earthquake, which is located to the south of the fore-arc geological segment boundary. Our results suggest that the megathrust in the Japan Trench is divided into three segments that are characterised by different frictional properties, and that the rupture of the Tohoku-Oki earthquake, which nucleated in the central segment, was terminated by the two adjacent segments.

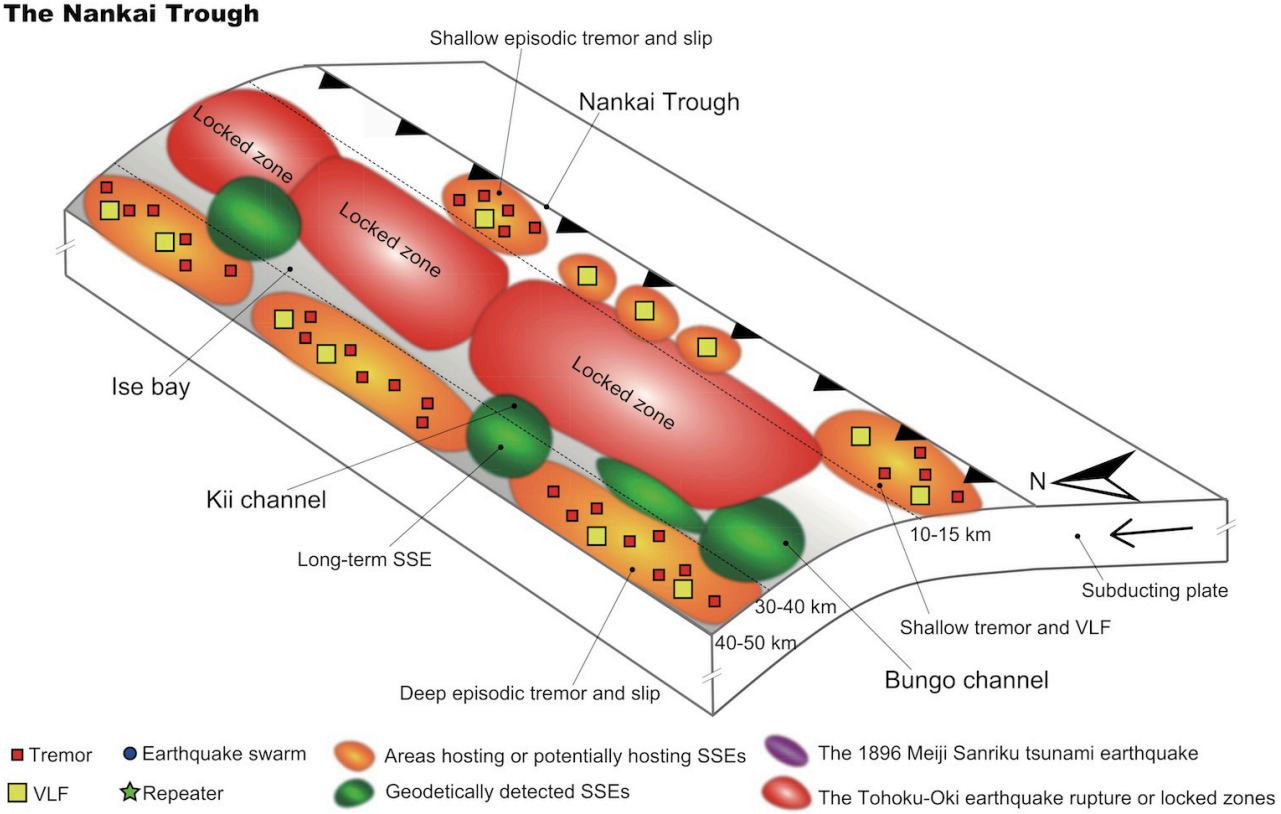
Keywords: Slow earthquake, Megathrust earthquake, Subduction zone, The 2011 Tohoku-Oki earthquake

©2019. Japan Geoscience Union. All Right Reserved.

The Japan Trench



The Nankai Trough



©2019. Japan Geoscience Union. All Right Reserved.

Tremor and slow slip associated with afterslip of the 2011 Tohoku earthquake

*Kazuaki Ohta[1], Yoshihiro Ito[1], Ryota Hino[2], Shukei Ohyanagi[1], Takanori Matsuzawa[3], Masanao Shinohara[4], Hajime Shiobara[4]

1. Disaster Prevention Research Institute, Kyoto University, 2. Graduate School of Science, Tohoku University, 3. National Research Institute for Earth Science and Disaster Resilience, 4. Earthquake Research Institute, the University of Tokyo

Characterizing shallow interplate slip is essential for modeling the potential generation of megathrust earthquakes and tsunamis. Large postseismic crustal deformation caused by the 2011 Tohoku-Oki earthquake suggests the occurrence of shallow afterslip, but it is unclear what kind of slip is dominant at the shallow plate interface. Here we report episodic tremor activity south of the primary rupture area based on ocean bottom seismometer observations.
We deployed 24 OBSs at 6 sites close to the trench axis in the Fukushima-Oki region. Three of these sites were small arrays, each consisting of 1 broad-band OBS and 6 short-period (1 Hz) OBSs. The 3 other sites each had 1 short-period OBS. Continuous observations were made from October 2016 to September 2017. For OBS records, we applied the envelope correlation method to detect and locate tremor activity. We also estimate the focal mechanisms of the detected tremor events using S-wave polarization particle motion.
We identified ~ 2000 tremor events in five burst episodes. The duration of each burst ranges from 6 to 18 days, with recurrence intervals of ~60 days. The tremor region largely coincides with the region of very low frequency earthquakes and lies between geodetically observed coseismic and afterslip region of the Tohoku earthquake. Tremor shows clear migration behavior with the speed of ~ 5 km/day and shear mechanisms consistent with plate subduction direction.
The characteristics of the tremor –episodicity, migration and shear mechanisms –strongly suggest that it is accompanied by slow slip events (SSEs). We further approximated the slip amount of SSEs based on the ground displacement of the tremor seismograms. The estimated slip of 1.5 cm/year corresponding to a seismic moment of ~7.4×10^{17} Nm is slightly smaller than but comparable to that of typical short-term SSEs, however, much smaller than that of afterslip. Thus, both SSEs and afterslip exist in the shallow part of the Japan trench. We propose that the tremor and SSE region illuminate the boundary between coseismic slip and stable aseismic slip that could limit the rupture extent of future megathrust earthquakes. Besides, the observed tremor and slow slip activities may also suggest that the interplate stress state has been recovered to the level of that before the Tohoku earthquake.

Keywords: tremor, slow slip, afterslip, Japan trench, Tohoku earthquake

©2019. Japan Geoscience Union. All Right Reserved.

High definition imaging of the Japan Trench by OBS Array of Arrays: Does shallow tectonic tremor occur in the plate interface?

*Shukei Ohyanagi[1], Kazuaki Ohta[2], Yoshihiro Ito[2], Ryota Hino[3], Yusaku Ohta[3], Ryosuke Azuma[3], Masanao Shinohara[4], Kimihiro Mochizuki[4], Toshinori Sato[5], Yoshio Murai[6]

1. Kyoto University, Graduate School of Science, 2. Kyoto University, Disaster Prevention Research Institute, 3. Tohoku University, 4. Tokyo University, Earthquake Research Institute, 5. Chiba University, 6. Hokkaido University

The Japan Trench is the host to various scale and slip behavior of seismic activities, such as the M9 Tohoku-Oki megathrust earthquake, slow slip events, low frequency tremors and very-low frequency earthquakes (VLFEs). Since these events occur under the seafloor, observation capability of the onshore seismic network is limited due to far distance from their source regions. During 2016 and 2017, we have performed the dense OBS Array of Arrays observation in the offshore Fukushima prefecture near the trench axis to achieve high resolution imaging of the shallow portion of the Japan Trench.
Our network consists of three OBS arrays. Each array consists of one broad band OBS, and six 1Hz short period OBSs. These seven OBSs form a triangular array of 300m to 500m of interstation distance, which results in the array diameter of ~1km. High resolution imaging of complicated seismic phenomena (such as tectonic tremor) is enabled by installing the arrays in the vicinity of the target region.
Based on visual inspection of the observed data, we have identified two episodes of low frequency tremors, triggered dynamically by M7.8 event in offshore Solomon Islands on December 2016, and M7.7 event in offshore Kamchatka Peninsula on July 2017. In both cases, the tremors were accompanied by arrival of Rayleigh waves. The episode of December 2016 lasted 7 minutes, and ceased after passage of Rayleigh wave. On the other hand, the episode of July 2017 continues even after passage of Rayleigh wave, and lasted for more than 12 minutes.
To reveal the origin of these tremors, we apply a beamforming technique to estimate back azimuth and slowness of incoming wave observed by the arrays. Observed tremors are beamformed in horizontal components of OBSs after their absolute orientations are determined using particle-motion of T-phase. From the resulting beam, we have estimated epicenters of the tremors every 60 seconds using only azimuthal information at each array. In this presentation, we are going to discuss about depth of the tremor sources from observed slowness. The tremor activities probably indicate the potential for the occurrence of shallow slow slip events near the Japan Trench, in which VLFEs and after slip were activated after the 2011 Tohoku-Oki earthquake.

Acknowledgements: This study is supported by JSPS KAKENHI (26000002).

Keywords: Low frequency tremor, Ocean Bottom Seismometer, Array analysis, Dynamic triggering, Japan Trench, Slow earthquake

©2019. Japan Geoscience Union. All Right Reserved.

The activity of small repeating earthquakes after the 2011 Tohoku-oki earthquake: an examination based on the S-net and land networks

*Naoki Uchida[1], Ryota Takagi[1], Satoshi Hirahara[1], Takashi NAKAYAMA[1], Toru Matsuzawa[1], Sachiko Tanaka[2], Youichi Asano[2]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2. National Research Institute for Earth Science and Disaster Resilience

We examined the activity of repeating earthquakes around the 2011 Tohoku-oki earthquake, Japan based on Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) and permanent land stations. We used earthquakes located by Japan Meteorological Agency to find repeating earthquakes based on the waveform similarity observed at the same station. The waveform coherences for 40 second window including P and S phases are evaluated and if they are larger than 0.8 we select them as repeating earthquakes. We performed long- and short-term analyses respectively to understand long-term activity change of repeating earthquakes and to compare land-based and offshore (S-net) data analyses. For the long-term analysis, we used earthquakes larger than M2.5 for the period from 1993 to 2018 obtained by the land stations. For the short-term analysis, we analyzed land and S-net stations separately for M2.0 or larger earthquakes for the period from August 2016 to October 2018.

The long-term analysis shows that the coseismic slip area of the 2011 Tohoku-oki earthquake continued to be quiet in the activity of the repeating earthquakes suggesting that the area have not reloaded enough after the earthquake. In the shallow area (depth <= 30km), the activity of repeating earthquakes decay with fluctuations to the north of the coseismic slip but decayed monotonically to the south of the coseismic slip area. In the deep area (depth >= 30km), the repeating earthquake activity also decayed but the activity was still high in 2018 especially in the down-dip part of the coseismic slip area. These results show different behavior of postseismic slip of the Tohoku-oki earthquake.

The short-term analysis that use the same set of earthquakes to detect repeating earthquakes (August 2016 to October 2018, M>=2) by the S-net and the land stations show similar number of detected repeating earthquakes (520 and 684 for S-net and land stations respectively). This is probably because the waveforms of earthquakes that are located by land stations (JMA’s catalogue) have good signal-to-noise ratio for the land stations. Since the completeness of magnitudes of the JMA’s catalogue in far off land area is larger than M2.0, the event detection by S-net will contribute to the detection of more repeating earthquakes in the offshore area. In addition to this, the land-station based long-term analysis has more repeating earthquakes (894 M>=2.5) for the 2.2-year period of the S-net data analysis, suggesting the increase of observation period will contribute for the detection of repeating earthquakes whose intervals are larger than the short analysis period .

Acknowledgement:

We used velocity seismometer data obtained by S-net and seismological network of Hokkaido and Tohoku University.

Keywords: repeating earthquakes, S-net, slow slip

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 201A 2F

[M-IS07] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Misato Fukagawa(名古屋大学大学院 理学研究科), Kosuke Fujishima(ELSI 地球生命研究所)

Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Individual themes related to Astrobiology, such as chemical evolution in the early Solar System, formation of planetary system, prebiotic chemistry in the early Earth, evolution of life in the Earth's history, extremophile, and habitable planetary environments, has been studied by the knowledge and methods from the multiple fields, which has enabled us to explain "Where we came from" in some ways. However, despite an overwhelming number of investigations and discussions through gathering of the scientists from different fields, there has remained the long-standing unsolved question: How did abiotic materials gain biological function in the Earth and elsewhere in universe? There is still a large gap between prebiotic organic chemistry and biochemistry toward Origins of Life and planetary habitability. Therefore, the JpGU Astrobiology session focuses on pathfinding of "integration of astronomy, geoscience, and biochemistry", which will face an increasing need for the future Astrobiology. In order to enhance our understanding of "What is life", we propose to discuss the biochemical events linked with planetary systems, which is beyond the knowledge in a test tube, by an integration of exoplanets and molecular biology, etc. Through this approach, we will lead the discussions and developments of life-detection strategies for the future exploration of life in universe.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

Introduction

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[MIS07-01] METEOROID AND DEBRIS IMPACT FLUX IN LOW EARTH ORBIT WITNESSED BY THE TANPOPO CAPTURE PANELS ONBOARD THE ISS IN 2015-2017

*Hajime Yano[1], K. Yamamoto[2], E. Minakami[2], M. Eitel[1,3], S. Sasaki[4], J. Imani[5], K. Okudaira[6], M. Higashide[7], E. Imai[8], Y. Kawaguchi[9], Yoko Kebukawa[10], H. Mita[11], M. Nishi[12], T. Noguchi[13], Makoto Tabata[14], A. Tsuchiyama[12], Hikaru Yabuta[15], K. Arai[8], H. Hashimoto[1], Kensei Kobayashi[10], A. Yamagishi[16] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Hosei University, 3.University of Stuttgart, 4.Tokyo University of Technology, 5.Yuki Seimitsu, Co. Ltd., 6.University of Aizu, 7.JAXA/Aerospace Research and Development Directorate, 8.Nagaoka University of Technology, 9.Chiba Institute of Technology, 10.Yokohama National University, 11.Fukuoka Institute of Technology, 12.Kyoto University, 13.Kyushu University, 14.Chiba University, 15.Hiroshima University, 16.Tokyo University of Pharmacy and Life Science)

3:50 PM - 4:10 PM JST | 6:50 AM - 7:10 AM UTC

[MIS07-02] Growth and transport of dust, ice, and organics in the inner part of protoplanetary disks

★Invited Papers

*Satoshi Okuzumi[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[MIS07-03] Model Prediction of Complex Organic Molecules in Protoplanetary Disks

*Hideko Nomura[1], Catherine Walsh[2], Tom J. Millar[3] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.School of Physics and Astronomy, University of Leeds, 3.School of Mathematics and Physics, Queen’s University Belfast)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[MIS07-04] Abiotic synthesis of organic matters in environments simulating asteroids and the catalytic effect of minerals on amino acid formation

*Walaa Elmasry[1], Yoko Kebukawa[1], Kensei Kobayashi[1] (1.Yokohama National University)

4:40 PM - 4:55 PM JST | 7:40 AM - 7:55 AM UTC

[MIS07-05] Peptide Formation from amino acid precursors under simulated submarine hydrothermal environments

*Kensei Kobayashi[1], Keisuke Naito[1], Koki Naito[1], Soushi Kuramoto[1], Ei-ichi Imai[2], MITA Hajime[3], Yoko Kebukawa[1] (1.Yokohama National University, 2.Nagaoka University of Technology, 3.Fukuoka Institute of Technology)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

Discussion

METEOROID AND DEBRIS IMPACT FLUX IN LOW EARTH ORBIT WITNESSED BY THE TANPOPO CAPTURE PANELS ONBOARD THE ISS IN 2015-2017

*Hajime Yano[1], K. Yamamoto[2], E. Minakami[2], M. Eitel[1,3], S. Sasaki[4], J. Imani[5], K. Okudaira[6], M. Higashide[7], E. Imai[8], Y. Kawaguchi[9], Yoko Kebukawa[10], H. Mita[11], M. Nishi[12], T. Noguchi[13], Makoto Tabata[14], A. Tsuchiyama[12], Hikaru Yabuta[15], K. Arai[8], H. Hashimoto[1], Kensei Kobayashi[10], A. Yamagishi[16]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Hosei University, 3. University of Stuttgart, 4. Tokyo University of Technology, 5. Yuki Seimitsu, Co. Ltd., 6. University of Aizu, 7. JAXA/Aerospace Research and Development Directorate, 8. Nagaoka University of Technology, 9. Chiba Institute of Technology, 10. Yokohama National University, 11. Fukuoka Institute of Technology, 12. Kyoto University, 13. Kyushu University, 14. Chiba University, 15. Hiroshima University, 16. Tokyo University of Pharmacy and Life Science

Twenty-three pairs of silica aerogels and aluminum covers consisted of the Tanpopo capture panels were optically investigated and over 200 hypervelocity impacts signatures were identified and documented for further detailed analyses.
Among them, a low Ca-pyroxene micrometeoroid was captured intact inside the 10mg/cc density silica aerogel. In particular, we compared these data from both space and ram pointing faces of the Tanpopo panels exposed on the International Space Station for deducing meteoroid impact flux by taking into account of effects of local shielding and secondary ejecta impacts. This direct measurement showed that the micrometeoroid impact flux in low Earth orbit in 2015-7 are generally consistent with the previous post-retrieval measurements of LDEF, EuReCa, and SFU in 1980’s to 1990’s.

©2019. Japan Geoscience Union. All Right Reserved.

Growth and transport of dust, ice, and organics in the inner part of protoplanetary disks

*Satoshi Okuzumi[1]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Dust grains in protoplanetary disks are the fundamental building blocks of planets. Although recent radio interferometric observations have provided us with detailed images of gas and dust in the outer part of protoplanetary disks, it is still poorly understood how solids evolve in the warmer inner regions of the disks. Understanding the physics of gas and dust evolution in the inner part of disks is thus essential to address the question of how Earth-like planets form.

In this talk, I will discuss two topics on the growth and transport of solids (silicates, ices, and organics) in inner protoplanetary disks. The first topic is related to the water content of planets in the habitable zones. Models of protoplanetary disks suggest that the snow line in the dusty disks migrates with time. In the particular case of the solar nebula, the snow line could have moved to the current orbit of Venus in a late stage of its evolution. This raises the question of why the Earth today is so "dry" with the bulk water content of much less than 1 wt%. I will present simulations of ice pebble accretion by terrestrial planetary embryos, showing that Mars-sized rocky embryos would have grown into Neptune-sized waterworlds unless either the solar nebula was compact or a gas giant's core formed early and blocked the inward flux of the ice pebbles. I will also present the results of our latest MHD simulations of protoplanetary disks that imply that the snow line can migrate much faster than expected from the classical accretion model. These results indicate that Earth-like, modestly "water-poor" planets with both oceans and continents do not necessarily form easily in habitable zones.

The second topic is related to the role of organics in the formation of rocky planetesimals. It is widely accepted that silicate grains are poorly sticky and their growth into planetesimal-sized bodies is severely hindered by collisional fragmentation. Here I propose a scenario in which the seeds of rocky planetesimals form through direct coagulation of silicates coated by an organic mantle, like those found in interplanetary dust particles. Our adhesion model for core-mantle particles show that organic-mantled grains are much stickier than bare silicate grains, in particular in warm environments, thanks to the low elasticity of organic matter. I present simulations of the collisional evolution of organic-mantled grains in the inner part of protoplanetary disks, demonstrating that aggregates of organic-mantled grains are able to overcome the fragmentation barrier and directly form km-sized bodies. These organic-rich planetesimals may further evolve into carbon-poor rocky planetesimals by accreting carbon-poor chondrules.

Keywords: protoplanetary disks, planet formation

©2019. Japan Geoscience Union. All Right Reserved.

Model Prediction of Complex Organic Molecules in Protoplanetary Disks

*Hideko Nomura[1], Catherine Walsh[2], Tom J. Millar[3]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2. School of Physics and Astronomy, University of Leeds, 3. School of Mathematics and Physics, Queen’ s University Belfast

Protoplanetary disks are the natal place of planets. Understanding chemical components of gas, dust and ice in the disks is essential to investigate the origins of materials in our Solar system and other planetary systems. We investigate the synthesis of complex organic molecules (COMs) in protoplanetary disks using a large gas-grain chemical network including COMs together with a 2D steady-state physical model of a disk irradiated by UV and X-rays from the central star. COMs are efficiently formed on cold and warm grains in the disk midplane via hydrogen adding as well as radical-radical reactions on grain surface. Radiation processing on ice forms reactive radicals and helps build further complexity. Part of the icy molecules are photodesorbed into gas and their transition lines become observable. Actually, ALMA observations have detected CH3CN and CH3OH from protoplanetary disks. The line emitting region of these molecules are the outer relatively cold disk, which suggests that the molecules are non-thermally desorbed from grains following the formation on dust garains. Based on our model calculations, we perform ray-tracing calculations to predict line spectra of complex organic molecules observable with SPICA. Also, we discuss possible connection of COMs in protoplanetary disks to those in the Solar system objects, such as comets.

Keywords: protoplanetary disks, astrochemistry, radiative transfer

©2019. Japan Geoscience Union. All Right Reserved.

Abiotic synthesis of organic matters in environments simulating asteroids and the catalytic effect of minerals on amino acid formation

*Walaa Elmasry[1], Yoko Kebukawa[1], Kensei Kobayashi[1]

1. Yokohama National University

Solar system materials, such as comets, meteorites, and interplanetary dust particles are known to contain extraterrestrial molecules, which might have a heritage from interstellar, nebular, and/or parent body processing. Delivery of these molecules including amino acids to the early Earth may have been important for the origin of life as they are the building blocks of proteins and enzymes. It is suggested that chondritic organic matter was produced through condensation of interstellar formaldehyde, which is an abundant component of the interstellar medium (ISM) organic inventory and, presumably, the solar nebula followed by condensation and carbonization probably during hydrothermal alteration on chondritic asteroids (Cody et al 2011). According to Kebukawa et al. (2013, 2015), the presence of ammonia significantly enhances the formation of organic solids similar to chondritic insoluble organic matter (IOM) from formaldehyde via the formose reaction at 150˚C and could produce amino acids. Carbonaceous chondrites contain abundant clay minerals. Clays may act as absorbents and catalysts for the polymerization of organic interstellar precursor molecules in the early solar system (Pearson et.al 2002).

In this research, we are studying amino acid formation from formaldehyde and ammonia at 150˚C and reveal the expected effect of minerals, namely, montmorillonite clay, olivine and serpentine to simulate the processes of amino acid productions in water-bearing planetesimals.

We synthesized organic compounds using a mixture of water, formaldehyde and ammonia (H_2O, H_2 CO, NH_3) in a ratio of 100:7:1 (mol) with adding minerals (6 mg/ 0.6 mL solution) by simulating primordial materials in comets and asteroids. Aqueous solutions were heated at 150˚C for 24 hours. The resulted products were divided into two parts, the first analyzed using a FT/IR and the other part was acid hydrolyzed, desalted, and subjected to amino acid analysis using a HPLC.

FT/IR spectra indicated that the differences in the spectral intensities are due to synthesis of more organic compounds. In HPLC analysis, various amino acids including glycine and alanine were detected. Presence of non-protein amino acids (β-Ala, γ-ABA) is considered as evidence against terrestrial contamination. Our preliminary results showed that the obtained amount of amino acids was elevated with the presence of minerals. These results suggested that the associated minerals act as catalysts to produce amino acid precursors during aqueous activities in the planetesimals.

References:

1. Cody, G. D. et al. PNAS 108, 19171–19176 (2011).

2. Kebukawa, Y., David Kilcoyne, A. L. & Cody, G. D. The Astrophysical Journal 771, 19 (2013).

3. Kebukawa, Y. & Cody, G. D. Icarus 248, 412–423 (2015).

©2019. Japan Geoscience Union. All Right Reserved.

4. Pearson, V. K. Meteoritics & Planetary Science 37, 1829–1833 (2002).

Keywords: Meteorite, Formaldehyde, Olivine, Serpentine

©2019. Japan Geoscience Union. All Right Reserved.

Peptide Formation from amino acid precursors under simulated submarine hydrothermal environments

*Kensei Kobayashi[1], Keisuke Naito[1], Koki Naito[1], Soushi Kuramoto[1], Ei-ichi Imai[2], MITA Hajime[3], Yoko Kebukawa[1]

1. Yokohama National University, 2. Nagaoka University of Technology, 3. Fukuoka Institute of Technology

Submarine hydrothermal systems have been recognized as one of most promising sites for chemical evolution toward the generation of the first life on the Earth [1]. In order to examine possible reactions in such environments, laboratory simulations by utilizing autoclaves and/or flow reactors have been conducted. Imai et al. reported that peptides were formed when glycine was subjected to heat-quench cycles in a flow reactor simulation submarine hydrothermal systems [2]. Amino acids have been detected in carbonaceous chondrites, and also in the products of experiments simulating interstellar environments. It should be noted that amino acid precursors rather than free amino acids were formed under extraterrestrial environments. Such exogenous amino acid precursors could have been delivered to the primitive Earth and processed in submarine hydrothermal systems. We studied possible reactions of amino acid precursors in simulated submarine hydrothermal environments.

Experimental: We chose the following compounds or materials for hydrothermal experiments: (i) Free glycine (Gly); (ii) aminoacetonitrile (AAN), a Strecker-type precursor; (iii) hydantoin (Hyd), a glycine precursor found in carbonaceous chondrites; (iv) CAW; complex organic molecules formed by proton irradiation of a mixture of CO, NH_3 and H_2O [3]. CAW gave various amino acids after acid hydrolysis, where glycine was predominant. The CAW stock solution used in this study yielded *ca.*10 mM glycine after acid hydrolysis.

In order to simulate submarine hydrothermal reactions, we used a flow reactor, composed of a HPLC pump, an infrared gold image furnace, a cold bath and a backpressure regulator [4]. Injected aqueous samples could be heated up to 400˚C in the furnace, and then quenched in the ice bath (0 ˚C). Carrier used was purified water (neutral) or 1 mM HCl (acidic). In the present study, 0.25 mL of each sample was processed in the furnace at room temperature (reference) or 200-400˚C for 2 min, and then quenched. Amino acids in the effluent were determined by cation exchange HPLC (Shimadzu LC-20 amino acid analyzer with a fluorescence detector) before or after acid-hydrolysis. Peptides were determined by ion-pair HPLC (Shimadzu LC-20 HPLC system with a UV detector).

Results and Discussion: Stability of each material at 300˚C was examined by using 4 mM of Gly, AAN or Hyd, or 10-times diluted CAW. Hyd, AAN and CAW gave some glycine in unhydrolized products. Recovery was calculated by glycine amount after hydrolysis against the reference. Hyd and CAW were more stable than Gly and AAN.

Peptide formation experiments were performed by using 40 mM each of Gly, AAN or Hyd, or the CAW stock solution. Diketopiperazine (DKP; a cyclic dimer of Gly) and diglycine (Gly_2) were detected in the unhydrolized samples after Gly or Hyd was heat-processed. Hyd gave much more Gly_2 and DKP than Gly. The Best yield of Gly_2 was 1.3 %, which was observed when Hyd was processed at 200 or 250˚C under neutral conditions. CAW gave so many peaks in ion-pair chromatograms, so that we could not identify peptides there.

©2019. Japan Geoscience Union. All Right Reserved.

In order to examine possible catalytic abilities of CAW, 10-times diluted CAW was added to 40 mM Gly or 40 mM Hyd and then heat-processed. Yields of Gly_2 were increased when CAW was added to Gly or Hyd and heated at 200˚C under acidic conditions.

It was shown that amino acid precursors such as Hyd and CAW was more stable than free amino acids, and that amino acid precursors like Hyd could yield more peptides than free amino acids. It was also found that CAW (complex amino acid precursors) could facilitate peptide formation. It is known that CAW has amide bonds in its structure, which could be a reason why CAW could work as a condensing agent.

In summary, amino acid precursors were more plausible starting materials than free amino acids in prebiotic reactions in primordial terrestrial environments. Kurihara et al. [5] showed that organic aggregates could be formed from water-soluble organics in hydrothermal environments. It is of interest to examine whether CAW could give such aggregates after processed in the flow reactor.

This work was partly supported by JSPS KAKENHI Grant Number JP17H02991.

References

[1] H. Yanagawa and K. Kobayashi, Orig. Life Evol. Biosph., 22, 147-159 (1995).
[2] E. Imai et al., Science, 283, 831-833 (1999).
[3] Y. Takano et al., Appl. Phys. Lett., 84, 1410-1412 (2004).
[4] Md. N. Islam et al., Bull. Chem. Soc. Jpn., 76, 1172-1178 (2003).
[5] Y. Kurihara et al., Chem. Lett., 41, 441-443 (2012).

Keywords: Submarine hydrothermal systems, Chemical Evolution, Amino acid precursors, Peptides, Flash and quench

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 104 1F

[M-GI30] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Takemasa Miyoshi(RIKEN), Chairperson:Takemasa Miyoshi(RIKEN Advanced Institute for Computational Science), Shin'ya Nakano(情報・システム研究機構 統計数理研究所)

Data assimilation is an inversion approach to estimate the evolution of a system by utilizing a constraint given by a dynamical simulation model. Data assimilation is now widely used not only in meteorology and oceanography but also other fields of geosciences such as hydrology, solid earth science, and space science. This session aims at providing an opportunity for discussion on data assimilation studies among researchers of various field of geosciences. We encourage contributions addressing novel methods and theoretical developments of data assimilation. Contributions dealing with useful applications of data assimilation are also welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI30-01] Recent progresses and applications of geomagnetic data assimilation

★Invited Papers

*Julien Aubert[1], Vincent Lesur[1], Alexandre Fournier[1], Gauthier Hulot[1] (1.Institut de Physique du Globe de Paris, France)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI30-02] Accounting for non-locality of vertical error correlation within ETKF through eigen-spectral localization

★Invited Papers

*Daisuke Hotta[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI30-03] Data assimilation experiments with MODIS LAI observations and the dynamic global vegetation model SEIB-DGVM over Siberia

★Invited Papers

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Yohei Sawada[1,2], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science, 2.Meteorological Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI30-04] Inversion of the ocean vertical diffusivity from steady-state tracer distributions by using an adjoint method

★Invited Papers

*Akira Oka[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI30-05] Nonlinear data assimilation with 4DEnVar using iterative weather forecast model

*Sho Yokota[1], Ko Koizumi[1], Masaru Kunii[2,1], Kosuke Ito[3,1] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Numerical Prediction Division, Forecast Department, Japan Meteorological Agency, 3.University of the Ryukyus)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MGI30-06] Development of Data Assimilation System for Atmospheric Density to Improve Satellite's Orbit Prediction Accuracy

*Hiroshi Kato[1], Hideaki Hinagawa[1], Kyohei Akiyama[1], Yuki Akiyama[1], Masaya Nakano[2], Daichi Obinata[2], Shinichi Nakamura[1] (1.Japan Aerospace Exploration Agency, 2.FUJITSU LIMITED)

Recent progresses and applications of geomagnetic data assimilation

*Julien Aubert[1], Vincent Lesur[1], Alexandre Fournier[1], Gauthier Hulot[1]

1. Institut de Physique du Globe de Paris, France

Over the past ten years, numerical simulations of Earth’ s core magnetohydrodynamics have advanced to a point where their output can be compared in detail to the geomagnetic field behaviour over time scales ranging from a few years to centuries. Motivated by this progress, geomagnetic data assimilation is an emerging discipline that aims at optimally combining the statistical output of such simulations with geomagnetic data. Among the many possible outcomes of this approach, the main goals are to infer the hidden dynamical properties of Earth’ s core from the surface observations, forecast the future evolution of the geomagnetic field in a dynamically consistent way and at horizons of a few years to a century, and improve the quality of source separation in analyses of the geomagnetic field. We will present a few examples to emphasize the value added by statistics extracted from Earth-like geodynamo simulations when attempting to tackle these underdetermined geophysical inverse problems. We will also put these works in context of forthcoming contributions to the 13th iteration of the International Reference Geomagnetic Field (IGRF 2020).

Keywords: Geomagnetism, Numerical Simulations, Earth's core, data assimilation

©2019. Japan Geoscience Union. All Right Reserved.

Accounting for non-locality of vertical error correlation within ETKF through eigen-spectral localization

*Daisuke Hotta[1]

1. Meteorological Research Institute, Japan Meteorological Agency

Covariance localization is an indispensable component of any EnKF and it is most straightforwardly formulated as tapering of the sampled background error covariance matrix by means of Schur product (B-loc). However, within most (L)ETKF implementations, this operation is substituted by artificial inflation of R-matrix for observations distant from the analyzed grid-point (R-loc) due to the computational the difficulty of B-loc approach. Recently studies (Bocquet et al. 2016; Bishop et al. 2017) have derived an efficient way to implement B-loc within an ETKF, so that B-loc within ETKF is now a feasible option.

The author's recent work has focused on clarifying the differences between B-loc and R-loc, and showed with idealized 1D models that B-loc can increase the effective rank of the background covariance while R-loc cannot and that B-loc can more faithfully reproduce canonical KF analysis than R-loc does when the observation operator is non-local, suggesting that B-loc is particularly advantageous in cases where the desired amount of assimilated observations are much larger than the affordable ensemble size and/or the observation operator is highly non-local.

This work extends the B-loc approach to accommodate situations where the true background error covariance is not well localized (i.e., the correlation between two grid-points is not given in terms of the physical distance between them). In the proposed scheme, the state vector of each background ensemble is first linearly transformed into the space spanned by the (truncated) eigenbasis of the climatological background error covariance prior to performing data assimilation. The transformed ensemble is then used to form sample covariance to which we apply localization (i.e., control on sampling noises) by neglecting all the off-diagonal components. This method reposes on two assumptions: (1) the true covariance, when expressed in its eigen-space, is diagonal, so that, in this space, any off-diagonal component present in the sample covariance from ensemble is a sign of sampling error, and (2) the eigenstructure of the true covariance is close to its climatological expectation.

In this presentation, I will show several preliminary verifications of this approach using an idealized 1-dimensional system and discuss its promise and limitations.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: data assimilation, covariance localization, EnKF

©2019. Japan Geoscience Union. All Right Reserved.

Data assimilation experiments with MODIS LAI observations and the dynamic global vegetation model SEIB-DGVM over Siberia

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Yohei Sawada[1,2], Takemasa Miyoshi[1]

1. RIKEN Center for Computational Science, 2. Meteorological Research Institute

In the previous study, Arakida et al. (2017) developed a data assimilation system with the SEIB-DGVM (Spatially Explicit Individual-Based Dynamic Global Vegetation Model, Sato et al. 2007) and assimilated satellite-observed Leaf Area Index (LAI) successfully at a flux measurement site in Siberia. In this study, we extend the experiment to a large domain in Siberia and estimate the vegetation functions and structures, and model parameters related to the phenology of the deciduous needle-leaved tree and the undergrowth. At the annual meeting in 2017, we presented the results of total LAI, tree LAI, above ground biomass, carbon flux, and the model parameters. This year, we present further comparisons with the previous studies: carbon flux (FLUXCOM: Tramontana et al., 2016, Jung et al., 2017) estimated by a machine learning method using in-situ flux measurements and various explanatory data, tree LAI (Delbart et al., 2005, Kobayashi et al., 2010) estimated by a radiative transfer model and satellite observations, and above ground biomass (Liu et al., 2015) estimated by satellite observations. The results showed high correlations between this study and the previous studies except for above ground biomass. This is probably because above ground biomass of Liu et al. [2015] is estimated from microwave-based observations, different from optical-based observations in this study, Kobayashi et al. [2010], and FLUXCOM. The results suggest that the type of the satellite sensor affect the estimation results. Most of the estimated variables by DA were highly correlated with the observed LAI and the previous studies, indicating that the DA system generally performed well over Siberia.

Arakida, H., T. Miyoshi, T. Ise, S. I. Shima, and S. Kotsuki (2017), Non-Gaussian data assimilation of satellite-based leaf area index observations with an individual-based dynamic global vegetation model, Nonlinear Proc. Geoph., 24, 553-567, doi:10.5194/npg-24-553-2017.

Delbart, N., L. Kergoat, T. L. Toan, J. Lhermitte, and G. Picard (2005), Determination of phenological dates in boreal regions using normalized difference water index, Remote Sens. Environ., 97, 26-38, doi:10.1016/j.rse.2005.03.011.

Jung, M., M. Reichstein, C. R. Schwalm, C. Huntingford, S. Sitch, A. Ahlström, A. Arneth, G. Camps-Valls, P. Ciais, P. Friedlingstein, F. Gans, K. Ichii, A. K. Jain, E. Kato, D. Papale, B. Poulter, B. Raduly, C. Rödenbeck, G. Tramontana, N. Viovy, Y. P. Wang, U. Weber, S. Zaehle and N. Zeng (2017), Compensatory water effects link yearly global land CO_2 sink changes to temperature, Nature, 541, 516-520, doi:10.1038/nature20780.

Kobayashi, H., N. Delbart, R. Suzuki, and K. Kushida (2010), A satellite-based method for monitoring seasonality in the overstory leaf area index of Siberian larch forest, J. Geophys. Res., 115, G01002, doi: 10.1029/2009JG000939.

Liu, Y. Y., A. I. J. M. van Dijk, R. A. M. de Jeu, J. G. Canadell, M. F. McCabe, J. P. Evans, and G. Wang (2015), Recent reversal in loss of global terrestrial biomass. Nat. Clim. Change, 5, 470-474, doi:10.1038/nclimate2581.

©2019. Japan Geoscience Union. All Right Reserved.

Sato, H., A. Itoh, and T. Kohyama (2007), SEIB–DGVM: A new Dynamic Global Vegetation Model using a spatially explicit individual-based approach, Ecol. Model., 200, 279–307, doi: 10.1016/j.ecolmodel.2006.09.006.

Tramontana, G., M. Jung, C. R. Schwalm, K. Ichii, G. Camps-Valls, B. Ráduly, M. Reichstein, M. A. Arain, A. Cescatti, G. Kiely, L. Merbold, P. Serrano-Ortiz, S. Sickert, S. Wolf, and D. Papale (2016), Predicting carbon dioxide and energy fluxes across global FLUXNET sites with regression algorithms, Biogeosciences, 13, 4291-4313, doi:10.5194/bg-13-4291-2016.

Keywords: data assimilation, vegetation model, satellite data

©2019. Japan Geoscience Union. All Right Reserved.

Inversion of the ocean vertical diffusivity from steady-state tracer distributions by using an adjoint method

*Akira Oka[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

The ocean vertical diffusivity is important for controlling the distribution of various ocean tracer including the temperature and salinity. Recent studies clarified that its spatial distribution is very inhomogeneous but the global coverage of its direct measurements from turbulent mixing observations are not enough and its quantification is still difficult. On the other hand, recent observational data about the ocean tracer including temperature and salinity are increasing significantly and dataset covering the global ocean is available. The inversion of ocean velocity distribution from ocean tracer has been reported in the previous studies (e.g. Wunsch, 1996). In the same way as this velocity inversion, some studies tried the inversion of the ocean vertical diffusivity (e.g. Ganachaud and Wunsch, 2000) but there are few studies which discuss its detail 3-dimmensional distribution. In this presentation, I would like to report some attempts about the inversion of the ocean vertical diffusivity from the ocean tracer distribution; we focus on the temperature, salinity, and carbon isotope (C14) and discuss how their steady-state distribution is useful for obtaining the 3-dimmensional distribution of the ocean vertical diffusivity.

Keywords: ocean vertical diffusivity, adjoint method, ocean tracer model

©2019. Japan Geoscience Union. All Right Reserved.

Nonlinear data assimilation with 4DEnVar using iterative weather forecast model

*Sho Yokota[1], Ko Koizumi[1], Masaru Kunii[2,1], Kosuke Ito[3,1]

1. Meteorological Research Institute, Japan Meteorological Agency, 2. Numerical Prediction Division, Forecast Department, Japan Meteorological Agency, 3. University of the Ryukyus

En4DVar and 4DEnVar are two popular ensemble-based variational data assimilation methods for the numerical weather prediction. Although the ensemble-based forecast error covariance can be reflected in the analyses of both methods, En4DVar calculates the gradient of the cost function with the adjoint of tangent linear forecast model, which requires large development and computational costs. Such costs are generally not required in 4DEnVar because 4DEnVar does not use the tangent linear forecast model. However, 4DEnVar analyses are generally worse than those of adjoint-based En4DVar probably because 4DEnVar does not iteratively calculate the nonlinear forecast model. In this study, therefore, we developed 4DEnVar with iterative nonlinear forecast model (hereafter, 4DEnVar-IF). In 4DEnVar-IF, the nonlinear forecast model is iteratively calculated to gain the non-quadratic cost function and its gradient in each iteration. The 4DEnVar-IF applied to the Lorenz63 model showed that the 4DEnVar-IF analysis can be better than those of En4DVar and general 4DEnVar when nonlinearity is strong and ensemble perturbations are appropriate. Moreover, we also applied 4DEnVar-IF to JMA nonhydrostatic model-based 4DVar data assimilation (JNoVA) system. The single-observation assimilation experiments with JNoVA showed that 4DEnVar-IF can make the cost function smaller than En4DVar when the assimilated observation has the strong nonlinearity as like potential temperature associated with cloud microphysics. In the assimilation experiment of multiple real observations with 4DEnVar-IF of the small localization scale, however, the minimization of the cost function was not sufficiently succeeded. As a next step, we will develop the localization and hybrid of forecast error covariance matrix.

Keywords: data assimilation, ensemble forecast, nonlinear, 4DEnVar

©2019. Japan Geoscience Union. All Right Reserved.

Development of Data Assimilation System for Atmospheric Density to Improve Satellite's Orbit Prediction Accuracy

*Hiroshi Kato[1], Hideaki Hinagawa[1], Kyohei Akiyama[1], Yuki Akiyama[1], Masaya Nakano[2], Daichi Obinata[2], Shinichi Nakamura[1]

1. Japan Aerospace Exploration Agency, 2. FUJITSU LIMITED

Satellite's orbit prediction with high accuracy requires atmospheric drag prediction with high accuracy, because there is a slight atmosphere in a low-orbital environment. The atmospheric drag can be calculated from the atmospheric density, the ballistic coefficient (mass, cross-sectional area, drag coefficient) of each satellite, but the uncertainty of the atmospheric density is considered to occupy most of the uncertainty of atmospheric drag prediction.
Several atmospheric density models have been proposed so far. Although observation information in low orbit environments is very limited, the models are based on slight satellite observation information. However, it is difficult to predict the atmospheric density with high accuracy, and the satellite operator improves the accuracy of orbit prediction by estimating correction amount based on the orbit determination value.
Since 2018, JAXA has started to develop the atmospheric density reanalysis system (data assimilation system). This system realizes the reanalysis of the atmospheric density from the atmospheric density observation, which is averaged atmospheric density on the satellite locus, and atmospheric density models. The averaged atmospheric density on the satellite locus can be estimated based on orbit information of TLE (two-line element) of each satellite provided by NORAD in the United States. The atmospheric density model uses the NRLMSIS-00 model and the Jacchia-Bowman 2008 model usually used in the orbit field. As data assimilation methods, the ensemble Kalman filter and the ensemble transformed Kalman filter are implemented.
In this presentation, we introduce the details of the atmospheric density reanalysis system and show the results of the twin experiment (numerical experiment) being advanced as system verification.

Keywords: Satellite orbit prediction, Atmospheric density, Data assimilation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 104 1F

[M-GI30] Data assimilation: A fundamental approach in geosciences

convener:Shin ya Nakano(The Institute of Statistical Mathematics), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), SHINICHI MIYAZAKI(Graduate School of Science, Kyoto University), Takemasa Miyoshi(RIKEN), Chairperson:Shinichi Miyazaki(Kyoto University), Yosuke Fujii

Data assimilation is an inversion approach to estimate the evolution of a system by utilizing a constraint given by a dynamical simulation model. Data assimilation is now widely used not only in meteorology and oceanography but also other fields of geosciences such as hydrology, solid earth science, and space science. This session aims at providing an opportunity for discussion on data assimilation studies among researchers of various field of geosciences. We encourage contributions addressing novel methods and theoretical developments of data assimilation. Contributions dealing with useful applications of data assimilation are also welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI30-07] An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS

★Invited Papers

*Shun Ohishi[1], Tsutomu Hihara[2], Hidenori AIKI[1], Joji Ishizaka[1], Yasumasa Miyazawa[2], Misako Kachi[3] (1.Nagoya University, 2.JAMSTEC, 3.JAXA)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI30-08] Validation of JCOPE-T DA ocean assimilation product

*Tsutomu Hihara[1], Sergey Varlamov[1], Yasumasa Miyazawa[1], Toru Miyama[1], Misako Kachi[2], Hiroshi Murakami[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Aerospace Exploration Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI30-09] Do surface lateral flows matter for land data assimilation?: Implication for hyper-resolution land modeling and observation

*Yohei Sawada[1] (1.Meteorological Research Institute)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI30-10] Geodynamo data assimilation for candidate models of IGRF13-SV from Japan team

*Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hisayoshi Shimizu[1], Hiroaki TOH[5] (1.Ocean Hemisphere Research Institute, Earthquake Research Institute,The University of Tokyo, 2.The Institute of Statistical Mathematics, 3.Faculty of Science, Kyushu University, 4.School of Science, Tokyo Institute of Technology, 5.Graduate School of Science, Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI30-11] A pilot study of geomagnetic data assimilation into a geodynamo model

*Shin ya Nakano[1], Takuto Minami[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5], Hisayoshi Shimizu[2] (1.The Institute of Statistical Mathematics, 2.Earthquake Research Institute, the University of Tokyo, 3.Faculty of Science, Kyushu University, 4.School of Science, Tokyo Institute of Technology, 5.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI30-12] Bayesian parameter estimation of a physics-based model of postseismic crustal deformation

★Invited Papers

*Jun'ichi Fukuda[1], Kaj Johnson[2] (1.Earthquake Research Institute, University of Tokyo, 2.Department of Earth and Atmospheric Sciences, Indiana University)

An LETKF-based ocean reanalysis for the Asia-Oceania region using Himawari-8 SSTs and SMOS/SMAP SSS

*Shun Ohishi[1], Tsutomu Hihara[2], Hidenori AIKI[1], Joji Ishizaka[1], Yasumasa Miyazawa[2], Misako Kachi[3]

1. Nagoya University, 2. JAMSTEC, 3. JAXA

With the global spread of the Argo floats and development of high-resolution ocean models, global ocean reanalysis datasets have been released. Although regional high-resolution ocean reanalysis datasets also have been established around the North Pacific, most of their coverage area is limited to regions north of 10˚N. We suggest that reanalysis datasets for tropical-subtropical oceans are yet to be constructed for coastal environmental monitoring and typhoon researches around the Asia-Oceania region.
Since July 2015, a geostationary satellite “Himawari-8” has been measuring sea surface temperatures (SSTs) with a high spatial and temporal resolution of 2 km and 10 min. in the western Pacific region using an infrared sensor. Because of the high temporal resolution, daily composite map shows that coverage area of Himawari-8 exceeds that of an orbital satellite “GCOM-W” with a microwave sensor. The infrared sensor enables us to capture fine nearshore SST structure, such as localized cool SSTs induced by Ekman upwelling along the Vietnam coast during the southwesterly summer monsoon.
We have established a one-way nest high-resolution ocean data assimilation system based on LETKF (Hunt et al. 2007) with 20 ensemble members at 1-day interval. The southeast Asia coastal region [98˚–115˚E, 0˚–22˚N] has been modeled at a spatial resolution of 1/36˚ and 47 layers with an intent to be applied for fishery and marine environmental monitoring, while the large-scale western Pacific region [95˚E–165˚W, 50˚S–50˚N] has been constructed at a spatial resolution of 1/12˚ and 47 layers to make contributions to tropical cyclone studies. Himawari-8 SSTs and sea surface salinity (SSS) derived from SMOS and SMAP satellites as well as sea surface height, and temperature/salinity derived from GTSPP and AQC Argo dataset have been assimilated. To improve the salinity field, freshwater fluxes also have been incorporated. To avoid generation of spurious gravity waves, the Incremental analysis Update (IAU) filter (Bloom et al. 1996) have been implemented. We will introduce low salinity water transport from the Mekong river in the southeast Asia system and the SST cooling with the passage of tropical cyclones in the western Pacific system.

Keywords: southeast Asia, western Pacific, data assimilation, LETKF, Himawari-8, SMOS/SMAP

©2019. Japan Geoscience Union. All Right Reserved.

Validation of JCOPE-T DA ocean assimilation product

*Tsutomu Hihara[1], Sergey Varlamov[1], Yasumasa Miyazawa[1], Toru Miyama[1], Misako Kachi[2], Hiroshi Murakami[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Aerospace Exploration Agency

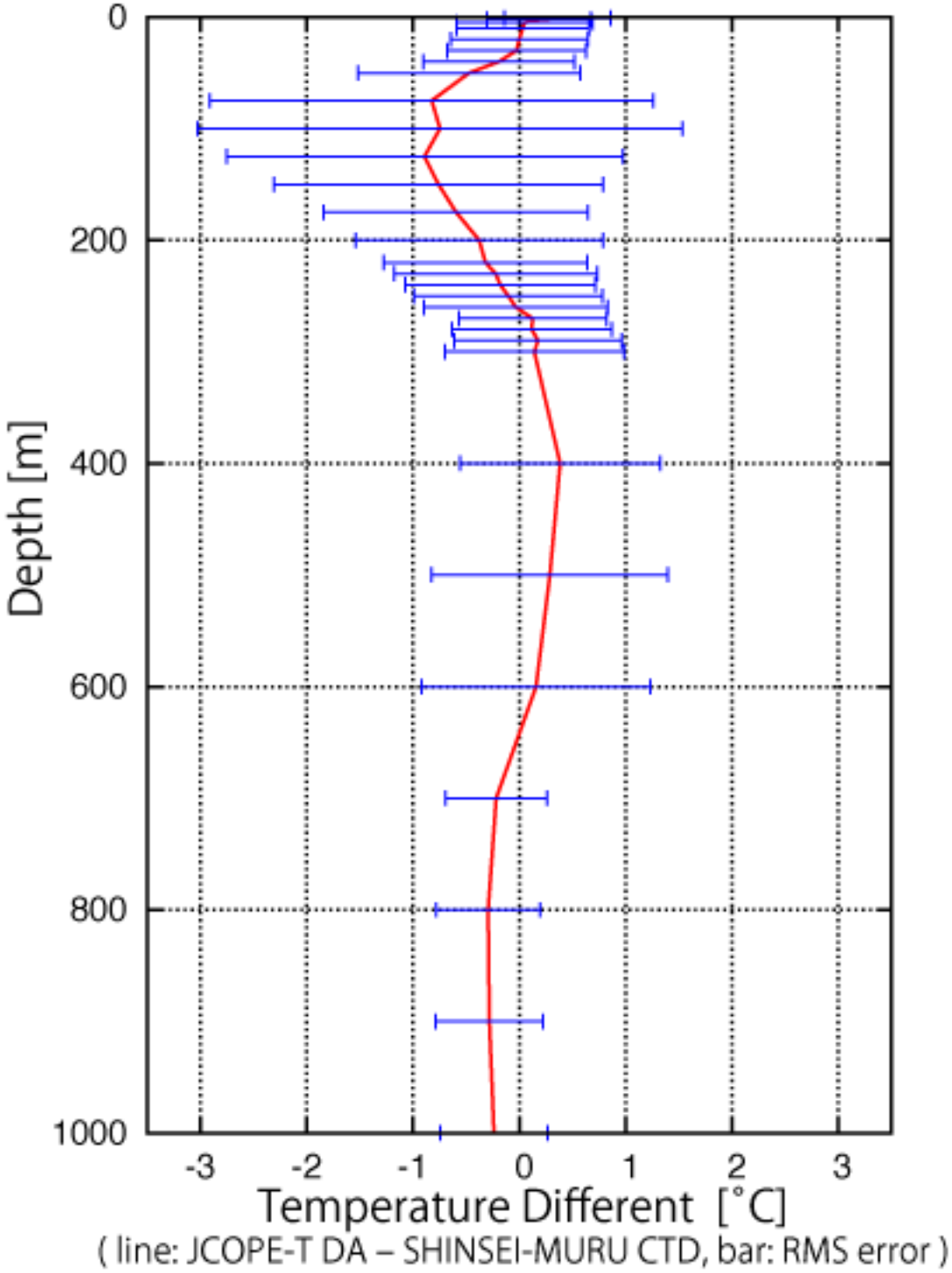
We constructed the high resolution (3km, 1hour) ocean data assimilation system named as JCOPE-T DA which targets around Japan. This system is running operationally and that’ s outputs have been provided by JAXA through the Himawari Monitor website and P-Tree System since November 2018. One of the aims in this system is to make the useful ocean analysis and forecast data by assimilating satellite SST data provided by JAXA directly. We assimilate the satellite SST data observed by Himawari/AHI, GCOM-W/AMSR2, GPM main satellite/GMI, and Coriolis/WindSAT. Multi-3DVAR (Miyazawa et al. 2017) and IAU are applied in this system.

We will show the results of validation of JCOPE-T DA using independent in situ data observed by buoys and ship in this presentation. The results of comparison with CTD data observed by SHINSEI-MARU off the Kii Channel show that JCOPE-T DA ocean temperature data are good estimate in upper layer (Figure 1). Biases and RMS error are lower than ±0.2 deg.C and 0.7 deg.C in 2 –40m depth respectively. On the other hand, there are negative bias and large RMS difference (over 1 deg.C) in thermocline (5 –200 m depth). These mean that mixed layer of JCOPE-T DA is deeper than that of observation.
JCOPE-T DA clearly show the internal tide because the ocean model of JCOPE-T DA considers the tide effects. Especially, we find that the channel between Taiwan and Philippines causes strong internal tide which is made change of several degree Celsius at 500m depth in a day.

In the future plan, we are going to construct the higher resolution (1km grid) ocean model with CaMa-Flood river flow data. And also, we are going to assimilate the GCOM-C/SGLI SST data which have 250m resolution. Furthermore, we will construct a nest model for coastal area.

Keywords: Data assimilation, Satellite SST data, Regional ocean model

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Do surface lateral flows matter for land data assimilation?: Implication for hyper-resolution land modeling and observation

*Yohei Sawada[1]

1. Meteorological Research Institute

Hyper-resolution land modeling is expected to innovate the simulation of terrestrial water, energy, and carbon cycles. One of the major advantages of existing hyper-resolution land models against conventional 1-demensional land surface models is that surface and subsurface lateral water flows can be explicitly simulated. Despite a lot of efforts on assimilating hydrological observations into the hyper-resolution integrated surface-groundwater land models, how and in what case topography-driven surface water flows matter for data assimilation of soil moisture observations has yet to be clarified. In this study, I perform a minimalist synthetic numerical experiment, in which shallow soil moisture observations are assimilated into an integrated surface-groundwater land model by an ensemble Kalman filter. Propagation of a background error due to surface lateral water flows is crucially important to adjust the unobserved model state and parameter variables by horizontally propagating the information of soil moisture observations. However, the non-Gaussianity of the background error induced by the nonlinear dynamics of topography-driven surface flows harms the performance of an ensemble Kalman filter and the efficiency of data assimilation strongly depends on soil characteristics. The new capability of data assimilation with the hyper-resolution land models found in this study may improve the monitoring and prediction of flash floods caused by local severe rainfalls.

Sawada, Y. (2018), Do surface lateral flows matter for data assimilation of soil moisture observations into hyperresolution land models?, *EarthArXiv,* https://doi.org/10.31223/osf.io/byguf

Keywords: land data assimilation

©2019. Japan Geoscience Union. All Right Reserved.

Geodynamo data assimilation for candidate models of IGRF13-SV from Japan team

*Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hisayoshi Shimizu[1], Hiroaki TOH[5]

1. Ocean Hemisphere Research Institute, Earthquake Research Institute,The University of Tokyo, 2. The Institute of Statistical Mathematics, 3. Faculty of Science, Kyushu University, 4. School of Science, Tokyo Institute of Technology, 5. Graduate School of Science, Kyoto University

International Geomagnetic Reference Field (IGRF) is a series of standard global geomagnetic field models that consist of Gauss coefficients to represent spatial distribution. International Association of Geomagnetism and Aeronomy (IAGA) produces IGRF every five years, the last version of which, the 12th generation of IGRF (IGRF-12), was released in December 2014 (Thebault et al., 2015). Each generation of IGRF comprises not only the main field part but secular variation (SV) part (first time derivative of the main field) to forecast evolution of the geomagnetic field for the next five years to come. The next generation, IGRF-13, will be published around December 2019, comprising the spatial distribution of the field at epoch 2020.0 and its secular variation in the period from 2020.0 to 2025.0. We plan to submit a candidate SV model to contribute for determining IGRF13-SV.
We employ data assimilation with geodynamo calculations to generate a SV candidate model for the period from 2020.0 to 2025.0. Although the two standard approaches, (1) adoption of SV at the IGRF release time and (2) spline extrapolation of the main field in the future, are common for generating SV candidates, they are not “physics-based” forecasts, and, intrinsically, cannot alleviate the effect of sudden changes in the SV field called “geomagnetic jerks” (Mandea et al., 2010). In this context, data assimilation is one of novel approach to obtain an appropriate initial condition for geodynamo calculations at the time of IGRF release time. Since the parameters used in geodynamo calculations are apart by some orders of magnitude from those for the Earth's core, it is not appropriate to take geodynamo solutions as they are for the predictions. Nevertheless, it is possible to rescale the time-axis of geodynamo calculations using the ratio of the so-called “secular-variation time-scale” (Chlistensen and Tilgner, 2004) between the geomagnetic field and geodynamo calculations. In this presentation, we are going to show candidate models of secular variation obtained by geodynamo data assimilation with discussions on the time-scales, the method of assimilation, and data-set employed for the assimilation.

Keywords: IGRF, Data assimilation, dynamo

©2019. Japan Geoscience Union. All Right Reserved.

A pilot study of geomagnetic data assimilation into a geodynamo model

*Shin ya Nakano[1], Takuto Minami[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5], Hisayoshi Shimizu[2]

1. The Institute of Statistical Mathematics, 2. Earthquake Research Institute, the University of Tokyo, 3. Faculty of Science, Kyushu University, 4. School of Science, Tokyo Institute of Technology, 5. Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University

Geomagnetic secular variation is a long-term variation of the Earth's magnetic field. The magnetic field of the Earth is originated from a dynamo in the outer core. Modeling of geodynamo process is thus a straightforward approach for predicting geomagnetic secular variations. However, it is intrinsically difficult to resolve the current state of the geodynamo from observable magnetic field and to predict future evolution of geodynamo. We are developing a framework for estimating the current state of the geodynamo by using a data assimilation approach. As a preliminary study, we performed data assimilation experiments using synthetic geomagnetic data in order to evaluate if data assimilation methods are effective for estimating the state of the geodynamo. Some data assimilation schemes based on ensemble-based variational method were applied and compared. Preliminary results of the experiments will be demonstrated.

Keywords: ensemble-based data assimilation, geodynamo model, secular variation

©2019. Japan Geoscience Union. All Right Reserved.

Bayesian parameter estimation of a physics-based model of postseismic crustal deformation

*Jun'ichi Fukuda[1], Kaj Johnson[2]

1. Earthquake Research Institute, University of Tokyo, 2. Department of Earth and Atmospheric Sciences, Indiana University

Recent development GPS and other geodetic networks makes it possible to capture transient crustal deformation at high resolution in both space and time. A primary example of geodetically observed transient deformation in plate boundary zones is postseismic deformation following large earthquakes. Two primary processes that are responsible for observed postseismic deformation are viscoelastic relaxation of in the asthenosphere and afterslip on the plate interface surrounding the coseismic rupture. Both of the processes are triggered by stress changes induced by an earthquake and the evolution of the two processes is governed by rheological properties of the asthenosphere and frictional properties of the plate interface as well as coseismic stress perturbations.

In this study, we develop a physics-based model of postseismic deformation following the 2011 Mw9.0 Tohoku-oki earthquake that incorporates stress-driven afterslip and viscoelastic relaxation. In this model, the evolution of afterslip is assumed to be governed by a velocity-strengthening friction law that is characterized with a friction parameter. Viscoelastic relaxation of the asthenosphere is modeled with a biviscous Burgers rheology that is characterized with steady-state and transient viscosities. The evolution of afterslip and viscoelastic relaxation is calculated using coseismic slip distribution as an initial condition. We treat the friction parameters, viscosity parameters, coseismic slip distribution, and a smoothing parameter for coseismic slip distribution as unknown parameters and estimate them using coseismic and postseismic GPS and seafloor geodetic data.

In order to quantify uncertainties of the model, we adopt a Bayesian approach and estimate the posterior probability density function (PDF) of the model parameters. In principle, the Markov chain Monte Carlo (MCMC) methods can be used for this purpose. However, the MCMC methods require many forward calculations and the forward model employed in this study is computationally intensive. Therefore, it is difficult to sample the posterior PDF within a realistic computation time. We thus combine a surrogate modeling approach with the MCMC methods to efficiently sample the posterior PDF. In this approach, we first obtain a function approximation to the posterior PDF by fitting a surrogate function to the posterior probability densities calculated for sample points in the model parameter space. Then a MCMC method is used to sample the surrogate posterior PDF. By using this approach, we obtain the posterior PDFs of the model parameters that successfully reproduce the observed coseismic and time-dependent postseismic displacement fields. Our results suggest that such approaches may be useful for parameter estimation and uncertainty quantification of computationally intensive forward models.

Keywords: Bayesian inference, parameter estimation, GPS, postseismic crustal deformation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Huixin Liu(Kyushu University, Japan), Stan Solomon(National Center for Atmospheric Research, US)

Vertical coupling mechanisms throughout the whole atmosphere are critical to understanding the near Earth space environment, as well as its sensitivity to the solar, geomagnetic, and atmospheric drivers. This international session focuses on physical/chemical processes occurring in the mesosphere, thermosphere, and ionosphere (MTI). Both quiet and disturbed states in response to lower atmospheric forcing or solar forcing are important for understanding the MTI system and its coupling to other regions. We invite presentations of observations and observational concepts with ground-based and/or space-borne instruments, theoretical studies, numerical simulations, and development of data analysis systems for various kinds of temporal and spatial variations in atmosphere-ionosphere coupled system.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[PEM09-11] Assimilation products of thermospheric and ionospheric measurements by the NASA Ionopsheric Connection Explorer

★Invited Papers

*Thomas J Immel[1], Chihoko Cullens[1], Yen-Jung Wu[1], Gary Bust[2], Jeffrey Forbes[3], Scott L England[4] (1.University of California, Berkeley, 2.Johns Hopkins University, 3.University of Colorado, 4.Virginia Tech)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[PEM09-12] petitSat - A 6U CubeSat to examine the link between MSTIDS and ionospheric plasma density enhancements

*Jeffrey Klenzing[1], Ryan L Davidson[2], Gregory D Earle[3], Alexa J Halford[4], Sarah L Jones[1], Carlos Martinis[5], Nikolaos Paschalidis[1], Robert F Pfaff[1], Jonathon M Smith[1,6] (1.NASA Goddard Space Flight Center, Greenbelt, MD, USA, 2.Utah State University, Logan, UT, USA, 3.Virginia Tech, Blacksburg, VA, USA, 4.The Aerospace Corporation, Chantilly, VA, USA, 5.Boston University, Boston, MA, USA, 6.Catholic Universtiy of America, Washington, DC, USA)

9:35 AM - 9:55 AM JST | 12:35 AM - 12:55 AM UTC

[PEM09-13] A three-dimensional ionospheric electrodynamics model

★Invited Papers

*Astrid I Maute[1], Arthur D Richmond[1] (1.High Altitude Observatory, National Center for Atmospheric Research, Boulder CO, USA.)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[PEM09-14] **Spatial Fluctuation of TEC Index: A new index of ionospheric irregularities**

*Guanyi Ma[1], Takashi Maruyama[2] (1.National Astronomical Observatories, Chinese Academy of Sciences, 2.National Institute of Information and Communications Technology)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[PEM09-15] Coupling of lower thermosphere planetary wave energy into the ionosphere

*Patrick J Espy[1,2], Nora Stray[1,2,3], Robert Hibbins[1,2] (1.Norwegian University of Science and Technology, Trondheim, Norway, 2.Birkeland Centre for Space Science, Bergen, Norway, 3.Teknova AS, Tordenskjolds Gate 9, 4612 Kristiansand, Norway)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

Discussion

Assimilation products of thermospheric and ionospheric measurements by the NASA Ionopsheric Connection Explorer

*Thomas J Immel[1], Chihoko Cullens[1], Yen-Jung Wu[1], Gary Bust[2], Jeffrey Forbes[3], Scott L England[4]

1. University of California, Berkeley, 2. Johns Hopkins University, 3. University of Colorado, 4. Virginia Tech

ICON is an orbiting NASA observatory built to simultaneously observe the characteristics of the ionosphere and thermosphere in order to understand the connection between conditions in space and energy sources in the atmosphere below. Ready for launch in 2019 into a 27 degree inclination, 575 km altitude orbit, it will provide neutral wind, density and temperature products as well as in-situ and remotely-sensed ionospheric densities. These products will inform the conditions of two models that assimilate the data in different ways, and be available on the ICON website. The first is the TIEGCM, where assimilation is accomplished through modification of the winds and temperatures at the lower boundary as prescribed by observations . The second is the IDA4D model, that through a Gauss-Markhov scheme modifies a background ionosphere with actual observations that include many different sources including ICON. Given the expected sampling and data uncertainties from ICON, the expected performance of these models is reported. ICON expects a launch in 2019.

Keywords: ionosphere , thermosphere, atmospheric tides

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

petitSat - A 6U CubeSat to examine the link between MSTIDS and ionospheric plasma density enhancements

*Jeffrey Klenzing[1], Ryan L Davidson[2], Gregory D Earle[3], Alexa J Halford[4], Sarah L Jones[1], Carlos Martinis[5], Nikolaos Paschalidis[1], Robert F Pfaff[1], Jonathon M Smith[1,6]

1. NASA Goddard Space Flight Center, Greenbelt, MD, USA, 2. Utah State University, Logan, UT, USA, 3. Virginia Tech, Blacksburg, VA, USA, 4. The Aerospace Corporation, Chantilly, VA, USA, 5. Boston University, Boston, MA, USA, 6. Catholic Universtiy of America, Washington, DC, USA

The mid- and low-latitude ionosphere is home to a variety of plasma density irregularities, including depletions (bubbles), enhancements (blobs), and small-scale scintillation, which result in the distortion of radio wave propagation. Recent observations from the C/NOFS satellite suggest that multiple mechanisms are responsible for forming plasma density enhancements, with wave action in the thermosphere as a significant driver of the enhanced densities. Indeed, statistical analysis of enhancements observed from satellites resembles the statistics of Medium-Scale Traveling Ionosphere Disturbances (MSTIDs) with respect to seasonal variability and solar activity. In order to investigate the link between these two phenomena, both in-situ data of the plasma enhancement and remote data of the MSTID at the magnetic footpoint are required. petitSat is a CubeSat mission designed to provide in situ measurements of the plasma density, 3D ion drift, as well as ion and neutral composition. The instrument suite includes a combined retarding potential analyzer and cross-track drift meter and an ion neutral mass spectrometer. This instrument suite will provide comprehensive information about the fluctuations in plasma, as well as changes in the neutral profile. petitSat will launch into a 51 deg inclination orbit at 400 km (consistent with an International Space Station deployment), allowing for numerous conjunctions with the Boston University All-Sky Imager network and GPS receivers from the International Global Navigation Satellite Systems (GNSS) Service (IGS) network over the mission lifetime.

Keywords: Ionosphere, CubeSat, MSTIDs

©2019. Japan Geoscience Union. All Right Reserved.

A three-dimensional ionospheric electrodynamics model

*Astrid I Maute[1], Arthur D Richmond[1]

1. High Altitude Observatory, National Center for Atmospheric Research, Boulder CO, USA.

Ionospheric electric fields and currents are driven by collisional interaction between thermospheric winds and ions, by magnetospherically driven convection and field-aligned currents at high latitudes, by gravitational and pressure-gradient forces on the ionospheric plasma, and by weak currents from the lower atmosphere. The electrodynamics of the ionospheric E and F regions are strongly coupled. For time scales longer than a few minutes the electric field is electrostatic. The electric potential is nearly constant along geomagnetic-field lines, and can be represented in two dimensions in a coordinate system aligned with the magnetic field. The current density, however, varies in all three dimensions. Knowing the ionospheric current flow in three dimension is important for determining the magnetic perturbations at Low Earth Orbit (LEO) satellite height.

We are developing a model of ionospheric electrodynamics that takes into account all of the sources and calculates the three-dimensional structure of currents and their associated magnetic perturbation fields. This model will be used to simulate ionospheric drifts, currents, and ground and LEO geomagnetic perturbations. In this presentation we discuss the modeling principles and present results relevant to the electrodynamics of the middle and low latitude ionosphere, including the effects of coupling with F-region electrodynamics and the expected observable effects at low Earth orbit satellites.

Keywords: Ionospheric electrodynamics, ionospheric current, magnetic perturbations

©2019. Japan Geoscience Union. All Right Reserved.

Spatial Fluctuation of TEC Index: A new index of ionospheric irregularities

*Guanyi Ma[1], Takashi Maruyama[2]

1. National Astronomical Observatories, Chinese Academy of Sciences, 2. National Institute of Information and Communications Technology

This study presents a new spatial fluctuation of total electron content (TEC) index (SFTI) to identify and analyze ionospheric irregularities. SFTI is defined as the dispersion of vertical TEC (VTEC) within a specific area at a given time. With the data from the Global Navigation Satellite System (GNSS) Earth Observation Network of Japan (GEONET), the size of the specific area for SFTI calculation can be chosen as 0.8˚× 0.8˚ in longitude and latitude. An SFTI map generated by sliding window shows the spatial variation of the ionospheric irregularities in two dimensions. It can be used to obtain the size, shape, orientation and intensity distribution of the irregularity structures. With a series of SFTI maps, we analyzed three strong irregularity events on 12 February 2000, 20 March 2001 and 10 November 2004. The irregularities are found to consist of branching structures, which are anisotropic and elongate along longitudinal direction when first seen at low latitudes. The structures can drift and eventually move perpendicular to their orientations. It is concluded that SFTI will provide an unprecedented view of irregularity development and help to understand the process of irregularity generation.

Keywords: ionospheric irregularities, GNSS observation, SFTI

©2019. Japan Geoscience Union. All Right Reserved.

Coupling of lower thermosphere planetary wave energy into the ionosphere

*Patrick J Espy[1,2], Nora Stray[1,2,3], Robert Hibbins[1,2]

1. Norwegian University of Science and Technology, Trondheim, Norway, 2. Birkeland Centre for Space Science, Bergen, Norway, 3. Teknova AS, Tordenskjolds Gate 9, 4612 Kristiansand, Norway

Neutral atmosphere winds derived from meteor trail drifts observed by a longitudinal chain of Super Dual Auroral Radar Network (SuperDARN) radars have characterized planetary waves with wavenumber 1 and 2 in the lower thermosphere near 95 km. The simultaneous wind observations at stations between 50° and 66° N removes the temporal-spatial aliasing associated with satellite observations and shows the continuous evolution of the planetary waves near the turbopause. A similar technique has been applied to a longitudinal chain of ionosondes in the same latitude band, and the same wavenumber components were observed in f_oF2. An analysis of the two signals shows them to be highly correlated, with the ionospheric waves lagging behind those in the lower thermosphere. We will describe the technique to extract the waves and compare it with other observations. We will also show the relationship of the ionospheric waves with magnetic and solar activity, and describe a process, commensurate with our measurements, by which planetary wave signals near the turbopause can be transmitted into the ionospheric electron density.

Keywords: dynamics, turbopause, ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM09] Vertical coupling in the atmosphere and Ionosphere

convener:Huixin Liu(Earth and Planetary Science Division, Kyushu University SERC, Kyushu University), Loren Chang(Institute of Space Science, National Central University), Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Jann-Yenq Liu(National Central University, Taiwan), Loren Chang(National Central University, Taiwan)

Vertical coupling mechanisms throughout the whole atmosphere are critical to understanding the near Earth space environment, as well as its sensitivity to the solar, geomagnetic, and atmospheric drivers. This international session focuses on physical/chemical processes occurring in the mesosphere, thermosphere, and ionosphere (MTI). Both quiet and disturbed states in response to lower atmospheric forcing or solar forcing are important for understanding the MTI system and its coupling to other regions. We invite presentations of observations and observational concepts with ground-based and/or space-borne instruments, theoretical studies, numerical simulations, and development of data analysis systems for various kinds of temporal and spatial variations in atmosphere-ionosphere coupled system.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM09-16] Modulation of Lightning Occurrence by the Solar Wind

*Omar Angelo Nava[1], Daniel Emmons[1], Robert Loper[1] (1.Air Force Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM09-17] Long Term Mesopause Temperature Variations resolved by SD-WACCM, MSISE-00,TIMED SABER and Local Observations in Irkutsk (52.29o, 104.29o), Russia

*Yi Chung Chiu[1], Loren Chang[1], Yi Duann[1], ALEXEI DMITRIEV[1], Irina Medvedeva[2], Konstantin Ratovsky[2], Jia Yue[3] (1.Institute of Space Science, National Central University, 2.Russian Academy of Sciences, Russian Federation, 3.Hampton University, USA)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM09-18] ISS-IMAP observation of the mesospheric disturbances generated by tropical cyclones

*Akinori Saito[1], Takeshi Sakanoi[2], Septi Perwitasari[4], Yuta Hozumi[3], Ryota Okada[1], Ryo Murakami[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 3.University of Electro-Communications, 4.Space and Upper Atmospheric Sciences Group, National Institute of Polar Research)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM09-19] A fast acoustic wave detected in GNSS total electron content after the foreshock of the 2011 Tohoku Earthquake

*Yoshihiro Kakinami[1], Hiroaki Saito[2], Tetsuo Yamamoto[3], Chia-Hung Chen[4], Masa-yuki Yamamoto[2], Kensuke Nakajima[5], JANN-YENQ Liu[6] (1.Hokkaido Information University, 2.Kochi University of Technology, 3.Hokkaido University, 4.National Cheng Kung University, 5.Kyushu University, 6.National Central University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM09-20] **Study of quiet-time high-latitude thermospheric winds using a Fabry-Perot interferometer at Tromsoe: Averages and exceptional events**

*Heqiucen XU[1], Kazuo Shiokawa[1], Shin-ichiro Oyama[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM09-21] **The longitudinal differences of lunar tidal characteristics between East Asian and American sectors during stratospheric sudden warming events: 2009-2018.**

*Jing Liu[1], Donghe Zhang[1] (1.Peking University)

Modulation of Lightning Occurrence by the Solar Wind

*Omar Angelo Nava[1], Daniel Emmons[1], Robert Loper[1]

1. Air Force Institute of Technology

The connection between terrestrial and space weather phenomena is an emerging field of study with implications for different aspects of operational weather forecasting. This study investigates the influence of solar wind events on the frequency of lightning occurrence over North America. Empirical mode decomposition (EMD) is applied to National Lightning Detection Network (NLDN) data from 1996 to 2012 and correlated against various solar wind parameters. EMD performs operations that partition the lightning time series data into modes or Intrinsic Mode Functions (IMFs). Using composite analysis, we identified an IMF that corresponds to a 27-day co-rotating interaction region (CIR) that results in a statistically significant decrease in thunderstorm occurrence across the entire NLDN for approximately three to nine days. This finding is consistent with previous studies indicating that faster solar wind speeds are correlated with a decrease in galactic cosmic ray (GCR) flux and a reduction in lightning reports. However, the analysis also highlighted a latitudinal stratification in the thunderstorm response. In the mid-latitudes (30-38 deg N), faster solar wind speeds initially increased the number of lightning occurrences before decreasing significantly over the next 14 days. In the upper mid-latitudes (38-46 deg N), the response was reversed with an increase in thunderstorm events followed by a significant decrease. Additional “lightning response reversals” are noted at even higher latitudes. It is hypothesized that solar energetic particles associated with the CIRs are able to penetrate to tropospheric altitudes and increase lightning rates at higher latitudes, while at lower latitudes, the solar wind modulated GCR flux drives the decrease in lightning occurrence. Overall, understanding the electrodynamic connection between the lower and upper atmospheres has important implications for both space physics and atmospheric science communities.

Keywords: Lightning, Solar Wind, Empirical Mode Decomposition, National Lightning Detection Network

©2019. Japan Geoscience Union. All Right Reserved.

Long Term Mesopause Temperature Variations resolved by SD-WACCM, MSISE-00,TIMED SABER and Local Observations in Irkutsk (52.29o, 104.29o), Russia

*Yi Chung Chiu[1], Loren Chang[1], Yi Duann[1], ALEXEI DMITRIEV[1], Irina Medvedeva[2], Konstantin Ratovsky[2], Jia Yue[3]

1. Institute of Space Science, National Central University, 2. Russian Academy of Sciences, Russian Federation, 3. Hampton University, USA

Measurements of mesopause temperature are quite challenging and must rely on remote sensing methods. As part of the Taiwan-Russia joint research cooperation program, we carry out an analysis comparing mesopause temperature measurements made by the Irkutsk spectrophotometer between 2008 - 2018 and those resolved by the SD-WACCM data assimilation model, the empirical MSISE-00 model, and TIMED SABER satellite measurements. Spectral decomposition is performed on the datasets to determine the differences between the different observed and modelled seasonal and inter-annual variability, as well as to resolve long term trends.

Keywords: Mesopause, Temperature variability

©2019. Japan Geoscience Union. All Right Reserved.

ISS-IMAP observation of the mesospheric disturbances generated by tropical cyclones

*Akinori Saito[1], Takeshi Sakanoi[2], Septi Perwitasari[4], Yuta Hozumi[3], Ryota Okada[1], Ryo Murakami[1]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 3. University of Electro-Communications, 4. Space and Upper Atmospheric Sciences Group, National Institute of Polar Research

Troposphere was investigated to elucidate the vertical atmospheric coupling process using the global observational data from the International Space Station (ISS). The vertical coupling between the lower and the upper atmospheres has been revealed to be significant to control the dynamics and disturbances in the upper atmosphere by recent studies. The phenomena generated by the vertical coupling processes have been detected with various observational instruments, and studied with numerical simulations. TC, such as typhoon, hurricane and cyclone, is regarded as one of the intense sources in the Troposphere to affect the Mesosphere, the Thermosphere and the Ionosphere. There is a plenty of studies that reports the observation of the upper atmospheric disturbances associating with TC using ground-based instruments, such as HF doppler radars, IS radars, GNSS receiver arrays, and optical imagers. Because the ground-based observation cannot track the movement of TC, and TC is much active over the ocean, the observational opportunity is limited for the ground-based instruments. ISS-Ionosphere, Mesosphere, upper Atmosphere, and Plasmasphere (ISS-IMAP) mapping mission made a global observation of the airglow in the mesosphere and the ionosphere for three years. The data set of visible-light and infrared spectrum imager (VISI) of ISS-IMAP is idealistic to investigate the effect of TC on the Mesosphere and the Ionosphere. Mesospheric disturbances were detected by the airglow from the molecular oxygen in 762nm of wavelength, and the ionospheric disturbances were detected by the airglow from the atomic oxygen in 630nm of wavelength. In its three years observation, the number of TC that ISS-IMAP/VISI made the conjugate observation was 171. It was found that more than 20% of TC was associated with the mesospheric disturbances that seems to be generated by TC. The duration of these disturbances was one or two days in spite of the lifetime of TC is longer than a week. The relationship among TC, the mesospheric and the ionospheric disturbances will be discussed in the presentation.

Keywords: ISS-IMAP, Tropical cyclone, airglow, Mesosphere, Ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

A fast acoustic wave detected in GNSS total electron content after the foreshock of the 2011 Tohoku Earthquake

*Yoshihiro Kakinami[1], Hiroaki Saito[2], Tetsuo Yamamoto[3], Chia-Hung Chen[4], Masa-yuki Yamamoto[2], Kensuke Nakajima[5], JANN-YENQ Liu[6]

1. Hokkaido Information University, 2. Kochi University of Technology, 3. Hokkaido University, 4. National Cheng Kung University, 5. Kyushu University, 6. National Central University

Acoustic waves are often emitted from large earthquakes, reach the thermosphere and disturb the ionosphere. The disturbances are observed by using of GNSS total electron content (TEC). After the foreshock of the 2011 Tohoku Earthquake, which occurred on 9 March 2011, traveling ionospheric disturbance induced by tsunami was detected. When vertical propagation of acoustic wave from the tsunami source area is assumed, the onset points of co-seismic ionospheric disturbance (CID) must coincide. However, the onset points of the co- CID were detected at different locations in different satellite data assuming that the altitude of CID were the same (ex. at 300 km). Furthermore, we found the onset times were different in the different satellite data. The results suggest that the altitudes of CID are different and timings of observation are also different in the different satellite data. By changing the altitudes of CID, we found coinciding onset point. Once the coinciding onset point is found in the different data sets, the altitudes of the CID are also estimated because the sub-ionospheric point is a function of the altitude of observation. The CID altitude were found at 155.4 and 234.9 km. Considering the time difference of the onset time (399.9 s to the altitude of 155.4 km and 476.1 s to 234.9 km), the acoustic wave velocity is estimated to be 1.04 km/s which is 1.4 times higher than the velocity calculated using the empirical model NRLMSISE-00. The fast acoustic wave would arise from temperature elevated by the limited degrees of freedom of motion of atmospheric molecules, and dissipation of the acoustic wave. Especially, the neutral temperature with heating by the dissipation of the acoustic wave would increase by a factor of 3 for acoustic waves with 0.1 Hz and a pressure at sea level of ~2 Pa, which is on the order of the pressure of the acoustic wave emitted from the sea surface during the observed event. The elevated temperature explains the fast acoustic wave.

Keywords: fast acoustic wave, the foreshock of the 2011 Tohoku Earthquake, co-seismic ionospheric disturbance , GNSS total electron content, altitude estimation of ionospheric disturbance , heating of the thermosphere

©2019. Japan Geoscience Union. All Right Reserved.

Study of quiet-time high-latitude thermospheric winds using a Fabry-Perot interferometer at Tromsoe: Averages and exceptional events

*Heqiucen XU[1], Kazuo Shiokawa[1], Shin-ichiro Oyama[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

In the previous reports, we studied the dependences of average winds on Kp and F10.7 indices by using a Fabry-Perot interferometer (FPI) at Tromsoe, Norway. In this study, we have further focused on the winds during both globally (Kp < 1+) and locally quiet times in order to provide a baseline wind without magnetic disturbances at latitude of Tromsoe. The wind variations were measured from the Doppler shift of both red-line (630.0 nm, altitudes: 200-300 km, upper thermosphere) and green-line (557.7 nm, altitudes: 90-100 km, mesopause region) emissions with a time resolution of ~13 min. The wind data were collected from 2009 to 2015. In the upper thermosphere, the quiet-time average zonal wind shows westward acceleration at pre-midnight side at ~21-24 LT, while the meridional wind has a minimum around the midnight. In the mesopause region, the average wind tends to show a westward and eastward flow at dusk and dawn side, respectively. By applying sinusoidal regression to the mesospheric average zonal wind, we found that the semidiurnal component has a dominant amplitude of 12.1 m/s. During quiet time, we also found a few exceptional events of more than 100 m/s westward at dusk side in the upper thermosphere. We speculate these exceptional westward winds are related to local plasma convection under quiet time or substorm activities occurred at some other latitudes/local times.

Keywords: Thermosphere, Fabry-Perot interferometer

©2019. Japan Geoscience Union. All Right Reserved.

The longitudinal differences of lunar tidal characteristics between East Asian and American sectors during stratospheric sudden warming events: 2009-2018.

*Jing Liu[1], Donghe Zhang[1]

1. Peking University

With data of total electron content (TEC), equatorial electrojet (EEJ), stratospheric temperature and wind field, variations of the low-latitudinal ionosphere in East Asian and American sectors were investigated during stratospheric sudden warming events from 2009-2018. The lunar tidal amplitudes (M2) were derived with the least-square method. Then their features were compared separately during outstanding major events, moderate major events, minor events, and a non-SSW winter. Brief results are listed as follows: (1) In the American sector, the M2 tides appeared to be dominant over solar tides in all major events since distinct time-shifted semi-diurnal patterns could always be detected during those periods. (2) In the East Asian sector, the M2 characteristics were less clear, and sometimes even hard to identify, which means the relative strengths of lunar and solar tides are more complex in this sector. (3) The M2 amplitudes in TEC tend to be larger in the American sector than in East Asian sector during the same event. (4) The longitudinal differences tend to be lessened in minor SSWs compared to major SSWs. (5) During the non-SSW winter, lunitidal features could still be detected in both sectors. Similar results can be found in previous works for different kinds of parameters. Such longitudinal differences were attributed to combined effects of the geomagnetic field configuration, the latitudinal dependence of lunar and solar tides, the changes of atmospheric circulation, and the coupling process from the lower-atmosphere to the F region ionosphere.

Keywords: Stratospheric Sudden Warming, Low-latitudinal Ionosphere, Longitudinal Differences, Lunitidal Characteristics

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Shin'ya Nakano(情報・システム研究機構 統計数理研究所), Motoharu Nowada(Shandong University)

This session provides an opportunity to present recent results from satellite and ground-based observations and theoretical and simulation studies on the magnetosphere, ionosphere, and their coupling processes. We invite talks and posters discussing various phenomena related to the magnetosphere-ionosphere system: solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, field-aligned current, magnetic storms/substorms, neutral-plasma interaction, ionospheric ion inflow and outflow, aurora phenomena, and so forth. Discussions on planetary and satellite ionosphere and magnetospheres, future missions and instrument developments are also welcome.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM11-07] **Nightside Distorted Transpolar Arcs and Their Possible Formation Process Model**

*Nowada Motoharu[1], Jun Yang[1], Benoit Hubert[2], Qiu-Gang Zong[3], Quan-Qi Shi[1], Yong-Fu Wang[3], Xu-Zhi Zhou[3], Zhao Hua-Yu[3] (1.Shandong University at Weihai, 2.Université de Liège, 3.Peking University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM11-08] Ionospheric Conductivity Dependence of the Subauroral Polarization Streams Observed by the SuperDARN HF Radars

Yuting Zhang[1], *Nozomu Nishitani[1], Tomoaki Hori[1], Simon G. Shepherd[2], William A. Bristow[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Thayer School of Engineering, Dartmouth College, 3.University of Alaska Fairbanks)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM11-09] Ionospheric convection modeling based on convolution with a localized vector-valued basis function

*Shin ya Nakano[1], Tomoaki Hori[2], Kanako Seki[3], Nozomu Nishitani[2] (1.The Institute of Statistical Mathematics, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Graduate School of Science, University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM11-10] **Occurrence Statistics and Driving Mechanisms of Ionospheric ULF Waves Observed by SuperDARN Radars**

★Invited Papers

*Xueling Shi[1], Joseph B. H. Baker[1], John Michael Ruohoniemi[1], Dong Lin[1], Michael Hartinger[1,2] (1.Virginia Tech, 2.Space Science Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM11-11] Magnetic Field Oscillations Observed by Swarm Satellites in the Nightside Upper Ionosphere During Low-latitude Pi2 Pulsations

*Khan-Hyuk Kim[1], Jae-Hee Park[1] (1.School of Space Research, Kyung Hee Univ.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM11-12] Magnetospheric Multiscale observations of ULF waves and correlated low-energy ion monoenergetic acceleration

*Bin Li[1], De-sheng Han[2], Ze-jun Hu[1], Jian-jun Liu[1], Lei Dai[3] (1.Polar Research Institute of China, 2.Tongji University, 3.National Space Science Center, Chinese Academy of Sciences)

Nightside Distorted Transpolar Arcs and Their Possible Formation Process Model

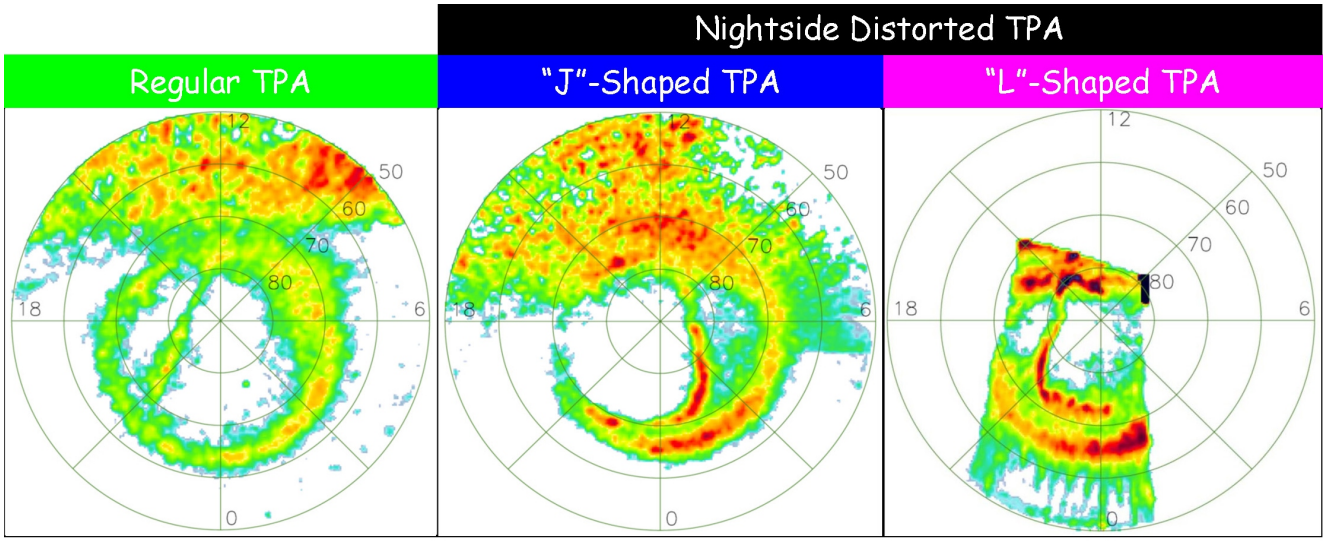
*Nowada Motoharu[1], Jun Yang[1], Benoit Hubert[2], Qiu-Gang Zong[3], Quan-Qi Shi[1], Yong-Fu Wang[3], Xu-Zhi Zhou[3], Zhao Hua-Yu[3]

1. Shandong University at Weihai, 2. Université de Liège, 3. Peking University

Transpolar Arc (TPA) is an important auroral phenomenon when considering how the energy stored in magnetotail is transported to ionosphere via magnetic reconnection under the northward interplanetary magnetic field. Magnetotail reconnection is considered to play a crucial role in TPA formation. Reconnection X-points are expected to retreat tailward as TPA grows from nightside auroral oval to the dayside. Usually, they straightforwardly retreat tailward, and reconnection-formed TPA morphology is straight-bar shape. However, we wonder how the TPA shape would be expected when traces of the tailward X-point retreats were not straightforward. The Wideband Imaging Camera (WIC), which is a part of Far Ultraviolet (FUV) instrument, onboard the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite detected an interesting type of TPAs, which are identified as “nightside distorted TPAs”. Their main bar-shaped parts were located at the dawn or dusk sides, and the nightside ends of them got distorted toward pre- or post-midnight sectors. Because these TPAs look like the shape of an alphabetical letter of “J” or “L”, we distinguished the nightside distorted TPAs from “J”- and “L”-shaped TPAs. We followed the time sequence of the evolutions of several nightside distorted TPAs with the IMAGE FUV-WIC imager data. In most cases, the “J” and “L”-shaped TPAs started to grow from the nightside main auroral oval, and protruded to the dayside auroral oval via the experience of distortion, suggesting that magnetotail magnetic reconnection was closely be related with the formation of the nightside distorted TPAs. In this study, we have proposed a model to explain the nightside distorted TPA formation, in order to discuss that TPAs with their nightside ends distorted toward pre- or post-midnight were formed through how physical process. Furthermore, we have tried to verify whether or not our model proposed is appropriate to adequately explain formation process of nightside distorted TPA based on the global MHD simulation using the BATS-R-US codes.

Keywords: Nightside distorted transpolar arc: “J”- and “L”-shaped TPAs, Nightside magnetic reconnection, Straightforward or wry tailward retreats of X-points , State of dynamic equilibrium, Magnetospheric convection

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Ionospheric Conductivity Dependence of the Subauroral Polarization Streams Observed by the SuperDARN HF Radars

Yuting Zhang[1], *Nozomu Nishitani[1], Tomoaki Hori[1], Simon G. Shepherd[2], William A. Bristow[3]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Thayer School of Engineering, Dartmouth College, 3. University of Alaska Fairbanks

We investigate the characteristics of the subauroral polarization stream (SAPS), with a main focus on the solar zenith angle (SZA) dependence using the Super Dual Auroral Radar Network (SuperDARN) HF radars and NOAA POES spacecraft data. In this study, we used 3 SuperDARN radars (HOK / CVE / ADW), and checked data from 2008 to 2017 and found 124 SAPS events where the line-of-sight velocity is larger than 150m/s, magnetic local time is 13 to 19 hours and the flow regions are identified to be equatorward of the auroral precipitation region. For each event, we examined the SZA using the geographic latitude, longitude and the UT span of SAPS. We found that the results of CVE radar are different from the result of HOK and ADW radar, the SAPS observed by CVE radar can happen in high conductivity occasion when both hemispheres are illuminated. However, we found that these illuminated SAPS could only occur under geomagnetically disturbed condition and mostly in spring and fall. In addition, when the geomagnetic activity is low, SAPS tends to appear when the minimum threshold of illuminated ionospheric altitude is 130 km or more, which is near and slightly above the altitude of the peak of Pedersen conductivity. These results suggest that the generation mechanism of SAPS is affected by both geomagnetic activity and the Pedersen conductivity. Results of detailed discussion will be presented.

Keywords: SuperDARN Hokkaido East radar, solar zenith angle, sub-auroral polarization stream (SAPS), magnetosphere-ionosphere coupling, Pedersen conductivity

©2019. Japan Geoscience Union. All Right Reserved.

Ionospheric convection modeling based on convolution with a localized vector-valued basis function

*Shin ya Nakano[1], Tomoaki Hori[2], Kanako Seki[3], Nozomu Nishitani[2]

1. The Institute of Statistical Mathematics, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Graduate School of Science, University of Tokyo

Divergence free assumption is useful for modeling the flow velocity distribution in the ionosphere where plasma velocity can be assumed to be orthogonal to a potential electric field. If the divergence of two-dimensional plasma velocity is assumed to be zero, we can consider a stream function yielding the plasma velocity distribution. In order to estimate the two-dimensional flow velocity distribution in the ionosphere, we propose a framework which expresses the stream function by a convolution with a spherical Gaussian function. From this spherical Gaussian function, we can obtain a localized vector-valued basis function for flow velocity distribution satisfying the divergence-free condition. Accordingly, flow velocity distribution can be represented by a convolution with the vector-valued basis functions. We combine this model with a state space model and estimate a temporal evolution using the Kalman filter algorithm. Hyperparameters of the model are determined by maximizing marginal likelihood.

The proposed framework is applied for estimating the two-dimensional ionospheric convection pattern from the Super Dual Auroral Radar Network (SuperDARN) data. Although there are some wide gaps in the spatial coverage of the SuperDARN radar network for ionospheric observation, the use of the localized basis function enhances the robustness of the estimate. This basis function also enables us to evaluate the uncertainty of the estimate which would be helpful for incorporating other observations. Some results of the analysis of the SuperDARN data will be demonstrated.

Keywords: ionospheric convection, SuperDARN, spherical Gaussian function

©2019. Japan Geoscience Union. All Right Reserved.

Occurrence Statistics and Driving Mechanisms of Ionospheric ULF Waves Observed by SuperDARN Radars

*Xueling Shi[1], Joseph B. H. Baker[1], John Michael Ruohoniemi[1], Dong Lin[1], Michael Hartinger[1,2]

1. Virginia Tech, 2. Space Science Institute

Ultra-low frequency (ULF; 1 mHz - 5 Hz) waves are known to play an important role in the transfer of energy from the solar wind to Earth's magnetosphere and ionosphere. The Super Dual Auroral Radar Network (SuperDARN) is an international network consisting of 35 low-power high frequency coherent scatter radars at middle to polar latitudes that look into Earth's upper atmosphere and ionosphere. In this study, we use Doppler velocity measurements obtained by the SuperDARN radars and coordinated spacecraft observations to investigate the occurrence statistics and driving mechanisms of ionospheric ULF waves. Pc3-5 band (1.7-40.0 mHz) ULF waves were surveyed using high time resolution radar data from 2010 to 2016. Specifically, we have investigated the wave spatial occurrence, frequency characteristics, seasonal factors, and dependence on solar wind and geomagnetic conditions. We note two particular findings: (i) an internal wave-particle interaction source is responsible for Pc4 waves at high latitudes in the duskside ionosphere; and, (ii) a source associated with the magnetotail dynamics during active geomagnetic times is suggested for Pc3-4/Pi2 waves at midlatitudes in the nightside ionosphere. A few interesting ULF wave events will be further analyzed for their driving mechanisms via coordinated observations from spacecraft. Collectively, these research findings provide better constraints on where and when ionospheric ULF waves occur and how they might affect magnetospheric and ionospheric dynamics.

Keywords: ULF Waves, SuperDARN, Ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

Magnetic Field Oscillations Observed by Swarm Satellites in the Nightside Upper Ionosphere During Low-latitude Pi2 Pulsations

*Khan-Hyuk Kim[1], Jae-Hee Park[1]

1. School of Space Research, Kyung Hee Univ.

Pi2-associated geomagnetic oscillations in the nighside upper ionosphere are studied using magnetic field data acquired by low-Earth orbiting multispacecraft Swarm and at the low-latitude Bohyun (BOH) station located at magnetic shell of L = 1.3 on 22 October 2014. Four Pi2 events were identified from the BOH data near midnight (MLT = 1.5) while Swarm A, B, and C spacecraft were orbiting on the nightside (MLT = 21-22) upper ionosphere from 70˚ to --60˚ in magnetic latitude (MLAT) at 450-500 km altitudes. It is found that the horizontal H component of BOH data is well correlated with the radial (B_x) and compressional (B_z) components of ionospheric magnetic fields when Swarm spacecraft were at |MLAT| < 30˚. Both B_x and B_z components exhibit in phase or out of phase with the BOH H oscillations depending on the location of the spacecraft (i.e., in the Northern Hemisphere or in the Southern Hemisphere). This indicates that Pi2-associated magnetic oscillation in the ionosphere is the consequence of field line displacement that is symmetric or odd mode about the magnetic equator. We also find that stationary magnetic field perturbation, which is similar to Pi2 oscillation but not associated Pi2 signals, in the upper ionosphere near magnetic equator. A statistical analysis for the global distribution of static/spatial magnetic field perturbations using low-latitude Pi2 oscillation as a reference is a subject of future work.

Keywords: Pi2 pulsation

©2019. Japan Geoscience Union. All Right Reserved.

Magnetospheric Multiscale observations of ULF waves and correlated low-energy ion monoenergetic acceleration

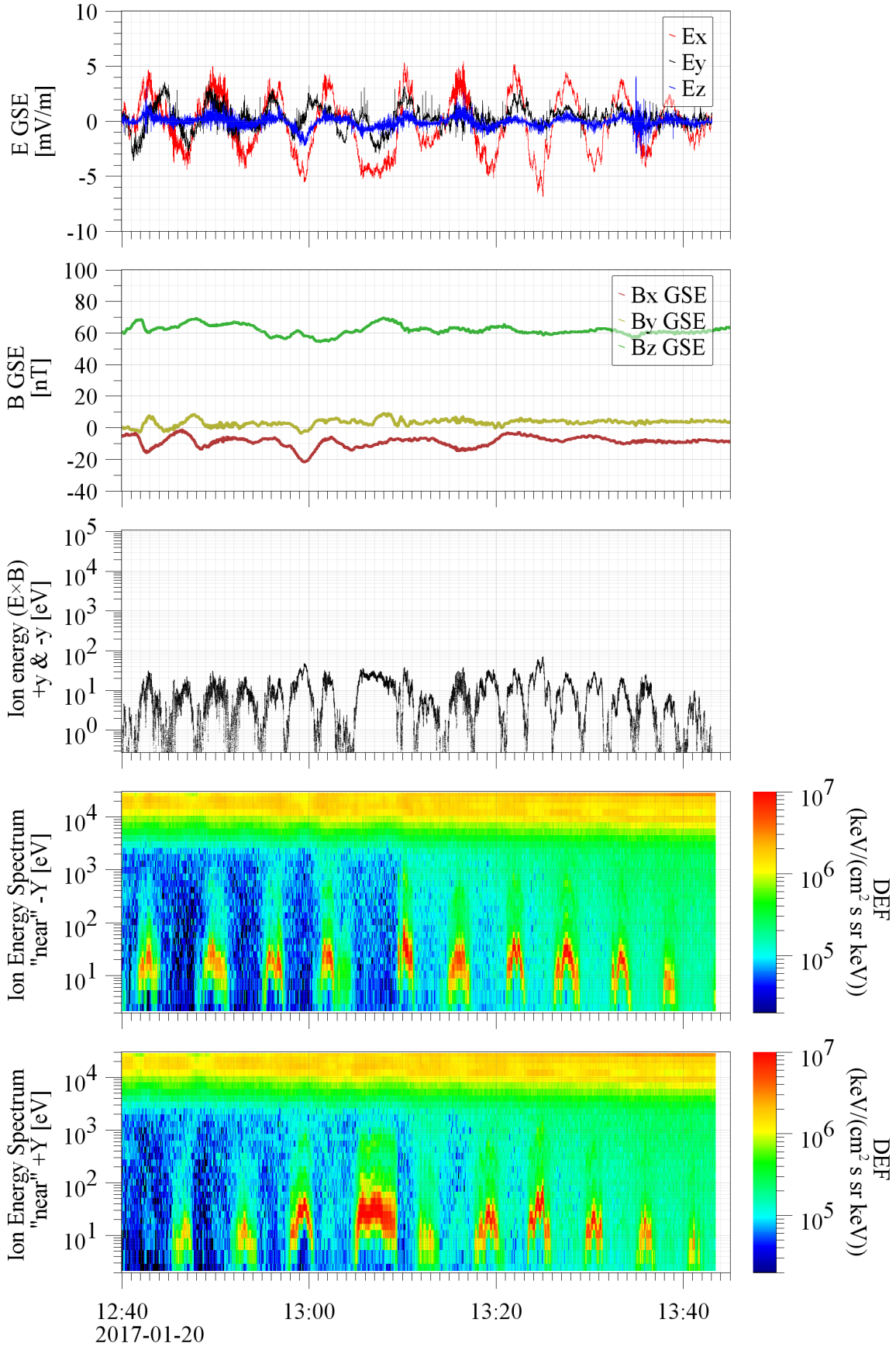
*Bin Li[1], De-sheng Han[2], Ze-jun Hu[1], Jian-jun Liu[1], Lei Dai[3]

1. Polar Research Institute of China, 2. Tongji University, 3. National Space Science Center, Chinese Academy of Sciences

Low-energy ions of ionospheric origin with energies below tens of eV dominate most of the volume and mass of the terrestrial magnetosphere. However, sunlit spacecraft often become positively charged to several tens of volts, which prevents low-energy ions from reaching the particle detectors on the spacecraft. Magnetospheric multiscale spacecraft (MMS) observations show that ultralow-frequency (ULF) waves drive low-energy ions to drift in the E×B direction with a drift velocity equal to $V_{E\times B}$, and low-energy ions were accelerated to a higher energy level to reach the detection range of the MMS/Fast Plasma Investigation (FPI). The maximum ion flux energy level detected by MMS1 DIS agreed perfectly with the theoretical calculation of H^+ ion E×B drift energy. The density of ions in the energy range below 2 eV was between 1 cm^{-3} and 3 cm^{-3} in the magnetosphere subsolar region in this event.

Keywords: low-energy ion monoenergetic acceleration, ultralow-frequency wave, E×B drift

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Kunuhiro Keika(東京大学大学院理学系研究科), Shin'ya Nakano(情報・システム研究機構 統計数理研究所), Motoharu Nowada(Shandong University)

This session provides an opportunity to present recent results from satellite and ground-based observations and theoretical and simulation studies on the magnetosphere, ionosphere, and their coupling processes. We invite talks and posters discussing various phenomena related to the magnetosphere-ionosphere system: solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, field-aligned current, magnetic storms/substorms, neutral-plasma interaction, ionospheric ion inflow and outflow, aurora phenomena, and so forth. Discussions on planetary and satellite ionosphere and magnetospheres, future missions and instrument developments are also welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM11-13] Statistical study on warm plasma in the magnetotail based on two-component fits of distribution functions

*Kunihiro Keika[1], Ryuta Asami[1], Masahiro Hoshino[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM11-14] Analysis on anisotropy variations for pitch angle distributions of electrons with various parameters at dipolarization sites in the inner plasma sheet

*Kaiti Wang[1], Zhuo-Ren Lang[2], Ching-Huei Lin[3], Tohru Hada[4], Toshi Nishimura[5] (1.Tamkang Univ., 2.National Cheng Kung Univ., 3.Chien-Hsin Univ. of Sci. & Tech., 4.Kyushu Univ., 5.Boston Univ.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM11-15] Study of slow-mode shock formation in the symmetric magnetic reconnection based on hybrid simulations

*Nehpreet Kaur Walia[1], Kanako Seki[1], Takanobu Amano[1] (1. Department of Earth & Planetary Science, Graduate School of Science, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM11-16] Reconstruction of the electron diffusion region of magnetotail reconnection seen by the Magnetospheric Multiscale spacecraft

*Hiroshi Hasegawa[1], Richard E. Denton[2], Rumi Nakamura[3], Kevin J. Genestreti[4], Takuma Nakamura[3], Kyoung Joo Hwang[5], Tai D. Phan[6], Roy B. Torbert[4], Jim L. Burch[5], Barbara L. Giles[7], Dan J. Gershman[7], Chris T. Russell[8], Bob J. Strangeway[8], Per Arne Lindqvist[9], Yuri V. Khotyaintsev[10], Robert E. Ergun[11], Naritoshi Kitamura[12], Yoshifumi Saito[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Dartmouth College, 3.Space Research Institute, Austrian Academy of Science, 4.University of New Hampshire, 5.Southwest Research Institute, 6.University of California Berkeley, 7.NASA Goddard Space Flight Center, 8.University of California Los Angeles, 9.Royal Institute of Technology, 10.Swedish Institute of Space Physics, 11.University of Colorado, 12.University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM11-17] **MMS observations of the dense high speed flow in the magnetotail**

*Mingyu Wu[1], Tielong Zhang[1] (1.Harbin Insitute of Technology, Shenzhen)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM11-18] The spatio-temporal development of lightning-induced electron precipitation events

★Invited Papers

*Robert C Moore[1], Dooyoung Kim[1] (1.University of Florida)

Statistical study on warm plasma in the magnetotail based on two-component fits of distribution functions

*Kunihiro Keika[1], Ryuta Asami[1], Masahiro Hoshino[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

A large number of observations reported two distinct plasma populations with different temperatures in the Earth's magnetotail: 1-10 keV for the hotter component and <1 keV for the colder. It is well accepted that plasma of solar wind origin can enter into the magnetosphere due to tailward convection of magnetic field lines that were reconnected at the dayside magnetopause, or due to instabilities or waves that develop on the dawn and dusk flanks. Cold plasma of ionospheric origin can be also transported into the plasma sheet predominantly along the field lines. Such cold plasma can be then heated/accelerated to 1 keV or higher. The dominant transport region(s) and heating mechanism(s) are, however, not well understood. This study investigates global characteristics of warm (10-1000 eV) plasma populations observed in the magnetotail in order to better understand transport regions of solar wind and ionospheric plasma.

We use data from plasma observations made by the Hot Plasma Composition Analyzer (HPCA) on board the Magnetospheric Multiscale (MMS) spacecraft. HPCA measures ions with energies of a few eV to ~40 keV with the determination of ion mass. We perform a one-component Maxwellian fit and a two-component Maxwellian fit to a distribution function of the omni-directional proton flux during intervals of slow flow speed (<~70 km/s). The best fit provides density and temperature of one-component Maxwellian plasma or density and temperature for each component of two-component Maxwellian plasma. This study is focused most on the colder (hotter) component of the two-component plasma, which we term a cold (normal) population. We apply this analysis and categorization to HPCA proton data obtained for a period of May 1 to August 31 of Year 2017. MMS dwelled in the magnetotail for the period, and HPCA data are available in the regions of 6 Re < r < 24 Re.

We examine dependence of density and temperature on plasma beta, which is the ratio of plasma thermal pressure to the magnetic pressure and thus represents the distance from the current sheet. The normal population shows clear positive correlations of density and temperature to plasma beta. This indicates adiabatic heating of lobe plasma transported toward the central plasma sheet. The cold population, on the other hand, does not show clear correlations. It is separated into three different types. Type 1 is characterized by positive correlations of density to plasma beta, similar to the normal population. Density is between 0.01 and 0.1 cm^{-3} at a beta range of 0.001 to 0.01, and increases to ~1 cm^{-3} at beta of >0.1. We confirm that the relation between density and temperature is well explained by adiabatic heating with the specific heat ratio of 5/3. Type 2 is seen only in the high beta (>0.1) regions, with density of ~0.01 cm^{-3}. Type 3 can be identified by a different relation between density and beta; density is between 0.01 and 1.0 with the highest occurrence frequency at 0.1 cm^{-3}, and temperature is a few 10s to 100s eV. Spatial distributions of each type show that Types 1 and 2 are observed at the radial distance of >10 Re. Type 1 shows no clear dawn-dusk asymmetry of occurrence frequency or average temperature, while Type 2 is more frequently observed on the dusk and dawn sides than around midnight. Type 3 occupies the region closer to 10 Re and is also observed at the radial distance of 10-20 Re with lower occurrence.

We interpret that Type 1 is dominated by plasma of solar wind origin transported over the polar regions, through the lobe toward the plasma sheet. Type 2 is likely solar wind plasma that enters through the flank

©2019. Japan Geoscience Union. All Right Reserved.

magnetopauses. Type 3 is of ionospheric origin, presumably from nightside auroral regions. We suggest that the north-south component of magnetospheric convection over the polar cap becomes dominant at the radial distance of 10 Re or further. Instabilities or waves that allow solar wind plasma to enter the plasma sheet are likely to sufficiently develop on the night side (i.e., $X < 0$).

Keywords: Entry of solar wind plasma, Supply of ionospheric plasma , plasma mixing, magnetospheric cold plasma

©2019. Japan Geoscience Union. All Right Reserved.

Analysis on anisotropy variations for pitch angle distributions of electrons with various parameters at dipolarization sites in the inner plasma sheet

*Kaiti Wang[1], Zhuo-Ren Lang[2], Ching-Huei Lin[3], Tohru Hada[4], Toshi Nishimura[5]

1. Tamkang Univ., 2. National Cheng Kung Univ., 3. Chien-Hsin Univ. of Sci. & Tech., 4. Kyushu Univ., 5. Boston Univ.

During geomagnetic activities, dipolarization of geomagnetic fields can been found to occur at tailside. In this study, we investigate variations in anisotropies of pitch angle distributions for electrons at 63 observed dipolarization sites around distance of 10 R_E (Earth radii) near the magnetic equator in the inner plasma sheet when auroral electrojet AL index decreases. Observational data from 2008 to 2011 for electrons below ~26 keV from the instrument ESA (ElectroStatic Analyzer) onboard of THEMIS mission are adopted. Followed from our previous presentation in which the dependence of these variations on field line lengths (FLL) was focused on [*Wang et al.*, 2018], we present new analysis results concentrating on the dependence of the changes as well as the rates of changes in FLL, magnetic field strengths, and dipolarization angles, during a dipolarizaion period. Comparisons between the anisotropy variations in pitch angle distributions of electrons and the associated bounce time of electrons, event dipolarization time, and measured environmental electric fields will also be presented and discussed.

References

Wang, K., Z. R. Lang, C. H. Lin, T. Hada, A. B. C. Chen, Y. Nishimura (2018). On the field line length dependence of variations in anisotropies for pitch angle distributions of keV electrons at dipolarization sites in the tailside. PEM16-25, JpGU Meeting 2018, Chiba, Japan.

Keywords: dipolarization, anisotropy of pitch angle distributions of electrons , observations of THEMIS mission

©2019. Japan Geoscience Union. All Right Reserved.

Study of slow-mode shock formation in the symmetric magnetic reconnection based on hybrid simulations

*Nehpreet Kaur Walia[1], Kanako Seki[1], Takanobu Amano[1]

1. Department of Earth & Planetary Science, Graduate School of Science, University of Tokyo

Fast magnetic reconnection is achieved in the Petschek' s reconnection theory [1964] via a pair of slow-mode shocks on each side of the diffusion region. The occurrence of these slow-mode shocks has been established in MHD regime by the various MHD and Hall-MHD simulation studies [e.g., e.g., Hoshino and Nishida, 1983; Biernat et al., 1989; Lin and Lee, 1993; Hau and Wang, 2016]. However, in the kinetic regime, their existence is still debated. Some of the hybrid and PIC simulations studies of magnetic reconnection region show slow-shock like structures, where either all the Rankine-Hugoniot (RH) or the Mach number conditions are not satisfied [e.g., Krauss-Varban and Omidi, 1995; Lottermoser et al. 1998; Higashimori and Hoshino, 2012], while some show the presence of Petschek like slow-mode shocks [e.g., Lin and Swift, 1996; Liu et al. 2012; Innocenti et al., 2015]. With satellite observations, the presence of slow-mode shocks have been confirmed for both asymmetric dayside magnetopause reconnection [Walia et al., 2018 and Sonnerup at al., 2016] and symmetric magnetotail reconnection [e.g. Feldman et al., 1987; Saito et al., 1995; Eriksson et al., 2004]. Walia et al. [2018] and Saito et al. [1995] reported that the detection probability of slow-mode shocks at around 20% and 10% in the dayside magnetopause and the magnetotail, respectively. One of the reasons for low detection probability of slow-mode shocks can be that the non-slow mode shock crossings used in the observational studies are very close to the X-point, and hence the slow-mode structure has not developed fully. The error in the determination of the shock normal direction and the shock frame of reference can be another reason for lack of observations of slow-mode shocks. In situ measurements via the use of the satellite data, can help us to look into the detailed structure of a magnetic reconnection crossing, but if one wants to look at the whole structure of magnetic reconnection region, simulation studies are needed. Especially, if one wants to look into the transition from the kinetic scales to MHD scales to find out how the structure of reconnection region changes and slow-mode shocks or other discontinuities form and develop.

In the present study we use 2D hybrid simulations for symmetric magnetic reconnection with isotropic temperature to investigate the formation of slow-mode shocks. The presence of slow-shocks in the magnetic reconnection region is established by checking the satisfaction of the RH conditions and specific conditions of Mach numbers, normal angles etc. [e.g., Seon et al., 1995, 1996]. We check the set of 12 slow-mode shock conditions and use the 30% satisfaction criteria [e.g., Walia et al., 2018; Eriksson et al., 2004] at all distances from the X-point to study the formation of slow-mode shocks from the ion inertial length scales to MHD scale. We found that the Petschek like slow-mode shocks can be identified as close as ~10 λ_i (λ_i = ion inertial length) to the X-point. Below, 10 λi slow-mode shocks are not fully developed, and rather slow shock-like structure is present. Also, it is found that the slow-mode shock identification is sensitive to the slow-shock normal determination. We will also report the differences in the satisfaction of various conditions (e.g., RH conditions, Mach numbers) and the characteristics of the ion distribution functions between the regions with slow-mode shocks and slow shock-like structures.

Keywords: Magnetic reconnection, Slow-mode shocks

©2019. Japan Geoscience Union. All Right Reserved.

Reconstruction of the electron diffusion region of magnetotail reconnection seen by the Magnetospheric Multiscale spacecraft

*Hiroshi Hasegawa[1], Richard E. Denton[2], Rumi Nakamura[3], Kevin J. Genestreti[4], Takuma Nakamura[3], Kyoung Joo Hwang[5], Tai D. Phan[6], Roy B. Torbert[4], Jim L. Burch[5], Barbara L. Giles[7], Dan J. Gershman[7], Chris T. Russell[8], Bob J. Strangeway[8], Per Arne Lindqvist[9], Yuri V. Khotyaintsev[10], Robert E. Ergun[11], Naritoshi Kitamura[12], Yoshifumi Saito[1]

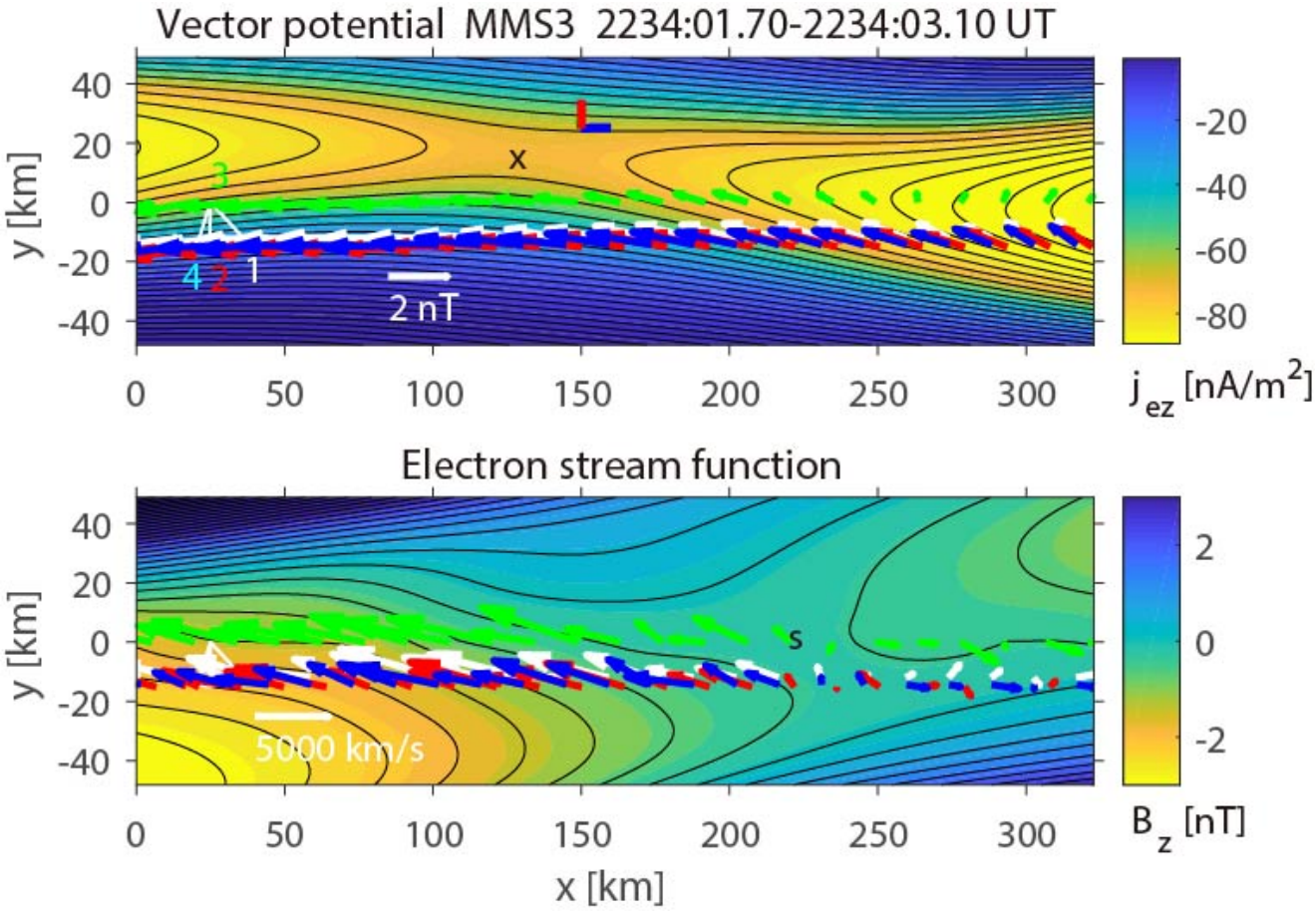
1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Dartmouth College, 3. Space Research Institute, Austrian Academy of Science, 4. University of New Hampshire, 5. Southwest Research Institute, 6. University of California Berkeley, 7. NASA Goddard Space Flight Center, 8. University of California Los Angeles, 9. Royal Institute of Technology, 10. Swedish Institute of Space Physics, 11. University of Colorado, 12. University of Tokyo

Magnetic reconnection is a fundamental plasma process that controls transfer of solar wind energy and mass to planetary magnetospheres and causes explosive energy release associated with solar flares and sudden auroral brightening. NASA's Magnetospheric Multiscale (MMS) mission, which consists of four identical spacecraft launched in March 2015, aims at elucidating how magnetic reconnection works with unprecedented high temporal and spatial resolution measurements of charged particles and electromagnetic fields in space. MMS has been observing Earth's magnetotail since May 2017, and encountered the central region of magnetic reconnection, called the electron diffusion region (EDR), on 11 July 2017 (Torbert et al., Science, 2018). We present results from the reconstruction of the electron diffusion region (EDR) observed in this event. The conditions were suited for the reconstruction technique, developed by Sonnerup et al. (JGR, 2016), that produces magnetic field and electron streamline maps based on a two-dimensional (2-D), time independent, inertia-less form of electron magnetohydrodynamic equation, assuming an approximately symmetric current sheet and negligible guide magnetic field. Our reconstruction results (Hasegawa et al., JGR, 2019) indicate that although the X point was not captured inside its tetrahedron, MMS approached the X point as close as one electron inertial length ~27 km. The opening angle of the recovered separatrix field line, combined with theory, suggests that the dimensionless reconnection rate was 0.17, which is consistent with the measured reconnection electric field 2–4 mV/m. The stagnation point of the reconstructed electron flow is shifted earthward of the X point by ~90 km, one possible interpretation of which is discussed. The energy conversion rate $\mathbf{j}^*\mathbf{E}'$ in the electron frame tends to be higher near the stagnation point, consistent with earlier observations and simulations, and is not correlated with the amplitude of broadband electrostatic waves observed in the upper-hybrid frequency range. The latter suggests that the waves did not contribute to energy dissipation in this particular EDR.

References:
Hasegawa, H., Denton, R. E., Nakamura, R., Genestreti, K. J., Nakamura, T. K. M., Hwang, K.-J., et al., Reconstruction of the electron diffusion region of magnetotail reconnection seen by the MMS spacecraft on 11 July 2017. Journal of Geophysical Research: Space Physics, 124. https://doi.org/10.1029/2018JA026051, 2019.
Sonnerup, B. U. O., H. Hasegawa, R. E. Denton, and T. K. M. Nakamura, Reconstruction of the electron diffusion region, J. Geophys. Res. Space Physics, 121, 4279-4290, doi:10.1002/2016JA022430, 2016.
Torbert, R. B., J. L. Burch, T. D. Phan, ... Y. Saito, Electron-scale dynamics of the diffusion region during symmetric magnetic reconnection in space, Science, doi:10.1126/science.aat2998, 2018.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: magnetic reconnection, magnetotail, electron diffusion region



©2019. Japan Geoscience Union. All Right Reserved.

MMS observations of the dense high speed flow in the magnetotail

*Mingyu Wu[1], Tielong Zhang[1]

1. Harbin Insitute of Technology, Shenzhen

With the MMS observations in the magnetotail, we report a earthward, dense, high speed, bulk flow event. In this event, two dense high speed flows (DHSF) are observed. Compared with the plasma sheet, DHSF contains much denser and colder plasma. Ion density of DHSF is about 8 times higher to plasma sheet density, while temperature of DHSF is several times lower to plasma sheet plasma. Due to the high density, DHSF can transport mass more effective than normal bursty bulk flows. Such DHSF can be generated by Magnetic reconnection, but the generation mechanism is still unclear.

Keywords: High-density bulk flow, Plasma sheet, Magnetic reconnection

©2019. Japan Geoscience Union. All Right Reserved.

The spatio-temporal development of lightning-induced electron precipitation events

*Robert C Moore[1], Dooyoung Kim[1]

1. University of Florida

Lightning-induced electron precipitation (LEP) events occur when the electromagnetic energy radiated by lightning couples to the magnetosphere and scatters ¬stably trapped radiation belt electrons. A portion of these scattered electrons in turn precipitate into the underlying ionosphere, producing electron density disturbances in the D-region ionosphere which can be detected by VLF remote sensing. When LEP events are observed nearly simultaneously at both the northern and southern ends of a field line, the LEP event is known as a conjugate LEP event. In this paper, an array of VLF receivers in the northern hemisphere is used to measure the spatial-temporal development of the LEP-related ionization patch produced within the D-region ionosphere. During one interesting event, LEP-associated VLF signal perturbations were observed at three receiver sites in the northern hemisphere (Florida, North Carolina, and Connecticut) and at one receiver in the conjugate hemisphere (Palmer Station, Antarctica). The LEP-related disturbance is observed to move poleward with time, consistent with many past observations. A second interesting event indicates the detection of an eastward expansion (with time) of the LEP-related disturbance, however. Together, these observations indicate that previous large-scale statistics compiled for conjugate LEP events may be seriously impacted by the spatio-temporal development of the LEP-associated ionospheric disturbances in the two hemispheres. Perhaps equally importantly, these observations indicate that VLF remote sensing can be used to measure the temporal and spatial development of energetic electron precipitation from the Earth's radiation belts.

Keywords: Lightning-induced electron precipitation, Radiation belts, Ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Naritoshi Kitamura(東京大学大学院理学系研究科), Yuka Sato(日本工業大学)

This session provides an opportunity to present recent results from satellite and ground-based observations and theoretical and simulation studies on the magnetosphere, ionosphere, and their coupling processes. We invite talks and posters discussing various phenomena related to the magnetosphere-ionosphere system: solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, field-aligned current, magnetic storms/substorms, neutral-plasma interaction, ionospheric ion inflow and outflow, aurora phenomena, and so forth. Discussions on planetary and satellite ionosphere and magnetospheres, future missions and instrument developments are also welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM11-19] Energy flow, dynamo and field-aligned current during a substorm

*Yusuke Ebihara[1], Takashi Tanaka[2] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.Kyushu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM11-20] **Electron flux and field-aligned current associated with Pc5 auroral arc pulsations observed onboard THEMIS and DMSP satellites**

*Natsuo Sato[1], Akira S Yukimatu[1,2], Yoshimasa Tanaka[1,2], Tomoaki Hori[3], Akira Kadokura[1,2], Tohru Sakurai[4], Desheng Han[5], Yuzhang Ma[6], Qinghe Zhang[6] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Nagoya University, 4.Tokai University, 5.Tongji University, 6.Shandong University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM11-21] Multiple spots of enhanced electron precipitation near the equatorward boundary of the cusp

*Satoshi Taguchi[1], Satoshi Kose[1], Kohei Takasu[1], Morio Tanaka[1], Keisuke Hosokawa[2], Yasunobu Ogawa[3] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.Department of Communication Engineering and Informatics, University of Electro-Communications, 3.National Institute of Polar Research)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM11-22] Statistical study of auroral/resonant-scattering 427.8-nm emission observed at subauroral latitudes over 14 years

*Kazuo Shiokawa[1], Yuichi Otsuka[1], Martin Connors[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Athabasca University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM11-23] Antarctic large area network observation of auroral phenomena using unmanned system: Conjugate auroral event studies (2)

*Akira Kadokura[1], Hisao Yamagishi[1], Masaki Okada[1], Yasunobu Ogawa[1], Yoshimasa Tanaka[1], Ryuho Kataoka[1], Herbert Akihito Uchida[1], Yuichi Otsuka[2] (1.National Institute of Polar Research, 2.Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM11-24] **Dawn-Dusk Asymmetry in Dayside and Nightside auroral Ovals: Surveys of auroral emissions based on the all-sky imagers in Arctic and Antarctic**

★Invited Papers

*Zejun Hu[1] (1.Polar Research Institute of China)

Energy flow, dynamo and field-aligned current during a substorm

*Yusuke Ebihara[1], Takashi Tanaka[2]

1. Research Institute for Sustainable Humanosphere, Kyoto University, 2. Kyushu University

A substorm is one of the most severe disturbances that occur in the magnetosphere. Extremely bright aurora is a great manifestation of the substorm. Since the bright aurora is caused by precipitating electrons, the bright aurora is closely associated with the upward field-aligned currents (FACs). Simultaneously, a large amount of energy, of the order of 10^{11} watts, is consumed in the auroral ionosphere due to Joule dissipation during the substorm. The dissipating energy is brought by the FACs that are rapidly intensified. Thus, the formation of the FACs is a key to understand the substorm. The generation of the FACs is accompanied with conversion of energy (dynamo). The energy comes from the solar wind. The purpose of this study is to provide a unified view of a substorm in terms of the energy flow, energy conversion (dynamo) and field-aligned current on the basis of a global magnetohydrodynamics (MHD) simulation. The recent global MHD simulation tells us that, at least, some dynamo regions appear one by one in association with the substorm. The first dynamo region is found in the bow shock where the solar wind kinetic energy is converted to the magnetic energy and the internal energy. However, the role of the bow shock dynamo is suggested to be minor. The second dynamo region is found in the lobe region when the interplanetary magnetic field (IMF) is northward. A complicated structure of the plasma pressure in the lobe gives rise to the generation of FACs that could manifest high-latitude auroral arcs during the growth phase. The third dynamo region appears in the mantle region when IMF is southward. The internal energy is converted to the magnetic energy by way of the kinetic energy in the mantle dynamo. Simultaneously, a large-scale FACs (known as Region 1 FACs) are generated in association with the mantle dynamo, which is probably responsible to the formation of a quiet auroral arc during growth phase. The fourth dynamo appears in the near-Earth magnetosphere on the nightside as a consequence of the formation of the near-Earth neutral line. The magnetic energy (coming from the lobe region) is converted to the internal energy, followed by the kinetic energy and the magnetic energy. The near-Earth dynamo is associated with the onset of the sudden intensification of the upward FACs that are related to the initiation of the auroral breakup. The fifth dynamo is located near the leading/trailing edges of the bright auroral surge where charge separation takes place due to the gradient of the ionospheric Hall conductivity. A localized upward FAC is generated, which probably manifests the bright auroral surge traveling westward. It is concluded that the evolution of the substorm can be understood to the evolution of the dynamo regions in the magnetosphere and the ionosphere.

Keywords: Substorm, Energy conversion, MHD simulation

©2019. Japan Geoscience Union. All Right Reserved.

Electron flux and field-aligned current associated with Pc5 auroral arc pulsations observed onboard THEMIS and DMSP satellites

*Natsuo Sato[1], Akira S Yukimatu[1,2], Yoshimasa Tanaka[1,2], Tomoaki Hori[3], Akira Kadokura[1,2], Tohru Sakurai[4], Desheng Han[5], Yuzhang Ma[6], Qinghe Zhang[6]

1. National Institute of Polar Research, 2. SOKENDAI, 3. Nagoya University, 4. Tokai University, 5. Tongji University, 6. Shandong University

Pc5 poleward moving auroral arc (PMAA) pulsations observed on the ground in the post-midnight sector exhibit east-west-aligned auroral arcs elongated ~ 1000-3000 km and behave poleward moving form with a recurrence period of ~ 2-10 minutes (Pc5 range). They appear just poleward side of common type pulsating auroras. We examined the space-ground coordinated observations with the THEMIS-A, D, and E spacecraft whose footprints were located near the PMAA observed with the all-sky imager on the ground. The latitudinal wave amplitudes and phase structures are consistent with the field-line resonance (FLR) model, while the period of oscillation was longer at the higher latitude side (not a monochromatic wave). The electron flux in the higher energy range of ~ 2–20 keV showed decreasing modulation in conjunction with the FLR oscillations. The intensity of the electric field and the velocity showed a spatial gradient that suggests the existence of a field-aligned current flow around the region of the satellites. The period of FLR oscillations in the magnetosphere was ~ 15–25% longer than that of the auroral pulsations in the ionosphere, and the enhancement of FLR oscillations was ~ 3–4 minutes ahead of the auroral pulsations. These signals imply that the FLR oscillations could not directly enhance the luminosity oscillation but needed some other process that could enhance the luminosity pulsation. We will examine the mechanism of how to produce the field-aligned electric field in association with the PMAA. In this study we focus on the characteristics of the electron flux variations observed onboard the THEMIS and DMSP satellites. The THEMIS satellites were located near the equatorial plane in the magnetosphere, and the DMSP satellites traversed in the ionosphere and crossed over the field of view of all-sky imager at observatories in Canada and Alaska and Syowa Station in Antarctica. It is found that the DMSP satellites observed the precipitating electron flux that behaved the feature of field-aligned acceleration and also observed the field-aligned currents when the DMSP satellite crossed the region of the PMAA.

Keywords: auroral arc pulsation, Pc 5 pulsation, pulsating aurora, field-line resonance, THEMIS spacecraft, DMSP satellite

©2019. Japan Geoscience Union. All Right Reserved.

Multiple spots of enhanced electron precipitation near the equatorward boundary of the cusp

*Satoshi Taguchi[1], Satoshi Kose[1], Kohei Takasu[1], Morio Tanaka[1], Keisuke Hosokawa[2], Yasunobu Ogawa[3]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. Department of Communication Engineering and Informatics, University of Electro-Communications, 3. National Institute of Polar Research

Localized enhancements of electron precipitation near the equatorward boundary of the cusp is thought to be caused by enhanced fluxes of soft magnetosheath electrons in the flux tube immediately after localized intermitted reconnection on the dayside magnetopause. A recent study based on an all-sky imager has reported an event which shows that enhanced electron precipitation appears in two separate locations along the equatorward boundary of the cusp, and that the distance between them is approximately 0.2 MLT. In this study we have examined if there is any characteristic scale in the distance between neighboring electron precipitation spots near the equatorward of the cusp to understand the characteristics of the occurrence point of intermittent reconnection. We analyzed 630-nm aurora data from an all-sky imager at Longyearbyen, Svalbard, and electron precipitation and field-aligned current data from DMSP spacecraft, which flied in the field-of-view of the auroral imager. A simultaneous observation event shows that six enhanced electron precipitation regions, each of which is accompanied with an upward/downward pair of mesoscale field-aligned currents, were observed along the pass of the DMSP satellite, and that all of those enhanced electron precipitation regions were also identified as auroral spots in the 630-nm auroral image data. By examining auroral image data obtained before the simultaneous observation event, we traced back to the initial brightening for each auroral spot. The result of analysis has shown that the longitudinal distance between the neighboring spots near the equatorward boundary of the cusp lies between 0.15 and 0.4 MLT. The statistical analysis with data obtained for longer period of time on the same day has also shown a similar tendency. We discuss why localized intermittent reconnection tends to occur in such locations.

Keywords: cusp, aurora, electron precipitation, reconnection

©2019. Japan Geoscience Union. All Right Reserved.

Statistical study of auroral/resonant-scattering 427.8-nm emission observed at subauroral latitudes over 14 years

*Kazuo Shiokawa[1], Yuichi Otsuka[1], Martin Connors[2]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Athabasca University

Auroral emission at 427.8-nm from N_2^+ ions is caused by precipitation of energetic electrons, or by resonant scattering of sunlight at high altitudes by N_2^+ ions. The latter often causes impressive purple aurora at high altitudes. However, statistical characteristics of auroral 427.8-nm emission have not well been understood. In this paper we report occurrence characteristics of high 427.8-nm emission intensities (more than 100 R) at subauroral latitudes, based on measurements by a filter-tilting photometer over 14 years (2005-2018) at Athabasca, Canada (magnetic latitude: ~62°). We divided the dataset into the elevation angles (θs) of the sun more than and less than -24° (shadow height of sunlight: 600 km) to separate the 427.8-nm emissions caused by resonant scattering of sunlight and those excited by auroral electrons, respectively. The occurrence rate of 427.8-nm emissions of more than 100 R is 10.6 % and 7.65 % for θs more than and less than -24°, respectively. The occurrence rate is high in the post-midnight sector, and increases with increasing geomagnetic activity, solar-wind speed, and density. The occurrence rate is highest in summer. A high occurrence rate was also observed in 2015-2018, from the maximum to the declining phase of the 11-year solar activity. Superposed epoch analysis indicates that the 427.8-nm emission exceeds 100 R when solar wind speed increases and solar wind density concurrently decreases, suggesting that the solar wind structures typically observed at the arrival of corotating interaction regions (CIR) can be responsible for the high 427.8-nm emission.

Keywords: 427.8 nm emission, resonant scattering of sunlight, purple aurora

©2019. Japan Geoscience Union. All Right Reserved.

Antarctic large area network observation of auroral phenomena using unmanned system: Conjugate auroral event studies (2)

*Akira Kadokura[1], Hisao Yamagishi[1], Masaki Okada[1], Yasunobu Ogawa[1], Yoshimasa Tanaka[1], Ryuho Kataoka[1], Herbert Akihito Uchida[1], Yuichi Otsuka[2]

1. National Institute of Polar Research, 2. Nagoya University

Conjugate auroral events observed at Syowa Station, Antarctica and observatories in Iceland on September 28 in 2017 are analyzed. During this period, auroral data obtained by the all-sky auroral imager of the Unmanned Auroral Observation system (UAO) at Amundsen Bay, which is located about 500 km eastward from Syowa Station, are also available. We will discuss development of the conjugate auroral activities in a broader longitudinal area than before.

Keywords: aurora, conjugate observation, substorm

©2019. Japan Geoscience Union. All Right Reserved.

Dawn-Dusk Asymmetry in Dayside and Nightside auroral Ovals: Surveys of auroral emissions based on the all-sky imagers in Arctic and Antarctic

*Zejun Hu[1]

1. Polar Research Institute of China

The synoptic distributions of dayside aurora in the Northern and Southern Hemispheres, acquired from all-sky imagers at Yellow River Station in Arctic and South Pole Station in Antarctica, respectively, present the same two-peak structure, namely, the prenoon 09:00 MLT and postnoon 14:00-15:00 MLT peaks. The auroral intensity presents a hemispheric asymmetry, i.e., the postnoon intensity is less than the prenoon intensity in the Southern Hemisphere but more in the Northern Hemisphere. The hemispheric asymmetry is not changed with the change of IMF’ s polarity, although 1) the negative (positive) IMF By favors the postnoon 557.7/630.0-nm auroral emissions, and the positive (negative) By favor to the excitation of 630.0-nm auroral on prenoon oval in the Northern (Southern) Hemisphere; 2) the 630.0-nm auroral intensity in dayside oval increases dramatically during the negative IMF Bz. We suggested that 1) the two-peak structure in the dayside oval are predominantly related with the prenoon/postnoon antiparallel reconnection in high-latitude magnetopause produced to the prenoon and postnoon peaks; 2) the IMF By should modulate the dayside aurora through the inter-hemispheric current, which is produced by a north-south oriented electric field , and changing the distribution of midday R0-R1 current; 3) the opposite prenoon-postnoon asymmetries of dayside auroral distributions in the two hemispheres are the combined effect of the prenoon-postnoon variations of the magnetosheath density and the variation of the local ionospheric conductivity in the two ground-based observatories.

The synoptic distributions of nightside aurora in the Northern Hemisphere, acquired from all-sky imagers at China-Iceland joint Aurora Observatory (CIAO) in Iceland, present that there are different characteristics on 427.8, 557.7, and 630.0 nm: 1) There is a two-peak structure on 427.8 and 557.7 nm, namely the pre-midnight 20:00- 21:00 MLT and post-midnight 04:00 peaks. For 427.8-nm auroral emission, the intensity of two peaks are same. For 557.7-nm emission, the maximal intensity is at peak 21:00 MLT. 2) There is only on peak on 630.0 nm, namely the pre-midnight 20:00-21:00 MLT. The dawn-dusk asymmetry in the nightside auroral oval should be related with the asymmetries of field-aligned currents and plasma waves in magnetosphere.

Keywords: dawn-dusk asymmetry, dayside & nightside auroral oval, particle precipitation, auroral morphology

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Naritoshi Kitamura(東京大学大学院理学系研究科), Yuka Sato(日本工業大学), Masaki Nishino(名古屋大学宇宙地球環境研究所)

This session provides an opportunity to present recent results from satellite and ground-based observations and theoretical and simulation studies on the magnetosphere, ionosphere, and their coupling processes. We invite talks and posters discussing various phenomena related to the magnetosphere-ionosphere system: solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, field-aligned current, magnetic storms/substorms, neutral-plasma interaction, ionospheric ion inflow and outflow, aurora phenomena, and so forth. Discussions on planetary and satellite ionosphere and magnetospheres, future missions and instrument developments are also welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM11-25] Enhancement of 10MeV protons associated with a change of magnetic field configuration at geosynchronous orbit

*Takahiro Obara[1] (1.Planetary Plasma and Atmospheric Research Center,Tohoku University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM11-26] Solar-cycle variations of >30 keV proton flux enhancements under the inner radiation belt

*ALLA SUVOROVA[1] (1.National Central University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM11-27] Auroral Imaging with Commercial DSLR Cameras near Athabasca, Canada

*Martin G Connors[1,2], Ian Schofield[1], Mike Noble[2], Alister Ling[2], Ryuho Kataoka[3], Ken Murata[4], Kazunori Yamamoto[4] (1.Athabasca University, 2.Edmonton Centre, Royal Astronomical Society of Canada, 3.National Institute for Polar Research, 4.National Institute for Communications Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM11-28] PARM: Investigation of precipitating high-energy electrons into the auroral ionosphere with sounding rockets

*Kazushi Asamura[1], Yoshizumi Miyoshi[2], Keisuke Hosokawa[3], Takefumi Mitani[1], Taku Namekawa[1,5], Takeshi Sakanoi[4], Naoshi Yagi[4], Mizuki Fukizawa[4], Genki Ishizawa[4], Satoshi Kasahara[5], Shin Sugo[5], Oya Kawashima[5], Reiko Nomura[6], Masahito Nose[2], Mariko Teramoto[2], Yasunobu Ogawa[7], Shinji Saito[2], Ryoichi Fujii[8] (1.ISAS / JAXA, 2.ISEE, Nagoya University, 3.The University of Electro-Communications, 4.Tohoku University, 5.The University of Tokyo, 6.NAOJ / NINS, 7.NiPR / ROIS, 8.ROIS)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM11-30] Development of a miniaturized X-ray imager for GEOspace X-ray imager (GEO-X)

*Kumi Ishikawa[1], Yuichiro Ezoe[2], Masaki Numazawa[2], Daiki Ishi[2], Maiko Fujitani[2], Ryota Otsubo[2], Aoto Fukushima[2], Hikari Suzuki[2], Tatsuya Yuasa[2], Hiroshi Nakajima[3], Junko Hiraga[4], Yoshizumi Miyoshi[5], Satoshi Kasahara[6], Kazuhisa Mitsuda[1] (1.Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science , 2.Tokyo Metropolitan University, 3.Kanto Gakuin University, 4.Kwansei Gakuin University, 5.Nagoya University, 6.The university of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC
Discussion

Enhancement of 10MeV protons associated with a change of magnetic field configuration at geosynchronous orbit

*Takahiro Obara[1]

1. Planetary Plasma and Atmospheric Research Center,Tohoku University

It was found that 10MeV proton flux enhanced at geosynchronous orbit during the thinning of the magnetic field configuration. Since no significant enhancement of 10MeV proton flux was observed outside of the magnetosphere, the 10MeV protons seem to be of magnetospheric origin. Drastic decrease of 2MeV electron flux was observed at the geosynchronous orbit when the thinning of the magnetic field commenced. The 2MeV electron flux recovered when the dipolarization of the magnetic field occurred, while 10MeV proton flux remained almost constant. Three hours before the increase of 10MeV protons, shock structure of the solar wind hit the Earth’ s magnetosphere. At that time, increase of 6.5MeV protons was observed at geosynchronous orbit. Low energy (1~10MeV) protons are thought to be produced by the interaction of the solar wind shock and the magnetopause (Shimazu and Tanaka, 2005). In this event, only 6.5 MeV protons could reach geosynchronous orbit just after the production. Due to the thinning of the magnetic field configuration, 10MeV protons could then reach geosynchronous orbit. Low energy (1~10MeV) protons will be probes of the magnetosphere configuration weather the magnetosphere is truly quiet when the first protons (6.5MeV protons) arrive at geosynchronous orbit altitude and time delay of second protons (10MeV protons) was accompanied by the magnetic field changes in the magnetosphere. This type of event will be interesting from the view of the magnetosphere configuration change during the solar wind shock arrival. We are collecting more events to confirm above mentioned scenario.

Keywords: Geosynchronous orbit, Enhancement of 10MeV protons , Magnetic field change

©2019. Japan Geoscience Union. All Right Reserved.

Solar-cycle variations of >30 keV proton flux enhancements under the inner radiation belt

*ALLA SUVOROVA[1]

1. National Central University

Upper atmosphere is continually affected by intense fluxes of energetic electrons and protons penetrating from the magnetosphere to low altitudes. The energetic particles ionize and excite neutral species altering local characteristics of the ionosphere. Continuous monitoring of energetic particles at low heights of ~850 km with the MEPED instrument onboard the NOAA/POES satellites allows studying of particle flux variations with geomagnetic activity and solar cycle. The instrument measures precipitating/trapped electrons and protons in the wide energy range. In the previous study, we revealed enhancements of electrons with energies 30 - 300 keV at low latitudes in a so-called forbidden zone. It was established that the electrons were injected from the inner radiation belt probably due to a mechanism of fast radial transport in the crossed electric and magnetic fields. In the current work, we study fluxes of >30 keV protons in the forbidden zone. We distinguish two types of proton enhancements, which have different spatial-temporal characteristics. One type of proton enhancements occurs due to the charge-exchange mechanism of the ring current and is always observed during magnetic storms. Another type is due to injections from the inner radiation belt. The last enhancements are similar to the electron enhancements. Results of long-term analysis of proton injections will be presented.

Keywords: magnetosphere-ionosphere, energetic protons, low latitudes, solar cycle

©2019. Japan Geoscience Union. All Right Reserved.

Auroral Imaging with Commercial DSLR Cameras near Athabasca, Canada

*Martin G Connors[1,2], Ian Schofield[1], Mike Noble[2], Alister Ling[2], Ryuho Kataoka[3], Ken Murata[4], Kazunori Yamamoto[4]

1. Athabasca University, 2. Edmonton Centre, Royal Astronomical Society of Canada, 3. National Institute for Polar Research, 4. National Institute for Communications Technology

Commercial DSLR Cameras have permitted a revolution in auroral imaging, due to their digital nature, low cost, high sensitivity, and other advantages. Athabasca University Geophysical Observatory is in the subauroral zone, but due to the high altitude of auroras, usually has optical auroral activity visible on its northern horizon. We have operated mostly northward-pointing DSLR cameras, either with a field of view of about 50 degrees, or nearly allsky coverage. Since the “allsky” cameras we have used in fact do not cover the whole sky, we have tilted them northward to cover that horizon preferentially. We have livestreamed images to http://autumn.athabascau.ca/auroracamhd.htm. Ironically, the northward orientation of cameras at the observatory has precluded us capturing images of the newly-recognized STEVE phenomenon, which is normally located south of our location. However, STEVE events found on auroral imaging campaigns in the Edmonton area can often be identified on EMCCD images from our Keo Scientific intensified allsky camera. Then we can combine the images, showing for example, that STEVE is roughly 200 km above the surface. The auroral imaging campaigns have used three fullframe DSLRs to produce partial sky images that are then stitched together using software to produce approximately 10k-pixel color auroral movies, suited for use with modem planetarium projector systems as impressive high resolution sky shows. Most recently we have used a Sony Alpha 7000 camera, taking advantage of the fiber optic internet link to the Athabasca site, to make livecasting of auroras to Japan possible. Since reliability of cameras with moving parts has been a problem, we hope that the direct imaging Sony Alpha camera will be more reliable than the “reflex” cameras previously used. To get around the problem of moving parts wearing out under the very high frame rate, we also tested inexpensive CMOS-type sensors controlled by single-board computers, and sending a digital image stream, but so far with different, but still present, reliability problems. Another issue faced is that in continuous operation, a large amount of data is produced due to the high pixel count of the cameras. We will discuss technical issues and challenges, but also show some results of DSLR operation over the years, including auroral movies and high resolution still frames.

Keywords: aurora, imaging, STEVE

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences) | P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

[P-EM11] Dynamics of Magnetosphere and Ionosphere

convener:Aoi Nakamizo(Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology), Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Akiko Fujimoto(Kyushu Institute of Technology), Tomoaki Hori(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Naritoshi Kitamura(東京大学大学院理学系研究科), Yuka Sato(日本工業大学), Masaki Nishino(名古屋大学宇宙地球環境研究所)

Thu. May 30, 2019 3:30 PM - 5:00 PM A04 (TOKYO BAY MAKUHARI HALL)

This session provides an opportunity to present recent results from satellite and ground-based observations and theoretical and simulation studies on the magnetosphere, ionosphere, and their coupling processes. We invite talks and posters discussing various phenomena related to the magnetosphere-ionosphere system: solar wind-magnetosphere interaction, magnetosphere-ionosphere convection, field-aligned current, magnetic storms/substorms, neutral-plasma interaction, ionospheric ion inflow and outflow, aurora phenomena, and so forth. Discussions on planetary and satellite ionosphere and magnetospheres, future missions and instrument developments are also welcome.

4:15 PM - 4:30 PM

[PEM11-28]PARM: Investigation of precipitating high-energy electrons into the auroral ionosphere with sounding rockets

*Kazushi Asamura[1], Yoshizumi Miyoshi[2], Keisuke Hosokawa[3], Takefumi Mitani[1], Taku Namekawa[1,5], Takeshi Sakanoi[4], Naoshi Yagi[4], Mizuki Fukizawa[4], Genki Ishizawa[4], Satoshi Kasahara[5], Shin Sugo[5], Oya Kawashima[5], Reiko Nomura[6], Masahito Nose[2], Mariko Teramoto[2], Yasunobu Ogawa[7], Shinji Saito[2], Ryoichi Fujii[8] (1.ISAS / JAXA, 2.ISEE, Nagoya University, 3.The University of Electro-Communications, 4.Tohoku University, 5.The University of Tokyo, 6.NAOJ / NINS, 7.NiPR / ROIS, 8.ROIS)

Keywords: electron microburst precipitation, sounding rocket, pulsating aurora

Bursty precipitations of high-energy electrons into the polar ionopshere have been observed by low-altitude satellite, for example, SAMPEX and FIREBIRD II. These precipitations, called microburst, may contribute to the loss of the terrestrial radiation belt through the collisional energy loss with the dense, cold atmospheric particles. Recent numerical simulations successfully reproduce these microburst precipitations with a few Hz modulations by taking into account the pitch angle scattering with the whistler chorus elements at off-equator regions in the inner magnetosphere. Therefore, one can expect that the miscroburst precipitations have properties depending on auroral activities especially the pulsating auroras. In order to investigate the mechanisms of the microburst precipitations by in-situ observations, we are developing two instrument packages: PARM (Pulsating AuRora and Microbursts; already developed) and PARM-2 (being developed), both of which are designed suitable for sounding rocket experiments. PARM consists of four sensors; HEP (high-energy electron energy spectrometer), MED (medium-energy electron detector), AIC (auroral camera), and AFG (ASIC-based fluxgate magnetometer). PARM was onboard the NASA's RockSat-XN sounding rocket, and launched from Andoya, Norway at 09:13UT, Jan 13, 2019. On the other hand, PARM-2 is under development. It consists of HEP, two AICs, and MIM (magneto-impedance magnetometer). PARM-2 is to be onboard the NASA's LAMP sounding rocket which will fly from Poker Flat, Alaska in the period between the end of 2019 and the

©Japan Geoscience Union

beginning of 2020.

We will present the overview of PARM missions including the initial results of RockSat-XN/PARM with ground-based observations and preparation status of LAMP/PARM-2.

©Japan Geoscience Union

Development of a miniaturized X-ray imager for GEOspace X-ray imager (GEO-X)

*Kumi Ishikawa[1], Yuichiro Ezoe[2], Masaki Numazawa[2], Daiki Ishi[2], Maiko Fujitani[2], Ryota Otsubo[2], Aoto Fukushima[2], Hikari Suzuki[2], Tatsuya Yuasa[2], Hiroshi Nakajima[3], Junko Hiraga[4], Yoshizumi Miyoshi[5], Satoshi Kasahara[6], Kazuhisa Mitsuda[1]

1. Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science , 2. Tokyo Metropolitan University, 3. Kanto Gakuin University, 4. Kwansei Gakuin University, 5. Nagoya University, 6. The university of Tokyo

A reduction in weight of instrument, especially optics, is a key technique for explorers or small satellite missions. GEO-X (GEOspace X-ray imager) is a Japanese small satellite mission for X-ray observations of the dayside boundaries of the Earth’ s magnetosphere. An instrument is composed of a X-ray telescope
and a radio hard semiconductor pixel detector. Conventional X-ray optics have a trend that optics with better angular resolution have larger ratio of the weight to effective area. Therefore, it is difficult to utilize them for the X-ray planetary mission which has a severe weight limit. Micro pore optics are being developed based on a concept of a miniature optics. An original micro pore optics based on Si micromachining technologies will be used. A CMOS image sensor and a DEPFET (DEPleted P-Channle FET) are candidates for the X-ray detector. These new type semiconductor detectors are radiation hard and have optical light resistance, which are crucial in GEO-X to observe magnetosheaths and cusps near the dayside of the Earth. We report a summary of the instrument design and development for GEO-X.

Keywords: X-ray, magnetosphere

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-EM15] Study of coupling processes in solar-terrestrial system

convener:Mamoru Yamamoto(Research Institute for Sustainable Humanosphere, Kyoto University), Yasunobu Ogawa(National Institute of Polar Research), Satonori Nozawa(Institute for Space-Earth Environment Research), Akimasa Yoshikawa(Department of Earth and Planetary Sciences, Kyushu University), Chairperson:Mamoru Yamamoto

The Earth accepts vast input of energy and material from the Sun. The Earth's environment is maintained by the balance between their inputs and outputs. It is therefore important to study energy and mass transport on the Earth. This is an international session that discusses studies of the coupling processes in the Sun-Earth system based on the project "Study of coupling processes in solar-terrestrial system" that was approved by the Master Plan 2011/2014/2017 of Science Council of Japan. We continue proposing the project to the Master Plan 2020. The facilities and networks included are Equatorial MU Radar (EMU) in Indonesia to study the whole equatorial atmosphere, the EISCAT_3D radar system in northern Scandinavia to study detailed structures and elementary processes of the magnetosphere-ionosphere coupling in the polar region, and global networks of various ground-based instruments and observation data. We will show the current status of the project and discuss sciences by soliciting variety papers. This session is open to the world, and we strongly encourage submission of papers related to other facilities and projects, i.e., atmospheric or incoherent scatter radars, observation networks, satellites, and simulation or theoretical studies, etc.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM15-01] Status of Equatorial MU Radar project in 2019

*Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Tatsuhiro Yokoyama[1], Toshitaka Tsuda[1] (1.Research Institute for Sustainable Humanosphere, Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM15-02] Recent Progress and Current Status of EISCAT_3D in 2018-2019

*Hiroshi Miyaoka[1], Yasunobu Ogawa[1], Satonori Nozawa[2], Koji Nishimura[1], Shin-ichiro Oyama[2], Takuji Nakamura[1], Ryoichi Fujii[2], Craig James Heinselman[3] (1.National Institute of Polar Research, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.European Incoherent Scatter Scientific Association)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM15-03] Current status of the ground-based multi-point network observation of the upper atmosphere, ionosphere, and magnetosphere by the PWING Project and the Optical Mesosphere Thermosphere Imagers (OMTIs)

*Kazuo Shiokawa[1], Yuichi Otsuka[1], PWING Team (1.Institute for Space-Earth Environmental Research, Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM15-04] Development of MAGDAS project: Search for global electromagnetic coupling from polar to equatorial ionosphere

*Akimasa Yoshikawa[1], Taisei Kabasawa[2], Teiji Uozumi[3], Akiko Fujimoto[4], Shuji Abe[3] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Graduate school of Sciences, Kyushu Univerity, 3.International center for Space weather science and education, Kyushu University, 4.Kyushu Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM15-05] IUGONET data analysis system for a study of coupling processes in the solar-terrestrial system

*Atsuki Shinbori[1], Yoshimasa Tanaka[2], Norio Umemura[1], Shuji Abe[3], Masahito Nose[1], Satoru UeNo[4] (1.Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2.National institute of Polar Research, 3.International Center for Space Weather Science and Education Kyushu University, 4.Observatory, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM15-06] Discussion on large-scale research project "Study of coupling processes in solar-terrestrial system" (1)

*Mamoru Yamamoto[1] (1.Research Institute for Sustainable Humanosphere, Kyoto University)

Status of Equatorial MU Radar project in 2019

*Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Tatsuhiro Yokoyama[1], Toshitaka Tsuda[1]

1. Research Institute for Sustainable Humanosphere, Kyoto University

Research Institute for Sustainable Humanosphere, Kyoto University (RISH) has been studying the atmosphere and ionosphere by using radars. The first big facility was the MU (Middle and Upper atmosphere) radar installed in Shiga, Japan in 1984. This is one of the most powerful and multi-functional radar, and is successful of revealing importance of atmospheric waves for the dynamical vertical coupling processes. The next big radar was the Equatorial Atmosphere Radar (EAR) installed at Kototabang, West Sumatra, Indonesia in 2001. The EAR was operated under close collaboration with LAPAN (Indonesia National Institute for Aeronautics and Space), and conducted the long-term continuous observations of the equatorial atmosphere/ionosphere. The EAR, however, had a limited sensitivity to the MU radar as the total output power is just 1/10 to the MU radar. Our new project is to establish "Equatorial MU (EMU) Radar" just next to the EAR site in Indonesia. The EMU will have an active phased array antenna with the 163 m diameter and 1055 cross-element Yagis. Total output power of the EMU will be more than 500 kW. The EMU is the "MU radar class" facility, and can detect turbulent echoes from the mesosphere (60-80 km). In the ionosphere incoherent-scatter observations of plasma density, drift, and temperature would be possible. Multi-channel receivers will realizes radar-imaging observations. Preparation for the EMU progress in many aspect including site survey for the construction, discussion with local government, etc. In March 2019, RISH and LAPAN have 1st Internal School on Equatorial Atmosphere (ISQUAR) 2019 with more than 100 participants at Bandung, Indonesia. ISQUAR aims to promote interesting studies of the equatorial atmosphere and use of the atmospheric radar including the EMU. The EMU is one of the key element in the project "Study of coupling processes in the solar-terrestrial system" that is one of the important project in the Master Plan 2014 and 2017 of the Science Council of Japan (SCJ). We continue proposing the project to the SCJ Masterplan 2020.

Keywords: Atmospheric radar, Equatorial atmosphere, Low-latitude ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

Recent Progress and Current Status of EISCAT_3D in 2018-2019

*Hiroshi Miyaoka[1], Yasunobu Ogawa[1], Satonori Nozawa[2], Koji Nishimura[1], Shin-ichiro Oyama[2], Takuji Nakamura[1], Ryoichi Fujii[2], Craig James Heinselman[3]

1. National Institute of Polar Research, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. European Incoherent Scatter Scientific Association

The European Incoherent Scatter(EISCAT) Scientific Association with associate members from Sweden, Norway, Finland, UK, China and Japan, has officially started the construction of the 1st stage of EISCAT_3D from September 2017 toward its completion by the end of 2021, including the commissioning of the radar system. EISCAT 3D is the major upgrade of the existing EISCAT mainland radars, with a multi-static phased array system composed of one central active (transmit-receive) site and 4 receive-only sites to provide us 50-100 times higher temporal resolution than the present system. The construction of EISCAT 3D is planned to implement by 4-staged approach, starting from the core site with half transmitting power about 5MW at Skibotn (Norway) and 2 receiving sites at Kaiseniemi (Sweden) and Karesuvanto (Finland) at the 1st stage. As for site preparation, geotechnical surveys have been completed at three sites, and ground cleaning with trenching for power lines and optical fiber cables have almost finished at the core site, Skibotn. All site buildings are scheduled to be built in 2019 to start installation of the radar system from 2020.

Through the international tendering process led by the EISCAT headquarter, antenna units with housing containers, first stage receiver units, sub-array transmitter units and pulse and steering control units have been completed and contracted providers have just started their preparation for productions to meet the EISCAT_3D implementation plan for sub-systems in 2020.

National Institute of Polar Research has been pursuing the opportunity to contribute in-kind to the construction of EISCAT_3D by supplying radar transmitter units in cooperation with the EISCAT Headquarters and ISEE/Nagoya University. The EISCAT_3D program in Japan was successfully granted as as one of high-priority programs of the Master Plan 2014/2017 and the Roadmap 2014 program, as a core facility of ’Study of Coupling Processes in the Solar-Terrestrial System’ (PI: Prof. Toshitaka Tsuda, ROIS/Kyoto Univ.). Supported by these positive evaluations, high energy-efficient transmitter power amplifiers (SSPAs) has been developed and produced for the engineering verification test at the EISCAT Tromso site with partial fundings for development since 2016.
In this paper, we will overview the recent progress and current status of the project including our strategy for the transmitter units as our national contribution to the EISCAT_3D project.

Keywords: incoherent scatter radar, space weather, arctic, master plan

©2019. Japan Geoscience Union. All Right Reserved.

Current status of the ground-based multi-point network observation of the upper atmosphere, ionosphere, and magnetosphere by the PWING Project and the Optical Mesosphere Thermosphere Imagers (OMTIs)

*Kazuo Shiokawa[1], Yuichi Otsuka[1], PWING Team

1. Institute for Space-Earth Environmental Research, Nagoya University

The Optical Mesosphere Thermosphere Imagers (OMTIs) consist of ~20 all-sky cooled-CCD imagers, 5 Fabry-Perot interferometers, 3 airglow temperature photometers, and 3 meridian-scanning photometers. They measure two-dimensional airglow images in the mesopause region and in the thermosphere, wind and temperatures in the lower thermosphere, and airglow rotational temperatures in the mesopause region. Details of the OMTIs project can be seen at http://stdb2.isee.nagoya-u.ac.jp/omti/. The PWING stands for "study of dynamical variation of Particles and Waves in the INner magnetosphere using Ground-based network observations." The PWING project started on April 2016 as a 5-year project of the Grant-in-Aid for Specially Promoted Research of the Japan Society for the Promotion of Science (JSPS) (16H06286). The PWING project deploy OMTIs all-sky cooled-CCD airglow imagers, 64-Hz sampled induction magnetometers, 40-kHz VLF receivers, and 64-Hz riometers at 8 stations at magnetic latitudes of ~60 degree around the north-pole to cover longitudinal variation of aurora and electromagnetic disturbances in the inner magnetosphere. Details of the PWING project can be seen at http://www.isee.nagoya-u.ac.jp/dimr/PWING/PWING_web_e.htm. These PWING and OMTIs instruments are in automatic operation at various locations from high to equatorial latitudes in Canada, US (Alaska), Russia, Norway, Finland, Iceland, Japan, Thailand, Indonesia, Nigeria, and Australia. In the presentation, we introduce current status and some recent results obtained by these multi-instrument ground networks around the world.

PWING Team: http://www.isee.nagoya-u.ac.jp/dimr/PWING/en/

Keywords: Optical Mesosphere Thermosphere Imagers (OMTIs) , PWING Project, upper atmosphere , ionosphere and magnetosphere

©2019. Japan Geoscience Union. All Right Reserved.

Development of MAGDAS project: Search for global electromagnetic coupling from polar to equatorial ionosphere

*Akimasa Yoshikawa[1], Taisei Kabasawa[2], Teiji Uozumi[3], Akiko Fujimoto[4], Shuji Abe[3]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Graduate school of Sciences, Kyushu Univerity, 3. International center for Space weather science and education, Kyushu University, 4. Kyushu Institute of Technology

The equatorial ionosphere is a final destination of electromagnetic energy brought about by energy incidence to the polar ionosphere. Distribution of geomagnetic disturbance accompanying such a coupling phenomenon shows strong asymmetry. Such an aspect suggests that the magnetosphere-ionosphere form a unique transmission and / or propagation system depending on each event.
The MAGDAS project investigates such a global electromagnetic coupling system by combining global geomagnetic field network observation with electric field observation using ionosonde installed at low and dip-equator region.
Recently, by using 250Hz sampling and 10Hz averaged MAGDAS 9 magnetometer data, we found that when the auroral substorm were enhanced during geomagnetic storm, together with enhancement of Pc1 wave at the polar region, the global Pc2 type disturbances (period range from 5 to 20 sec) can be captured from polar to equatorial region. In this talk, we will present recent update of MAGDAS project and of which scientific results.

Keywords: global electromagnetic coupling, Pc2 pulsation, Magnetosphere-ionosphere Coupling

©2019. Japan Geoscience Union. All Right Reserved.

IUGONET data analysis system for a study of coupling processes in the solar-terrestrial system

*Atsuki Shinbori[1], Yoshimasa Tanaka[2], Norio Umemura[1], Shuji Abe[3], Masahito Nose[1], Satoru UeNo[4]

1. Institute for Space-Earth Environment Research (ISEE), Nagoya University, 2. National institute of Polar Research, 3. International Center for Space Weather Science and Education Kyushu University, 4. Observatory, Kyoto University

The earth’ s atmosphere in a height range of more than 80 km is called the upper atmosphere, and the atmospheric layer is influenced by both the solar activity and the atmospheric waves propagating from the lower atmosphere. Therefore, in order to understand the physical mechanism of the short-term and long-term variations in the upper atmosphere, we need to perform an integrated analysis of various kinds of ground-based and satellite observation data taken by different instruments. Since these observation data were separately being managed by each institute, it was difficult for users to effectively find and analyze them for promotion of an interdisciplinary study. In order to solve this problem, the Inter-university Upper atmosphere Global Observation NETwork (IUGONET) project has been initiated in 2009, consisting of five institutes (Tohoku University, National Institute of Polar Research, Nagoya University, Kyoto University, and Kyushu University). In this project, we have added data information (metadata) for various kinds of ground-based observation data in the solar-terrestrial physics and built a practical database (IUGONET Type-A) to share them on the Internet. We have also developed an integrated data analysis tool (IUGONET Data Analysis Software: UDAS) written in an Interactive Data Language (IDL). This analysis tool is a plugin software for Space Physics Environment Data Analysis Software (SPEDAS) to analyze and visualize various kinds of ground-based and satellite observation data. In the IUGONET Type-A, users can easily learn characteristics of observation data through the quick look images/plots and how to use several basic commands to visualize the data. Recently, we developed a UDAS EGG (UDAS Easy Guide to Generate your load routines) to provide users with the templates for IDL procedures that can load their own data in CSV and CDF format into SPEDAS/IDL. In order to enhance an international use of these IUGONET products and to promote an interdisciplinary study of coupling processes on the sun-earth system, we have held tutorial seminars and workshops several times in Japan and foreign countries (India, Indonesia, Nigeria, Malaysia etc.). As a result, many scientific papers [e.g., Dao et al., 2017; Batubara et al., 2018; Koushik et al., 2018] and Master/Doctor theses become published by preparing an analysis environment, and the IUGONET products effectively works as an international platform. This fact suggests that the IUGONET project is in the position enough to serve the subjects of a large research project: Study of coupling processes in the solar-terrestrial system (Master Plan 2014/2017, Load Map 2014) through a collaboration with other ground-based and satellite observation plans and international programs as already planned by Master Plan 2014/2017. Judging from the above situations, the IUGONET project has a potential possibility to extend human development and strong international cooperation to a whole equatorial region (South America, Africa) in addition to India and Indonesia in future. Therefore, it can be concluded that the IUGONET activity effectively promotes the equatorial and polar atmospheric observations, international collaboration and data science (data assimilation), which are three main subjects of Master Plan (2014/2017).

Reference:

©2019. Japan Geoscience Union. All Right Reserved.

Batubara. M, et al., Long-term distribution of meteors in a solar cycle period observed by VHF meteor radars at near-equatorial latitudes, J. Geophysical Res., doi:10.1029/2018JA025906, 2018.

Koushik, N., et al., Response of equatorial and low latitude mesosphere lower thermospheric dynamics to the northern hemispheric sudden stratospheric warming events, JAtmos.Solar-Terr. Phys., 169, 66-77, doi:10.1016/j.jastp.2018.01.021, 2018.
Dao, T., et al., Coordinated observations of postmidnight irregularities and thermospheric neutral winds and temperatures at low latitudes, J. Geophys. Res. Space Physics, 122, 7, 7504-7518, doi:10.1002/2017JA024048, 2017.

Keywords: IUGONET, Study of coupling process in the solar-terrestrial system, International collaboration, Database, Analysis tool (SPEDAS/UDAS), Equatorial atmosphere

©2019. Japan Geoscience Union. All Right Reserved.

Discussion on large-scale research project "Study of coupling processes in solar-terrestrial system" (1)

*Mamoru Yamamoto[1]

1. Research Institute for Sustainable Humanosphere, Kyoto University

The large-scale research plan "Study of coupling processes in solar-terrestrial system" is recognized in the important projects in Master Plan 2014 and 2017. We are currently preparing for a continuous proposal to Master Plan 2020. In this international session, we will apply discussion time in order to proceed the research plan.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-EM15] Study of coupling processes in solar-terrestrial system

convener:Mamoru Yamamoto(Research Institute for Sustainable Humanosphere, Kyoto University), Yasunobu Ogawa(National Institute of Polar Research), Satonori Nozawa(Institute for Space-Earth Environment Research), Akimasa Yoshikawa(Department of Earth and Planetary Sciences, Kyushu University), Chairperson:Satonori Nozawa

The Earth accepts vast input of energy and material from the Sun. The Earth's environment is maintained by the balance between their inputs and outputs. It is therefore important to study energy and mass transport on the Earth. This is an international session that discusses studies of the coupling processes in the Sun-Earth system based on the project "Study of coupling processes in solar-terrestrial system" that was approved by the Master Plan 2011/2014/2017 of Science Council of Japan. We continue proposing the project to the Master Plan 2020. The facilities and networks included are Equatorial MU Radar (EMU) in Indonesia to study the whole equatorial atmosphere, the EISCAT_3D radar system in northern Scandinavia to study detailed structures and elementary processes of the magnetosphere-ionosphere coupling in the polar region, and global networks of various ground-based instruments and observation data. We will show the current status of the project and discuss sciences by soliciting variety papers. This session is open to the world, and we strongly encourage submission of papers related to other facilities and projects, i.e., atmospheric or incoherent scatter radars, observation networks, satellites, and simulation or theoretical studies, etc.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[PEM15-07] Numerical Experiments on Stratosphere-Troposphere Two-Way Dynamical Coupling in the Tropics through Organizations of Moist Convective Systems

★Invited Papers

*Shigeo Yoden[1], Hai Bui[2], Takahiro Banno[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Geophysical Institute, University of Bergen)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM15-08] Future development of numerical simualtion of equatorial plasma bubbles

*Tatsuhiro Yokoyama[1] (1.Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM15-09] Characteristics of CME- and CIR-driven ion upflows in the polar ionosphere

*Yasunobu Ogawa[1], Kanako Seki[2], Kunihiro Keika[2], Yusuke Ebihara[3] (1.National Institute of Polar Research, 2.School of Science, the University of Tokyo, 3.Research Institute for Sustainable Humanosphere, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM15-10] SuperDARN Hokkaido Pair of (HOP) radars and mid-latitude SuperDARN: today and future

*Nozomu Nishitani[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM15-11] Simultaneous observation of Ionospheric Incoherent Scatter and Field Aligned Irregularities using adaptive signal processing techniques by the PANSY radar at Antarctic Syowa Station (39.6°E, 69.0°S)

*Taishi Hashimoto[1], Akinori Saito[2], Koji Nishimura[3], Masaki Tsutsumi[3], Kaoru Sato[4], Toru Sato[1] (1.Graduate School of Informatics, Kyoto University, 2.Graduate School of Science, Kyoto University, 3.National Institute of Polar Research, 4.Graduate School of Science, The University of Tokyo)

Numerical Experiments on Stratosphere-Troposphere Two-Way Dynamical Coupling in the Tropics through Organizations of Moist Convective Systems

*Shigeo Yoden[1], Hai Bui[2], Takahiro Banno[1]

1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2. Geophysical Institute, University of Bergen

Recently, we started a new international research activity on Stratospheric And Tropospheric Influences on Tropical Convective Systems (SATIO-TCS) under WCRP/SPARC. It focuses on stratosphere-troposphere (S-T) two-way dynamical coupling in the tropics, where moist convection and its large-scale organization in the troposphere could be influenced by the stratospheric variations, such as stratospheric sudden warming events, the equatorial quasi-biennial oscillation (QBO), or anthropogenic cooling trend in the lower stratosphere, as revealed by some observational studies. For example, Nishimoto and Yoden (2017) made a statistical analysis on the influence of QBO on the Madden-Julian oscillation (MJO) during boreal winter in neutral ENSO periods from 1979 to 2013, and showed that the composite OLR anomaly for a particular MJO phase over the Maritime Continent has a larger negative value and slower eastward propagation with a prolonged period of active convection in the easterly phase of QBO than in the westerly phase.

The tropical dynamics is largely different from the counterpart in the extratropics where dry quasi-geostrophic dynamics prevail. Multi-scale dynamics of moist convection and its organizations are likely to play a vital role in determining the tropospheric response to the stratospheric variations, but numerical model studies from such viewpoint are still limited. Thus, we had performed a series of numerical experiments on radiative-moist convective quasi-equilibrium states in a highly-idealized two-dimensional regional model of an S-T coupled system with explicit moist convection under a periodic lateral boundary condition without Coriolis effects, in which self-sustained oscillations dynamically analogous to the QBO were obtained (Yoden et al. 2014). Modulation of moist convective systems is associated with the QBO-like oscillation of the mean zonal wind, as alternative appearance of squall-line- or back-building-type precipitation patterns, and vertical momentum transports associated with slant-wise moist convection and convectively generated gravity waves are periodically modulated in the oscillation (Nishimoto et al. 2016). Downward influence of the QBO-like oscillation on organized moist convective systems was further investigated in a series of experiments that control the vertical shear of the mean zonal wind with a nudging term (Bui et al. 2017).

Recently, we have performed numerical experiments in a three-dimensional minimal model framework that produces a QBO-like oscillation in a radiative-moist convective quasi-equilibrium state. The computational domain is rectangular (640 km x 160 km, 5 km grid size; Bui et al., 2019), or square (100 km x 100 km, 1 km grid size), without Coriolis effects under doubly periodic boundary conditions. In these experiments, an oscillation with a period of about 300 days emerges in the stratosphere, both in the domain-averaged zonal wind and meridional wind. Synchronization of the zonal and meridional winds is characterized as an anti-clockwise rotation of a skewed spiral feature with height in the horizontal wind hodograph. The QBO-like wind oscillation penetrates into the troposphere with large reduction of oscillation amplitude, and influences tropospheric temperature anomalies and precipitation with an irregular period of about 100 days. Heavy precipitation is associated with positive temperature anomalies.

©2019. Japan Geoscience Union. All Right Reserved.

The simulation reveals three types of precipitation patterns; fast-moving back-building- and squall-line-type patterns, and isolated quasi-stationary type clusters, which is newly identified in this three-dimensional model. The zonal-height cross sections of the meridionally averaged clouds and relative humidity for this pattern show clear-sky areas with low humidity without shallow clouds, whereas shallow clouds exist over the entire domain including non-precipitating areas with high humidity for the fast-moving two patterns. Intermittent self-organization of convective systems into quasi-stationary type and transition back to the fast-moving back-building- or squall-line-type patterns are fundamental characteristics of self-aggregation in the three-dimensional model.

References

Bui, H.-H., E. Nishimoto, and S. Yoden, 2017: *J. Atmos. Sci.*, 74, 3635–3655.

Bui H., S. Yoden, and E. Nishimoto, 2019: *SOLA*, **15**, 59–62.

Nishimoto, E., and S. Yoden, 2017: *J. Atmos. Sci.*, **74**, 1105–1125.

Nishimoto, E., S. Yoden, and H.-H. Bui, 2016: *J. Atmos. Sci.*, **73**, 2935–2957.

Yoden, S., H.-H. Bui, and E. Nishimoto, 2014: *SOLA*, **10**, 112–116.

Keywords: Stratosphere-Troposphere Dynamical Coupling, Moist Convective Systems, Tropical Meteorology

©2019. Japan Geoscience Union. All Right Reserved.

Future development of numerical simualtion of equatorial plasma bubbles

*Tatsuhiro Yokoyama[1]

1. Kyoto University

Equatorial plasma bubbles (EPBs) have been a longstanding and increasingly important subject because they cause severe scintillations in radio waves from Global Navigation Satellite System satellites. The phenomenon was found in the 1930s as irregular ionosonde observations and was termed equatorial spread F (ESF). ESF is interpreted as plasma density irregularities associated with EPBs that have nonlinearly evolved into the topside ionosphere. Since late 1970s, numerical simulations have been powerful tools to study the fully nonlinear evolution of EPBs, which cannot be wholly understood from theoretical predictions. The most recent model, High-Resolution Bubble (HIRB) model, could reproduce very turbulent structures inside EPBs such as bufurcation, zonal asymmetry, and two-component power law spectral characteristics. Future directions toward scintillation evaluation and forecasting are discussed.

Keywords: equatorial plasma bubble, simulation, ionosphere

©2019. Japan Geoscience Union. All Right Reserved.

Characteristics of CME- and CIR-driven ion upflows in the polar ionosphere

*Yasunobu Ogawa[1], Kanako Seki[2], Kunihiro Keika[2], Yusuke Ebihara[3]

1. National Institute of Polar Research, 2. School of Science, the University of Tokyo, 3. Research Institute for Sustainable Humanosphere, Kyoto University

We investigated how velocity and flux of ionospheric ion upflows vary during magnetic storms driven by corotating interaction regions (CIRs) and coronal mass ejections (CMEs), using data from the European Incoherent Scatter (EISCAT) Tromsø UHF and Svalbard radars between 1996 and 2015. The characteristics of ion upflows were compared with ion and electron temperature variations measured with the EISCAT radars, and also joule heating rate, electric field, and field-aligned current (FAC) distribution derived from the Weimer model. Upward ion velocity increases in the nighttime at Tromsø (66.2 $^{\circ}$N geomagnetic latitude) just after the CIR- and CME-driven storms, corresponding to electron temperature enhancements due to soft particle precipitation and also ion temperature enhancements in the strong westward electric field region. The CME-driven storms have larger upward ion flux (~1.7×10^{13} $m^{-2}s^{-1}$) than those under the CIR-driven storms (~0.3×10^{13} $m^{-2}s^{-1}$). In the daytime, ion upflows are seen at Longyearbyen, Svalbard (75.2 $^{\circ}$N geomagnetic latitude), with an upward flux of typically 10^{13} $m^{-2}s^{-1}$ for small CIR and CME storm cases. Substantial ion upflows last for a few days after the storm onsets under small CIR storms, whereas they last for only a day under small CME storms. Under both the cases, the substantial ion upflows are associated with an enhancement of the Region 1 FAC, eastward electric field and Joule heating rate. For large CME storms, substantial ion upflows are absent in the daytime probably due to equatorward expansion of the auroral oval.

Keywords: polar ionosphere, M-I coupling, EISCAT

©2019. Japan Geoscience Union. All Right Reserved.

SuperDARN Hokkaido Pair of (HOP) radars and mid-latitude SuperDARN: today and future

*Nozomu Nishitani[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

The Super Dural Auroral Radar Network (SuperDARN) is a network of HF radars. At present there are total of 36 SuperDARN radars located in high- to mid-latitude regions of both northern (23) and southern (13) hemispheres. Mid-latitude SuperDARN radars started operation about 15 years ago and have been acquiring scientific data, which could be obtained using the pre-existing high-latitude radars. The SuperDARN Hokkaido Pair of (HOP) radars consisting of Hokkaido East / West radars are located equatorward of 40 degrees geomagnetic latitude (currently located at the lowest geomagnetic latitude) and have been storing important scientific data during quiet to very active periods. In this presentation accomplishments, present status and future directions of the SuperDARN HOP radars and mid-latitude SuperDARN be reviewed.

Keywords: mid-latitude SuperDARN

©2019. Japan Geoscience Union. All Right Reserved.

Simultaneous observation of Ionospheric Incoherent Scatter and Field Aligned Irregularities using adaptive signal processing techniques by the PANSY radar at Antarctic Syowa Station (39.6˚E, 69.0˚S)

*Taishi Hashimoto[1], Akinori Saito[2], Koji Nishimura[3], Masaki Tsutsumi[3], Kaoru Sato[4], Toru Sato[1]

1. Graduate School of Informatics, Kyoto University, 2. Graduate School of Science, Kyoto University, 3. National Institute of Polar Research, 4. Graduate School of Science, The University of Tokyo

The Program of Antarctic Syowa Mesosphere-Stratosphere-Troposphere (MST) / Incoherent Scatter (IS) radar (the PANSY radar) is a large VHF-band atmospheric radar located at Antarctic Syowa Station. Besides the general functionalities of MST radars, the PANSY radar is also capable of observing IS from 100 km to 500 km in altitude to estimate ionospheric plasma parameters. The ionospheric observation was successfully performed in 2015, which was the first in the Antarctic region.

In contrast to existing IS radars using higher frequencies, the ionospheric observation of the PANSY radar suffers contamination from E-region Field Aligned Irregularities (FAIs). Because the perpendicular condition between the line of sight and the geomagnetic field is satisfied around 100 km in altitude using the VHF-band at this latitude, strong coherent echoes from FAIs fall into the same range gates with the F-region peak of IS.

To mitigate the contamination of FAIs in IS observation of the PANSY radar, we have developed a signal processing procedure using adaptive beamforming techniques [1]. The PANSY radar has two peripheral linear antenna arrays, each with twelve three-element antennas for the Directionally Constrained Minimization of Power approach, to separate signals from different directions. Hence, this technique makes it possible not only to measure the background electron densities accurately, but also to observe the structure and motion of FAIs simultaneously.

In this presentation, we briefly overview the signal processing procedure applied to the ionospheric observation of the PANSY radar, and show recent results from simultaneous observations of IS and FAIs, including some radar images of FAIs obtained by adaptive beamforming techniques.

[1] Hashimoto et al., 2018: “First incoherent scatter measurements and adaptive suppression of field-aligned irregularities by the PANSY radar at Syowa Station, Antarctic”, *J. Atmos. Oceanic Technol.*, conditional acceptance.

Keywords: PANSY, ionospheric incoherent scatter, adaptive signal processing, field aligned irregularities, Antarctic Syowa Station, IS radar

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-EM15] Study of coupling processes in solar-terrestrial system

convener:Mamoru Yamamoto(Research Institute for Sustainable Humanosphere, Kyoto University), Yasunobu Ogawa(National Institute of Polar Research), Satonori Nozawa(Institute for Space-Earth Environment Research), Akimasa Yoshikawa(Department of Earth and Planetary Sciences, Kyushu University), Chairperson:Yasunobu Ogawa

The Earth accepts vast input of energy and material from the Sun. The Earth's environment is maintained by the balance between their inputs and outputs. It is therefore important to study energy and mass transport on the Earth. This is an international session that discusses studies of the coupling processes in the Sun-Earth system based on the project "Study of coupling processes in solar-terrestrial system" that was approved by the Master Plan 2011/2014/2017 of Science Council of Japan. We continue proposing the project to the Master Plan 2020. The facilities and networks included are Equatorial MU Radar (EMU) in Indonesia to study the whole equatorial atmosphere, the EISCAT_3D radar system in northern Scandinavia to study detailed structures and elementary processes of the magnetosphere-ionosphere coupling in the polar region, and global networks of various ground-based instruments and observation data. We will show the current status of the project and discuss sciences by soliciting variety papers. This session is open to the world, and we strongly encourage submission of papers related to other facilities and projects, i.e., atmospheric or incoherent scatter radars, observation networks, satellites, and simulation or theoretical studies, etc.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM15-12] Mini/Micro Satellite Constelaltion for the study of LAI coupling

*Koichiro Oyama[1,2,3] (1.Institute of Plasma and Space Sciences,National Cheng Kung Univ., Taiwan, 2.International Ceneter for Space Weather Sudy and Education, Kyushu Univ.,, 3.CoLtd. Asia Space Environment Research Consortium, Japan)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM15-13] Statistical study of daily and seasonal variation of the equatorial anomaly in Asia based on satellite-ground beacon experiment

*Yuki Sakamoto[1], Mamoru Yamamoto[1], Kornyanat Hozumi[2] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.National Institute of Information and Communications Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM15-14] Latest installation of FM-CW radar in Peru

*Akiko Fujimoto[1], Akihiro Ikeda[2], Akimasa Yoshikawa[3] (1.Kyushu Institute of Technology, 2.National Institute of Technology,Kagoshima College, 3.Kyushu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM15-15] **Understanding the OH Meinel Band Emissions on the Terrestrial Planets**

*Konstantinos S. Kalogerakis[1] (1.Center for Geospace Studies, SRI International, Menlo Park, California, U.S.A.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM15-16] Statistical study of Sporadic Sodium Layer (SSL) observed at Tromsø

*Satonori Nozawa[1], Takuo T. Tsuda[2], Norihito Saito[3], Toru Takahashi[4], Takuya Kawahara[5], Yasunobu Ogawa[4], Hitoshi Fujiwara[6], Satoshi Wada[3], Youhei Ogawa[1], Chris Hall[7], Asgeir Brekke[7] (1.Institute for Space-Earth Environment Research, 2.The University of Electro-Communications, 3.RIKEN Center for Advanced Photonics, 4.National Institute of Polar Research, 5.Faculty of Engineering, Shinshu University, 6.Faculty of Science and Technology, Seikei University, 7.UiT The Arctic University of Norway)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM15-17] Discussion on large-scale research project "Study of coupling processes in solar-terrestrial system" (2)

*Mamoru Yamamoto[1] (1.Research Institute for Sustainable Humanosphere, Kyoto University)

Mini/Micro Satellite Constelaltion for the study of LAI coupling

*Koichiro Oyama[1,2,3]

1. Institute of Plasma and Space Sciences,National Cheng Kung Univ., Taiwan, 2. International Ceneter for Space Weather Sudy and Education, Kyushu Univ.,, 3. CoLtd. Asia Space Environment Research Consortium, Japan

Recent Studies show that ionosphere influenced by Thunder cloud, Typhoon, Sudden Stratosphere warming, Earth quake, and so on. Possible atmosphere perturbation to generate Radio wave scintillation is still not confirmed by observation in spite of the long history of radio scintillation research. Since 1970’ s, no break through is found in ionosphere physics. The reason is the lack of information of the atmosphere below which is needed simultaneously with ionopshere information. We propose here the satellite constellation of /Pico /mini satellites combined with one /two small satellite (200-500 Kg). Pico/mini satellite should be constellation to measure basic ionosphere parameter. These are electron density, temperature, ion temperature, ion mass, electric field, and neutral wind at ionosphere height. Information on the atmospheric wind down to ground surface below 120 km should be simultaneously measured. This means that we need photometric instruments such as TIDI and SABAR accommodated in TIMED satellite or instruments to measure electromagnetic waves radiated by neutral particles. These observations can be done through international collaboration.

References

Oyama, K.-I., J. T. Jhou, J. T. Lin, M. L. Hsu , C. Lin ,Y. S. Wu, H. Liu, and K.Yumoto, Behavior of the northern ionosphere during 2009 Sudden Stratosphere Warming, J.Geophys.Res., doi:10.1002/2014JA020014, 2014

Chou, M. Y., C. C. H. Lin, J. Yue, H. F. Tsai, Y. Y. Sun, J. Y. Liu, and C. H. Chen (2017), Concentric traveling ionosphere disturbances triggered by Super Typhoon Meranti (2016), Geophys. Res. Lett., 44, 1219–1226, doi:10.1002/2016GL072205.

Oyama, K. -I., Y.Kakinami, ,J.Y.Liu, T.Kodama, and C.Y.Chen, Micro/mini satellites for earthquake studies - toward international collaboration, Advances in Geoscience, 21, 251- 256, 2010.

Oyama, K.-I., Y. Kakinami, J. Y. Liu, M. A. Abdu, and C. Z. Cheng, Anomalous Ion Density Latitudinal Distribution as a precursor of large earthquake, J.Geophys. Res., 116, A04319, doi:10.1029/2010JA015948, 2011

Keywords: EAI coupling, Satellite Obserbation, International Collaboartion

©2019. Japan Geoscience Union. All Right Reserved.

Statistical study of daily and seasonal variation of the equatorial anomaly in Asia based on satellite-ground beacon experiment

*Yuki Sakamoto[1], Mamoru Yamamoto[1], Kornyanat Hozumi[2]

1. Research Institute for Sustainable Humanosphere, Kyoto University, 2. National Institute of Information and Communications Technology

Studies of ionospheric structures by the satellite-ground beacon experiment were conducted in southeast Asia. We have deployed a meridional chain of five beacon receivers from 8S to 27N along 100E meridian, they showed meridional distribution of total-electron content (TEC) of the ionosphere. We revealed time and spatial variabilities of the equatorial anomaly in a certain period of time (Watthanasangmechai et al., 2014, 2015). The data analysis was, however, not easy mainly because of difficulty in estimating bias of the measurement to get the absolute TEC.
In this study, we developed the method of bias estimation. As a result, we can get TEC distribution by computers automatically. Using this method, we analyzed latitude distribution of TEC from Thai to Indonesia in 2012-2015. It is valuable to measure such latitudinal distribution of TEC in the wide latitudinal range from the ground fixed sites.
Using these data, we classified TEC distribution with the equatorial anomaly. It shows some distribution patterns depends on season or time. Classifying the TEC distribution data of LT14-17 and LT20-23, assuming after the formation of the equatorial anomaly (EIA), we take the average in 2012-2015. The plasma fountain makes the 2 peaks (northern and southern of the magnetic equator) in the TEC-Lat graph. In the northern hemisphere summer, the northern peak is larger than the southern one. In winter, the southern peak is larger than the northern one. Classifying the data of LT10-13, assuming the right after formation of the EIA. It shows the opposite result. In summer, the southern one is larger. In winter, the northern one is larger. We will compare these analysis results with atmospheric parameters from the whole atmosphere model GAIA and MSIS.

Keywords: total-electron content, equatorial anomaly

©2019. Japan Geoscience Union. All Right Reserved.

Latest installation of FM-CW radar in Peru

*Akiko Fujimoto[1], Akihiro Ikeda[2], Akimasa Yoshikawa[3]

1. Kyushu Institute of Technology, 2. National Institute of Technology,Kagoshima College, 3. Kyushu University

An FM-CW (Frequency Modulated Continuous Wave) radar is a type of HF (High Frequency) radar. The FM-CW radar can measure the range of target as well as Doppler shift for reflected radio waves from the target (e.g., ionized layer). From the observed Doppler shift, we can estimate east-west electric field in the ionosphere. Poole (1985) and Poole and Evans (1985) first used FM-CW radar for Doppler observation. Nozaki and Kikuchi (1987, 1988) made improvements to the design. We have installed three FM-CW stations along the Japanese longitude, at Japan, Russia and Philippine, in order to measure the electric fields that penetrate the ionosphere (Yumoto, 2006).

Our goals are, (i) to estimate EEJ (Equatorial Electrojet) structure including the generation, variance and modulation of EEJ, (ii) to understand the electrodynamics of EEJ and the generation mechanism of the Equatorial Spread F (ESF) associated with Plasma Bubbles (PBs) and (iii) to reveal the generation mechanisms of ULF pulsation waves at the lower and equatorial latitudes.

In 2018, the new FM-CW radar has been installed in Peru. This FM-CW observation will give the opportunity of the simultaneous ionospheric observation at the Japan local time and the opposite side of Japan (for example dayside and nightside). ICSWSE (International Center for Space Weather Science and Education, Kyushu University) also have the ground-based magnetometer network (MAGDAS) on the world including Peru MAGDAS chain. With the both magnetometer and FM-CW observations, we try to understand the energy transfer and propagation process from the poles to the equator, in the terms of the coupling the solar-magnetosphere-ionosphere-atmosphere.

We will give the detail and current status of FM-CW radar project.

©2019. Japan Geoscience Union. All Right Reserved.

Understanding the OH Meinel Band Emissions on the Terrestrial Planets

*Konstantinos S. Kalogerakis[1]

1. Center for Geospace Studies, SRI International, Menlo Park, California, U.S.A.

The OH Meinel band emissions, originating from vibrationally excited hydroxyl radicals, OH(v), represent some of the most important airglow features in the Earth's upper atmosphere. Such emissions were also observed on the night side of Venus during the Venus Express mission [*Piccioni et al.*, A&A 483, L29-L33 (2008)]. Data obtained by CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) aboard the MRO (Mars Reconnaissance Orbiter) revealed OH(v) emissions in the nightglow of Mars [*Clancy et al.*, Icarus 226, 272-281 (2013)]. Modeling studies have shown that the predicted OH(v) emission intensities can vary dramatically depending on the nature of the vibrational relaxation mechanism assumed [e.g., *García Muñoz et al.*, Icarus 176, 75-95 (2005)]. Despite several investigations, the details of all the relevant OH(v) relaxation kinetics and pathways are not well understood.

Our recent studies demonstrated a previously unknown, efficient pathway for vibrational relaxation of OH(v) by O atoms that couples the mesospheric OH(v) emissions with the CO_2 4.3-micron emission and resolves a long-standing problem of severe discrepancies between model predictions and observations of the 4.3-micron emission in the Earth's atmosphere [*Panka et al.* , ACP 17, 9751-9760 (2017); *Kalogerakis et al.*, GRL 43, 8835-8843 (2016)]. This recent breakthrough development highlights the importance of investigating the mechanistic details of OH(v) collisional energy transfer.

We will discuss our efforts to investigate OH(v) vibrational relaxation relevant to the atmospheres of the terrestrial planets. Important areas of interest are the key OH(v) vibrational relaxation rate constants at temperatures relevant to the altitude of the emission layer and the pathways of OH(v) vibrational energy relaxation. The Meinel OH(v) emissions can be used as an indicator of atmospheric composition, variability, circulation, gravity waves, and as a probe of local temperature. A detailed understanding of the sources and sinks of these emissions is a prerequisite before they can be reliably used as a proxy for the aforementioned processes.

Keywords: OH Meinel band emission, Nightglow, vibrational relaxation, Terrestrial planets

©2019. Japan Geoscience Union. All Right Reserved.

Statistical study of Sporadic Sodium Layer (SSL) observed at Tromsø

*Satonori Nozawa[1], Takuo T. Tsuda[2], Norihito Saito[3], Toru Takahashi[4], Takuya Kawahara[5], Yasunobu Ogawa[4], Hitoshi Fujiwara[6], Satoshi Wada[3], Youhei Ogawa[1], Chris Hall[7], Asgeir Brekke[7]

1. Institute for Space-Earth Environment Research, 2. The University of Electro-Communications, 3. RIKEN Center for Advanced Photonics, 4. National Institute of Polar Research, 5. Faculty of Engineering, Shinshu University, 6. Faculty of Science and Technology, Seikei University, 7. UiT The Arctic University of Norway

Based on about 3000 hours of sodium density data obtained with the Tromsø sodium LIDAR over 7 year seasons between 2012 and 2018, we have identified about 40 events of Sporadic Sodium Layer (SSL) in the polar mesosphere and lower thermosphere (MLT) region. A SSL is a thin sodium layer (about 1-2 km) with high sodium density (usually factor of 2 or more higher than that of a normal layer), and its life time is about a few minutes to a few hours. We have investigated an occurrence rate of sporadic sodium layer (SSL) as well as necessary conditions for a SSL to form in the polar MLT region. SSLs appeared for shorter than 5 % of the overall observational time, indicating it is a rare event. Auroral electron precipitation as well as appearance of a sporadic E layer would be necessary conditions to form a SSL.

The sodium LIDAR at Tromsø (69.6 deg N, 19.2 deg E) has made simultaneous five directional (vertical position, plus 4 horizontal positions with zenith angle = 30 deg or 12.5 deg and azimuth = 0, 90, 180, 270 deg) observations, and has obtained about 3000 hours of temperature, sodium density, and wind data between October 2012 and February 2019. Analyzing the datasets with temporal and height resolutions of 3 min and 500 m, respectively, we have identified about 40 SSL events over the seven winter seasons. By utilizing five point observations, we have determined if a SSL was in-situ generated or was advected. Most SSLs show feature of advection (systematic and similar temporal variations of sodium density), indicating associated sharp rise of sodium density, whose mechanism has long been not understood, can be explained with an advection effect.

Observational results can be summarized as follows:
(1) most SSLs found are probably advected, (2) ionization of aurora would be a necessary condition, (3) sporadic E (Es) layers are almost always associated, (4) local time dependence of appearance of SSL is found, suggesting convectional electric field and semidiurnal tide would play an important role. We will address a generation mechanism of SSL.

Keywords: Sodium layer, Tromso, SSL, Es layer, Sodium LIDAR

©2019. Japan Geoscience Union. All Right Reserved.

Discussion on large-scale research project "Study of coupling processes in solar-terrestrial system" (2)

*Mamoru Yamamoto[1]

1. Research Institute for Sustainable Humanosphere, Kyoto University

The large-scale research plan "Study of coupling processes in solar-terrestrial system" is recognized in the important projects in Master Plan 2014 and 2017. We are currently preparing for a continuous proposal to Master Plan 2020. In this international session, we will apply discussion time in order to proceed the research plan.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 104 1F

[A-AS02] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Kosuke Ito(University of the Ryukyus), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Chairperson:Sachie Kanada(Nagoya University), Akiyoshi Wada(Meteorological Research Institute)

Tropical cyclones (TC) sometimes cause destructive disasters in many countries by torrential rainfall, strong wind, storm surge, and high surf. In 2008, the western Japan suffered a record-breaking heavy rainfall related to Typhoon Prapirooon (2018) in July. Furthermore, two Category 4 typhoons, typhoons Jebi (2018) and Trami (2018), made landfalls on the western Japan in September and caused devastating disasters over the Japanese Islands. In the Northern Atlantic, Hurricane Florence caused catastrophic damage in the eastern side of U.S. Recent studies reported a northward shift of the location where a TC achieved the peak intensity and also reported increases in the frequency of rapidly intensifying storms. Thus, understanding the TC processes related to translation, intensity change and precipitation in the changing climate, and to provide more accurate forecasts and long-term projections are essential for the earth and planetary science.
Advances in innovative observations such as meteorological aircraft, weather satellite, supercomputer systems such as the Earth Simulator and K-computer, and introduction of new methods such as the deep-learning, have led to novel development of numerical weather forecasting and understanding of the phenomena related to TCs in the past, present and future climates. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide a new direction for future TC researches.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AAS02-01] A GRAPES-based mesoscale EPS for TC forecasting: configuration and performance

*Xubin Zhang[1] (1.Institute of Tropical and Marine Meteorology, CMA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AAS02-02] **Evaluation of operational Ensemble based Global Forecast System prediction for Tropical Cyclones over the North Indian Ocean**

*Medha Deshpande[1], Radhika Kanase[1], R P M Krishna[1], Emmanuel Rongmie[1], P Mukhopadhyay[1] (1.IITM, Pune, INDIA)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS02-03] Structural Changes Preceding Rapid Intensification in Tropical Cyclones as shown in a Large Ensemble of Idealized Simulations

*Yoshiaki Miyamoto[1], David S Nolan[2] (1.Faculty of Environment and Information Studies, Keio University, 2.Rosenstiel School of Marine and Atmospheric Science, University of Miami)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AAS02-04] Potential impacts of tropical cyclone inner-core convective activity on the predictability of rapid intensification

*Masashi Minamide[1], Derek J. Posselt[1] (1.Jet Propulsion Laboratory, california institute of technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS02-05] A link between high-speed solar wind streams and rapid intensification of tropical cyclones

*Paul Prikryl[1,2], Lidia Nikitina[2], Vojto Rušin[3] (1.Physics Department, University of New Brunswick, Fredericton, NB, Canada, 2.Geomagnetic Laboratory, Natural Resources Canada, Ottawa, ON, Canada, 3.Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovak Republic)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS02-06] Influence of Tropical Lower Stratospheric Cooling on Extreme Deep Convective Activity and Tropical Cyclones

*Kunihiko Kodera[1], Nawo Eguchi[2], Rei Ueyama[3], Beatriz M Funatsu[4], Chantal Claud[5] (1.Meteorological Research Institute, 2.Kyushu University, 3.NASA Ames Research Center, 4.Université de Nantes, 5.Ecole Polytechnique)

A GRAPES-based mesoscale EPS for TC forecasting: configuration and performance

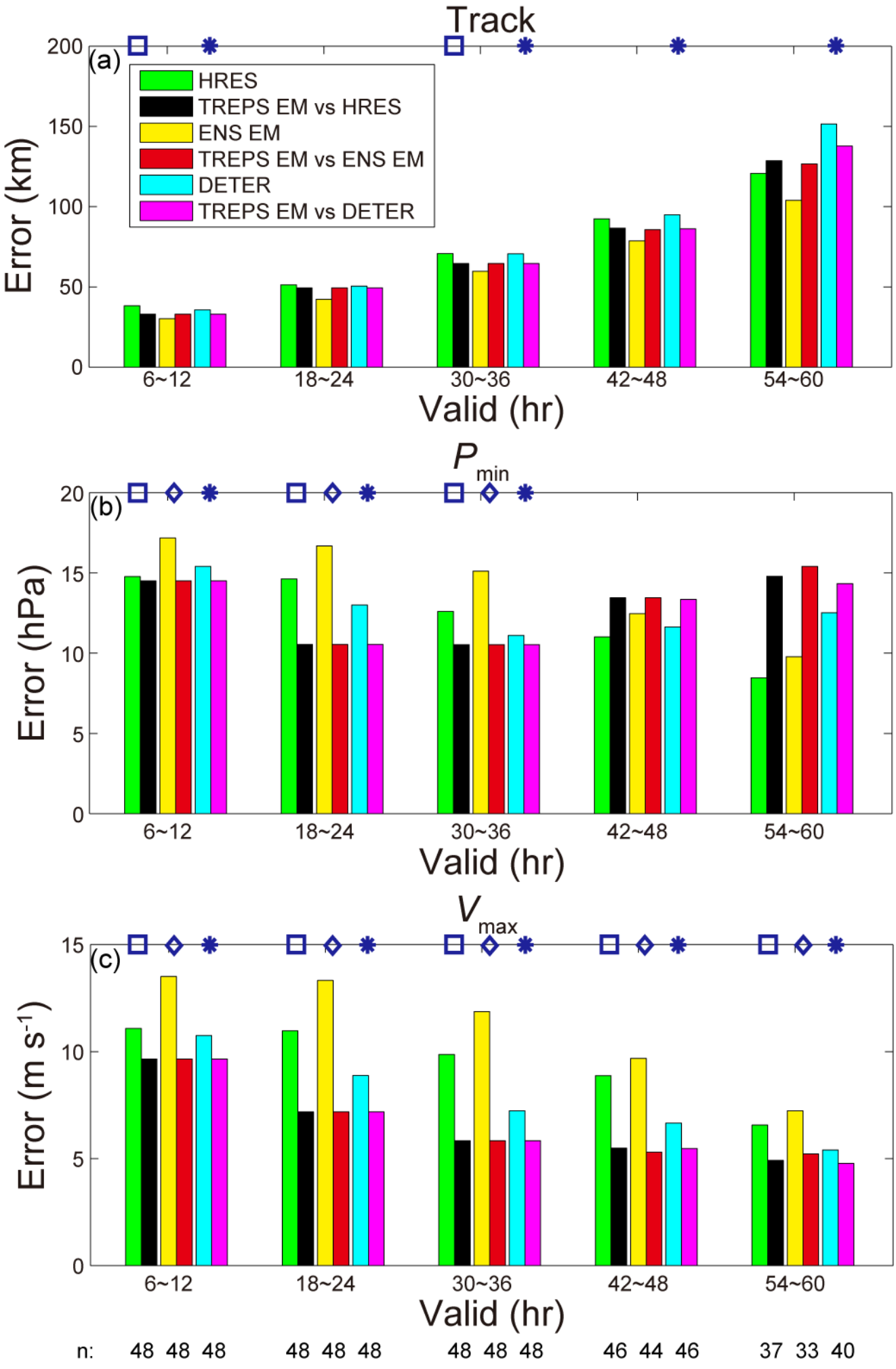
*Xubin Zhang[1]

1. Institute of Tropical and Marine Meteorology, CMA

To improve short-range tropical cyclone (TC) forecasting in China from both deterministic and probabilistic standpoints, a mesoscale ensemble prediction system (TREPS) based on the Global/Regional Assimilation and Prediction System (GRAPES) is constructed as a planned operational system. TREPS comprises one unperturbed and 30 perturbed forecasts ranging up to 60 h at horizontal resolution of 9 km. Downscaling perturbations from the ECMWF ensemble prediction system (ENS) are used to generate initial perturbations by blending them with balanced random perturbations implemented around the TC and to generate perturbations for lateral boundary conditions. The surface temperature around the TC is also perturbed, with a combination of multi-physics and stochastically perturbed parametrization tendencies considered to represent uncertainties in the model physics. These perturbation methods contribute a full-area, multi-scale and multi-variable mutual complement to increasing forecast perturbations. TREPS is evaluated for 19 TCs making landfall in China during 2014–2016. For deterministic guidance, TREPS significantly improves TC forecasting for intensity, rainfall and wind compared to ECMWF deterministic and ensemble forecasts. TREPS demonstrates significant advantages over its deterministic forecasts in predicting track, intensity, (extremely) heavy rainfall and wind. Furthermore, TREPS effectively reduces the degree of underdispersion in intensity forecasting compared to ENS. For probabilistic forecasting, TREPS outperforms ENS in accurately predicting extremely heavy rainfall and (extremely) strong wind owing to its better discriminating ability, but performs worse in predicting modest wind, light and heavy rainfall. Two post-processing techniques –optimal member and optimal probability –to improve, respectively, deterministic and probabilistic guidance of TREPS in rainfall and wind forecasting are proposed. The former is shown to be effective only for light rainfall, while the latter demonstrates consistent (partial) improvements in rainfall (wind). The superiorities and inferiorities of TREPS, as well as possible reasons for these, are intuitively illustrated in a case-study for Rammasun.

Keywords: ensemble prediction system, mesoscale, tropical cyclone

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of operational Ensemble based Global Forecast System prediction for Tropical Cyclones over the North Indian Ocean

*Medha Deshpande[1], Radhika Kanase[1], R P M Krishna[1], Emmanuel Rongmie[1], P Mukhopadhyay[1]

1. IITM, Pune, INDIA

The importance of accurate prediction of Tropical Cyclone (TC) genesis, rapid intensity changes, location and intensity during landfall is well known. Reliable prediction of these at 3-5 days lead time is crucial for disaster managing point of view. Bearing in mind the uncertainty in initial condition and model physics there was a need for high resolution ensemble based forecast system for region specific probabilistic prediction of weather over India. Considering this along with the existing Global Forecast System deterministic model (GFS T1534), the ensemble forecast system GEFS (T 1534) with 20 members is implemented and is in operation since June 2018 for the probabilistic prediction.

This paper evaluates the skill of operational high resolution (12.5 km) modelling system in predicting track and intensity of recent cases of TCs over North Indian Ocean at various lead time. Ensemble prediction of tracks of cyclones and its strike probability are evaluated. Ensemble mean track is better than the deterministic track particularly at longer lead time (figure 1). The vertical thermo-dynamic structure at the mature stage of the cyclone is well captured by the deterministic model. Evaluation of deterministic model (figure 2) specify average track error is ranging from < 100 km at Day 1 lead up to about 280 km at day 5 lead time and average error in intensity prediction is ranging from 10 kt –20 kts. In general model indicates early intensification and slightly overestimates the peak intensity in majority of the cases. It is challenging to predict the variation in the intensity. Skill in the prediction of genesis is also evaluated by calculating Genesis Potential Index (GPI). Further developments like improving the physics and dynamics of the model along with use of proper land use land cover data are underway.

Keywords: Tropical Cyclones, North Indian Ocean, High Resolution ensemble Prediction System

©2019. Japan Geoscience Union. All Right Reserved.

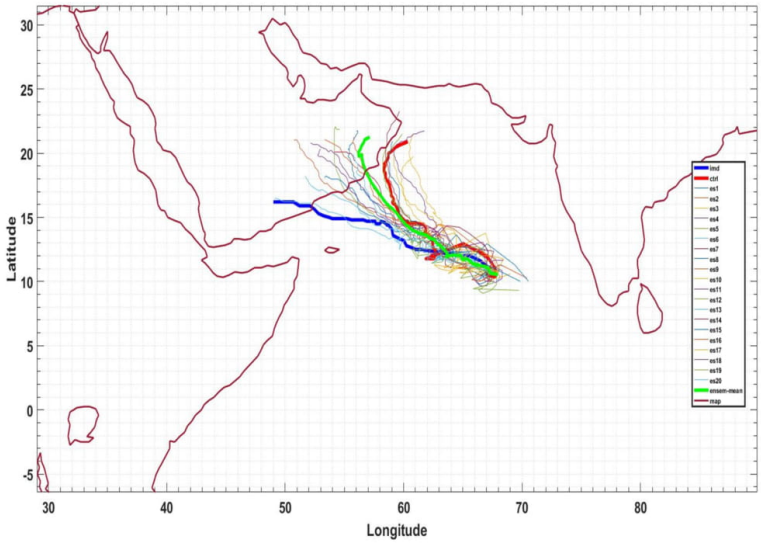


Figure1: Ensemble prediction of tracks based on 6 Oct Initial Condition for the case of Luban (6-14 Oct 2018)

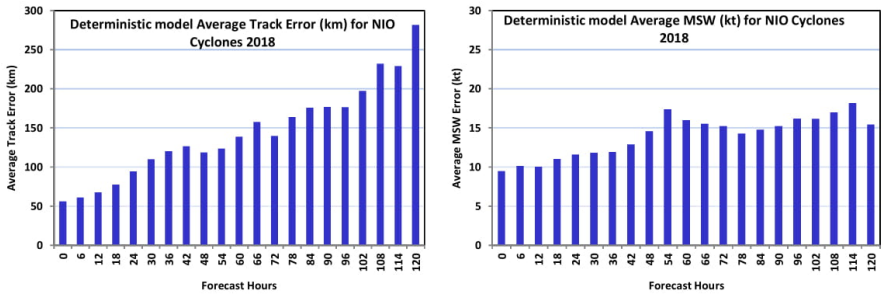


Figure 2: Deterministic model (GFS (T1534) average Track and intensity error for NIO cyclones 2018

©2019. Japan Geoscience Union. All Right Reserved.

Structural Changes Preceding Rapid Intensification in Tropical Cyclones as shown in a Large Ensemble of Idealized Simulations

*Yoshiaki Miyamoto[1], David S Nolan[2]

1. Faculty of Environment and Information Studies, Keio University, 2. Rosenstiel School of Marine and Atmospheric Science, University of Miami

Structural changes that precede rapid intensification (RI) of tropical cyclones (TCs) are examined in a full physics model by conducting a large ensemble (270) of simulations.

The processes leading to RI in a representative case with moderate shear are consistent with previous studies for weakly sheared cases. The most distinct changes are that the vortex tilt and the vortex size begin to decrease more rapidly 6 h before the onset of RI.

A vorticity budget analysis for the upper layer around the low--level center reveals that the vertical vorticity is increased by vertical advection, stretching, and tilting terms before RI, whereas the horizontal advection is small. Thus, the upright vortex structure is not achieved through a vortex alignment process, but rather is built upward by deep convection.

The ensemble simulations are generated by changing the intensity and size of the initial vortex, the magnitude of vertical wind shear, and the translation speed. The ensemble members that show RI are consistent with the control case and many previous studies:

before the onset of RI, the intensity gradually increases, the radius of maximum tangential velocity (RMW) decreases, the flow structure becomes more symmetric, the vortex tilt decreases, and the radius of maximum convergence approaches the radius of maximum winds.

A dimensionless parameter representing a tendency for the formation of the vertically upright structure is considered.

The product of this parameter and the local Rossby number is significantly larger for TCs that exhibit RI in the next 24 hours.

Keywords: Tropical Cyclone, Rapid Intensification

©2019. Japan Geoscience Union. All Right Reserved.

Potential impacts of tropical cyclone inner-core convective activity on the predictability of rapid intensification

*Masashi Minamide[1], Derek J. Posselt[1]

1. Jet Propulsion Laboratory, california institute of technology

Predictions of significant changes in tropical cyclone (TC) intensity, such as rapid intensification (RI), have emerged as a more challenging topic than forecasting TC tracks, since intensification of TCs involves multi-scale physical processes with significant contributions from convective-scale phenomena. Before the onset of RI, intensifying TCs are known to experience a precession process, in which tilted vortex rotates counter-clockwise to develop axisymmetric structure. From both modeling and observational studies, there is an agreement in the qualitative features of precession process among TCs, but the quantitative features, such as the vortex tilt magnitude, the duration of the precession process and whether or not the vortex is able to complete the precession process, vary among TCs. The predictability of the variety of precession process and subsequent RI is reported to be ultimately dominated by the chaotic nature of moist convection. Given the large influence of RI on the TC intensity forecasts, the further understandings in its uncertainty sources are necessary.

In this study, mechanisms that determine the variability of these precession processes are explored through sets of sensitivity and ensemble forecast experiments. We have used the Pennsylvania State University's experimental real-time ensemble Kalman filter analysis of Hurricane Harvey (2017) that assimilated GOES-16 all-sky satellite radiances (which has an equivalent monitoring capability to Himawari-8) in convection-permitting Weather Research and Forecasting model (WRF-ARW) simulations. This analysis resulted in a highly accurate forecast of intensity and track, and realistically represented the storm's rapid intensification. Starting with an analysis based on 18 hours of cycling data assimilation, we have conducted sensitivity experiments in which we reduced the initial atmospheric moisture amount by 5 to 20 %. Even initialized with the same wind field, and with fully developed convective updrafts and organization, the vortex tilt magnitude and the duration of precession are significantly modified by the inner-core moist processes. We explore the characteristics of the vortex structures that underwent short/long/uncompleted precession process, together with the theoretical background for these varieties of precession process by using a simplified toy-model. The results have implications for the design of future observation networks tasked with providing constraint on predictions of convections and rapidly intensifying tropical cyclones.

Keywords: tropical cyclones, numerical weather prediction, all-sky satellite radiance, convection

©2019. Japan Geoscience Union. All Right Reserved.

A link between high-speed solar wind streams and rapid intensification of tropical cyclones

*Paul Prikryl[1,2], Lidia Nikitina[2], Vojto Rušin[3]

1. Physics Department, University of New Brunswick, Fredericton, NB, Canada, 2. Geomagnetic Laboratory, Natural Resources Canada, Ottawa, ON, Canada, 3. Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovak Republic

Physical processes responsible for changes of tropical cyclone intensity are not well understood [1]. To improve the current understanding of tropical cyclone structure and intensity changes the future research needs to focus on response to all external forcing [2]. We examined rapid intensification of tropical storms in the context of solar wind coupling to the magnetosphere-ionosphere-atmosphere system. Tropical cyclone “best tracks” in the southern and northern hemispheres are used in the superposed epoch analysis of time series of solar wind parameters. The results indicate that rapid intensification of tropical storms tends to follow arrivals of high-speed solar wind from coronal holes and coronal mass ejections [3]. The ensuing auroral and polar cap activity including ionospheric currents and ionospheric convection generates atmospheric gravity waves that propagate from the high-latitude lower thermosphere both upward and downward [4,5,6]. If ducted in the lower atmosphere, they can reach tropical troposphere. Despite significantly reduced wave amplitude, but subject to amplification upon reflection in the upper troposphere, these gravity waves can trigger/release moist instabilities to initiate convective bursts, with the latent heat release leading to intensification of storms [7]. Convective bursts have been linked to rapid intensification of tropical cyclones. Tropical cyclone intensifications are preceded by atmospheric gravity waves generated by the solar wind magnetosphere-ionosphere-atmosphere coupling process. The gravity waves are observed in the ionosphere as traveling ionospheric disturbances. Their propagation in the lower atmosphere is examined by ray tracing in a model atmosphere to show that they can reach tropical cyclones. It is suggested that the interaction of aurorally-generated gravity waves with the tropical cyclone vortex and the inner primary eyewall could play a role in the intensification process. Assuming that quasi-periodic convective bursts lead to vortex waves, a two-dimensional barotropic approximation [8] is used to obtain asymptotic solutions representing propagation of vortex waves. The absorption of vortex waves by the mean flow in the critical layer leads to formation of the secondary eyewall and ultimately to a process of eyewall replacement cycle, one of the well-established paradigms of intensity changes in tropical cyclones [9].

[1] Kaplan J., et al., Wea. Forecasting, 25, 220–241, 2010. https://doi.org/10.1175/2009WAF2222280.1
[2] Wang Y., Wu C.-C., Meteor. Atmos. Phys., 87, 257–278, 2004.
[3] Prikryl P., et al., J. Atmos. Sol.-Terr. Phys., 183, 36-60, 2019. https://doi.org/10.1016/j.jastp.2018.12.009.
[4] Mayr H.G., et al., J. Geophys. Res., 89, 10929–10959, 1984.
[5] Mayr H.G., et al., Space Sci. Rev. 54, 297–375, 1990.
[6] Prikryl P., et al., Ann. Geophys., 23, 401–417, 2005. doi:10.5194/angeo-23-401-2005
[7] Prikryl P., et al., Ann. Geophys. 27, 31–57, 2009. https://doi.org/10.5194/angeo-27-31-2009.
[8] Nikitina L.V., Campbell L.J., Stud. Appl. Math., 135, 377–446, 2015.
[9] Willoughby H.E., et al., J. Atmos. Sci., 39, 395–411, 1982.

Keywords: Solar wind-magnetosphere-ionosphere-atmosphere coupling, High-speed solar wind stream, Atmospheric gravity wave, Extratropical and tropical cyclones

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Influence of Tropical Lower Stratospheric Cooling on Extreme Deep Convective Activity and Tropical Cyclones

*Kunihiko Kodera[1], Nawo Eguchi[2], Rei Ueyama[3], Beatriz M Funatsu[4], Chantal Claud[5]

1. Meteorological Research Institute, 2. Kyushu University, 3. NASA Ames Research Center, 4. Université de Nantes, 5. Ecole Polytechnique

In previous studies we showed that stratospheric sudden warming (SSW) event can induce rapid cooling in the tropical stratosphere and impact on the tropical convective activity. Case studies on two large SSWs in January 2009 and January 2010, showed that convective activity increased along ascending branch of the Hadley circulation in the austral summer hemisphere. It is also found that frequency of the convective overshooting clouds, and the tropical cyclones (TCs) increased following the tropical stratospheric cooling. Detailed analysis on the relationship between the tropical stratospheric cooling and tropical cyclones are made for 2010 January case. In January 2010, TCs have been generated one after another over Indian Ocean, Maritime continent, and Pacific sectors following a eastward propagation of convective active center associated with the Madden-Julian Oscillation (MJO) until rapid cooling started in the tropical stratosphere in late January. Then, after that, MJO became stationary over the central Pacific and TCs developed or re-developed simultaneously over 3 different sectors: Southwest Indian Ocean, Australia, and central Pacific. TC does not form over the lands, however, extreme deep convective activity simultaneously enhanced with the TCs over African and South American continents. It is suggested that a decrease of static stability in the tropical tropopause layer (TTL) due to a cooling in the lower stratosphere, produced favorable condition for the development of extreme deep convection. The increase of extreme deep convection around 15° S latitudinal zone following the tropical stratospheric cooling can be characterized as a strengthening of deep ascending branch of the Hadley circulation connected to the Brewer-Dobson circulation.

Keywords: tropical cyclone, stratosphere, deep convection

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 104 1F

[A-AS02] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Kosuke Ito(University of the Ryukyus), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Chairperson:Yoshiaki Miyamoto, Kosuke Ito(University of Ryukyus)

Tropical cyclones (TC) sometimes cause destructive disasters in many countries by torrential rainfall, strong wind, storm surge, and high surf. In 2008, the western Japan suffered a record-breaking heavy rainfall related to Typhoon Prapirooon (2018) in July. Furthermore, two Category 4 typhoons, typhoons Jebi (2018) and Trami (2018), made landfalls on the western Japan in September and caused devastating disasters over the Japanese Islands. In the Northern Atlantic, Hurricane Florence caused catastrophic damage in the eastern side of U.S. Recent studies reported a northward shift of the location where a TC achieved the peak intensity and also reported increases in the frequency of rapidly intensifying storms. Thus, understanding the TC processes related to translation, intensity change and precipitation in the changing climate, and to provide more accurate forecasts and long-term projections are essential for the earth and planetary science.
Advances in innovative observations such as meteorological aircraft, weather satellite, supercomputer systems such as the Earth Simulator and K-computer, and introduction of new methods such as the deep-learning, have led to novel development of numerical weather forecasting and understanding of the phenomena related to TCs in the past, present and future climates. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide a new direction for future TC researches.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[AAS02-07] A change in the inner-core structure of Typhoon Trami (2018) as observed through upper-tropospheric aircraft reconnaissance of T-PARCII

★Invited Papers

*Hiroyuki Yamada[1], Kazuhisa Tsuboki[2], Taro Shinoda[2], Hisayuki Kubota[3], Yukihiro Takahashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Tadayasu Ohigashi[5], Kosuke Ito[1], Munehiko Yamaguchi[6], Tetsuo Nakazawa[6] (1.University of the Ryukyus, 2.Nagoya University, 3.Hokkaido University, 4.Meisei Electric, 5.National Research Institute for Earth Science and Disaster Resilience, 6.Meteorological Research Institute, Japan Meteorological Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS02-08] **Dramatic changes in the inner-core structure of Typhoon Jebi (2018) at landfall and relationship between a mesovortex and strong wind gusts**

*Udai Shimada[1], Ryo OYAMA[1], shingo shimizu[2] (1.Meteorological Research Institute, 2.National Research Institute for Earth Science and Disaster Prevention)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS02-09] **Revisiting Asymmetric CAPE in Sheared Tropical Cyclones**

*Qingqing Li[1] (1.NUIST Nanjing University of Information Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS02-10] **Observed rainfall asymmetry of tropical cyclone in the process of making landfall in Guangdong, South China**

*Guanhuan Wen[1] (1.Guangzhou Institute of Tropical and Marine Meteorology, China Meteorological Administation)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS02-11] Volumetric Detection of Tornadic Vortices Associated with Typhoon Nanmadol (2017) Using PAWR and Deep Learning

*Toru Adachi[1], Naoki Ishitsu[2], Kenichi Kusunoki[1], Hanako Inoue[1], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3] (1.Meteorological Research Institute, 2.Alpha Denshi/Meteorological Research Institute, 3.East Japan Railway Company)

A change in the inner-core structure of Typhoon Trami (2018) as observed through upper-tropospheric aircraft reconnaissance of T-PARCII

*Hiroyuki Yamada[1], Kazuhisa Tsuboki[2], Taro Shinoda[2], Hisayuki Kubota[3], Yukihiro Takahashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Tadayasu Ohigashi[5], Kosuke Ito[1], Munehiko Yamaguchi[6], Tetsuo Nakazawa[6]

1. University of the Ryukyus, 2. Nagoya University, 3. Hokkaido University, 4. Meisei Electric, 5. National Research Institute for Earth Science and Disaster Resilience, 6. Meteorological Research Institute, Japan Meteorological Agency

Upper-tropospheric aircraft reconnaissance with dropsonde deployment using a Gulfstream-II aircraft was carried out for the inner core of Typhoon Trami on four successive days since 25 September 2018. According to the JMA best track, the central pressure reached its minimum value of 915 hPa on the first day and was subsequently maintained at 950 hPa for three days. Using dropsonde data, this study examined the change in the inner-core structure associated with the intensity change. Based on satellite imagery, this intensity change was associated with the rapid expansion of the eye (with radius increasing from 35 to 90 km) and the gradual increase in the eyewall cloud-top height. A composite analysis of dropsonde profiles in the radius-height domain on each day revealed a change in the flow structure, with the decrease (increase) in the tangential wind component near the radius of 40 km (120 km). This caused an increase in the radial gradient of angular momentum, corresponding to an increase in inertial stability. These results suggest that this typhoon underwent the structural change similar to eyewall replacement cycle while the central pressure was maintained.

Acknowledgements: This work was supported by JSPS KAKENHI Grant Numbers JP16H06311, JP16H04053, JP18H03805, and the Science and Technology Research Partnership for Sustainable Development (SATREPS) Understanding Lightning and Thunderstorm (ULAT) project.

Keywords: aircraft reconnaissance, tropical cyclone, western North Pacific

©2019. Japan Geoscience Union. All Right Reserved.

Dramatic changes in the inner-core structure of Typhoon Jebi (2018) at landfall and relationship between a mesovortex and strong wind gusts

*Udai Shimada[1], Ryo OYAMA[1], shingo shimizu[2]

1. Meteorological Research Institute, 2. National Research Institute for Earth Science and Disaster Prevention

Landfalling tropical cyclones experience dramatic structural changes due to increased friction, topography, reduced surface heat fluxes, and reduced moisture supply. Typhoon Jebi (2018) made landfall in Shikoku Island on September 4, 2018, and then it caused record-breaking gust wind speeds greater than 40 m s^{-1} and heavy rainfall greater than 50 mm h^{-1} along its track. Dramatic changes in the inner-core structure of Jebi at landfall and the relationship between heavy rainfall and strong wind gusts, and structural features were examined by using observations. The azimuthal-mean structure of Jebi after landfall shows that while the tangential wind at 1-km altitude decreased from 45 m s^{-1} to 30 m s^{-1}, the structure became more compact, with the radius of maximum wind (RMW) at ~50 km and radar reflectivity increasing inside the RMW at altitudes from 1 to 5 km. Because of increasing forward speed and active convection inside the RMW, maximum wind speed below 6-km altitude did not decrease significantly even after landfall. Inside the RMW, a mesovortex with a scale of 50 km formed in the downshear-left quadrant. The formation of the mesovortex was likely attributed to dynamically forced updraft associated with the storm vortex tilted by vertical wind shear and attributed to tilting of horizontal vorticity associated with the convergence of enhanced frictional inflow. The mesovortex contributed to the strong wind gusts and heavy rainfall. Also, the fast forward speed of more than 15 m s^{-1} increased wind gusts on the right-hand side of Jebi’ s track.

Keywords: landfalling tropical cyclones, radar analysis, mesovortices

©2019. Japan Geoscience Union. All Right Reserved.

Revisiting Asymmetric CAPE in Sheared Tropical Cyclones

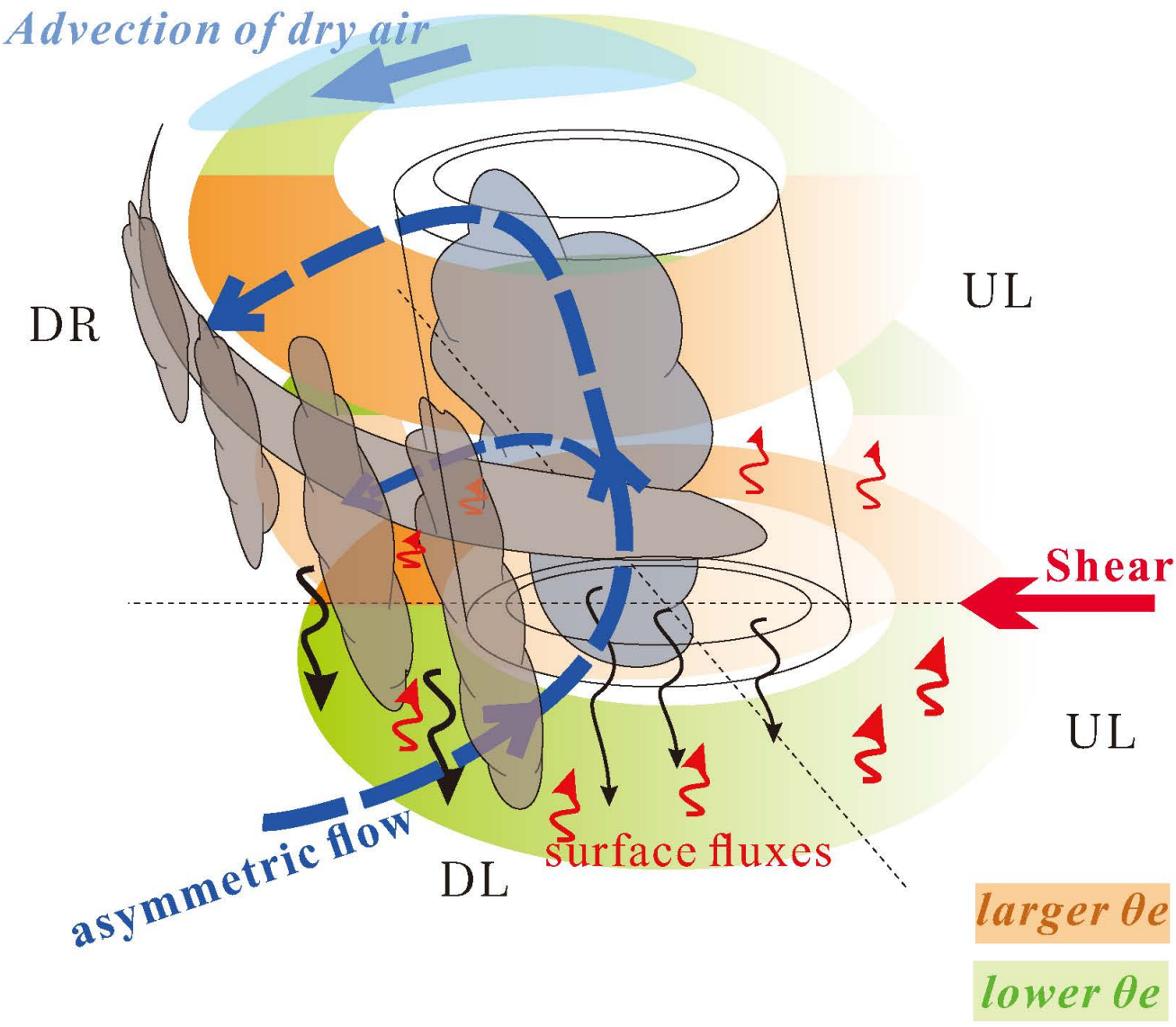
*Qingqing Li[1]

1. NUIST Nanjing University of Information Science and Technology

This study numerically revisits the characteristics and physical processes of azimuthally asymmetric convective available potential energy (CAPE) in the outer cores of vertically sheared tropical cyclones (TCs), which has been observed previously. The results indicate that a downshear-upshear contrast in CAPE occurs in weakly sheared TCs as pointed out in prior studies, while an enhanced downshear left-downshear right contrast is found in strongly sheared storms. Specifically, less (larger) CAPE values arise downshear left (right) under large shear environments. Downward transport of low entropy by the convective and mesoscale downdrafts in principal rainbands reduces the equivalent potential temperature (θe) in the downshear-left boundary layer, whereas positive horizontal advection by the asymmetric outflow contributes to the presence of a mid-level maximum of θe in the same quadrant. Resultantly, lower outer-core CAPE is present downshear left. In the downshear-right quadrant, a lack of convective downdrafts together with surface fluxes leads to higher θe in the boundary layer. The intrusion of dry air by ventilation produces lower θe in the upper troposphere on the right of the shear. Larger CAPE values thus arise downshear right. The effects of such azimuthally asymmetric CAPE on TC structure and intensity are also discussed.

Keywords: tropical cyclone, CAPE, shear

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Observed rainfall asymmetry of tropical cyclone in the process of making landfall in Guangdong, South China

*Guanhuan Wen[1]

1. Guangzhou Institute of Tropical and Marine Meteorology, China Meteorological Administation

This study investigates the rainfall asymmetry of tropical cyclones (TCs) in the process of making landfall in Guangdong (GD), South China, on the basis of satellite-based and reanalysis precipitation data. We mainly focus on TC rainfall asymmetry, its main influencing factor, and its change in the process of landfall, and the difference between different ENSO phases. The results reveal that vertical wind shear (VWS) is the dominant influencing factor of TC rainfall asymmetry in GD. The rainfall maximum is located in downshear left of VWS. The TC rainfall asymmetry has little change in the process of making landfall, though the rain rate decreases. Both the phase and amplitude of TC rainfall asymmetry have no significant change from 24 hours prior to landfall to 12 hours after landfall. The rainfall maximum steadily lies in downshear left. The amplitude of rainfall asymmetry is about 50%, suggesting that the asymmetric rainfall is about half of the axisymmetric rainfall. There is no obvious difference in TC rainfall asymmetry between El Niño, La Niña, and neutral years.

Keywords: Tropical cyclone, Rainfall asymmetry, TRMM, Vertical wind shear

©2019. Japan Geoscience Union. All Right Reserved.

Volumetric Detection of Tornadic Vortices Associated with Typhoon Nanmadol (2017) Using PAWR and Deep Learning

*Toru Adachi[1], Naoki Ishitsu[2], Kenichi Kusunoki[1], Hanako Inoue[1], Ken-ichiro Arai[2], Chusei Fujiwara[3], Hiroto Suzuki[3]

1. Meteorological Research Institute, 2. Alpha Denshi/Meteorological Research Institute, 3. East Japan Railway Company

Tornadoes spawned by miniature supercells associated with typhoon are one of critical issues for disaster risk reduction in Japan. However, it is not easy to monitor and predict their occurrence because the parent storm is considerably small compared with classic-type tornadic supercell. We try to overcome this problem by combining cutting-edge technologies using rapid-scan phased array weather radar (PAWR) and deep learning analysis. We present a case study of tornado-like vortices which caused damages in Souka city, Saitama, during the approach of Typhoon Nanmadol (2017). We performed data analysis of two rapid-scan phased array weather radars operated by Meteorological Research Institute in Tsukuba and operated by Japan Radio Co., Ltd. in Chiba. To detect vortices from the PAWR-observed Doppler velocity data, we employed a vortex pattern finding scheme using convolutional neural network. Since PAWR carries out quasi-simultaneous observation of multi-elevational angles, we considered a group of vortices located in a radius of 4-km as a single vertically-extending volumetric vortex. By analyzing the spatiotemporal structure, we found a significant growth of a tornadic vortex about five minutes prior to its passage over the ground damage area. This finding suggests that a combination of rapid-scan PAWR observation and deep learning analysis is useful for monitoring and short-term forecasting of tornadoes associated with typhoon.

Acknowledgement: This work is supported by JSPS KAKENHI Grant 17K13007. In this analysis, we used PAWR data operated by Japan Radio Co., Ltd.

Keywords: Typhoon, Tornado, Phased Array Weather Radar, Deep Learning

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 104 1F

[A-AS02] Advances in Tropical Cyclone Research: Past, Present, and Future

convener:Sachie Kanada(Nagoya University), Akiyoshi Wada(Department of Typhoon and Severe Weather Research, Meteorological Research Institute), Kosuke Ito(University of the Ryukyus), Yoshiaki Miyamoto(Faculty of Environment and Information Studies, Keio University), Chairperson:Sachie Kanada(Nagoya University), Yoshiaki Miyamoto

Tropical cyclones (TC) sometimes cause destructive disasters in many countries by torrential rainfall, strong wind, storm surge, and high surf. In 2008, the western Japan suffered a record-breaking heavy rainfall related to Typhoon Prapirooon (2018) in July. Furthermore, two Category 4 typhoons, typhoons Jebi (2018) and Trami (2018), made landfalls on the western Japan in September and caused devastating disasters over the Japanese Islands. In the Northern Atlantic, Hurricane Florence caused catastrophic damage in the eastern side of U.S. Recent studies reported a northward shift of the location where a TC achieved the peak intensity and also reported increases in the frequency of rapidly intensifying storms. Thus, understanding the TC processes related to translation, intensity change and precipitation in the changing climate, and to provide more accurate forecasts and long-term projections are essential for the earth and planetary science.
Advances in innovative observations such as meteorological aircraft, weather satellite, supercomputer systems such as the Earth Simulator and K-computer, and introduction of new methods such as the deep-learning, have led to novel development of numerical weather forecasting and understanding of the phenomena related to TCs in the past, present and future climates. In this session, we welcome papers on various aspects of TC studies. We hope that the session will provide a new direction for future TC researches.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AAS02-12] Evaluation of the monthly Potential of the 2018 typhoon activity and the effect of the positive PMM and SST of the eastern northwestern Pacific

*Takahiro Ishiyama[1], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AAS02-13] **Contributions of different time scale variations to tropical cyclogenesis over the western North Pacific**

*Xi Cao[1] (1. Institute of Atmospheric Physics, Chinese Academy of Sciences)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AAS02-14] Binary interaction between TC Chanthu (2016) and a nearby cold low

*Kosuke Ito[1], Miyabi Higa[1], Johnny Chan[2] (1.University of the Ryukyus, 2.City University of Hong Kong)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AAS02-15] **Response of landfalling North Indian Ocean cyclonic disturbances to warming climate and associated environmental parameters**

*JAGABANDHU PANDA[1], KASTURI SINGH[1] (1.Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, India)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS02-16] **Rainfall contribution of North Indian Ocean cyclonic disturbances over India in a warming climate**

*KASTURI SINGH[1], JAGABANDHU PANDA[1] (1.Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, India)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS02-17] Analysis of typhoon tracks and associated precipitation amount over western Japan: A case study with Typhoon Nancy and Typhoon Jebi

*Sridhara Nayak[1], Tetsuya Takemi[1] (1.Disaster Prevention Research Institute, Kyoto University)

Evaluation of the monthly Potential of the 2018 typhoon activity and the effect of the positive PMM and SST of the eastern northwestern Pacific

*Takahiro Ishiyama[1], Masaki Satoh[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Typhoons in the northwest Pacific in 2018 exceeded the average for 29 occurrences, the number of landings to Japan to 5, and for the typhoon which became extreme strength it was updated with the most record and the activity was active. In the ENSO phase, La Niña phenomenon occurred in the beginning of 2018 but converged by early spring and El Niño phenomenon occurred in October. However, during the most active period of the typhoon (from June to November), the ENSO phase was still in a neutral state. Therefore, Pacific Meridional Mode (hereafter PMM) (Chiang and Vimont 2004) is focused recently. At the positive phase of PMM, a zone of warming sea surface temperature (hereafter SST) is formed in the northeast - southwest direction of 20 degrees north latitude, 120 degrees west latitude to 0 degrees north latitude and 180 degrees west longitude. Previous studies have pointed out that this positive PMM favors TC activities in the northwest Pacific (Zhang et al. 2016). Looking at the PMM index (SST) from 1948 to 2018, there was positive PMM in 2018 and the intensity was strong enough to be within 15th place of 71 in each month of active typhoon season. Especially, in August and September, strong positive PMM phenomenon was developed in 4th place and 2nd place.

The purpose of this research is to focus on the monthly SST variation such as ENSO and PMM and to evaluate the Potential of the 2018 typhoon activity. We also focus on the PMM and the SST over the eastern of northwest Pacific, and investigate how they affect the 2018 typhoon activity.

For the above purpose, we conducted perpetual experiments in which boundary conditions were fixed from July to October, respectively, using a nonhydrostatic model NICAM. The horizontal resolution was 56 km, and the number of vertical layers was 38 layers. In sensitivity experiments, PMM region and PMM + eastern northwest Pacific regions of SST in July 2018 sensitivity experiment 1 and sensitivity experiment 2 replaced with climate value were conducted. Comparing the experimental result of sea level pressure (hereafter SLP) with JRA-55, although the position of the maximum value of the high pressure in July is misaligned, the position and overhang of the high pressure does not differ greatly in each month, and perpetual experiments also reproduce the reality well. Both reanalysis and perpetual experiments have more typhoons in July and August than in September and October. Also, the occurrence position of the typhoon occurs more frequently in the eastern side of the northwestern Pacific in order of July, August, September. The same tendency was observed. Such differences in active areas of typhoon activity had an effect on the monsoon trough.
Subsequently, the SLPs of the 2018 experiment, sensitivity experiment 1 and sensitivity experiment 2 were compared. In comparison with the sensitivity experiment 1, the sensitivity experiment 1 became a lower pressure deviation in the west side of the northwest Pacific than 2018 experiment, whereas in the sensitivity experiment 2, the sensitivity experiment 2 had higher SLP in the whole northwest Pacific than 2018 experiment. From this, it was found that the positive SST deviation in the eastern northwest Pacific was more involved in the typhoon activity of 2018.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: tropical cyclone, Pacific Meridional Mode, nonhydrostatic model

©2019. Japan Geoscience Union. All Right Reserved.

Contributions of different time scale variations to tropical cyclogenesis over the western North Pacific

*Xi Cao[1]

1. Institute of Atmospheric Physics, Chinese Academy of Sciences

The present study investigates relative contributions of different time scale variations of environmental factors to the tropical cyclone (TC) genesis over the western North Pacific (WNP) during July-August-September-October (JASO). Distinct from previous studies that are concerned with large-scale spatial patterns during a certain period, the present study focuses on local and instantaneous conditions of the TC genesis. Analysis shows that the contribution of convection and lower-level vorticity to the TC genesis is mainly due to intraseasonal and synoptic variations. The contribution of vertical wind shear is largely related to synoptic variations. The contribution of mid-level specific humidity is almost two times more from intraseasonal variations than from synoptic variations. The contribution of sea surface temperature (SST) to the TC genesis is mainly due to interannual and intraseasonal variations. The barotropic energy for synoptic-scale disturbances during the TC genesis comes mainly from climatological mean flows over the southwest quadrant and from intraseasonal wind variations over the northeast quadrant of the WNP, respectively. The contribution of interannual variations to the TC genesis is enhanced over the southeast quadrant of the WNP. More TCs form under weak easterly and westerly vertical shears, respectively, during El Niño developing and decaying JASO. The contribution of interannual variations of SST tends to be larger during the El Niño decaying than developing JASO.

Keywords: tropical cyclone genesis, western North Pacific , different time scales

©2019. Japan Geoscience Union. All Right Reserved.

Binary interaction between TC Chanthu (2016) and a nearby cold low

*Kosuke Ito[1], Miyabi Higa[1], Johnny Chan[2]

1. University of the Ryukyus, 2. City University of Hong Kong

Tropical cyclone (TC) Chanthu (2016) caused the heavy rainfall and strong wind on Hokkaido Prefecture, Japan. However, this was one of the "busted" cases in which the track forecast error reached up to 900 km in a 72-h forecast by the Regional Specialized Meteorological Center (RSMC) Tokyo. In fact, the re-forecast experiment with Japan Meterological Agency Non-Hydrostatic Model (JMA-NHM) that employed Kain-Fritsch scheme as a convective parameterization correctly captured the observed northward translation speed of TC Chanthu, while the JMA Global Spectral Model (JMA-GSM) and JMA-NHM that employed Arakawa-Schubert scheme failed to predict the accurate northward translation speed. The mesoscale analysis showed that there was a cold low located at 200km west of TC Chanthu (2016). With Kain-Frische scheme, the binary interaction between TC Chanthu and the nearby cold low was reproduced so that it contributed the faster translation to the north as consistent with the best track. In contrast, the binary interaction was not reproduced in the simulations with Arakawa-Schubert scheme because a triggered large-scale convection made TC Chanthu and the nearby cold low merged. It exemplifies that the reproduction of fine-scale features diminishes "busted" cases, which contributes to the disaster prevention and mitigation.

Keywords: tropical cyclone, Fujiwhara effect, track forecast

©2019. Japan Geoscience Union. All Right Reserved.

Response of landfalling North Indian Ocean cyclonic disturbances to warming climate and associated environmental parameters

*JAGABANDHU PANDA[1], KASTURI SINGH[1]

1. Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, India

Most of the studies focusing on cyclonic disturbances (CDs) concentrate on their frequency. However, the system that causes destruction to nearby coastal areas is the landfalling one. The impact of warming climate on landfalling CD activity is an interesting topic. Thus, the present study focuses on the landfalling activity of CDs formed over North Indian Ocean (NIO) and associated environmental parameters responsible for the same. The study is divided into two epochs i.e. pre-warming period (PWP) 1891-1946 and current warming period (CWP) 1947-2016 based on the sea surface temperature anomaly variation.

Over NIO, nearly 88 and 84.80% of systems made landfall over coastal areas associated with Bay of Bengal (BOB) basin and the respective percentages are 53.03 and 39% for AS during PWP and CWP respectively. The percentage of landfalling CDs shows a decreasing and stable trend respectively during PWP and CWP for BOB sub-basin. Over AS, the Kendall’ s coefficients are found to be −0.255 and −0.0024 during PWP and CWP respectively. The study reveals that Bangladesh, Andhra Pradesh (AP), and Tamil Nadu (TN) are more vulnerable to severe cyclones formed over BOB during the current warming climate. Whereas, for Arabian Sea (AS) region, Gujrat (GJ) is prone to severe cyclones and Arabian Peninsula countries are vulnerable to cyclonic storms during the current warming climate. For pre-monsoon season, among all NIO coastal states, Bangladesh and Arakan face a greater number of CD landfalls during CWP for BOB systems. Whereas, for post-monsoon season, AP, TN and Bangladesh suffered maximum landfalls. The seasonal landfalling activity of CDs over AS shows that Arabian Peninsula is more vulnerable than GJ in pre-monsoon season during CWP. However, for post-monsoon season, both Arabian Peninsula and GJ are significantly prone to landfalling CDs. During PWP, most of the systems formed over middle sector of BOB recurve in north-eastward direction. Whilst, one climatological track is found to be recurving towards Bangladesh, another one is towards AP during CWP. CDs formed over southern sector of BOB prefers two tracks, one being westward towards TN and the other is in north-east direction towards Bangladesh during CWP. The enhanced genesis over southern and middle sector of BOB is mainly responsible for more landfalls over AP, TN and Bangladesh. The CDs formed over the eastern AS basin recurve to make landfall over GJ or Oman during PWP. However, during CWP, another preferable track towards Yemen is also seen for the systems formed over eastern AS.

The climatological vertically integrated (mass-weighted) tropospheric wind pattern near TN coast has changed direction from westward during PWP to north-westward during CWP (Figure 1), favouring more landfall over AP and TN. Over the central part near the latitude 14˚N, change in the magnitude has occurred with change in the direction of the winds from NW-N to NE. Because of the prevailing wind steering pattern, the systems that formed over the middle and southern BOB do not prefer to make landfall to WB and Odisha during CWP. Over AS, the wind is mostly directed towards GJ irrespective of the period considered, which favours more landfalling of CDs over the place. These winds are primarily part of mid-latitude westerly troughs. For BOB, the SST gradient is in meridional direction and hence most of the systems formed, suffer landfall over Indian coastal states and other rim countries face less landfalls. Over AS, SST gradient is zonally distributed and therefore, the eastward deflection of CDs is more observed, making the Indian state of GJ to be the most affected region. The study is expected to be helpful in the decision-making process in view of socio-economic impacts of landfalling CDs.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Cyclonic disturbances, North Indian Ocean, Landfall, Bay of Bengal, Arabian Sea

©2019. Japan Geoscience Union. All Right Reserved.

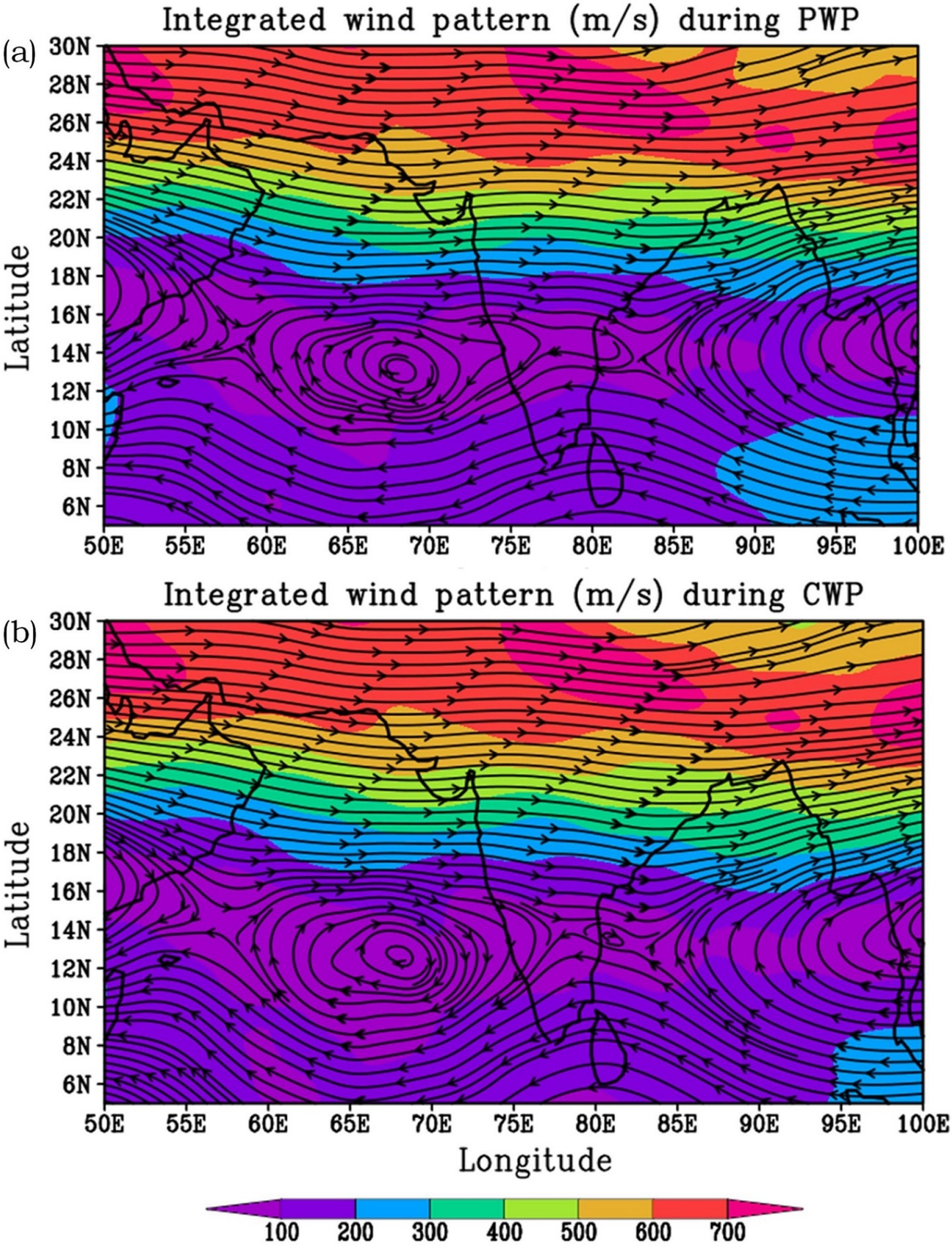


Figure 1: Climatological variation of mass weighted vertically integrated tropospheric wind magnitude (shaded) and wind pattern (vector) in m/s over NIO for the period 1891-2014 during PWP (a) and CWP (b). Here, NOAA-CIRES global re-analyses data set is used.

©2019. Japan Geoscience Union. All Right Reserved.

Rainfall contribution of North Indian Ocean cyclonic disturbances over India in a warming climate

*KASTURI SINGH[1], JAGABANDHU PANDA[1]

1. Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, India

Rainfall associated with cyclonic disturbances (CDs) poses mostly significant threat to the society. Such type of systems and their remnants are capable of producing heavy rainfall, which often produce flash flooding. The warming climate is considered from 1947 onwards based on sea surface temperature anomaly variation over North Indian Ocean (NIO) basin. Nearly 71.42% of CDs in pre-monsoon and 87.07% CDs in post-monsoon season crossed or gazed the Indian coast during 140 cyclone seasons of the warming climate. The trend for annual variation of CD rainfall (CDR) anomaly is decreasing along with CD anomaly during pre-monsoon season (P=4.89901E-15). The trend for CDR anomaly is observed to be almost stable while the CD anomaly is decreasing drastically (P=1) in the post-monsoon season, indicating increased amount of rainfall is contributed by CDs over India in this period.

Among eastern coastal states, Andhra Pradesh (AP), Tamil Nadu (TN), Mizoram, Tripura and among western coastal states, Kerala (KL), Karnataka (KA) and Gujarat (GJ) received most of the accumulated rainfall in pre-monsoon season. The rainfall contributed by CDs during pre-monsoon season is limited to the coastal districts of India only. However, the rainfall occurrences during post-monsoon season could penetrate up to very interior districts. During post-monsoon season, Odisha (OD), AP and TN received the highest rainfall contribution from CDs. Jharkhand, KL, KA, parts of Maharashtra (MH) and coastal GJ received significantly higher amount of rainfall in comparison to other interior places. Up to ~70% of rainfall is contributed by CDs over GJ, nearly 20-30% over AP and 15-18% over western Rajasthan during pre-monsoon (Figure 1). During post-monsoon season, considerable rainfall (60% of annual value) contribution is seen over all states. The trend in CD rainfall is observed to be increasing over western GJ, western Rajasthan, northeast AP and southeast OD during pre-monsoon months. The spatio-temporal trend of CD rainfall over Bihar, Jharkhand, northern OD, northern Chhattisgarh, eastern Madhya Pradesh, Sikkim and Meghalaya are observed to be increasing during post-monsoon months. The rainfall contributed by CDs over the border regions of AP and TN is observed to be decreasing. Among eastern coastal states, AP has received 200cm of accumulated rainfall contribution during pre-monsoon season. The corresponding values for TN, OD and WB are 180, 140 and 140cm respectively. During post-monsoon season, AP received 1100cm of rainfall, OD and TN with 900cm of rainfall each, and WB received 450cm of accumulated rainfall contributed by CDs. For western coastal states, during pre-monsoon season, the maximum amount of accumulated rainfall contributions over GJ, MH, KA and KL are about 85, 75, 110 and 160cm respectively. During post-monsoon season, the corresponding values are nearly 134, 145, 320 and 350cm. Comparing the trend for maximum and minimum rainfall received by a coastal state, it can be concluded that even though the maximum values for some years are slightly less in comparison to other years, the minimum contribution is quite significant for those particular years. The possible reason can be due to larger and faster moving storms those result in longer precipitation durations with greater area coverage.

Further, the association of such rainfall contributions with ENSO, MJO and IOD cannot be undermined and thus, analyzed using observations and modeling output. The preliminary results indicate relative dominance of MJO in determining the CDR over Indian region during pre-monsoon months. During IOD –ve, heavy rainfall is contributed by CDs over AP and TN. The explicit discussion regarding the same will

©2019. Japan Geoscience Union. All Right Reserved.

be included in the presentation.

Keywords: cyclonic disturbances, rainfall, North Indian Ocean, India

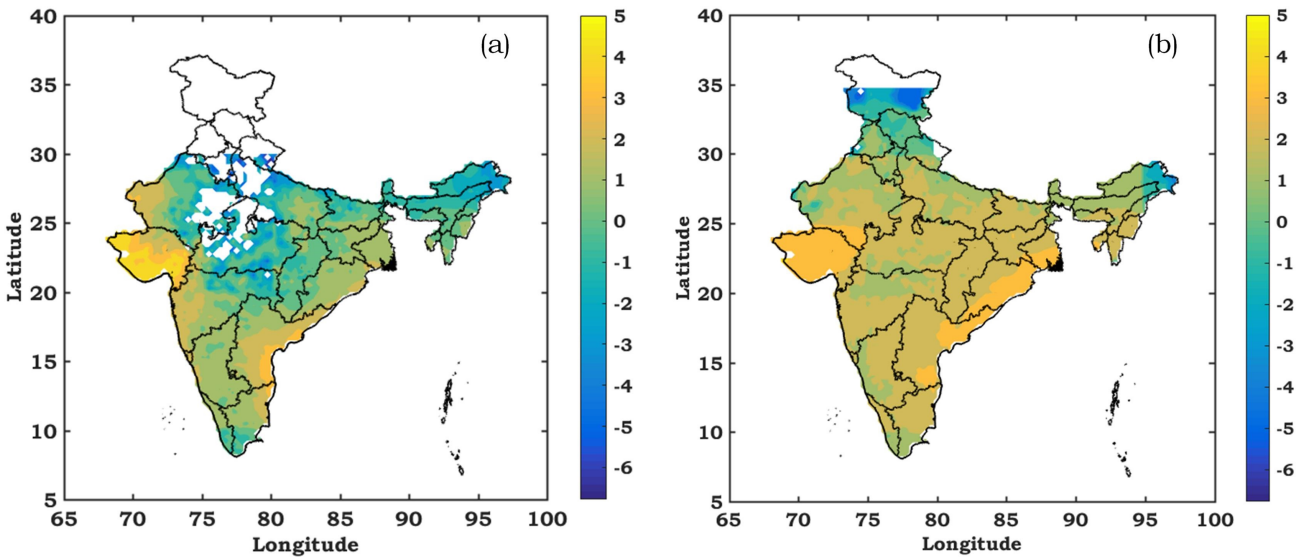


Figure 1: Percentage rainfall (cm) contributed by CDs formed over NIO during (a) pre-monsoon and (b) post-monsoon season respectively over India. Here, the percentage contribution of rainfall is shown in terms of logarithmic scale of actual value.

©2019. Japan Geoscience Union. All Right Reserved.

Analysis of typhoon tracks and associated precipitation amount over western Japan: A case study with Typhoon Nancy and Typhoon Jebi

*Sridhara Nayak[1], Tetsuya Takemi[1]

1. Disaster Prevention Research Institute, Kyoto University

Recent research suggests that typhoons under future warming climate will be more powerful and bring excessive precipitations to the landfall areas. In our study, we downscaled two very strong Typhoons [Typhoon Nancy (international #196118) and Typhoon Jebi (international #201821)] at 1-km grid resolution in present climate and with pseudo global warming (PGW) conditions by using Weather Research and Forecasting (WRF) model. An attempt is also made to examine whether the precipitation amounts carried by Typhoon Jebi can be projected from Typhoon Nancy with PGW conditions, because both typhoons made landfall over same region of Japan with a difference of 57 years. Our results indicate that the typhoon tracks in present climate simulation have good agreement with that of from the RSMC, Tokyo’ s best track datasets. The precipitation amounts over western Japan in the present climate simulation also follows the Radar-AMeDAS observed precipitation amounts. We again find similar typhoon tracks under PGW conditions for both typhoons with higher winds and precipitations compared to that of in present climate simulation. The precipitation amounts associated with the Typhoon Nancy in future climate is found to be higher than that of with Typhoon Jebi during the landfall. However, the 24 hours accumulated precipitation amount brought by Typhoon Nancy with PGW conditions has an overall good agreement with that of by Typhoon Jebi in present climate simulation especially over landfall region. Closer investigation on the typhoon tracks and typhoon induced precipitation amounts suggests that Typhoon Jebi is a possible projection of Typhoon Nancy although it was formed over different location.

Keywords: Typhoon Nancy, Typhoon Jebi, Typhoon track, Typhoon intensity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 105 1F

[A-OS07] Climate variability and predictability on subseasonal to decadal timescales

convener:Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Doug Smith(Met Office), Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Chairperson:V Ramaswamy(NOAA GFDL), Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology)

Climate variability poses growing threats to human lives and socio-economic activities through changes in frequency and intensity of abnormal weather such as cold/heat waves and floods/droughts. This involves several climate phenomena with a wide range of timescales from subseasonal to decadal variations (e.g. MJO, IOD, ENSO, PDV, AMV). Many efforts have been made for understanding and predicting climate variations on each timescale, but there remain large uncertainties in simulation and prediction of subseasonal to decadal climate variations. This highlights lack of understanding of weather and climate interaction across different spatial and temporal timescales (e.g. tropical cyclones and ENSO) as well as multiple physical processes underlying climate variations (e.g. troposphere-stratosphere coupling, air-sea-ice interaction). This session aims to share current knowledge of subseasonal to decadal climate variability and predictability in order to identify the unresolved issues for better understanding and accurate prediction. This session invites all the abstracts related to the observational, theoretical, process-level and modelling research on subseasonal to decadal climate variability and predictability.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS07-01] Seasonal Predictions of Tropical Cyclones in 2018 using GFDL and NICAM High-Resolution Global Models

★Invited Papers

*Hiroyuki Murakami[1,2], Masuo Nakano[3], V Ramaswamy[1], Thomas Delworth[1], Sarah Kapnick[1], Rich Gudgel[1], Takashi Mochizuki[3], Takeshi Doi[3], Yushi Morioka[3] (1.Geophysical Fluid Dynamics Laboratory, 2.University Corporation for Atmospheric Research, 3.JAMSTEC)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS07-02] **Future change of tropical cyclone-induced waves in the Indian Ocean; An analysis based on super-high-resolution MRI-AGCM3.2 climate model**

*Bahareh Kamranzad[1,2], Nobuhito Mori[1] (1.Disaster Prevention Research Institute, Kyoto University, 2.Hakubi Center for Advanced Research, Kyoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS07-03] The ocean-coupled global cloud-resolving modeling era

★Invited Papers

*Tomoki Miyakawa[1] (1.Atmosphere and Ocean Research Institute University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS07-04] Westerly Wind Burst (WWB)/Easterly Wind Surge (EWS)-like stochastic forcing and the effects on ENSO prediction by the SINTEX-F system

*Takeshi Doi[1], Swadhin Behera[1], Toshio Yamagata[1] (1.JAMSTEC)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS07-05] **The life-cycle of annual waves in the Pacific Ocean as identified by a seamless diagnosis for the energy flux**

*Hidenori AIKI[1], Takahiro Shimura[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Graduate School for Environmental Studies, Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS07-06] Development of weakly coupled atmosphere-ocean data assimilation system and the evaluation of the coupled reanalysis in JMA/MRI

★Invited Papers

*Yosuke Fujii[1], Chiaki Kobayashi[1], Toshiyuki Ishibashi[1], Yuhei Takaya[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

Seasonal Predictions of Tropical Cyclones in 2018 using GFDL and NICAM High-Resolution Global Models

*Hiroyuki Murakami[1,2], Masuo Nakano[3], V Ramaswamy[1], Thomas Delworth[1], Sarah Kapnick[1], Rich Gudgel[1], Takashi Mochizuki[3], Takeshi Doi[3], Yushi Morioka[3]

1. Geophysical Fluid Dynamics Laboratory, 2. University Corporation for Atmospheric Research, 3. JAMSTEC

We conduct real-time seasonal forecast using high-resolution global models (GFDL-FLOR, GFDL-HiFLOR, and NICAM) that have skill in predicting tropical cyclone statistics over the global ocean basins. The seasonal predictions starting from 2018 July initial conditions show above normal frequency of tropical cyclones in the Western North Pacific and Central Pacific Oceans as observed. To understand physical mechanisms behind the active storm season in the Pacific, we conducted idealized seasonal forecasts by changing sea surface temperature spatial patterns, which is so called "real-time attribution" simulations. We find out that warmer subtropical Pacific associated with positive Pacific Meridional Mode (PMM), rather than central Pacific El Nino, was responsible for the active storm season. In the presentation, we will also show preliminary results for impact of anthropogenic forcing on the 2018 active storm season.

Keywords: Tropical Cyclone, Seasonal Prediction, Pacific Meridional Mode, Anthropogenic Forcing, Typhoon, Global Warming

©2019. Japan Geoscience Union. All Right Reserved.

Future change of tropical cyclone-induced waves in the Indian Ocean; An analysis based on super-high-resolution MRI-AGCM3.2 climate model

*Bahareh Kamranzad[1,2], Nobuhito Mori[1]

1. Disaster Prevention Research Institute, Kyoto University, 2. Hakubi Center for Advanced Research, Kyoto University

Indian Ocean experiences intensive tropical cyclones in both northern and southern parts. The Northern Indian Ocean (NIO) includes 7% of the global tropical cyclones which results in generating severe wave climate during the extreme events. In this study, future change of tropical cyclone-induced waves due to climate change is assessed in terms of change in the spatial distribution patterns and magnitude. The cyclone seasons in NIO are divided by pre-monsoon (especially May) and northeast monsoon (October–December). Moreover, there are few cyclones form the southwest monsoon during June and September. Hence, the assessment of future change of intensity of tropical cyclones and the generated waves is necessary to be performed on a monthly scale. For this purpose, wind field obtained from super-high-resolution atmospheric global climate model MRI-AGCM3.2S of the Japan Meteorological Agency (JMA) -with horizontal spatial and temporal output resolutions of 20 km and 1 hr., respectively- was used to force a numerical wave model (SWAN) in historical (1979-2003) and future (2075-2099) periods (based on Representative Concentration Pathway (RCP) 8.5 scenario).
Spatial distribution of annual extreme events in the domain shows that the concentration of tropical cyclones is in the NIO and around Madagascar (located in the Southern Indian Ocean (SIO)) generating high waves of the magnitudes of around 20 m during the events. Spatial distribution of monthly maximum values of the historical and future wind speed (WS) and significant wave height (SWH) indicates that according to historical projection, intense cyclones happen during May and June in NIO, while they can be observed mostly during December to April in the SIO. The future monthly distribution of cyclone induced waves in SIO shows a similar pattern to the historical events, except for winter tropical cyclones (November and December), which are decreased in the future, while increasing in the intensity can be observed during October and April in NIO.
Monthly variation of maximum events in the domain was assessed in the NIO and SIO, separately. According to the past studies, due to the global warming, tropical cyclones of hurricane intensity -which currently occur only in the pre and post-monsoon seasons- will likely be formed even during the summer monsoon in NIO. Our results illustrate an increase in the intensity of cyclones in the future, not only during the summer monsoon (July) but also during the winter monsoon (September and October). Results show that the range of change in the highest SWH in NIO is between -27% (in February) and +26% (in October). In the northern part of SIO, the intensity of future tropical cyclones will increase during the southwestern inter-monsoon season (March and April), whereas it will decrease at the end of southwestern monsoon season (September). In the southern part of SIO, the intensity of tropical cyclones will increase around 20% during northeastern monsoon (February and March), which results in a future increase of 40% in maximum SWH in February. Generally, change in highest SWH in the future follows the pattern of WS except for the northern parts of SIO when the highest increase in maximum SWH (21%) occurs in March whereas the highest increase in maximum WS occurs in April (25%). There is a 20% increase in maximum WS during February in southern parts of SIO which can be a reason for the increase of SWH during March in northern parts. It can be concluded that the change in the intensity of future tropical cyclones in NIO is higher than SIO. The range of change in highest SWH in NIO is larger than SIO, except for February when the maximum wave height in southern parts of SIO will increase about 40% in

©2019. Japan Geoscience Union. All Right Reserved.

the future. Furthermore, the change in maximum SWH in northern parts of SIO seems to be affected by the change of tropical cyclones in southern parts of SIO.

Keywords: Indian Ocean, tropical cyclone, wave climate, climate change

©2019. Japan Geoscience Union. All Right Reserved.

The ocean-coupled global cloud-resolving modeling era

*Tomoki Miyakawa[1]

1. Atmosphere and Ocean Research Institute University of Tokyo

Developments of global cloud/cloud-system resolving models are recently in full activity in many modeling centers, with 9 members participating in a model inter-comparison project called the DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains (DYAMOND). With the aid of the supercomputers, they are eyeing to become the main-stream in the next generation models for global simulations in the seasonal to multi-decadal range. Implementation of a fully dynamical ocean model is certainly an essential component in these developments. NICAM, a front-runner in DYAMOND project, can be coupled to COCO, the ocean component of a global climate model MIROC. The coupled version is called NICAM-COCO, or NICOCO, and is now being tested in pilot studies that involve atmosphere-ocean interactions.

An overview of these early studies will be presented, including how convection is affected by the existence of fine-scale ocean fronts, and how the Madden-Julian oscillation affects the initiation and termination of ENSO.

Keywords: ocean-coupled model, global cloud-resolving model, seasonal prediction

©2019. Japan Geoscience Union. All Right Reserved.

Westerly Wind Burst (WWB)/Easterly Wind Surge (EWS)-like stochastic forcing and the effects on ENSO prediction by the SINTEX-F system

*Takeshi Doi[1], Swadhin Behera[1], Toshio Yamagata[1]

1. JAMSTEC

Intra-seasonal surface westerly wind bursts (WWB)/easterly wind surges (EWS) in the tropical Pacific play important roles in the onset of El Nino/La Nina. However, the latest version of the SINTEX-F seasonal prediction system tends to underestimate the chance of occurrence of those winds. This problem may cause the relatively low skill of predicting the onset of ENSO, and the over-confident problems of ENSO prediction. In this study, we developed the WWB/EWS-like stochastic forcing parameterization, and examined the effects on ENSO prediction by the SINTEX-F system. In my talk, failure of 2014 El Nino prediction is the focus.

Keywords: ENSO prediction, Westerly Wind Burst, Easterly Wind Surge

©2019. Japan Geoscience Union. All Right Reserved.

The life-cycle of annual waves in the Pacific Ocean as identified by a seamless diagnosis for the energy flux

*Hidenori AIKI[1], Takahiro Shimura[2]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Graduate School for Environmental Studies, Nagoya University

Synoptic-scale waves play an important role in tropical-extratropical interactions, that has been little investigated in terms of the transfers of wave energy owing to the lack of an appropriate diagnosis scheme in previous studies. A recent theoretical study has derived a seamless scheme that is able to identify the direction of group velocity for both gravity and planetary waves at all latitudes. This new scheme has been used in the present study to provide a first-ever energetic view for the life-cycle of annual waves in the Pacific Ocean in a set of shallow-water model experiments with climatological wind forcing. The new scheme is able to show, in particular for the third baroclinic mode, the signals of eastward energy flux associated with equatorial Kelvin waves that are distributed in the eastern part of the tropical Pacific Ocean. Waves in the tropical and subtropical regions are connected each other at the eastern boundary of the Pacific Ocean that has been viewed, for the first time in the history of geophysical fluid dynamics, in terms of the circulation of wave energy. Concerning the low-pass filtered time evolution of the energy flux, the reflection of equatorial waves at the western boundary is more clearly identified than that at the eastern boundary. These results for the analysis of climatological annual waves provide a basis for the analysis of waves with interannual variations in a future study to better understand, for example, tropical-extratropical interactions during El Nino and La Nina.

Keywords: tropical-extratropical interaction, seasonal climatology experiment, group velocity

©2019. Japan Geoscience Union. All Right Reserved.

Development of weakly coupled atmosphere-ocean data assimilation system and the evaluation of the coupled reanalysis in JMA/MRI

*Yosuke Fujii[1], Chiaki Kobayashi[1], Toshiyuki Ishibashi[1], Yuhei Takaya[1]

1. Meteorological Research Institute, Japan Meteorological Agency

JMA/MRI have developed a weakly-coupled Data Assimilation (DA) system, MRI-CDA1, based on JMA's operational systems. MRI-CDA1 is composed of the global atmosphere Four-Dimensional Variational (4DVAR) system for numerical weather predictions, the global ocean Three-Dimensional Variational (3DVAR) system for seasonal predictions, and the coupled atmosphere-ocean model for seasonal predictions. The coupled atmosphere-ocean model is adopted as the outer model of the atmospheric 4DVAR routine although the uncoupled atmospheric model is used as the inner model. While the atmospheric 4DVAR analysis is performed every 6 hours, the oceanic 3DVAR analysis is performed every 10 days and the oceanic analysis increments are applied in the integrations of the outer (coupled) model.

Coupled reanalysis experiments based on MRI-CDA1 are conducted for the period from November 2013 to December 2015. In the coupled reanalysis the excess rainfall found in the tropics in Japanese 55-year Reanalysis (JRA-55) is effectively suppressed, particularly in the Intertropcal Convergence Zone (ITCZ) in the Pacific. We also confirmed that the coupled DA system properly reproduces the lagged-correlated variations of Sea Surface Temperature (SST) and precipitation in the far western tropical North Pacific which is not reproduced by a regular uncoupled DA system. The variation of the precipitation is improved in the coupled reanalysis over the uncoupled one when only conventional data and oceanic data are assimilated. But the coupled DA system adjusts SST to the change of precipitation, instead of correcting the precipitation field, when atmospheric data from satellite are additionally assimilated. We also conducted another coupled reanalysis experiment in which the atmospheric observation error variances set larger than the original, and found that the variation of the precipitation in the tropics is roughly improved over the original coupled reanalysis.

Keywords: coupled data assimilation, coupled analysis, Subseasonal-to-seasonal prediction, sea surface temperature, precipitation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 105 1F

[A-OS07] Climate variability and predictability on subseasonal to decadal timescales

convener:Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology), V Ramaswamy(NOAA GFDL), Doug Smith(Met Office), Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yushi Morioka(Japan Agency for Marine-Earth Science and Technology), Takashi Mochizuki(Japan Agency for Marine-Earth Science and Technology)

Climate variability poses growing threats to human lives and socio-economic activities through changes in frequency and intensity of abnormal weather such as cold/heat waves and floods/droughts. This involves several climate phenomena with a wide range of timescales from subseasonal to decadal variations (e.g. MJO, IOD, ENSO, PDV, AMV). Many efforts have been made for understanding and predicting climate variations on each timescale, but there remain large uncertainties in simulation and prediction of subseasonal to decadal climate variations. This highlights lack of understanding of weather and climate interaction across different spatial and temporal timescales (e.g. tropical cyclones and ENSO) as well as multiple physical processes underlying climate variations (e.g. troposphere-stratosphere coupling, air-sea-ice interaction). This session aims to share current knowledge of subseasonal to decadal climate variability and predictability in order to identify the unresolved issues for better understanding and accurate prediction. This session invites all the abstracts related to the observational, theoretical, process-level and modelling research on subseasonal to decadal climate variability and predictability.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS07-07] Decadal variability and predictability of the North Atlantic Oscillation

★Invited Papers

*Rosemary Eade[1,2], David Stephenson[2], Doug Smith[1], Adam Scaife[1,2], Leon Hermanson[1], Nick Dunstone[1] (1.Met Office Hadley Centre, 2.University of Exeter)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS07-08] Seasonal to multi-year climate predictability in a climate model MIROC6

*Takahito Kataoka[1], Hiroaki Tatebe[1], Hiroshi Koyama[1], Takashi Mochizuki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS07-09] Identifying the early 2000s hiatus associated with internal climate variability

*Xin-Gang Dai[1], Ping Wang[2] (1.Institute of Atmospheric Physics, Chinese Academy of Sciences, 2.Chinese Academy of Meteorological Sciences)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS07-10] Decadal Evolution of the Surface Energy Budget during the Fast Warming and Global Warming Hiatus Periods in the ERA-Interim

*XIAOMING HU[1] (1.Sun Yat-sen University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS07-11] **The role of ocean variability for multi-year droughts in Australia**

*Andrea Taschetto[1,2], Alex Sen Gupta[1,2], Caroline C Ummenhofer[3], Matthew H England[1,2] (1.Climate Change Research Centre, University of New South Wales, Sydney, Australia, 2.ARC Centre of Excellence for Climate Extremes, University of New South Wales, Sydney, Australia, 3.Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS07-12] Decadal variability and predictability in the Southern Ocean - implications for interpreting recent observed trends

★Invited Papers

*Liping Zhang[1,2], Thomas L Delworth[2], William Cooke[2,3], Xiaosong Yang[2,3] (1.Princeton University, 2.Geophysical Fluid Dynamics Laboratory, 3.UCAR)

Decadal variability and predictability of the North Atlantic Oscillation

*Rosemary Eade[1,2], David Stephenson[2], Doug Smith[1], Adam Scaife[1,2], Leon Hermanson[1], Nick Dunstone[1]

1. Met Office Hadley Centre, 2. University of Exeter

The winter of 1962/63 was the coldest in the UK in over a century while the mildest winter occurred in 1988/89. For countries to be resilient against the impacts of large weather variations in the future, it is important to assess the likelihood of seeing such extreme fluctuations and understand the physical drivers. In Europe and North America, these fluctuations are related to a combination of year-to-year variability and low-frequency variability of the North Atlantic Oscillation (NAO). The NAO is now a significant source of predictability for seasonal forecasts in these regions, however the signal-to-noise ratio of the ensemble mean to total variability in these ensemble predictions has been shown to be anomalously small, which means the real world is more predictable than our climate models suggest. Here we provide a new evaluation of the ability of climate models to simulate and predict longer-term variability and extreme trends in the NAO. For this we use statistical analyses of the observations and climate model simulations, and assess predictability with a large multi-model ensemble of decadal predictions. We also investigate the drivers of NAO variability and trends using new results from the CMIP6 Decadal Climate Prediction Project and the Polar Amplification MIP.

Keywords: Decadal variability, North Atlantic Oscillation, Polar Amplification, Trend analysis

©2019. Japan Geoscience Union. All Right Reserved.

Seasonal to multi-year climate predictability in a climate model MIROC6

*Takahito Kataoka[1], Hiroaki Tatebe[1], Hiroshi Koyama[1], Takashi Mochizuki[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology

Seasonal to multi-year climate predictability is examined in hindcast experiments using the latest version of a climate model MIROC (MIROC6). The model is initialized by assimilating observed ocean temperature and salinity anomaly fields and full-filed of sea ice concentration. In addition, the atmospheric initial conditions are replaced with variables from JRA55 reanalysis and the hindcasts are issued on November 1st. On seasonal timescales, the MIROC6 prediction system shows an improvement in Niño3.4 prediction skill from that of MIROC5, though the skill itself is still modest. SLP variability around Japan appears to have predictive skill up to second winter (lead time of about 15 month) and summer (lead time of about 21 month) possibly due to the improved ENSO prediction skill and the better representation of East Asian monsoon. On longer timescales, although the predictive component largely originates from the externally forced variability, MIROC6 shows predictive skills in the surface air temperature particularly in the North Pacific and the North Atlantic.

Keywords: near-term prediction, seasonal prediction

©2019. Japan Geoscience Union. All Right Reserved.

Identifying the early 2000s hiatus associated with internal climate variability

*Xin-Gang Dai[1], Ping Wang[2]

1. Institute of Atmospheric Physics, Chinese Academy of Sciences, 2. Chinese Academy of Meteorological Sciences

This study focuses on re-examining the early 2000s hiatus and the associated key components of the global mean surface temperature (GMST) using multiscale statistics for five well-known gridded surface temperature and two reanalysis datasets. The hiatus is characterized as a near-zero trend on the decadal scale corresponding to the maximum P-value via an F-test in statistics. The results reveal that the hiatus exists in both the GMST and global mean air temperature (GMAT) time series, rather than in global warming component, which has maintained an approximately constant rate of change of approximately 0.08ºC/decade over the past three decades. The hiatus' s duration is different from that of time series such as 2002-2012/2001-2013/2002-2014 in HadCRUT4, NOAA-old, ERA-Interim and NCEP-R2. The newly gridded datasets with data infilling or bias correction for interpreting the sea surface temperature (SST) measurement from the old versions show a slightly higher trend from for 2002-2012 than the hiatus, which is thus regarded as a slowdown. Comparison suggests that the hiatus should be during the period 2002-2012. Orthogonal wavelet decomposition of the temperature time series shows that the hiatus was merely a decadal balance between cooling from interannual variability and global warming, in addition to weak warming from interdecadal and multidecadal climate oscillations. In addition, the evolutions of the GMST' s interannual composite well coincided with Niño3.4 SST anomalies, which is consistent with the numerical simulation performed by Kosaka and Xie in 2013. Hence, it is the anomalous El Niño Southern Oscillation (ENSO) events in the early 2000s that caused the hiatus despite a constant rate of global warming and the maximum magnitude of the multidecadal composite that led to the limited contribution to the trend during this period. The multidecadal composite follows a downward path, which implies that future climate conditions will likely rely on competition between multidecadal cooling and global warming if the multidecadal climate cycle repeats, as was experienced during the second half of the twentieth century.

Keywords: Global mean temperature, early 2000s hiatus, multiscale decomposition, global warming, multidecadal oscillation, interannual variability

©2019. Japan Geoscience Union. All Right Reserved.

Decadal Evolution of the Surface Energy Budget during the Fast Warming and Global Warming Hiatus Periods in the ERA-Interim

*XIAOMING HU[1]

1. Sun Yat-sen University

The global-mean surface temperature has experienced a rapid warming from the 1980s to early-2000s but a muted warming since, referred to as the global warming hiatus in the literature. Decadal changes in deep ocean heat uptake are thought to primarily account for the accelerated warming rate and subsequent slowdown. Here, we examine the role of ocean heat uptake in establishing the fast warming and warming hiatus periods in the ERA-Interim through a decomposition of the global-mean surface energy budget. We find the increase of carbon dioxide alone yields a nearly steady increase of the downward longwave radiation at the surface from the 1980s to the present, but neither accounts for the fast warming nor warming hiatus periods. During the global warming hiatus period, the transfer of latent heat energy from the ocean to atmosphere increases and the total downward radiative energy flux to the surface decreases due to a reduction of solar absorption caused primarily by an increase of clouds. The reduction of radiative energy into the ocean and the surface latent heat flux increase cause the ocean heat uptake to decrease and thus contribute to the slowdown of the global-mean surface warming. Our analysis also indicates that in addition to a reduction of deep ocean heat uptake, the fast warming period is also driven by enhanced solar absorption due predominantly to a decrease of clouds and by enhanced longwave absorption mainly attributed to the air temperature feedback.

Keywords: global warming, global warming hiatus, surface energy budget

©2019. Japan Geoscience Union. All Right Reserved.

The role of ocean variability for multi-year droughts in Australia

*Andrea Taschetto[1,2], Alex Sen Gupta[1,2], Caroline C Ummenhofer[3], Matthew H England[1,2]

1. Climate Change Research Centre, University of New South Wales, Sydney, Australia, 2. ARC Centre of Excellence for Climate Extremes, University of New South Wales, Sydney, Australia, 3. Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, USA

Australian climate is strongly affected by variations in sea surface temperature in the Pacific, Indian and Southern Oceans. Over the northern and eastern regions of Australia, the El Niño –Southern Oscillation (ENSO) is the main phenomenon causing profound impacts in rainfall. On the southern regions, a large proportion of rainfall comes from synoptic weather systems at the mid-latitudes, such as cold fronts and cut-off lows. The interaction between the tropical modes of variability and the atmosphere dynamics at mid-latitudes makes difficult to understand the role of the oceans for droughts relative to the atmosphere internal variability.

The contribution of ocean versus atmosphere variability for Australian rainfall is investigated in this study. Numerical experiments are performed using the National Center for Atmospheric Research (NCAR) Community Earth System Model (CESM). Three multi-century simulations are integrated to address the role of the oceans for rainfall variability: (i) a fully coupled climate system run, (ii) an run forced with climatological cycle of SST, i.e. no SST variability beyond one year, and (iii) a run forced with varying SST, i.e. containing SST variability but no air-sea feedback.

Our results show that interannual variations in sea surface temperature has a significant impact on rainfall variability and extremes, such as multi-year droughts and pluvials. Ocean variability makes droughts more intense and modulates the duration of short-term dry spells. However, interannual variability in the oceans does not significantly affect the duration of droughts longer than 3 years. On the other hand, in a world with no year-to-year ocean variability, multi-year dry spells can last longer than oceanic-driven droughts. This can be explained by the influence that ENSO has over the tropics:ENSO is a crucial phenomenon for restoring droughts and pluvials. In the absence of ocean variability, there is no dominant climate driver that can act to terminate extended dry or wet periods.

Keywords: Precipitation variability, Droughts, El Niño - Southern Oscillation, atmospheric variability , ocean variability

©2019. Japan Geoscience Union. All Right Reserved.

Decadal variability and predictability in the Southern Ocean - implications for interpreting recent observed trends

*Liping Zhang[1,2], Thomas L Delworth[2], William Cooke[2,3], Xiaosong Yang[2,3]

1. Princeton University, 2. Geophysical Fluid Dynamics Laboratory, 3. UCAR

While decadal variability and predictability in the North Atlantic and North Pacific have received considerable attention, there has been less work on decadal variability and predictability in the Southern Ocean. As shown previously, a coherent mode of decadal to centennial variability exists in multiple climate models. The mechanism involves a multidecadal accumulation of heat in the subsurface of the Southern Ocean, which is then rapidly discharged through intense oceanic convection when the accumulation of subsurface heat reduces the stratification of the water column. The release of this accumulated subsurface heat can have considerable regional scale climatic impacts, along with substantial impacts on ocean heat uptake. Using a large suite of perfect predictability experiments, in concert with long control simulations, we show that this variability has a high degree of predictability. We present further results that show this type of variability may play an important role for interpreting recently observed trends of sea ice and temperature in the Southern Ocean. Specifically, observed trends over the last several decades resemble a particular phase of this variability in which reduced oceanic convection leads to subsurface warming and surface cooling, with associated increases in sea ice extent. This phase of natural variability may substantially contribute to observed decadal trends, working in concert with other factors.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 105 1F

[A-OS10] Atlantic climate variability, and its global impacts and predictability

convener:Ingo Richter(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Hiroki Tokinaga(Research Institute for Applied Mechanics, Kyushu University), Noel S Keenlyside(Geophysical Institute Bergen), Carlos R Mechoso(University of California Los Angeles), Chairperson:Hiroki Tokinaga(京都大学白眉センター), Ingo Richter

The Atlantic Ocean is subject to pronounced climate variations that occur on a wide range of time scales, including interannual variability in the equatorial and subtropical regions, and Atlantic multi-decadal variability (AMV), which has been linked with the Atlantic meridional overturning circulation (AMOC). These are connected to other climate variations across the globe. The AMV, e.g., has long been known to have global impacts, such as changes in the Indian, Asian and South American summer monsoons, and changes in the Pacific associated with the "global hiatus". Interannual variability in the equatorial and subtropical Atlantic has also been shown to influence global climate, including over Asia, while the freshening of the North Atlantic by melting of the Greenland ice cap is expected to influence all ocean basins via atmospheric bridges. Likewise, misrepresentation of the Atlantic can have global ramifications in climate models. Misrepresentation of the AMOC, e.g., has been associated with model biases in the entire Northern Hemisphere.

This session seeks observational, modeling, and theoretical studies on the mechanisms that determine the Atlantic mean climate and variability, as well as the predictability and global impacts of such variability. We also seek studies that evaluate climate model performance in the region. Topics include atmosphere-ocean-cloud interactions in the tropical Atlantic and their remote impacts; relationships between tropical and mid/high latitude variability; air-sea interaction along the Gulf Stream and its influence on cyclones and storm track evolution; variability in the Benguela upwelling region; influence of Agulhas leakage on the South Atlantic; coupled climate models biases in the region and their impacts; AMOC and long-term climate change.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS10-01] Atlantic impacts on the tropical Pacific climate in the 2000s

*Takashi Mochizuki[1], Masahiro Watanabe[2], Masahide Kimoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Atmosphere-Ocean Research Institute, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS10-02] Recent acceleration of Arabian Sea warming induced by the Atlantic-western Pacific trans-basin multidecadal variability

*Cheng Sun[1] (1.Beijing Normal University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS10-03] **Westward Wind Changes over the Tropical and Mid-latitude Pacific in the Past Three Decades Driven by the Inter-basin Teleconnections**

★Invited Papers

*Xichen Li[1] (1.Institute of Atmospheric Physics)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS10-04] On the Usefulness of the Atlantic Multidecadal Oscillation Index for Identifying Origins of North Atlantic Sea Surface Temperature Variability

*Jing Sun[1,2], Mojib Latif[1,3], Wonsun Park[1], Taewook Park[1,4] (1.GEOMAR Helmholtz Centre for Ocean Research Kiel, 2.Ocean University of China, 3.University of Kiel, 4.Korea Polar Research Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS10-05] Atlantic Multidecadal SST Signal Modulated by the Low-Frequency Mixed Layer Depth Variability

*Ayako Yamamoto[1], Hiroaki Tatebe[1], Masami Nonaka[1] (1.Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS10-06] A High-Resolution Future Wave Climate Projection for the Northwestern Atlantic

*Adrean Webb[1], Tomoya Shimura[1], Nobuhito Mori[1] (1.Kyoto University, Disaster Prevention Research Institute)

Atlantic impacts on the tropical Pacific climate in the 2000s

*Takashi Mochizuki[1], Masahiro Watanabe[2], Masahide Kimoto[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Atmosphere-Ocean Research Institute, The University of Tokyo

A subdecadal (i.e., 3-year-running means) variation over the tropical Pacific is very distinctively observed in the 2000s. Here, we have demonstrated that sea surface temperature (SST) anomalies in the tropical Atlantic contribute to forming high ocean temperature anomalies of the tropical Pacific in the early-2000s, by performing partial data assimilation of global climate model. Low SST over the equatorial Atlantic changes the Walker circulation and the associated weakening of the Pacific trade wind raises the equatorial SST on the subdecadal timescales. At the same time, high SST anomaly is generated also in the off-equatorial North Pacific through deepening of the upper ocean thermocline due to an accompanying anti-cyclonic surface wind anomaly aloft. In addition, the north tropical Atlantic SST may help the subdecadal warming in the equatorial Pacific, similar to the common changes working as a seasonal trigger of the so-called central Pacific El Nino Southern Oscillation event.

Keywords: subdecadal variability, interbasin influence, partial data assimilation, Pacific trade wind

©2019. Japan Geoscience Union. All Right Reserved.

Recent acceleration of Arabian Sea warming induced by the Atlantic-western Pacific trans-basin multidecadal variability

*Cheng Sun[1]

1. Beijing Normal University

The rapid warming of the Arabian Sea (AS) brings an increased risk of extreme weather and climate events,
e.g., flood, heat wave and cyclone. AS warming has significantly accelerated since the 1990s, in particular in the
spring season, stemming from the multidecadal variability of AS sea surface temperature (SST). Here, we show
that this variability is closely related to the Atlantic multidecadal oscillation (AMO). A set of Atlantic pacemaker
experiments with slab mixed-layer ocean model successfully reproduce the AS spring multidecadal variability and
its connection with the AMO. An atmospheric teleconnection from the Atlantic to the AS in the preceding winter
and associated thermodynamic air-sea feedback are found important. The teleconnection can be recreated by the
atmospheric model when the SSTs of AMO and its trans-basin footprint over western Pacific (WP) are prescribed
simultaneously. The WP SST warming associated with AMO positive phase induces a Gill-type Rossby wave
response over the AS, showing an anomalous low and converging southerlies that weaken the winter northerly.
A positive wind-evaporation-SST feedback further develops, leading to the AS SST anomalies being formed and
maintained to the subsequent spring. The concurrent cold-to-warm phase shift of AMO and its WP SST footprint
since the 1990s contributes constructively to the rapid warming of AS. Our results suggest a key role of trans-basin
interactions in the attribution of historical regional SST warming and constraint of projected future warming.

Keywords: Atlantic multidecadal oscillation , Trans-basin variability, Arabian Sea warming

©2019. Japan Geoscience Union. All Right Reserved.

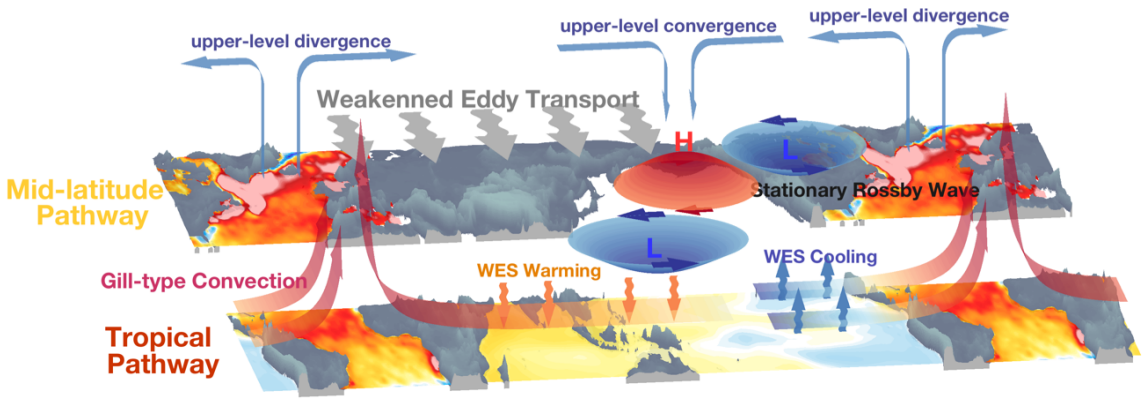
Westward Wind Changes over the Tropical and Mid-latitude Pacific in the Past Three Decades Driven by the Inter-basin Teleconnections

*Xichen Li[1]

1. Institute of Atmospheric Physics

Due to its active role in the atmosphere-ocean interactions and in the global climate variability, the trade wind regime over the Pacific Ocean has been receiving increased attention. Although the intensification of the equatorial trade wind in recent decades has been widely investigated, the meridional extension of this easterly wind change and the associated mechanism remain unclear. To untangle this problem, we combine observations, reanalysis datasets, and a hierarchy of climate model simulations. Analysis based on measurements and reanalysis datasets show that the intensified easterly wind anomaly is not only confined within the tropical basin, but also extends to the mid-latitude Pacific, from 40˚S to 40˚N. In the tropics, the trade wind change is primarily attributed to the enhanced Walker circulation driven by the inter-basin teleconnection and further the decadal variability over the Atlantic and the Pacific oceans, whereas in the mid-latitudes, the changes in sub-tropical highs and Aleutian Low become more dominant. While the altered winds can contribute to the observed sea surface temperature (SST) changes in both tropical and mid-latitude Pacific, they are not driven by the regional Pacific SST changes. Instead, the wind changes are mostly caused by remote influences originated from the tropical Atlantic and Indian Ocean SST changes through stationary Rossby waves. This finding builds a direct pathway linking the tropical Atlantic and Indian Ocean to the mid-latitude Pacific. This pathway has a broad implication for understanding air-sea interactions and sea level changes over the Pacific, and may have an important impact on the interannual and decadal predictability of the Pacific climate variability, such as Pacific Decadal Oscillation and El Niño –Southern Oscillation.

Keywords: Pacific, Westerly Wind, Interbasin Teleconnection



©2019. Japan Geoscience Union. All Right Reserved.

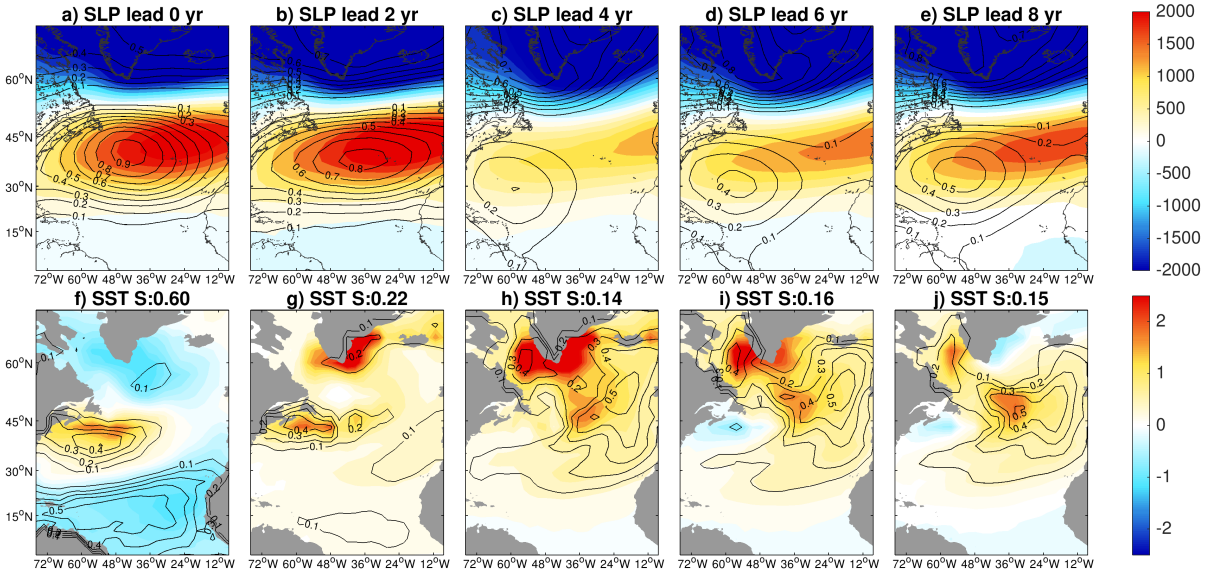
On the Usefulness of the Atlantic Multidecadal Oscillation Index for Identifying Origins of North Atlantic Sea Surface Temperature Variability

*Jing Sun[1,2], Mojib Latif[1,3], Wonsun Park[1], Taewook Park[1,4]

1. GEOMAR Helmholtz Centre for Ocean Research Kiel, 2. Ocean University of China, 3. University of Kiel, 4. Korea Polar Research Institute

We provide, on the basis of observations and climate models, an interpretation of the Atlantic Multidecadal Oscillation (AMO) index which is widely used in studies addressing sea surface temperature (SST) variability over the North Atlantic (NA). In particular, the AMO index is often used as an index of the Atlantic Meridional Overturning Circulation (AMOC). The AMO index, defined here as the anomalous North Atlantic SST averaged over 0˚ - 60˚ N, accounts for significant SST variability over the tropical and subpolar NA. Climate models analyzed in this study suggest that the AMOC only accounts for significant SST variability over the subpolar NA. In these models, a low-pass filtered AMO index also is associated with SST variability only over the subpolar NA and tracks well multidecadal AMOC variability. SST variability over the tropical NA has previously been suggested to be largely governed by local surface wind variability, which can be amplified the wind-evaporation-SST feedback, and remote forcing by El Niñ o/Southern Oscillation, the leading mode of interannual variability over the tropical Pacific. The AMO index lumps together SST variability associated with different physical mechanisms, which limits the usefulness of the index to understand the origins of NA SST variability. Our results may help to reconcile seemingly competing results about the role of ocean dynamics in NA SST variability.

Keywords: Atlantic Multidecadal Oscillation/Variability, Atlantic Meridional Overturning Circulation, North Atlantic sea surface temperature



©2019. Japan Geoscience Union. All Right Reserved.

Atlantic Multidecadal SST Signal Modulated by the Low-Frequency Mixed Layer Depth Variability

*Ayako Yamamoto[1], Hiroaki Tatebe[1], Masami Nonaka[1]

1. Japan Agency for Marine-Earth Science and Technology

Atlantic Multidecadal Oscillation (AMO) has conventionally been attributed to the heat transport associated with the Atlantic Meridional Overturning Circulation. A recent study, however, challenged this paradigm and indicated that the North Atlantic basin-wide sea surface temperature (SST) pattern analogous to AMO can emerge owing to the atmospheric stochastic forcings in slab ocean models, without an active ocean. Subsequent studies have disputed this finding, arguing that the cause of the SST warming differ between the slab ocean models and fully-coupled models; however, a consensus is yet to be reached.

In this study, we take an approach to resolve this conundrum, by partitioning the multidecadal SST tendency into a part that is induced by the surface heat fluxes and another by the ocean, using a latest version of a fully-coupled climate model, MIROC6. We found that the heat flux term is primarily responsible for the North Atlantic subpolar SST warming, opposing the cooling caused by the oceanic term, despite that the associated heat flux anomalies are upward. Further decomposition of the heat flux term indicates that it is the mixed layer depth (MLD) deepening that makes the ocean less susceptible for cooling. This MLD variability is essentially induced by the anomalous salinity transport by the Gulf Stream modulated by the multidecadal North Atlantic Oscillation. The tropical North Atlantic SST signal, in contrast, arises due to the surface heat fluxes. Our study thus implies the key role of both air-sea fluxes and the ocean dynamics in the emergence of the AMO signal.

Keywords: Atlantic Multidecadal Oscillation/Variability, Gulf Stream, mixed-layer depth

©2019. Japan Geoscience Union. All Right Reserved.

A High-Resolution Future Wave Climate Projection for the Northwestern Atlantic

*Adrean Webb[1], Tomoya Shimura[1], Nobuhito Mori[1]

1. Kyoto University, Disaster Prevention Research Institute

A high-resolution wave climate projection for the Northwestern Atlantic has been conducted to help assess possible regional impacts under an RCP8.5 climate forcing scenario. Here, NOAA WAVEWATCH III is utilized to resolve the Northwestern Atlantic and US Eastern Coast at approximately 21 km and 7 km, respectively. Hourly wind field forcings are provided by MRI-AGCM 3.2S at a 21 km/lat resolution and the increased temporal frequency and spatial resolution allow for better modeling of large storm events. Climatological (25-year) significant wave height differences between future and historical periods indicate that a seesaw effect will occur, with decreases occurring in the Northwest Atlantic and Gulf of Mexico and increases occurring in the Caribbean Sea. Other notable changes include decreases in incident shoreline energy along the US East Coast. Further details of the projection will be discussed, including underlying wind field changes and extreme wave statistics.

Keywords: wave climate, Northwest Atlantic, WaveWatch III

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 105 1F

[A-OS10] Atlantic climate variability, and its global impacts and predictability

convener:Ingo Richter(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Hiroki Tokinaga(Research Institute for Applied Mechanics, Kyushu University), Noel S Keenlyside(Geophysical Institute Bergen), Carlos R Mechoso(University of California Los Angeles), Chairperson:Ingo Richter, Hiroki Tokinaga(京都大学白眉センター)

The Atlantic Ocean is subject to pronounced climate variations that occur on a wide range of time scales, including interannual variability in the equatorial and subtropical regions, and Atlantic multi-decadal variability (AMV), which has been linked with the Atlantic meridional overturning circulation (AMOC). These are connected to other climate variations across the globe. The AMV, e.g., has long been known to have global impacts, such as changes in the Indian, Asian and South American summer monsoons, and changes in the Pacific associated with the "global hiatus". Interannual variability in the equatorial and subtropical Atlantic has also been shown to influence global climate, including over Asia, while the freshening of the North Atlantic by melting of the Greenland ice cap is expected to influence all ocean basins via atmospheric bridges. Likewise, misrepresentation of the Atlantic can have global ramifications in climate models. Misrepresentation of the AMOC, e.g., has been associated with model biases in the entire Northern Hemisphere.

This session seeks observational, modeling, and theoretical studies on the mechanisms that determine the Atlantic mean climate and variability, as well as the predictability and global impacts of such variability. We also seek studies that evaluate climate model performance in the region. Topics include atmosphere-ocean-cloud interactions in the tropical Atlantic and their remote impacts; relationships between tropical and mid/high latitude variability; air-sea interaction along the Gulf Stream and its influence on cyclones and storm track evolution; variability in the Benguela upwelling region; influence of Agulhas leakage on the South Atlantic; coupled climate models biases in the region and their impacts; AMOC and long-term climate change.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS10-07] Tropical Atlantic Impact on ENSO predictability

★Invited Papers

*Belen Rodriguez-Fonseca[1,2], Irene - Polo[1], Elsa - Mohino[1], Teresa - Losada[1], Marta - Martin-Rey[5], Roberto - Mechoso[3], Noel - Keenlyside[4] (1.Department of Physics of the Earth and Astrophysics, UCM, Madrid, Spain, 2.Institute of Geosciences, IGEO, UCM-CSIC, Madrid, Spain, 3.Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, USA, 4.Geophysical Institute, University of Bergen, Norway, 5.Instituto de Ciencias del Mar, Barcelona, Spain)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS10-08] Interannual variability of Antarctic Intermediate Water in the tropical North Atlantic

*Yao Fu[1], Chunzai Wang[1], Peter Brandt[2,3], Richard J. Greatbatch[2,3] (1.State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, 2.GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany , 3.Christian-Albrechts-Universität zu Kiel, Kiel, Germany)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS10-09] Understanding the mechanisms of the Atlantic meridional climate variability

*Hyacinth C Nnamchi[1], Riccardo Farneti[2], Noel S Keenlyside[3], Fred Fred Kucharski[2], Mojib Latif[1] (1.GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, 2.Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 3.Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS10-10] The corss-equatorical gradient variability: The role of heat, momentum, and freshwater flux

*Takahito Kataoka[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS10-11] Generation mechanisms of the Benguela Nino with a focus on local amplification

*Tomoki Tozuka[1], Ryo Kobayashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS10-12] **Seasonal energy analysis for baroclinic waves in equatorial Atlantic through a diagnostic scheme for energy flux**

*Qingyang Song[1], Hidenori AIKI[1] (1.Institute of space-earth environmental research, Nagoya University)

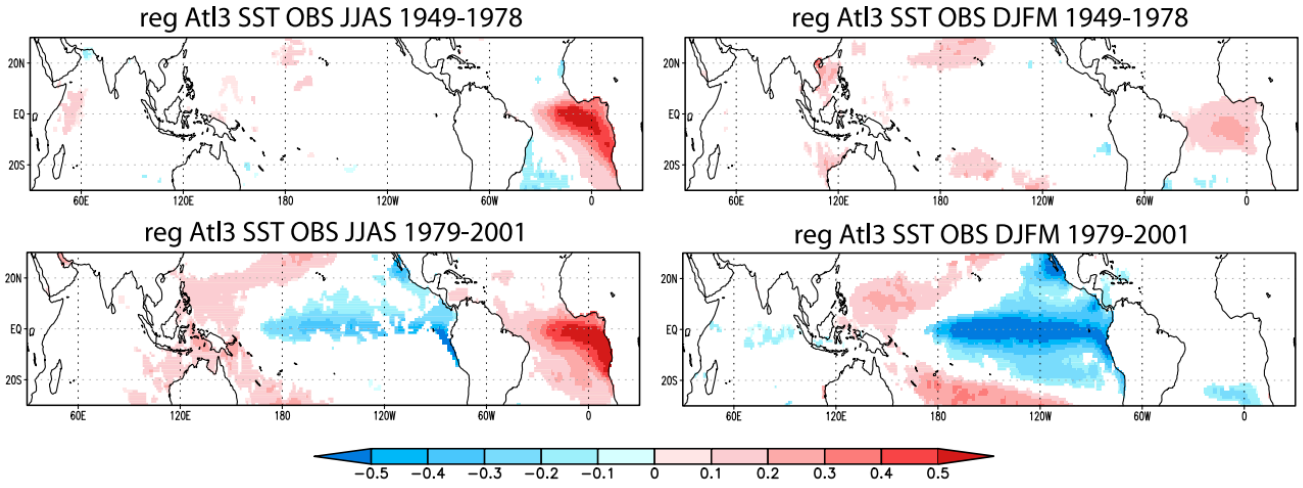
Tropical Atlantic Impact on ENSO predictability

*Belen Rodriguez-Fonseca[1,2], Irene - Polo[1], Elsa - Mohino[1], Teresa - Losada[1], Marta - Martin-Rey[5], Roberto - Mechoso[3], Noel - Keenlyside[4]

1. Department of Physics of the Earth and Astrophysics, UCM, Madrid, Spain, 2. Institute of Geosciences, IGEO, UCM-CSIC, Madrid, Spain, 3. Department of Atmospheric and Oceanic Sciences, UCLA, Los Angeles, USA, 4. Geophysical Institute, University of Bergen, Norway, 5. Instituto de Ciencias del Mar, Barcelona, Spain

Observational studies have identified periods of enhanced ENSO predictability from tropical Atlantic variability. Some works have found that this enhancement is provided by the boreal summer Atlantic Equatorial Mode (EM) impact on the atmospheric processes that trigger the following winter ENSO phenomenon. Other works have found how the variability of sea surface temperature (SST) in the northern tropical Atlantic (NTA) during boreal spring acts as ENSOs optimal predictor. The periods of enhanced ENSO predictability appear in phase with the Atlantic Multidecadal Variability (AMV) but no physical explanation has been posed so far. Here we present a hypothesis that conciliates for the first time the existence of both relationships in observations . The results are tested in CMIP5 PI-Control simulations, which allows consideration of a large number of time-periods in which either the NTA or the EM impact ENSO are tested. Model results are consistent with our hypothesis about the switch for the inter-basin connections and the proposed mechanisms. In addition, the model bias in global SST consisting of too high values south of the equator favors some interbasin teleconnections more than others.

Keywords: Atlantic-Pacific interbasin connections, tropical Atlantic variability, ENSO predictability, CMIP5



©2019. Japan Geoscience Union. All Right Reserved.

Interannual variability of Antarctic Intermediate Water in the tropical North Atlantic

*Yao Fu[1], Chunzai Wang[1], Peter Brandt[2,3], Richard J. Greatbatch[2,3]

1. State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, 2. GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany , 3. Christian-Albrechts-Universität zu Kiel, Kiel, Germany

Interannual variability of Antarctic Intermediate Water (AAIW) in the tropical North Atlantic is investigated using the GECCO2 ocean state estimate and Argo data. AAIW salinity variability near the western boundary is shown to be highly correlated with the western boundary current (WBC) transport on interannual timescales. Northward propagating anomalies are associated with the WBC variability that, in turn, is related to the large-scale wind stress curl forcing by means of the Sverdrup balance. AAIW anomalies also propagate westward with the speed of baroclinic Rossby waves, indicating that the westward propagation of baroclinic Rossby waves also plays a role in the variability of AAIW characteristics. Slow eastward spreading of AAIW anomalies is also identified on decadal timescales. Understanding the observed interannual and decadal variability of AAIW salinity is important to properly interpret salinity changes with respect to changes in the hydrological cycle.

Keywords: Interannual variability of Antarctic Intermediate Water (AAIW) in the tropical North Atlantic, Meridional propagating AAIW salinity anomalies associated with the western boundary current variability, Zonal propagating AAIW anomalies related to baroclinic Rossby wave propagation

©2019. Japan Geoscience Union. All Right Reserved.

Understanding the mechanisms of the Atlantic meridional climate variability

*Hyacinth C Nnamchi[1], Riccardo Farneti[2], Noel S Keenlyside[3], Fred Fred Kucharski[2], Mojib Latif[1]

1. GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, 2. Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 3. Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway

Decadal climate variability over tropical Atlantic is dominated by the Atlantic meridional mode (AMM). The AMM is characterized by opposite sea surface temperature anomalies to the north and south of the equator, anomalous wind flow from the cooler to the warmer hemisphere and meridional shift of the inter-tropical convergence zone. The tropical variability has also been linked to meridional variability in the South Atlantic and the extratropics of North Atlantic, with far-reaching impacts over the adjacent continents. The AMM is primarily understood in terms of the thermodynamic ocean-atmosphere interactions, particularly, the wind-evaporation sea surface feedback. Using a global ocean model forced by atmospheric observations, this study suggests that the Atlantic meridional overturning circulation may affect the Atlantic-scale meridional climate variability.

Keywords: Atlantic meridional mode, AMOC, WES feedback

©2019. Japan Geoscience Union. All Right Reserved.

The corss-equatorical gradient variability: The role of heat, momentum, and freshwater flux

*Takahito Kataoka[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology

The ocean-atmosphere feedback associated with the thermodynamic coupling among wind speed, evaporation, and sea surface temperature (SST), called the wind-evaporation-SST (WES) feedback, contributes to the cross-equatorial SST gradient over the tropical oceans. By conducting an eigenanalyses of simple linear air-sea coupled models, it is shown that three additional feedback processes are present when the variable oceanic mixed layer depth (MLD) is considered. The horizontal structures of the leading modes are similar to the WES mode, which shows a meridional dipole in the SST anomalies straddling the equator with cross-equatorial wind anomalies that represent the weakening/strengthening of the trade winds over the warm/cool SST anomalies.
In the presence of the damping term, the WES mode exists as a least damped mode consistent with previous studies. When the buoyancy flux anomaly associated with the latent heat flux anomaly is considered, a similar dipole mode in obtained, but the decaying time scale is about 40 % smaller. The freshwater flux coupling also gives a cross-equatorial gradient mode, but its stability is even smaller (decaying time scale is about 30 % of that of the WES). On the other hand, the momentum coupling allows a strongest meridional dipole variability, which is weakly unstable, indicating the importance of the wind mixing effect on the tropical meridional modes.

Keywords: air-sea interaction, tropics, ocean mixed layer

©2019. Japan Geoscience Union. All Right Reserved.

Generation mechanisms of the Benguela Nino with a focus on local amplification

*Tomoki Tozuka[1], Ryo Kobayashi[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Benguela Nino is associated with positive sea surface temperature (SST) anomalies off the west coast of Angola and Namibia in the South Atlantic. Although both local and remote forcing have been indicated to contribute to the development of Benguela Nino, the reason why their relative contribution varies among the events has not been clarified. Thus, the generation mechanisms of the Benguela Nino are investigated in this study by categorizing the events into locally amplified and non-locally amplified events depending on whether alongshore wind anomalies contribute to the development of the Benguela Nino. It is found that the locally events are associated with alongshore northerly wind anomalies related to anomalous weakening of the subtropical anticyclone in the South Atlantic known as St. Helena High and the continental low named Angola Low. On other hands, no alongshore wind anomalies that favor the development of SST anomalies exist in the non-locally amplified events. A mixed layer heat budget analysis reveals that the surface heat flux term is greater in the locally amplified events owing to smaller latent heat release associated with the weakening of the climatological southerly winds, while the anomalous warming by the advection term is stronger in the non-locally amplified events.

Keywords: Coastal Nino, South Atlantic, Interannual variation, St. Helena High, Angola Low

©2019. Japan Geoscience Union. All Right Reserved.

Seasonal energy analysis for baroclinic waves in equatorial Atlantic through a diagnostic scheme for energy flux

*Qingyang Song[1], Hidenori AIKI[1]

1. Institute of space-earth environmental research, Nagoya University

This study applied a gravity-reduced ocean model to simulate three baroclinic normal modes covering 20 years for energy analysis in Atlantic Ocean. The model, considering lateral mixing, is driven by decomposed wind forcing for each mode. Energy flux were calculated through a recently proposed diagnostic scheme with model output for all the three modes. The scheme is capable of altering pressure flux to the direction parallel to group velocities of Rossby and mixed Rossby waves in equatorial region (4° N to 4°S) without affecting the divergence. The obtained annual energy flux confirmed the dominant of westward Rossby waves in the northern and southern part of the equatorial region, while eastward Kelvin and mixed Rossby waves are most prevail in central and eastern part. The results are consistent with the fact that in the west tropical Atlantic, the most prominent signal is annual and in the central and east Atlantic, is semi-annual. Additionally, three monthly averaged energy flux revealed the seasonal energy cycle of baroclinic waves in equatorial Atlantic. Two energy sources in August and April emerged in western (around 35°W) and central part (around 15°W) of the equator in Atlantic ocean respectively. Those results suggested that the energy flux calculated by new proposed scheme in Atlantic Ocean can provide a powerful tool for energy analysis making significant contributions for further climate predictions.

Keywords: Equatorial basin mode, Energy flux, Tropical Atlantic, Seasonal variability

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Adina Paytan(University of California, Santa Cruz)

This session aims to synthetize watershed sciences in order to understand dynamical processes of materials transport and nutrient cycles in watersheds from headwaters to coastal seas. The session will be integrating a variety of research disciplines including limnology, ground water hydrology, coastal oceanography, meteorology, pedology, sedimentology, forestry, agriculture, fishery, ecology, social science and more. This session calls for ideas on new methods for the watershed sciences, such as tracer and molecular technique, hydrological modeling, paleontological approaches, laboratory and field experiments, social-scientific evaluation of ecosystem services and social-ecological systems, and so on, in order to elucidate physical, chemical and biological mechanisms for shedding light on natural phenomena and their changes over time in complex and dynamic watershed systems under human and climate impacts. Through this session, we would like to facilitate interdisciplinary collaboration among participants to create new knowledge on watershed sciences.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AHW22-06] Biodiversity increases integrated trophic position of macroinvertebrate communities in coastal food webs: testing the vertical diversity hypothesis

*Noboru Okuda[1], Jin'ichi Karube[2], Yoichiro Sakai[3], Tomohiro Takeyama[4], Ichiro Tayasu[1], Chikage Yoshimizu[1], Toshi Nagata[5] (1.Research Institute for Humanity and Nature, 2.Kindai University, 3.Lake Biwa Environmental Research Institute, 4.Okayama University of Science, 5.University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AHW22-07] The analysis of the community composition of riverine bacteria and microalgae in relation to nutrient status and diversity: the case in irrigation season in the Yasu River, Japan

*Tohru Ikeya[1], Takuya Ishida[1], Yoshitoshi Uehara[1], Satoshi Asano[2], Ichiro Tayasu[1], Noboru Okuda[1], Masayuki Ushio[3,4,5], Shohei Fujinaga[4], Chia-Ying Ko[6], Elfritzson Martin Peralta[7], Naoto F. Ishikawa[8], Tomoya Iwata[9] (1.Research Institute for Humanity and Nature, 2.Lake Biwa Environmental Research Institute, 3.Hakubi Center, Kyoto University, 4.Center for Ecological Research, Kyoto University, 5.PRESTO, Japan Science and Technology Agency, 6.National Taiwan University, 7.University of Santo Tomas, 8.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 9.Faculty of Life and Environmental Sciences, Yamanashi University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AHW22-08] **Multiple stressors and protection efforts in highly urbanized watersheds in the Philippines**

*Elfritzson M. Peralta[1,3], Leocris S. Batucan Jr.[4,6], Alexis E. Belen[2,3], Irisse Bianca B. De Jesus[1,3], Takuya Ishida[5], Chia-Ying Ko[7], Yuki Kobayashi[5], Tohru Ikeya[5], Yoshitoshi Uehara[5], Tomoya Iwata[8], Adelina S. Borja[9], Jonathan Carlo A. Briones[1,2,3], Francis S. Magbanua[4], Rey Donne S. Papa[1,2,3], Noboru Okuda[5] (1.Research Center for the Natural and Applied Sciences, University of Santo Tomas, PH, 2.Department of Biological Sciences, University of Santo Tomas, PH, 3.The Graduate School, University of Santo Tomas, PH, 4.Institute of Biology, University of the Philippines Diliman, PH, 5.Research Institute for Humanity and Nature, JP, 6.Academia Sinica and Department of Life Science, National Taiwan Normal University, TW, 7.Institute of Fisheries Science and Department of Life Science, National Taiwan University, TW, 8.Faculty of Life and Environmental Sciences, University of Yamanashi, JP, 9.Resource Management and Development Department, Laguna Lake Development Authority, PH)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AHW22-09] Ammonium contamination of shallow groundwater beneath vegetable fields in Central Vietnam

★Invited Papers

*Maeda Morihiro[1], Takuya Fujimura[1], Van Ngoc Tuong Hoang[2], Daisuke Inoue[3], Hidetaka Chikamori[1], Fujio Hyodo[1] (1.Okayama University, 2.Hue University, 3.Osaka University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AHW22-10] Modelling nutrient and organic waste behaviour in a tropical wetland in Singapore under projected anthropogenic scenarios

*Swee Yang Edmund Low[1], Dong Eon Kim[1], Canh Tien Trinh Nguyen[1], Yixiong Cai, Shie-Yui Liong[1] (1.National University of Singapore)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AHW22-11] **Benthic macroinvertebrate assemblages and water quality reflect the impacts of land use and land cover in Marikina Watershed, Philippines**

*Julie - An N. Gregorio[1,2], Elfritzson M. Peralta[3,5], Irisse Bianca B. de Jesus[3,5], Tohru Ikeya[6], Jonathan Carlo A. Briones[3,4,5], Rey Donne S. Papa[3,4,5], Francis S. Magbanua[1], Noboru Okuda[6] (1.Institute of Biology, University of the Philippines, Diliman, Quezon City, 1101 Philippines, 2.Institute of Environmental Science and Meteorology, University of the Philippines, Diliman, Quezon City 1101 Philippines, 3.Research Center for the Natural and Applied Sciences, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 4.Department of Biological Sciences, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 5.The Graduate School, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 6.Research Institute for Humanity and Nature, 457-4 Motoyama, Kamigamo, Kyoto, 603-8047, Japan)

Biodiversity increases integrated trophic position of macroinvertebrate communities in coastal food webs: testing the vertical diversity hypothesis

*Noboru Okuda[1], Jin'ichi Karube[2], Yoichiro Sakai[3], Tomohiro Takeyama[4], Ichiro Tayasu[1], Chikage Yoshimizu[1], Toshi Nagata[5]

1. Research Institute for Humanity and Nature, 2. Kindai University, 3. Lake Biwa Environmental Research Institute, 4. Okayama University of Science, 5. University of Tokyo

Introduction

Study on relationships between biodiversity and ecosystem functioning (BEF) has attracted social as well as ecological interests because the biodiversity can affect ecosystem processes, especially productivity, which determines provisioning service for humanity. Because of difficulty in accurate measurement of the productivity, however, biomass has been traditionally used as its proxy to assess the BEF. Positive correlations between biodiversity and biomass-based productivity indices have been reported for many plants both in terrestrial and aquatic ecosystems. Such correlations are also true for consumers in terrestrial systems. In aquatic ecosystems, in contrast, the biomass-based BEF relationships are inconsistent among consumer communities: some are positive or convex and others non-significant (Waide et al. 1999).

Such an inconsistency can be explained by vertical diversity, i.e., diversity of trophic positions. In systems with multitrophic interactions, in theory, consumer biomass exponentially decreases with the increasing trophic position, while underlying more primary products. The use of the consumer biomass as a proxy of its productivity is, therefore, inappropriate to view the BEF relationships in complex multitrophic systems, as in the case of aquatic food webs. Considering the multitrophic and multifunctional nature of real food webs, Wang & Brose (2018) recently have constructed a theoretical model to test vertical diversity hypothesis (VDH), predicting that functional diversity across the TPs can enhance trophic biomass flows from basal resources to top predators.

In the multitrophic and multifunctional systems, one of better ways for full-understanding of the BEF is to estimate trophic biomass flows, using carbon (δ^{13}C) and nitrogen (δ^{15}N) stable isotope analysis, which is a powerful tool for the food web analysis. Taking advantage of this analysis, Ishikawa et al. (2017) have proposed a novel index of food web properties, integrated trophic position (hereafter, *i*TP), defined as the summed TPs of all taxa in a focal food web weighed by the relative biomass of each taxon. The *i*TP can provide appropriate estimate for ecosystem functioning of vertical diversity because it indicates how many times consumer biomass experiences metabolic turnover as a whole of community within its food web. Here we test how the biodiversity can affect *i*TP for benthic macroinvertebrates in coastal waters of Lake Biwa, focusing on within-lake variation in coastal environments which can alter their local communities and thus food web properties.

Materials & Methods

We collected benthic macroinvertebrates and their basal food sources from 33 shallow coastal waters of Lake Biwa. For each sampling site, the macroinvertebrates were sorted, identified and counted to

©2019. Japan Geoscience Union. All Right Reserved.

calculate Shannon-Wiener diversity index (H'). For each taxon at each site, its dry mass was measured to calculate its biomass per unit area. Individual taxa and their basal foods at each site were provided for $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis. After this analysis, we calculated *i*TP, according to Ishikawa et al. (2017).

Results & Discussion

A total of 27 benthic macroinvertebrate taxa were found in coastal waters of Lake Biwa. In the coastal communities, oligochaetes and chironomids are the most dominant taxa in numerical abundance, while gazing snails and a suspension-feeding bivalve were the most dominant in biomass abundance. Most taxa of grazers and deposit feeders located around TP=2, while carnivorous leeches and a freshwater prawn had the highest TP, regarded as top predators of macroinvertebrate communities.
The community biomass tended to increase significantly but weakly with macroinvertebrate diversity H'. By contrast, *i*TP of coastal macroinvertebrate communities markedly increased when they have the higher H' (Fig. 1). The within-lake variation in their *i*TPs was better accounted for not only by the relative biomass abundance of top predators with highest TPs and lower numerical abundance but also by that of deposit feeders with lower TP and highest numerical abundance: the former can increase the relative contribution of predator TPs to the *i*TP, while the latter can have negative effects not only on the *i*TP but also on H' because of its numerical abundance. This is possible explanation for such a correlational pattern of BEF found in the coastal macroinvertebrate communities, empirically supporting the VDH. Our study demonstrated that the *i*TP rather than the consumer community biomass can be a promising indicator for BEF related to vertical diversity in aquatic food webs with multitrophic interactions.

Keywords: Biodiversity-Ecosystem functioning, Food web, Integrated trophic position, Lake Biwa, Stable isotope analysis, Vertical diversity

©2019. Japan Geoscience Union. All Right Reserved.

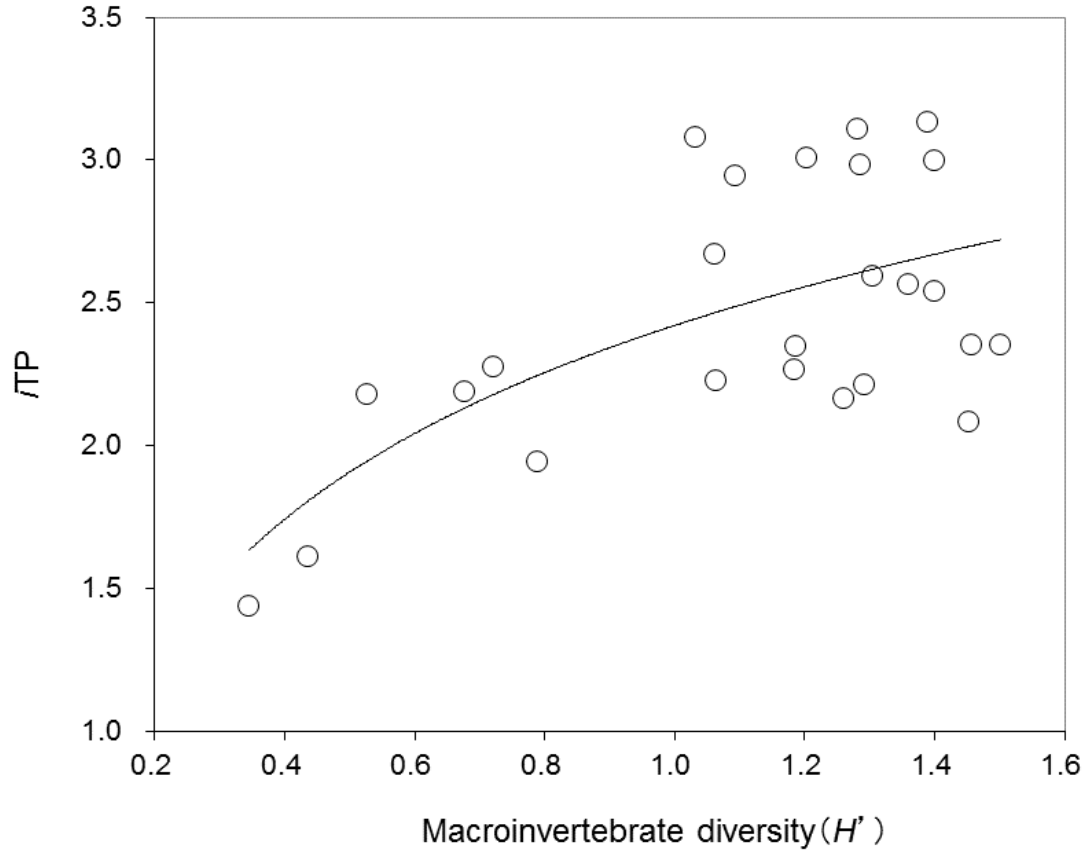


Fig. 1 A positive correlation between diversity (H') and integrate trophic position (iTP) for benthic macroinvertebrate communities in coastal waters of Lake Biwa.

©2019. Japan Geoscience Union. All Right Reserved.

The analysis of the community composition of riverine bacteria and microalgae in relation to nutrient status and diversity: the case in irrigation season in the Yasu River, Japan

*Tohru Ikeya[1], Takuya Ishida[1], Yoshitoshi Uehara[1], Satoshi Asano[2], Ichiro Tayasu[1], Noboru Okuda[1], Masayuki Ushio[3,4,5], Shohei Fujinaga[4], Chia-Ying Ko[6], Elfritzson Martin Peralta[7], Naoto F. Ishikawa[8], Tomoya Iwata[9]

1. Research Institute for Humanity and Nature, 2. Lake Biwa Environmental Research Institute, 3. Hakubi Center, Kyoto University, 4. Center for Ecological Research, Kyoto University, 5. PRESTO, Japan Science and Technology Agency, 6. National Taiwan University, 7. University of Santo Tomas, 8. Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 9. Faculty of Life and Environmental Sciences, Yamanashi University

The previous our analysis based on the community composition of microalgae and bacteria have shown that; 1) the beta diversity distances of algae and bacteria were significantly different between the four categories of land use in the Yasu River, 2) the ordinations of the sampling sites by the riverine microbial composition can be regressed by the environmental gradients between the sites in the watershed, 3) the diversity indices of bacteria increased with diversity index of algae. The further analyses of elemental composition of epilithic matter, most of which may be constituted from algae and bacteria, were made in order the assess the internal nutrient status of the epilithon. Both phosphorus amount per unit area and chlorophyll per carbon showed a significant positive correlation with phosphorus per carbon ($P < 10^{-8}$). Such ordination may help to realize whether phosphorus availability is limited to sustain the biofilm abundance or microbial activities so as to consider the possible impact of land use on the community composition and diversity of algae and bacteria. The richness of algae decreased with the decline of phosphorus per carbon of epilithic matter whereas that of bacteria was bifurcated. So, the richness and the Shannon diversity index (H') of algae showed a significant positive relationship with the phosphorus per carbon (possible index of phosphorus availability) ($P < 10^{-4}$), whereas those of bacteria showed insignificant relationship ($P > 0.2$). Most of low bacteria richness sites at low phosphorus per carbon corresponded to those where chlorophyll abundance per unit area is relatively high in spite of low phosphorus availability.

Keywords: bacteria, microalgae, 16S, MiSeq, phosphorus

©2019. Japan Geoscience Union. All Right Reserved.

Multiple stressors and protection efforts in highly urbanized watersheds in the Philippines

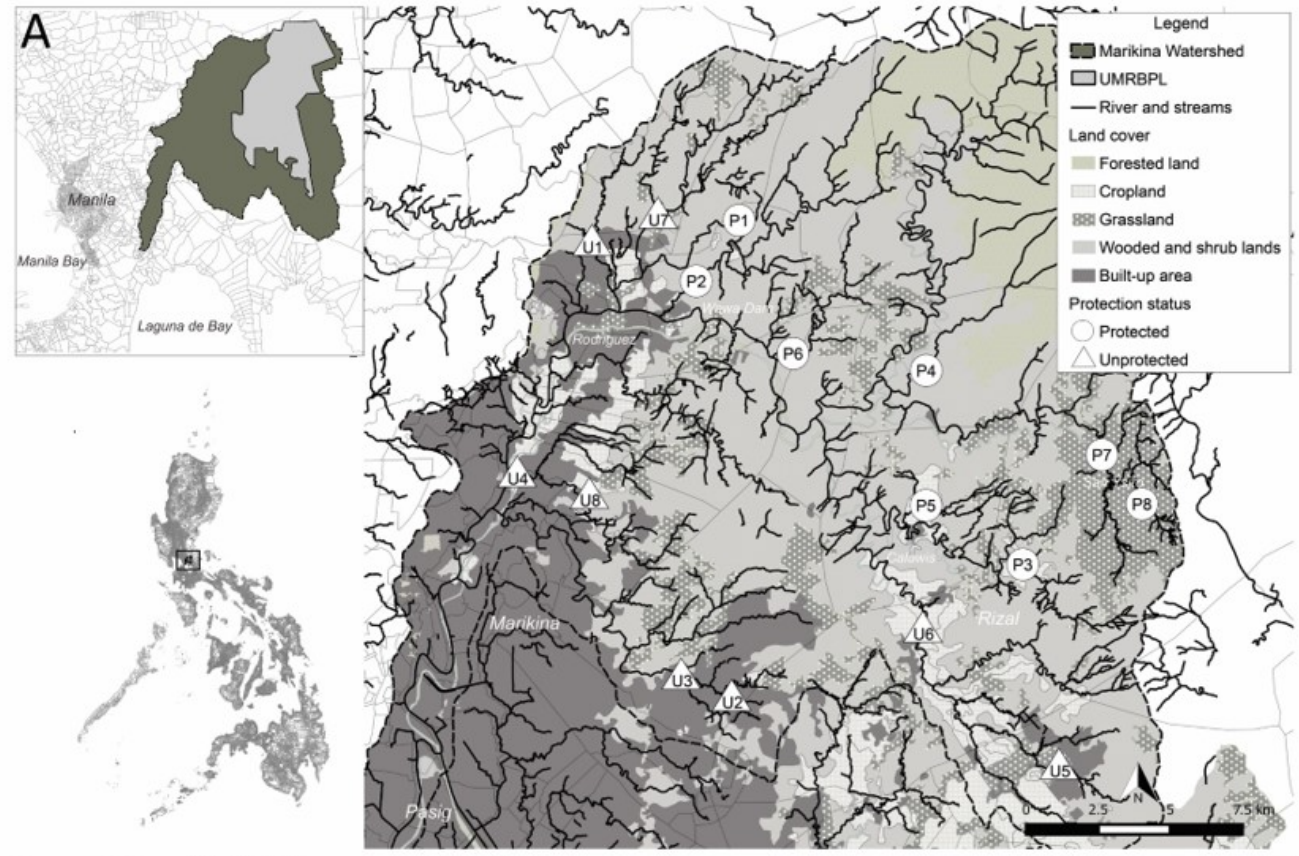
*Elfritzson M. Peralta[1,3], Leocris S. Batucan Jr.[4,6], Alexis E. Belen[2,3], Irisse Bianca B. De Jesus[1,3], Takuya Ishida[5], Chia-Ying Ko[7], Yuki Kobayashi[5], Tohru Ikeya[5], Yoshitoshi Uehara[5], Tomoya Iwata[8], Adelina S. Borja[9], Jonathan Carlo A. Briones[1,2,3], Francis S. Magbanua[4], Rey Donne S. Papa[1,2,3], Noboru Okuda[5]

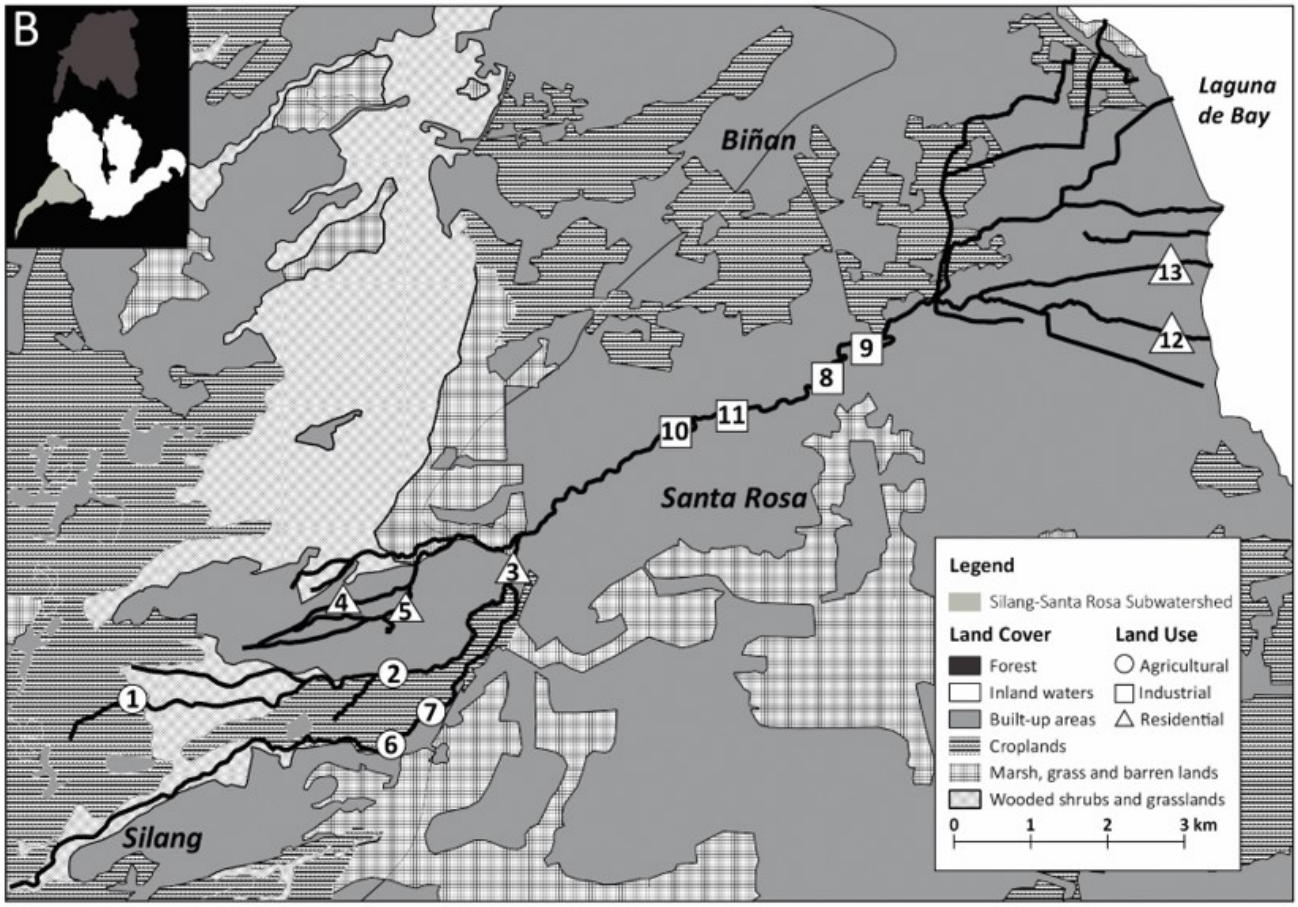
1. Research Center for the Natural and Applied Sciences, University of Santo Tomas, PH, 2. Department of Biological Sciences, University of Santo Tomas, PH, 3. The Graduate School, University of Santo Tomas, PH, 4. Institute of Biology, University of the Philippines Diliman, PH, 5. Research Institute for Humanity and Nature, JP, 6. Academia Sinica and Department of Life Science, National Taiwan Normal University, TW, 7. Institute of Fisheries Science and Department of Life Science, National Taiwan University, TW, 8. Faculty of Life and Environmental Sciences, University of Yamanashi, JP, 9. Resource Management and Development Department, Laguna Lake Development Authority, PH

Among developing countries in the tropics, urban stream syndrome is primarily driven by multiple environmental stressors, such as nutrient pollution and habitat degradation, due to social-economic developments in the catchment. To aid in environmental mitigation, improved conservation effort was recently set based on the Convention of Biological Diversity Aichi Target 11 that underscores global expansion of protected areas in terrestrial and aquatic environments. As such, this study aims to disentangle the overlaying effects of nutrient pollution and deforestation on benthic macroinvertebrate communities and assess the recent protection efforts in the watersheds of Laguna de Bay, Philippines. Study sites in Silang-Santa Rosa Subwatershed (13) and Marikina Watershed (16) were sampled for benthic macroinvertebrates and surveyed for environmental factors such as land cover and land use patterns, human population density (HPD), and stream physicochemistry including nutrient concentrations. Multivariate and multiple regression analyses on macroinvertebrate assemblages and environmental variables efficiently delineated sites according to degree of human impacts in Silang-Santa Rosa Subwatershed and the status of protection in Marikina Watershed. Canopy openness, HPD, conductivity, dissolved oxygen, and nutrients (total phosphorus, nitrates, ammonia) appeared to be the most important variables in predicting assemblages of benthic macroinvertebrates. This study effectively demonstrated how Silang-Santa Rosa Subwatershed's HPD and canopy openness, as proxies for human activities and deforestation, respectively, impact stream environments and the benthic communities. Furthermore, the recent establishment of Upper Marikina River Basin Protected Landscape inside Marikina Watershed was successfully used to show how freshwater protected areas are effective in combatting stream habitat destruction and biodiversity loss. Our findings timely show the crucial role of freshwater protected areas in conserving stream ecosystems from the effects of unsustainable urbanization in a developing country like the Philippines.

Keywords: Human population density, Deforestation, Freshwater protected area, Aichi Target 11, Biodiversity loss

©2019. Japan Geoscience Union. All Right Reserved.





©2019. Japan Geoscience Union. All Right Reserved.

Ammonium contamination of shallow groundwater beneath vegetable fields in Central Vietnam

*Maeda Morihiro[1], Takuya Fujimura[1], Van Ngoc Tuong Hoang[2], Daisuke Inoue[3], Hidetaka Chikamori[1], Fujio Hyodo[1]

1. Okayama University, 2. Hue University, 3. Osaka University

Nitrogen contamination in shallow groundwater occurs in a coastal area in Central Vietnam. In agricultural fields close to the residential area, high concentrations of NH_4^+ and NO_3^- in groundwater was attributed to unintended inflow of livestock wastes and/or domestic wastewater. On the other hand, NH_4^+ concentration reaches to several milligrams N per liter even in vegetable fields away from the residential area. The objective of this study was to determine NH_4^+ contamination mechanisms of the shallow groundwater without domestic wastewater inflow. In this study, we tested three hypotheses: (i) NH_4^+ derived from fertilizer or manure applied to the fields was transported to groundwater thorough soil, (ii) nitrate (NO_3^-) produced as a result of nitrification in topsoil was transferred to deep soil and again transformed to NH_4^+, or (iii) nitrogen mineralization occurred in deep soil. Soil samples were collected up to 240 cm from a vegetable production field in Quang Thang Commune, Central Vietnam in June (dry season) and November (rainy season) of 2016 and 2017. The groundwater table existed at 57 or 67 cm in June and 33 cm from the soil surface in November. Concentrations of NH_4^+ in PVC pipe wells fluctuated between 1 and 3 mg N L^{-1} in accordance with the detection of soil NH_4^+ content (5-20 mg kg^{-1}) in the 150-240 cm layer. On the other hand, soil NH_4^+ was not detected in the 30-80 cm layer whereas it was 2-6 mg kg^{-1} in the 0-10 cm layers, indicating that NH_4^+ was not transferred to layers deeper than 30 cm. The absence of a functional gene of dissimilatory nitrate reduction to NH_4^+ (DNRA) in the 150-240 cm soil layer shows that DNRA did not occur in this deep layer. Natural abundance values of ^{15}N ($\delta^{15}N$) for soil NH_4^+ (+3.6 to 5.5‰) were similar to those in soil total N (+1.9 to 3.6‰) in the 150-240 cm layer. In addition, anaerobically incubated soil from the 140-160 cm layer was mineralized by 1-2 mg NH_4^+-N kg^{-1} for 8 weeks. These experimental results suggest that the high concentration of NH_4^+ found in wells was originated from mineralization of deep soil.

Keywords: ammonium , dissimilatory nitrate reduction to ammonium, nitrogen mineralization

©2019. Japan Geoscience Union. All Right Reserved.

Modelling nutrient and organic waste behaviour in a tropical wetland in Singapore under projected anthropogenic scenarios

*Swee Yang Edmund Low[1], Dong Eon Kim[1], Canh Tien Trinh Nguyen[1], Yixiong Cai, Shie-Yui Liong[1]

1. National University of Singapore

Nee Soon swamp forest is one of the last vestiges of tropical wetland in Singapore, and is important both as a site for ecological preservation, as well as a source of water for potable treatment. Understanding the hydrological regime of the swamp forest and implications for water quality is critical to guide stakeholders in implementing effective measures to preserve the wetland against anthropogenic impacts. In particular, although current field measurement data do not indicate a concern with organic or nutrient pollution, reviewing the ways in which the wetland responds to elevated waste discharges can help identify potential hotspots, and the impact on the outflow from the catchment which drains into downstream controlled watercourses. An integrated water quality model is therefore developed in this study to investigate spatial and temporal concentrations of DO levels, organic pollution (as quantified by biochemical oxygen demand, BOD), and nutrient pollution (NH3-N and NO3-N) within the catchment’s river network under projected scenarios of upstream wastewater inflow. The model was developed using MIKE HYDRO for modelling the study domain, as well as the MIKE ECO Lab numerical laboratory for characterising water quality processes. Model parameters are calibrated against time series of observed discharges and dissolved oxygen levels at measurement stations along the river network. The calibrated model was then applied to study downstream impact due to elevated BOD and ammonia from upstream wastewater discharge. Over a simulation period of April 2014 to December 2015, the model predicted that a spiked inflow of 400 mg/l BOD and 30 mg/l NH3-N upstream will elevate downstream concentrations at the catchment outlet to an average of 13 mg/l BOD, and 0.7 mg/l nitrogen (NH3-N, NO3-N), from a baseline of 0.4 mg/l BOD, 0.03 mg/l NH3-N, and 0.07 mg/l NO3-N. Levels of DO were decreased from an initial 5.4 mg/l to 3.6 mg/l. Though a scenario of spiked pollutant influx at the swamp forest’s undeveloped upstream sub-catchments is currently unlikely to occur, the outcomes nevertheless will be beneficial for future planning studies in understanding how the water quality of the catchment will be impacted should urban redevelopment works be considered around the swamp forest.

Keywords: Wetland, Organic waste impact, Nutrient impact, Water quality, Modeling

©2019. Japan Geoscience Union. All Right Reserved.

Benthic macroinvertebrate assemblages and water quality reflect the impacts of land use and land cover in Marikina Watershed, Philippines

*Julie - An N. Gregorio[1,2], Elfritzson M. Peralta[3,5], Irisse Bianca B. de Jesus[3,5], Tohru Ikeya[6], Jonathan Carlo A. Briones[3,4,5], Rey Donne S. Papa[3,4,5], Francis S. Magbanua[1], Noboru Okuda[6]

1. Institute of Biology, University of the Philippines, Diliman, Quezon City, 1101 Philippines, 2. Institute of Environmental Science and Meteorology, University of the Philippines, Diliman, Quezon City 1101 Philippines, 3. Research Center for the Natural and Applied Sciences, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 4. Department of Biological Sciences, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 5. The Graduate School, University of Santo Tomas, España Boulevard, Manila, 1015, Philippines, 6. Research Institute for Humanity and Nature, 457-4 Motoyama, Kamigamo, Kyoto, 603-8047, Japan

Watershed systems provide various ecological services such as good water quality, regulate water flow, maintain water balance and biodiversity conservation. However, human disturbances greatly affect the water quality and composition of biotic communities. Although anthropogenic changes in freshwater systems were truly evident, studies focusing on the human impacts on tropical watersheds are still limited in developing countries. Thus, this study aims to investigate the response of freshwater macroinvertebrates to varying land use patterns and land cover characteristics in Marikina Watershed, Philippines. For a total of 30 streams, which were categorized into 7 protected, 3 forested, 8 agricultural, and 12 residential streams based on land use and cover in their catchments, were collected benthic macroinvertebrates and measured environmental variables. PCA plots were not able to classify water quality according to land use and was supported with no significant difference in Kruskal –Wallis test. However, water quality of primarily vegetated and primarily non-vegetated sites as well as protected and protected streams had delineation, as accorded with the results of independent *t* - tests with significant differences ($p<0.05$) on dissolved oxygen, conductivity, total dissolved solids and salinity. While the forested streams are clustered together in the NMDS plot but there is no clear pattern in the assemblage of benthic macroinvertebrates. The similarities in the composition of macroinvertebrates could be attributed to the similar magnitude and intensity of landscape alteration of each land use among the streams. Interestingly, the nMDS plot shows strong separation of macroinvertebrate assemblages across gradient of vegetation area (Global $R = 0.388$, $P = 0.001$) and were supported independent *t*- test where with macroinvertebrate diversity, density and abundance of pollution-sensitive taxa on primarily vegetated areas exhibited significant differences from non-vegetated areas ($p < 0.05$). Additionally, biotic indices such as such as SingScore, Average Score per Taxon THAI ($ASPT^{THAI}$), Biological Monitoring Working Party ($BMWP^{THAI}$), and Stream Invertebrate Grade Number Average Level version 2 (SIGNAL 2) reveal significant differences among protection status, land use types and land cover ($p<0.05$). CCA plot also revealed pollution –sensitive taxa with primarily vegetated sites were associated with pollution-sensitive taxa and primarily non-vegetated sites are associated with pollution-tolerant organisms to on CCA plot. The findings of this study demonstrate the effects of land alteration to the macroinvertebrate community and water quality. Furthermore, it emphasizes the importance of vegetation cover and designation of protected areas to have better ecological quality in a watershed. This study thus suggests for an extensive and improved policy development and implementation. Furthermore, extensive biomonitoring and formulation of Marikina Watershed Biotic Index are recommended.

Keywords: Marikina Watershed, land use, land cover, water quality, benthic macroinvertebrates

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Yasumoto Jun(University of the Ryukyus, Faculty of Agriculuture Department of Regional Agricultural Engineering)

This session aims to synthetize watershed sciences in order to understand dynamical processes of materials transport and nutrient cycles in watersheds from headwaters to coastal seas. The session will be integrating a variety of research disciplines including limnology, ground water hydrology, coastal oceanography, meteorology, pedology, sedimentology, forestry, agriculture, fishery, ecology, social science and more. This session calls for ideas on new methods for the watershed sciences, such as tracer and molecular technique, hydrological modeling, paleontological approaches, laboratory and field experiments, social-scientific evaluation of ecosystem services and social-ecological systems, and so on, in order to elucidate physical, chemical and biological mechanisms for shedding light on natural phenomena and their changes over time in complex and dynamic watershed systems under human and climate impacts. Through this session, we would like to facilitate interdisciplinary collaboration among participants to create new knowledge on watershed sciences.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AHW22-12] Characterization, distribution and degradation of environmental plastics in inland river system of Mongolia

*Batdulam Battulga[1], Masayuki Kawahigashi[1], Bolormaa Oyuntsetseg[2] (1.Department of Geography, Tokyo Metropolitan University, Tokyo, 192-0397, Japan , 2.Department of Chemistry, National University of Mongolia, Ulaanbaatar, 210646, Mongolia)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AHW22-13] Multi-site and multi-approach sediment transport modeling in tropical watersheds

★Invited Papers

*Assefa M Melesse[1], Alemu Osore Aga[2], Hagos Gebreselassie[2] (1.Florida International University, 2.Addis Ababa University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AHW22-14] Calculation of SS concentration coefficients of river water for each land use by a simple watershed model.

*Seiko Yoshikawa[1], Donglai Ma[1,2], Tadamasa Saito[1,3], Kenji Matsumori[4], Yuko Itoh[5], Masahiro Kobayashi[5] (1.Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization, 2.Graduate Scool, Tsukuba University , 3.Faculty of Agriculture, Ibaraki University , 4.Western Region Agricultural Research Center, National Agriculture and Food Research Organization, 5.Forestry and Forest Products Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AHW22-15] Evaluation of long term variation in water balance and discharge of sediment and nitrogen in the urbanized catchment of Yamato River, using SWAT model

*Kunyang Wang[1,2], Yuta Shimizu[3], Shin-ichi Onodera[1], Mitsuyo Saito[4], Yusuke Tomozawa[1] (1.Graduate School of Integrated Arts and Science, Hiroshima University, 2.Capital Normal University, 3.National Agriculture and Food Research Organization, 4.Okayama University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AHW22-16] Causal correlation between water-use of the Tedori River and coastal erosion of Chirihama Nagisa Driveway, Ishikawa, Japan

*Toshihiko Momose[1] (1.Ishikawa Prefectural University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AHW22-17] Role of suspended solids on elemental dynamics in the Selenga River system

★Invited Papers

*Masayuki Kawahigashi[1], Orgilbold Myangan[2], Bolormaa Oyuntsetseg[2] (1.Tokyo Metropolitan University, 2.National University of Mongolia)

Characterization, distribution and degradation of environmental plastics in inland river system of Mongolia

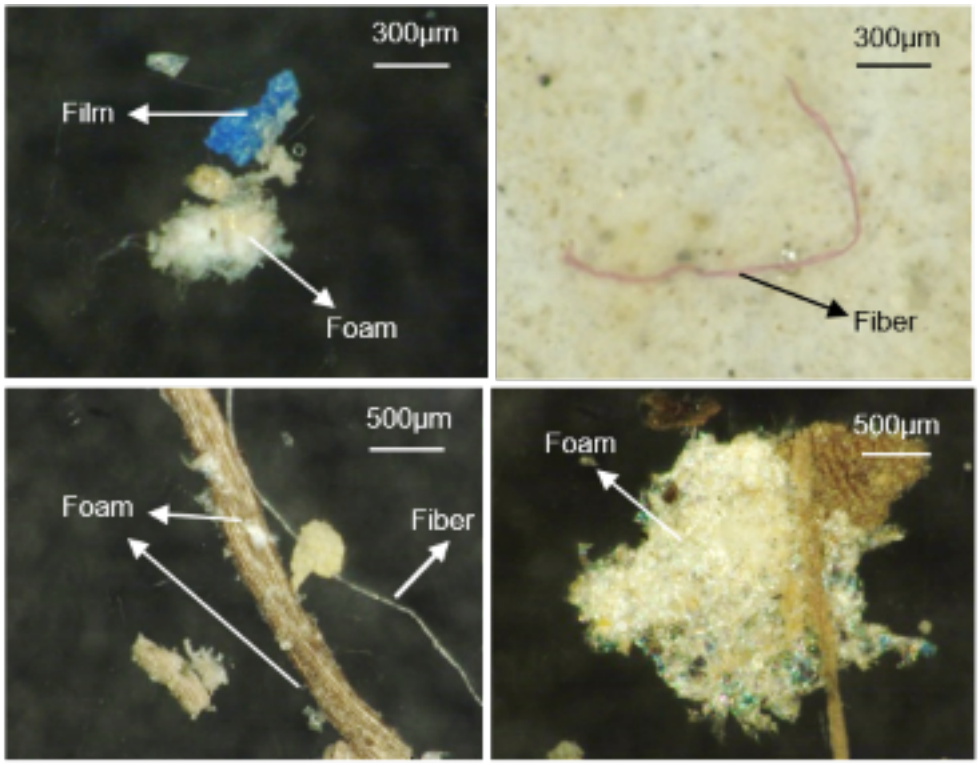
*Batdulam Battulga[1], Masayuki Kawahigashi[1], Bolormaa Oyuntsetseg[2]

1. Department of Geography, Tokyo Metropolitan University, Tokyo, 192-0397, Japan , 2. Department of Chemistry, National University of Mongolia, Ulaanbaatar, 210646, Mongolia

Marine plastic abundance and distribution have been reported toward increasing importance of their behavior as anthropogenic influences on aquatic environment. However, remains of plastics particularly in freshwater are largely unknown. Tributaries in the Selenga River system are important sources of fresh water in Central and Northern Mongolia, although the river system has been alarmed by various kinds of pollution because of growing population and increasing demand of land and resources. Evaluating fate of plastics in the river is vital to assess how the urban system affects plastic pollution in Selenga River. This study aimed to identify the fate of environmental plastics in the Selenga River system of Mongolia.
In 2017 and 2018, totally 18 sampling sites have been surveyed according to geographical locations from the capital city, Ulaanbaatar. Collected plastics were classified as their sizes (micro, meso, macro and mega) and materials such as films, foams, fragments and fibers. Visually sorted plastics identified by FTIR micro-spectroscopy to determine chemical characterization. Furthermore, a degradation index of collected plastics was examined using a ratio of two specific IR absorptions. Invisible microplastics (MP) attached onto the collected plastics were separated mainly from polystyrene foam (PSF), which was the most dominant environmental plastics in the research field. Characterization of the invisible MP was conducted using a digital microscope and an FTIR micro-spectroscopy.
Plastic films and foams were largely occupied in the collected plastics from the researched rivers. Surprisingly great amount of PSF were found in micro and meso size ranges. The results illustrate that on-site fragmentation and degradation of bulk PSF occurred in the research sites probably due to solar radiation and freeze-thaw cycles. A broad range of the degradation index was recorded in micro, meso and macro sized PSF, indicating that various stages of degradation occurred in the river environment. Apart from the other plastics types, PSF was considered as a carrier of invisible MP. A greater diversity of invisible MP types and numbers were found in a microscopic view using a digital microscope on the surface of PSF. Polyethylene (PE) and polystyrene (PS) were major components of the sorbed MP.
This study represents the first detailed examination of the distribution, types and degradation processes of plastics in the Mongolian river system. Environmental plastics were widespread litter in the investigated Mongolian river shores due to low-level of waste management with rapidly growing population and urbanization.

Keywords: Plastic debris, River shore, Mongolia, Degradation, Microplastics

©2019. Japan Geoscience Union. All Right Reserved.



Microscopic view of microplastics attached onto visible polystyrene foam (PSF).

©2019. Japan Geoscience Union. All Right Reserved.

Multi-site and multi-approach sediment transport modeling in tropical watersheds

*Assefa M Melesse[1], Alemu Osore Aga[2], Hagos Gebreselassie[2]

1. Florida International University, 2. Addis Ababa University

Land degradation and poor watershed management have been the major factors that led to severe soil erosion and hence sedimentation in receiving water bodies and reservoirs. The environmental impacts of sediment transport and loading is highly pronounced in tropical watersheds where rainfall is erratic and torrential and soil and conservation measures are poor. In this study, a soil erosion, sediment yield and transport modeling were conducted in three tropical watersheds in Ethiopia and Kenya. Field plot experiment, model development and evaluation were conducted. The impact of land use, rainfall intensity and slope were evaluated at plot and watershed scales. Three models (WEPP, SWAT and Erosion 3D) were tested and compared. The results indicate that the models performed differently with Erosion 3D and WEPP performed better in sediment load simulation. In the absence of the observed sediment data, sediment rating curves developed and validated were useful and are promising.

Keywords: Sediment flux, Sediment modeling, Erosion 3D, SWAT, WEPP, Tropical watersheds

©2019. Japan Geoscience Union. All Right Reserved.

Calculation of SS concentration coefficients of river water for each land use by a simple watershed model.

*Seiko Yoshikawa[1], Donglai Ma[1,2], Tadamasa Saito[1,3], Kenji Matsumori[4], Yuko Itoh[5], Masahiro Kobayashi[5]

1. Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization, 2. Graduate Scool, Tsukuba University , 3. Faculty of Agriculture, Ibaraki University , 4. Western Region Agricultural Research Center, National Agriculture and Food Research Organization, 5. Forestry and Forest Products Research Institute

In recent years, sediment-related disasters are increasing due to intensification and localization of rainfall caused by climate change. Although it is difficult to predict the place and extent of sediment-related disasters, we firstly grasp the average concentrations of sediment discharge in recent years and predict increase and decrease in the sediment concentrations when the way of rain changes. Sediment runoff is depend on land use and land cover, conservative measures, topography, climate condition mainly rainfall etc.. Among them, the land use and land cover is expected to be great in normal climate conditions. Here, in order to contribute to the prediction of sediment-related disasters in the future, coefficients that indicate the SS load intensity to rivers of each land use for the river watersheds across the country are calculated using a simple watershed land use model.
Watersheds whose lower ends are observation points of water quality, and whose land use ratios were determined by GIS technique using published database of DEM (GSI, 10B, raster data) and LULC mesh data (JAXA , ALOS AVNIR-2, 10m mesh data). The SS concentration coefficients of paddy, upland, forest, and urban were calculated by applying the below multiple regression equation using the land use ratios and published SS data(Ministry of Environment).

$C = a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4$

C: SS concentration (mg L^{-1}) a_i : SS concentration coefficient for land use i, x_i : ratio of land use i, Land use i : 1;paddy 2;upland fields 3;forest 4;urban

The SS concentration coefficient is 15.4 (lower limit 95% value 12.0 to upper limit 95% value 18.8), 11.5 (7.4 to 15.6), 3.9 (2.6 to 5.1), 11.2 (9.2 to 13.2) for paddy fields, upland fields, forests and urban areas respectively (n=5103).
In order to investigate further in detail, it is necessary to analyze fertilization, soil properties, livestock industry in the watershed, climatic conditions (especially rainfall amount), topographical and geographical features and so on.

Keywords: watershed land-use model, SS, concentration coefficient

©2019. Japan Geoscience Union. All Right Reserved.

Evaluation of long term variation in water balance and discharge of sediment and nitrogen in the urbanized catchment of Yamato River, using SWAT model

*Kunyang Wang[1,2], Yuta Shimizu[3], Shin-ichi Onodera[1], Mitsuyo Saito[4], Yusuke Tomozawa[1]

1. Graduate School of Integrated Arts and Science, Hiroshima University, 2. Capital Normal University, 3. National Agriculture and Food Research Organization, 4. Okayama University

Land-use changes, freshwater use, and the biochemical flow are important factors affecting the Earth's environmental threshold. In the research topics of Planetary Boundaries (PB), these factors have been defined as entering high-risk levels. One-third of the planet's freshwater resources come from groundwater, and now, in some countries and regions, it is also exposed to the risk of groundwater depletion. Large-scale urbanization brings economic development but also increases the possibility of urban waterlogging.

Yamato river is the highest-level river in Japan. It has a watershed area of 1067 square kilometers, covering almost half area of Nara prefecture. Yamato river catchment includes Nara basin which as an important agricultural base, Nara city and part of Sakai city. The water environment in the catchment is closely related to the healthy life of human beings. Especially in recent years, there are frequent flooding in the catchment. Therefore, the study of Yamato river is very necessary.

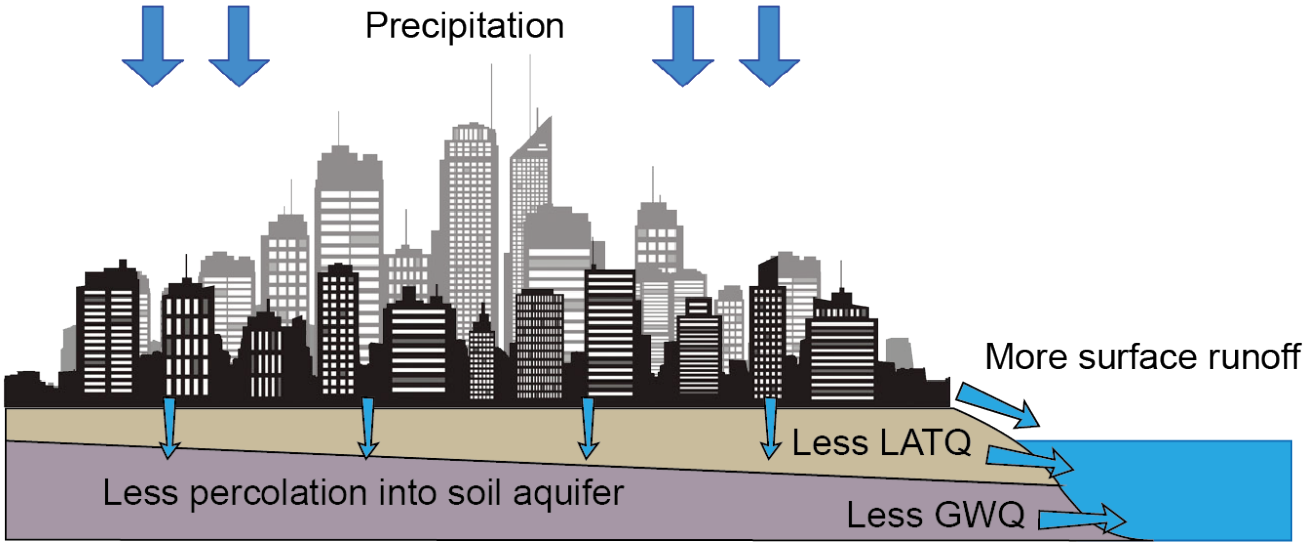
This thesis uses the SWAT (Soil and Water Assessment Tool) model and Geographic Information System (GIS) methodology. The SWAT model can not only simulate the water discharge and nutrient load but also find the essence of the change of water environment through the change of parameter sensitivity. Select Coefficient of determination (R2), Nash–Sutcliffe efficiency (NSE), and percentage of bias (PBIAS) as a factor of assessing results and obtained the experimental results with credibility.

It is found that the land use in the basin is mainly manifested in the change from farmland to urban land use type, which probably accounts for 1/3 of the total area of land use type changed. Over a period of 2009-2016, the average of water discharge from the total outlet in the main channel is 2.37 million m3/day while it's 2.06 million m3/day in 1971-1978. As a result of changes in land use, water yield from farmland decreased by 45% compared with the 1970s, while the yield from the city increased by 43%. Among them, Surface runoff generated increase by about 70%. In Sakai and its surrounding cities, surface runoff generated increased by 18% per 100 mm precipitation. Curb length density in the high-density urban area increased about one time. That means Sakai now, in the face of flooding caused by torrential rains, needs to take on higher risks.

Sediment yield reducing by more than 70% from 1988 to 2014. The change comes mainly from the management of the river channel. The non-point source load of nitrate increased from 1096 tons to 1534 tons, this is mainly due to the increase in precipitation and the increase in population. The growth of forests also has a certain impact. This is because the type of land used in farmland and forests, there has a large number of fertilizers on the surface of the soil from human agriculture activities or the decay of animal and plant debris. Under the driving effect of precipitation, it mainly transported by the lateral flow in farmland and forest area and the surface runoff in the urban area, a large part will enter the river channel.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Land use change, Water balance, Nitrogen load, SWAT Model, Long term variation



©2019. Japan Geoscience Union. All Right Reserved.

Causal correlation between water-use of the Tedori River and coastal erosion of Chirihama Nagisa Driveway, Ishikawa, Japan

*Toshihiko Momose[1]

1. Ishikawa Prefectural University

Awarded as the best beach of Japan (Reported by TripAdvisor, Inc. 2016), Chirihama Nagisa Driveway is a sandy beach located in Ishikawa, attracting people as the place that allows for driving cars and even large tourist buses along the shore. The source of the Chirihama sand is debris from Mt. Haku-san, which is transferred by the Tedori River and the Tsushima Current. At the river mouth, the finer sands are transferred to further offshore, and then drifted to further beach such as the Chirihama coast (50 km far from the river mouth). Due to the natural sand drifting process, the Chirihama coast is composed of the sands with fine and uniform grain size, the feature which guarantees for comfortable drive on the beach. The Chirihama coast is a treasure of Ishikawa; however, it faces a crisis of disappearance due to beach erosion.

According to Ishikawa prefectural government, the amount of sand loss of the Chirihama coast is 70000 m^3/year and its width decreases at 1 m/year. While the Chirihama coast is disappearing, a large-scale landslide of 1300000 m^3 occurred at upstream region of the Todori River in 2015 and the massive derbies moved downstream. The turbid water released for the ocean seemed to contribute to the formation of the Chirihama coast, but there are no reports on the recovery of the Chirihama coast. Where do the sands released from the Tedori River move?

Field investigations along the coast have found that the beach sediment at 4 –5 km far from the river mouth has the same feature as the Chirihama sand. From the viewpoint of recent water-use of the Tedori river, this presentation explains a possible reason why the fine sand released from the Tedori River cannot move to the Chirihama coast.

Keywords: Chirihama Nagisa Driveway, Coastal erosion, Tedori River, River structure

©2019. Japan Geoscience Union. All Right Reserved.

Role of suspended solids on elemental dynamics in the Selenga River system

*Masayuki Kawahigashi[1], Orgilbold Myangan[2], Bolormaa Oyuntsetseg[2]

1. Tokyo Metropolitan University, 2. National University of Mongolia

Lake Baikal is one of the cleanest lake in the world. However, there are many sources of pollution such as mining, industry and agriculture in the river basin of the main tributary, Selenga River which is flowing into Lake Baikal. Lake Baikal actually face to severe pollution affected by anthropogenic activities in the watershed. Natural cleaning mechanism can still be functioning to prevent pollutants flow into the Baikal. Since suspended solids (SS) in the Selenga River can play a role as carriers of heavy metals and organic pollutants, their dynamics should be addressed to know the mechanism.

Water and sediment samples were collected in the Russian territory from the Mongolian border to the shore of the Baikal including the Selenga Delta. SS samples were further recovered using a glass fiber filter from the water samples. Surface sediments and SS samples were digested with the mixture of nitric acid and perchloric acid for determination of elements using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES).

Elemental concentrations were changeable depending on SS concentration along the tributary. Changes in SS concentration can be controlled by flow rate of the tributary. The significant relationship were observed between SS and sesquioxides mainly consisting of Fe and Al. Both of Mn and Cr were also common constituents of the SS oxides despite of their low concentration in SS. In contrast, Zn and Cu have no correlation with SS, indicating that they are specifically accumulated onto SS surface at a point where the two elements were released. The concentration of SS gradually decreased accompanied by decrease in heavy metals in SS in the delta region. On the contrary, those elements in the surface sediments increased to downstream in the delta region. Deposition process of SS in the delta can be occurred due to decrease in flow rate by channel bifurcation of tributaries, back water effect from Lake Baikal and SS trapping by vegetation in the delta. The delta has a potential to trap SS, resulting that water quality in the Lake Baikal has been protected of water quality in Lake Baikal.

Keywords: Lake Baikal, SS deposition, channel bifurcation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 201B 2F

[A-HW22] Materials transport and nutrient cycles in watersheds; from headwaters to coastal seas

convener:Masahiro Kobayashi(Forestry and Forest Products Research Institute), Seiko Yoshikawa(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization), Jun Yasumoto(University of the Ryukyus, Faculty of Agriculuture), Adina Paytan(University of California Santa Cruz), Chairperson:Yoshikawa Seiko(Institute for Agro-environmental Sciences, National Agriculture and Food Research Organization)

This session aims to synthetize watershed sciences in order to understand dynamical processes of materials transport and nutrient cycles in watersheds from headwaters to coastal seas. The session will be integrating a variety of research disciplines including limnology, ground water hydrology, coastal oceanography, meteorology, pedology, sedimentology, forestry, agriculture, fishery, ecology, social science and more. This session calls for ideas on new methods for the watershed sciences, such as tracer and molecular technique, hydrological modeling, paleontological approaches, laboratory and field experiments, social-scientific evaluation of ecosystem services and social-ecological systems, and so on, in order to elucidate physical, chemical and biological mechanisms for shedding light on natural phenomena and their changes over time in complex and dynamic watershed systems under human and climate impacts. Through this session, we would like to facilitate interdisciplinary collaboration among participants to create new knowledge on watershed sciences.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AHW22-18] Relationship between topographical characteristics in catchment area and dissolved iron concentration of river in permafrost area

*Yuto Tashiro[1], Muneoki Yoh[1], Takayuki Shiraiwa[2], Takeo Onishi[3] (1.Tokyo University of Agriculture and Technology, 2.Hokkaido University, 3.Gifu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AHW22-19] Water Source Zones and Hydrochemical Properties of Fluoride Water in Mt. Meru Watershed, Tanzania

*Shinji Nakaya[1], Ryogo Takada[1], Jun Yasumoto[2], Junichi Yoshitani[1], Innocent Lugodisha[3], Zuberi Dominicus Lwimbo[3], Hans Komakech[4], Thomas Reuben Mollel[5] (1.Department of Water Environment and Civil Engineering, Faculty of Engineering, Shinshu University, Japan, 2.Department of Regional Agriculture Engineering, University of the Rykuyus, Japan, 3.School of Materials, Energy, Water and Environmental Sciences, NM-AIST, Tanzania, 4.WISE-Future, NM-AIST, Tanzania, 5.SGSS and Institute of resources assessment-UDSM, Tanzania)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AHW22-20] Development and Application of a System for Measurement of Total Load of Water Quality

★Invited Papers

*Keiji Takase[1], Yuko Itoh[2] (1.Ishikawa Prefectual University, 2.Forestry and Forest Products research Institute, Japan)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AHW22-21] Water infiltration and uptake around a Japanese cypress growing on a flat upland

*Masahiro Kobayashi[1], Shin-ichi Onodera[2], Yuko Itoh[1], Tadashi Sakata[1] (1.Forestry and Forest Products Research Institute, 2.Graduate School of Integrated and Arts Sciences, Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AHW22-22] Innovative Rainfall Simulator Design for Moving Storm Scenarios with Different Storm Patterns

*RAVI KUMAR MEENA[1], SUMIT SEN[2] (1.M.Tech Student, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India, 2. Associate Professor, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Relationship between topographical characteristics in catchment area and dissolved iron concentration of river in permafrost area

*Yuto Tashiro[1], Muneoki Yoh[1], Takayuki Shiraiwa[2], Takeo Onishi[3]

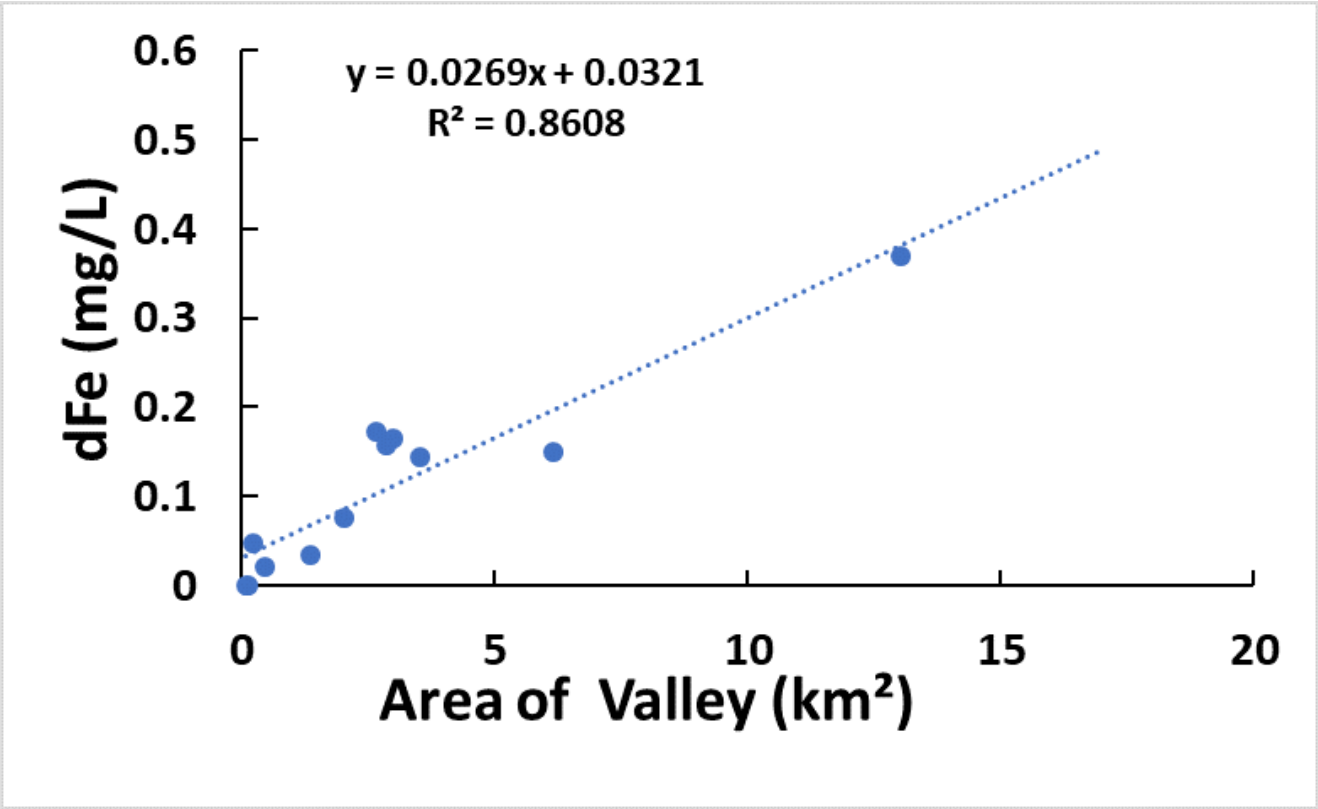
1. Tokyo University of Agriculture and Technology, 2. Hokkaido University, 3. Gifu University

[Background]
Dissolved iron flowing out from the wetlands in the Amur River basin is an important nutrient that supports the primary production of phytoplankton in the Sea of Okhotsuk. Therefore, the amount of iron supplied to the sea is supposed to change due to the increase and/or decrease of the wetland area within the Amur basin. However, in the longterm observation of the dissolved iron concentration in the Amur River, the considerably high concentration, which can not be explained by the land-use change of the wetland, was observed in the latter of the 1990s. In the 1990s, because the relatively higher temperature had been continued, Shamov et al.,2014 speculated that permafrost thawing might be caution. Therefore, we hypothesized that permafrost thawing might promote the forming of humid and reductive condition which was suited to dFe generation in active layer, and have been conducting research on the mechanism of dissolved iron production and the distribution of permafrost. It has become clear that permafrost exists under the vegetation called Mari. Mari is the wetland which is covered by hygrophyte and sphagnum in a valley, and thick peat soil is accumulated underground.On the other hand, forest areas where birch or larch are densely spread with thin peat layers on the slope and ridge. Thus, the topographical features such as valley, slope and ridge in the catchment area dominate the vegetation and soil properties, and the dissolved iron cycling. In this study, we focused on the area of the valley as a topographical feature within the catchment area, and researched with the aim to discover the relationship to dissolved iron concentration in the river.
[Materials and Methods]
The research was conducted in the Tyrma River basin, which is a further tributary of the Tributary of the Amur River, in Khabarovsk. This area corresponds to the sporadic permafrost zone. In September 2018, we collected the water from 12 rivers in total; 5 rivers flowing into the Tyrma River and 5 rivers flowing into the Gujar river which is a tributary of the Tyrma River (basin area 7 to 200 km2). After sampling the water, immediately filtration was carried out with a disposable 0.45 μm filter and stored in polyethylene containers. Dissolved iron concentration was measured by the phenanthroline method after adding a few drops of HNO3- to the sample water to adjust pH <2.
We extracted the valley area using GIS soft "QGIS". The altitude data of field site, a global numerical surface model (DSM) corresponding to a resolution of 30 m by a panchromatic stereoscopic sensor (PRISM) equipped with JAXA 's Land Observing Satellite "ALOS" was used. The catchment area on the upstream side from the sampling point of each river was extracted and the Topographic Position Index (TPI) and the inclination (degree) were calculated. Next, the cells with TPI <0 - [standard deviation of TPI ×1/2] and inclination <3 (degree) were judged as a valley and these areas were calculated. The radius(R) of TPI was set to R = 500 m or R = 1000 m according to the valley width of the river. The reason why the condition of inclination <3 (degree) was added was that if only the condition of TPI was included, even the lower part of the slope was included, so that the valley area could be overestimated.
[Results and Discussion]
Dissolved iron concentrations in some rivers showed a very low concentration of <0.02 mg / L, which is below the detection limit, while others showed high concentrations of 0.37 mg / L. The relationship between these concentration differences and the valley area in the catchment area is shown in Fig.1. In the rivers whose valley area was less than 1 km2, the concentration of dissolved iron was less than 0.05

©2019. Japan Geoscience Union. All Right Reserved.

mg / L. On the other hand, it was revealed that the concentration of dissolved iron tended to be higher with larger valley area in the catchment area. For the rivers with the low dFe concentrations, the catchment areas ware less than 15 km2, and the valley area occupied as low as 3% or less. The other rivers whose the dissolved iron concentration higher than 0.1 mg / L, the valley area accounted for 5-8% of the catchment area. The flat valley exists along the river is a typical topography in the Tyrma basin. In such places where the inclination is small, since the movement of water is also limited and make the residence time longer, the moisture and reductive environment can be maintained in the active layer on the permafrost, and wetland like Mari which is taken precedence by hygrophyte is widely formed in the valley. As the result, this study showed that Mari covering the valley has the function of dissolved iron generation and dissolved iron flow out into rivers.

Keywords: Dissolved Iron, Permafrost, Wetland



©2019. Japan Geoscience Union. All Right Reserved.

Water Source Zones and Hydrochemical Properties of Fluoride Water in Mt. Meru Watershed, Tanzania

*Shinji Nakaya[1], Ryogo Takada[1], Jun Yasumoto[2], Junichi Yoshitani[1], Innocent Lugodisha[3], Zuberi Dominicus Lwimbo[3], Hans Komakech[4], Thomas Reuben Mollel[5]

1. Department of Water Environment and Civil Engineering, Faculty of Engineering, Shinshu University, Japan, 2. Department of Regional Agriculture Engineering, University of the Rykuyus, Japan, 3. School of Materials, Energy, Water and Environmental Sciences, NM-AIST, Tanzania, 4. WISE-Future, NM-AIST, Tanzania, 5. SGSS and Institute of resources assessment-UDSM, Tanzania

Fluoride is leaching to natural water system from volcanic rocks and ashes with alkali volcanic activity along Great Lift Valley in east Africa. Tanzanian people in Great Lift Valley are also suffering drinking water including high fluoride (> 1.5 mgF/L of WHO) and water shortage. We investigated the groundwater and river water fluoride pollutions in area between Arusha of Mt. Meru watershed and Moshi of Mt. Kilimanjaro watershed in September, 2018 to provide the solutions to these issues as No. 6 of SDGs. We find some results below:

1. Average fluoride content is 4.0 mgF/L in Mt. Meru watershed, and 0.5 mgF/L in Mt. Kilimanjaro watershed.

2. Fluoride concentrates in Na-HCO_3 type water, and Fluoride tend to increase with Na and pH.

3. Groundwater fluoride tends to be increasing with residence time, but in recent twenty five years, fluoride is
higher in younger groundwater.
4. Well waters supplied to Arusha city come from the recharge zone of 2,000 m to 3,000 m in altitude of Mt. Meru, and the fluoride content tend to increase with the recharge altitude.

Keywords: Fluoride, Great Lift Valley, Tanzania, Mt. Meru watershed

©2019. Japan Geoscience Union. All Right Reserved.

Development and Application of a System for Measurement of Total Load of Water Quality

*Keiji Takase[1], Yuko Itoh[2]

1. Ishikawa Prefectual University, 2. Forestry and Forest Products research Institute, Japan

Conservation and management of water quality is most important to conserve the water environment as well as to secure good water resource. Water quality has been conventionally controlled by regulation of emission concentration. On the other hand, divergence of emission material and increase of waste water in recent years indicates that the regulation of total emission will be most important. In addition, the knowledge of total load of a material such as nitrogen and phosphorous is fundamental to understand a cycle and mass balance of the material. However, the measurement of water quality load is not so easy because it requires much of time and labor well as high cost. So, we established a new system by which we could easily determine the total load of water quality. In this paper, the system is applied in a forested watershed to discuss validity of the system.

Keywords: Water Quality, Concentration, Total load of water quality, System for collecting water, Forested watershed

©2019. Japan Geoscience Union. All Right Reserved.

Water infiltration and uptake around a Japanese cypress growing on a flat upland

*Masahiro Kobayashi[1], Shin-ichi Onodera[2], Yuko Itoh[1], Tadashi Sakata[1]

1. Forestry and Forest Products Research Institute, 2. Graduate School of Integrated and Arts Sciences, Hiroshima University

In forest ecosystems, trees strongly influence the water movement above and below the ground. During rainfall events, some rainwater flows as stemflow, which provides concentrated water input into soil. The redistribution of soil water during periods without rainfall is affected by water uptake by roots. To clarify the effects of trees on soil water dynamics during and after rainfall events, we monitored the distribution and temporal dynamics of the soil water potential around the stem of a Japanese cypress (*Chamaecyparis obtusa*) using a two-dimensional array of tensiometers installed at multiple soil depths and distances from the tree. During rainfall events with wet antecedent moisture conditions, stemflow infiltrated into the soil and recharged the shallow groundwater near the stem. The matric potential often increased at lower positions before upper positions, indicating bypass flow through macropores. After large rainfall events, once the matric potential distribution became uniform horizontally, gravity-driven drainage proceeded. During the drying process, the matric potential decreased markedly proximal to the stem compared to distally. A horizontal gradient in the matric potential was observed in both the shallow and deeper soil layers. This indicates an intense sink caused by water uptake by roots from the deeper soil layer. Upon excavating the roots after monitoring the matric potential, dense fine roots were observed in the deeper soil layer. The tree studied may feed the deeper soil around its root zone with rainwater as stemflow and use the water advantageously following the drying process.

Keywords: tree, stemflow, water uptake

©2019. Japan Geoscience Union. All Right Reserved.

Innovative Rainfall Simulator Design for Moving Storm Scenarios with Different Storm Patterns

*RAVI KUMAR MEENA[1], SUMIT SEN[2]

1. M.Tech Student, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India, 2. Associate Professor, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India

Rainfall simulators are widely used in the field of hydrology, biosystem engineering, agronomy, and geomorphology to understand the processes involved in these disciplines. Usually, rainfall simulators are not able to generate spatio-temporal variation in rainfall intensity simultaneously unlike natural conditions. Majority of methods used in rainfall simulator studies assumes that the rainstorm reaches instantaneously and remains steady over an area for a certain time period. Hence, most of the rainfall experiments ignore the effect of runoff response caused by moving storm across a watershed which results in under or over estimation of runoff peaks. Considering these limitations of traditional rainfall simulators, we are developing an advanced rainfall simulator using eleven full cone nozzles to simulate moving front storm. These nozzles can generate rainfall intensity in the range of 65 to 190 mm/hr at a pressure range of 50 kPa to 180 kPa with a varying height from 1.5m to 4m above the ground surface. All the eleven nozzles are controlled by flow control valves and the valves are individually regulated by servo motors. Arduino Mega microcontroller system is used to control all the servo motors to generate variable rainfall intensities. Further, we have developed a mobile application for Android users to regulate all the valves of rainfall simulator. This simulator is able to simulate nearly natural rainfall conditions in the controlled environment in four different patterns i.e. uniform, advanced, delayed and intermediate. A tray of 250cm×140cm×50cm has also being designed and fabricated to conduct different hydrological experiments. This tray is designed with a provision to generate and record overland, subsurface and base flow. Tray area can also be divided in three partition to analyze three different soil conditions simultaneously. Slope adjustment, leachate collection unit and piezo metric head measurement unit are also incorporated in this experimental tray. Overall, the whole rainfall simulator with tray can be used to study the impact of moving storm on soil erosion, infiltration, and runoff in the simulated near natural environment along with pollutant transport mechanisms. This study is being focused on detailed analysis of moving storms and their impact on hydrograph characteristics, especially in terms of time of concentration (tc), time to peak (tp), and peak discharge (Qp) for two different storm directions (upstream and downstream) with different storm movement velocity and rainfall intensity.

Keywords: Rainfall simulator, Moving Storm experiments, Spatio-temporal variation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 301A 3F

[A-GE28] Subsurface Mass Transport, Material Cycle, and Environmental Assessment

convener:Yuki Kojima(Department of Civil Engineering, Gifu University), Shoichiro Hamamoto(Department of Biological and Environmental Engineering, The University of Tokyo), Hirotaka Saito(Department of Ecoregion Science, Tokyo University of Agriculture and Technology), Yasushi Mori(Graduate School of Environmental and Life Science, Okayama University), Chairperson:Yuki Kojima(Gifu University), Shoichiro Hamamoto(The University of Tokyo), Yasushi Mori(Okayama University), Hirotaka Saito(Tokyo University of Agriculture and Technology)

This session covers the topics on mass transport, water and energy cycles in geoenvironment. Subjects related to laboratory and field measurements, theoretical analysis, and numerical modeling will be discussed. Presentations on geo-pollution, remediation, geological disposal of hazardous wastes, ground source heat utilization, mass transport in vadose zone, soil-water monitoring, and environmental assessment are encouraged.

9:00 AM - 9:25 AM JST | 12:00 AM - 12:25 AM UTC

[AGE28-01] **Humic substances in deep sedimentary groundwater**

★Invited Papers

*Takumi Saito[1] (1.School of Engineering, The University of Tokyo)

9:25 AM - 9:40 AM JST | 12:25 AM - 12:40 AM UTC

[AGE28-02] Nano-Bubble Retention in Saturated Porous Media under Different Solution Chemistry

*Shoichiro Hamamoto[1], Takuya Sugimoto[1], Takato Takemura[2], Taku Nishimura[1], Scott A Bradford[3] (1.Department of Biological and Environmental Engineering, The University of Tokyo, 2.College of Humanities and Sciences, Nihon University, 3.U. S. Salinity Laboratory)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[AGE28-03] **Geochemical Investigation of Metals and Trace Elements around the Abandoned Cu – Ni Mine Site in Selibe Phikwe, Botswana**

*Fiona Segolame Motswaiso[1], Kengo - Nakamura[1], Noriaki - Watanabe[1], Takeshi - Komai[1] (1.Tohoku Univeristy Graduate School of Environmental Studies)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[AGE28-04] Removal of Arsenic (III) From Aqueous Solution Using Pumice and Zeolite Supported Zero-Valent Iron Nanoparticle

*Shashi Ranjan[1], Brijesh kumar yadav[1], Himanshu Joshi[1] (1.Indian Institute of Technology Roorkee)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[AGE28-05] **Unsaturated Hydraulic Conductivity Estimation from Multi-step Centrifuge Outflow**

*Thanh Long Bui[1], Yasushi Mori[1] (1.Graduate School of Environmental and Life Science, Okayama University)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

Discussion

Humic substances in deep sedimentary groundwater

*Takumi Saito[1]

1. School of Engineering, The University of Tokyo

Humic substances (HSs) are ubiquitous in various environments and play important roles for the fate of nutrients and pollutants. Deep underground environment is not an exception, although the properties of HSs there are largely unknown due to their limited availability. Recently, we reported the physicochemical and ion-binding properties of HSs extracted from sedimentary groundwater at -250 m below ground surface of the Horonobe underground research center operated by the Japan Atomic Energy Agency. The Horonobe HSs (HHSs) consist of relatively small organic molecules rich in aliphatic carbon and reduced sulfur. The densities of acidic functional groups such as carboxylic groups are relatively high for HHSs, and they are chemically homogenous. Nevertheless, the binding of Cu^{2+} to HHSs are smaller than that to surface HSs, suggesting the presence of different coordination environments for Cu^{2+} in HHSs. Cadmium, a thiophilic metal, tends to form CdS(s) nano-particles with HHSs likely due to the high concentrations of reduced sulfur. In this talk, the particularity of the HHSs will be discussed, comparing their properties with those of their counterparts in surface environments.

Keywords: Humic substance, Groundwater

©2019. Japan Geoscience Union. All Right Reserved.

Nano-Bubble Retention in Saturated Porous Media under Different Solution Chemistry

*Shoichiro Hamamoto[1], Takuya Sugimoto[1], Takato Takemura[2], Taku Nishimura[1], Scott A Bradford[3]

1. Department of Biological and Environmental Engineering, The University of Tokyo, 2. College of Humanities and Sciences, Nihon University, 3. U. S. Salinity Laboratory

An understanding of nano-bubble (NB) migration in porous media is needed for potential environmental applications. This research investigates factors that control the transport, retention, and release of air NBs in repacked glass beads. One-dimensional column transport studies with air NBs were conducted under different solution IS, ionic composition, and pH conditions. Collected data were simulated using a mathematical model that considered advective and dispersive transport, first-order kinetic retention, and transient release. Results were interpreted with the aid of interaction energy calculations that considered electric double layer, van der Waals, and Lewis acid-base interactions on surfaces with different amounts of nanoscale roughness. NB concentrations in the effluent were reduced with an increase in ionic strength (IS) or a decrease in pH due to a reduction in the repulsive force between the glass surface and NBs, especially when the solution contained Ca^{2+} as compared to Na^{+} and for larger NBs. NB retention on the surface was explained by ubiquitous nanoscale roughness on the glass beads that significantly lowered the energy barrier, and localized attractive charge heterogeneity and/or hydrophobic interactions.

Keywords: Nano bubble, Transport, Porous media, Solution chemistry

©2019. Japan Geoscience Union. All Right Reserved.

Geochemical Investigation of Metals and Trace Elements around the Abandoned Cu –Ni Mine Site in Selibe Phikwe, Botswana

*Fiona Segolame Motswaiso[1], Kengo - Nakamura[1], Noriaki - Watanabe[1], Takeshi - Komai[1]

1. Tohoku Univeristy Graduate School of Environmental Studies

Metals and trace elements may occur naturally in rocks and soils, but elevated quantities of them are gradually released into the environment by anthropogenic activities such as mining. In order to address issues of trace element water and soil pollution, a distinction needs to be made between natural and anthropogenic anomalies. The current study aims at characterizing the spatial distribution of trace elements and evaluate site-specific geochemical background concentrations of trace elements in the mine soils and river sediments and also to discriminate between lithogenic and anthropogenic sources of enrichment around a copper-nickel mining town in Selibe-Phikwe, Botswana.

A total of 43 soil, 30 river sediments, and 9 river water samples were collected from an area of 500m2 within the precincts of the mine. The total concentration of Cu, Ni, Pb, Cr, As, and Co in soils and sediments were determined using ED-XRF while river water samples were analyzed by ICP-AES. Geochemical pollution indices such as Geo-accumulation Index (Igeo), Enrichment Factor (EF) and Integrated Pollution Index (IPI) were employed for the assessment of metal and trace element contamination. The average metal concentration in soil of Cu, Ni, Pb, Cr, As, and Co in the study area were 73.27, 78.10, 25.83, 61.43, 4.28 and 6.43 mg/kg, respectively. To calculate the geochemical baseline, Relative cumulative frequency curves and the 4 s -outlier test methods suggested by Matschullat (2000) were incorporated. The estimated average baseline concentrations of Cr, Cu, Ni, Co, Zn and As are 53.8, 51.85, 53.95, 5.6, 32.36 and 4.27 mg kg 1, respectively. Soil leachate, sediment leachate, and river water pH levels ranged from basic (9) to very acidic (3) in areas closer to the mine. There is high variation in heavy metal concentration, eg. Cu, depicting regional natural background concentrations while others depict anthropogenic sources. The calculated Igeo values revealed moderate pollution level by the same metals. The result of integrated pollution indices suggested a generally deteriorating site quality. The results of chemical analysis also indicate that the trace elements in soils decreased with respect to distance from the mine; controlled mainly by water movement, wind direction, and topography.

Keywords: Soil Contamination, Geochemical baseline, Pollution indices, Trace elements

©2019. Japan Geoscience Union. All Right Reserved.

Removal of Arsenic (III) From Aqueous Solution Using Pumice and Zeolite Supported Zero-Valent Iron Nanoparticle

*Shashi Ranjan[1], Brijesh kumar yadav[1], Himanshu Joshi[1]

1. Indian Institute of Technology Roorkee

Arsenic is a naturally occurring toxic element and is widely distributed in natural ecosystems. Due to the natural as well as human-induced actions, its presence in groundwater is expanding its horizons and is becoming a major concern in lower Gangetic plains. Large active surface area and high arsenic adsorption capacity make nano-zero valent iron nanoparticle (nZVI) a promising adsorbent to remove arsenic species but due to high surface energy and the inherent magnetic forces of nZVI, it gets agglomerated and reduces its efficiency for adsorption. The objective of the present study was to develop supported nZVI over the porous material (pumice and zeolite) and their use for As (III) removal from aqueous solution. The chemical approach, i.e., Liquid Phase Synthesis, was used to infuse the iron nanoparticle on the surface of the porous material via reduction of iron in the presence of the base material by sodium borohydride. The shape, size, and surface morphology studied by Fe-SEM and shows a uniform distribution of nZVI over the surface of granular (0.5-1 mm) base materials. Batch studies were performed to determine the applicability of prepared composites as an adsorbent for As (III) removal at varying initial As (III) concentration (0.5 -5 mg/L), adsorbent dose (1-10 g/L) and pH (3-12). Adsorption kinetics and isotherms were studied in detail for the synthesized adsorbent to deduce the overall performance. Batch experiments demonstrated the quick removal of As (III) at initial stages followed by a slower removal rate, making it a two-stage process. The supported nZVI was found to be an effective adsorbent for As (III) removal and due to its mechanical strength, it can be applied for in-situ remediation of arsenic-polluted groundwater

Keywords: Arsenic, Nano Zerovalent Iron, Remediation, Pumice and Zeolite

©2019. Japan Geoscience Union. All Right Reserved.

Unsaturated Hydraulic Conductivity Estimation from Multi-step Centrifuge Outflow

*Thanh Long Bui[1], Yasushi Mori[1]

1. Graduate School of Environmental and Life Science, Okayama University

In the age of blooming technologies, direct and indirect laboratory methods, which identified soil function, are developed to shorten experiment time. In developing countries of Asia area, research on soil physic is sometimes limited because it is not easy to bring samples from those countries. In addition, it is impossible to identify soil function from the soil sample without original structure. Therefore if we can measure soil hydraulic conductivity or water holding capacity with small volume of samples, it is very beneficial for the region where soil data is limited. In this study, centrifuge multi-step outflow method was examined to estimate drainage process, i.e., unsaturated hydraulic properties.

The experiment was conducted using 2-mL centrifuge tube with two pin-holes at the top and bottom of the tube. After saturated from the bottom, multi-step pressurized outflow was performed on four kinds of soil samples including standard soil, granite decomposed soil, rice paddy field soil and volcanic ash soil. Transient outflow volume was measured using small centrifuge machine within 5 and 15 minutes at room temperature (25oC). The centrifuge pressure step was 1000, 2000, 3000, 4000, and 5000rpm, which was approximately 90, 360, 810, 1400, and 2250cmH2O respectively. Based on the outflow volume and accumulated time as input data for inverse solution model (HYDRUS 1D v4.6), hydraulic conductivity was optimized.

We found out that the optimization was successful with clayey soils and volcanic ash soils, but not with granite decomposed soil and standard sandy soils. The more sand particles it contained, the less convergence for hydraulic conductivity optimization we had obtained.

Keywords: Unsaturated Hydraulic Conductivity, Multi-step outflow, Centrifuge

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 301A 3F

[A-GE29] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Institute for Geo-Resources and Environment, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University), Chairperson:Ming Zhang(AIST), Hirotaka Saito(Tokyo University of Agriculture and Technology), Yonghong Hao(Tianjin Normal University)

This session provides a broad platform for discussion and presentation of fundamental and up-to-date scientific results related to clean energy production, environmental remediation and restoration, waste management, water cycle, monitoring of water quality, management of water resources and interconnections among them for sustainable development. Presentations on the topics associated with social science that enhance public awareness, stakeholder empowerment and involvement, and policy decisions regarding the management of water, energy and the environment are also encouraged.

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

Introduction

10:50 AM - 11:05 AM JST | 1:50 AM - 2:05 AM UTC

[AGE29-01] Input-Output Analysis of Taiwan’s Food-Energy-Water Risk

*CHU-CHUN YAO[1], Gene Jiing-yun You[1] (1.National Taiwan University)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[AGE29-02] **Groundwater potential analysis using the multiple spatiotemporal remote sensing approach in fractured rock of mountainous region**

*Jung-Jun Lin[1,2], Yuei-An Liou[1], Chien-Chung Ke[2], Su-Yun Chi[2], Jia-Hung Liang[3] (1.National Central Univ., 2.Sinotech Engineering Consultants, Inc., 3.Ministry of Economic Affairs)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[AGE29-03] Estimating Soil Water Content with Color Calibration Method in the Image of Remote Sensing by Unmanned Aerial Vehicle

*Hong-Yi Li[1], Hong-Ru Lin[1], Jyun-Lin Chen[1], Shao-Yang Huang[1], Jet-Chau Wen[1] (1.National Yunlin University of Science and Technology)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[AGE29-04] **Characterizing Geotechnical Properties of Drinking Water Sludge Blended with Graded Crushed Clay Brick for Road Subgrade: Effects of Gradation and Mixing Proportion of Crushed Clay Brick on CBR and Water Permeability**

*Muhammad Rashid Iqbal[1], Akihiro Matsuno[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[AGE29-05] Investigation and Evaluation of the Multiple-liquefaction Site at the Southern Taiwan

*Chih-Sheng KU[1] (1.I-Shou University)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

Discussion

Input-Output Analysis of Taiwan’s Food-Energy-Water Risk

*CHU-CHUN YAO[1], Gene Jiing-yun You[1]

1. National Taiwan University

The water, energy, and food (WEF) nexus means that the three sectors are inextricably linked and that actions in one area more often than not have impacts in one or both of the others. From a national planning perspective, it is necessary to more precisely investigate the relationships among food-energy-water sectors. This study applies input-output analysis based on interdependencies between economic sectors or industries in Taiwan’s food-energy-water challenge and risk. In this study, the research data is based on Taiwan’s trade association tables of 52 economic sectors (including food, energy, and water-related sectors) for the year 1996, 2001, 2006, and 2011. We develop the extrapolation method to produce available I-O table. The future I-O table can be forecasted by applying different predictive models (e.g., linear or nonlinear regressions). We will observe the changes in Taiwan’s economic structures during the time period (e.g., between 1996 and 2001) and also investigate the uncertainty of economic impact focusing on food, energy, and water. Based on the results of analysis of Taiwan’s trade association tables, we can predict the risks that Taiwan’s industries may face under different conditions in the future and might provide some useful information to the government for taking countermeasures.

Keywords: WEF, input-output analysis, extrapolation, I-O table, economic structures, risk

©2019. Japan Geoscience Union. All Right Reserved.

Groundwater potential analysis using the multiple spatiotemporal remote sensing approach in fractured rock of mountainous region

*Jung-Jun Lin[1,2], Yuei-An Liou[1], Chien-Chung Ke[2], Su-Yun Chi[2], Jia-Hung Liang[3]

1. National Central Univ., 2. Sinotech Engineering Consultants, Inc., 3. Ministry of Economic Affairs

Because of the costly field investigation, an optimum benefit technique, the multiple spatiotemporal remote sensing analysis, was used for long-term monitoring and assessment of groundwater potential capacity. In this study, we used the mentioned approach to derive the spatiotemporal index from Landsat imagery for identifying the land use change and understanding the regional hydrogeological characteristics, such as normalized difference vegetation index (NDVI), soil moisture index (SMI), land surface temperature (LST) and so on. To verify the index evaluation results, the hydrogeological properties including the core inspection, geophysical logging and hydraulic testing of totally 108 boreholes drilling in the fractured rock mass in mountainous region were collected. The pumping test results such as well capacity from 76 groundwater monitoring wells were also used to compare the potential groundwater capacity evaluated from remote sensing analysis. It was found a good agreement between the field investigation data and remote sensing analysis results. Therefore, the multi-scaled comprehensive analyses of natural and anthropogenic geomorphic features are suitable for providing more information to qualify and estimate the selections of investigated sites in the future.

Keywords: groundwater, fractured rock, remote sensing

©2019. Japan Geoscience Union. All Right Reserved.

Estimating Soil Water Content with Color Calibration Method in the Image of Remote Sensing by Unmanned Aerial Vehicle

*Hong-Yi Li[1], Hong-Ru Lin[1], Jyun-Lin Chen[1], Shao-Yang Huang[1], Jet-Chau Wen[1]

1. National Yunlin University of Science and Technology

From the previous research results, there are many methods for measuring soil water content (SWC), but most of the SWC measurement methods are destructive methods for soil structure. Moreover, it takes a lot of time and manpower. In recent years, the method of estimating SWC from digital images of unmanned aerial vehicle (UAV) is a novel and rapid for measuring SWC non-destructive. While estimating SWC in the field using digital images, the effects are produced sunlight and climates and setting of the camera white balance. While estimating the SWC by digital images, these influences will let these methods have a bias between the hue value of digital images and the color of actual soil. So, the purpose of this study is to add a color calibration method while the process of estimating to remove the influences of sunlight, climates and white balance of camera, to improve the accuracy of estimating SWC by digital images.

At first, this study collected the surface soil samples from 0 to 5 cm below the ground surface at the study site which is the sampling range of in-situ planning. A standard color card (ColorChecker) is placed at the study site as a basis for image color calibration. After that, this study used UAV to take a photo-shooting at 30 meters above the ground, and obtain the digital images of the study site. After the sampling is completed, the surface soil sample is obtained its gravimetric water content by thermogravimetry in the laboratory. Next, the digital images taken by the UAV is used to cut the study area and image color calibration using the image processing software.

Then, using Matlab 2018b software to calculates the hue value of RGB color space (Red (R), Green (G), and Blue (B)) of the digital images before and after the color calibration separately, and transforms them into other six color spaces (normalized RGB, HIS, I1I2I3, Lab, YCbCr, and Lch). At last, this study used multiple linear regression to establish the SWC estimation models separately, and then compare the influences which before and after color calibration.

The results of this study show the influences of sunlight, climates and white balance of camera make a significant bias when estimating SWC using the digital images before color calibration. However, this study which added color calibration improves the accuracy in the estimation of SWC by digital images. Finally, the achievements of this study can apply in reducing the number of water resources of the agriculture irrigation widely.

Keywords: Surface soil, Aerial photo-shooting, Digital image processing, Color calibration

©2019. Japan Geoscience Union. All Right Reserved.

Characterizing Geotechnical Properties of Drinking Water Sludge Blended with Graded Crushed Clay Brick for Road Subgrade: Effects of Gradation and Mixing Proportion of Crushed Clay Brick on CBR and Water Permeability

*Muhammad Rashid Iqbal[1], Akihiro Matsuno[1], Ken Kawamoto[1]

1. Graduate School of Science and Engineering, Saitama University

Effective uses of construction and demolition waste, sludge, and industrial by-products for engineering purposes are highly demanded in developing countries. Currently, these materials are used for other construction works such as ground levelling and backfilling without any quality control of materials and/or directly dumped at the landfill site. In this research, an attempt was made to use drinking water sludge (DWS) by blending with crushed clay bricks (CCB) to propose their utilization for constructing road subgrade. DWS with less than 2-mm was blended with CCB with three different particles range; (a) finer fraction having particle size 2-10mm, (b) Coarser fraction 10-30mm, and (c) graded fraction 2-30mm. The mixing proportion has been controlled from 0 to 100% on the dry mass basis. Geotechnical properties such as California bearing ratio (CBR) and water permeability were investigated in the laboratory. Experimental results showed that addition of a finer fraction of CCB from 0 to 100% with DWS improved CBR values from 45% to 88% which was almost double than the DWS itself and captured a well linear relationship. Up to 60% addition of a coarser and graded fraction of CCB increased CBR value from 45% to 110% which was 2.44 times higher than the DWS itself. However, at 80% addition of CCB, graded fraction enhanced the CBR value more as compared to coarser fraction which was due to the well packing and reduction of the voids. On the other hand, at 100% blend of CCB coarser fraction showed quite higher values which could be due to the breakage of the bigger particles and filling the voids effectively. The water permeabilities of all these blended samples showed a very well relationship with Hazen model as compared to Kozeny-Carman model. It can be concluded that graded and coarser fraction 60% blend had an equal or superiority effect than the 100% of the finer fraction blends. All the tested sample fulfilled the improved subgrade requirement to utilize for the road subgrade.

Keywords: Drinking water sludge, Crushed Clay bricks, California Bearing Ratio (CBR), Water Permeability

©2019. Japan Geoscience Union. All Right Reserved.

Investigation and Evaluation of the Multiple-liquefaction Site at the Southern Taiwan

*Chih-Sheng KU[1]

1. I-Shou University

Southern Taiwan experienced several large earthquakes on 5 December 1946 (M_w=6.3), 4 March 2010 (M_w=6.4) and 6 February 2016 (M_w=6.6), respectively. Liquefaction phenomenon evidences was observed at Hsinhwa district, Tainan city, Taiwan during the 1964, 2010, and 2016 earthquake. Re-liquefaction at this site was confirmed by GPS surveying at the sand boiling locations after last two earthquakes. Seismic cone penetration test (SCPT) and boring were conducted at this site after 2010, and 2016 earthquake. The recurrence of liquefaction, availability of pre-earthquake logging, and high fine content in the liquefied soil stratum make this case valuable for detail study. This paper presents the results of the investigation and evaluates the liquefaction potential of the reliquefied site by different period exploration data. The comparison of the SCPT strength profile before and after the last earthquakes seems to indicate that no significant variation has occurred in this multiple liquefied site, making the area vulnerable to liquefaction induced sand boiling in future large-scale earthquakes. Liquefaction analyses with in situ test data show that this site is still highly susceptible to liquefaction.

Keywords: Earthquake, Liquefaction, Seismic Cone Penetration Test



03-05-2010



02-13-2016

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 301A 3F

[A-GE29] Energy-Environment-Water Nexus and Sustainable Development

convener:Ming Zhang(Institute for Geo-Resources and Environment, Geological Survey of Japan, AIST), Ken Kawamoto(Graduate School of Science and Engineering, Saitama University), Jet-Chau Wen(National Yunlin University of Science and Technology), Yonghong Hao(Tianjin Normal University), Chairperson:Ken Kawamoto(Saitama University), Jet- Chau Wen(National Yunlin University of Science and Technology, Taiwan)

This session provides a broad platform for discussion and presentation of fundamental and up-to-date scientific results related to clean energy production, environmental remediation and restoration, waste management, water cycle, monitoring of water quality, management of water resources and interconnections among them for sustainable development. Presentations on the topics associated with social science that enhance public awareness, stakeholder empowerment and involvement, and policy decisions regarding the management of water, energy and the environment are also encouraged.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[AGE29-06] Investigating the Reproducibility of Hydraulic Tomography Estimates with Time-Variable Boundary Conditions

*Jian-Dao Li[1], Jyun-Lin Chen[1], Hong-Ru Lin[1], Shao-Yang Huang [1], Tian-Chyi Jim Yeh[2], Jet-Chau Wen[1] (1.National Yunlin University of Science and Technology, 2.The University of Arizona)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[AGE29-07] **Applying river pollution index and QUAL2K model for water quality assessment and management in Ke-Ya river, Taiwan**

*Hong-Syuan Li[1], Yu-Chih Lin[1] (1.Department of Environmental Engineering & Health, Yuanpei University of Medical Technology)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[AGE29-08] Environmental assessment at CDW disposal sites in Vietnam: Case study in Thanh Tri landfill, Hanoi

*Thanh Ha Ngo[1], Akihiro Matsuno[1], Ken Kawamoto[1] (1.Graduate School of Science and Engineering, Saitama University)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[AGE29-09] **Modeling Study on the Impacts of Groundwater Pumping to Regional Hydroclimatology in 37 World Major Aquifers**

*Pat J.-F. Yeh[1] (1.Monash University Malaysia)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[AGE29-10] CHRATERIZING BURIED WASTE COMPOSITION AT CONSTRUCTION AND DEMOLITION WASTE (CDW) DISPOSAL SITE IN VIETNAM: A CASE STUDY IN THANH TRI LANDFILL IN HANOI

*Tselmeg Aldarjav[1], Akira Kato[1], Akihiro Matsuno[1], Ken Kawamoto[1,2] (1.Graduate School of Science and Engineering, Saitama University, Japan , 2.International Institute for Resilient Society, Saitama University, Japan)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

Discussion

Investigating the Reproducibility of Hydraulic Tomography Estimates with Time-Variable Boundary Conditions

*Jian-Dao Li[1], Jyun-Lin Chen[1], Hong-Ru Lin[1], Shao-Yang Huang [1], Tian-Chyi Jim Yeh[2], Jet-Chau Wen[1]

1. National Yunlin University of Science and Technology, 2. The University of Arizona

In recent years, the hydraulic tomography (HT) is a popular method for the delineation of the spatial distributions of hydraulic properties in the groundwater aquifer. Previous researches investigated the spatial distributions of hydraulic properties by the HT survey using the constant head boundary condition. However, the constant head is not the real condition in the boundary condition at the field. The study purpose is the case studies of two years at the same site using the time-variable boundary conditions to delineate the reproducibility of hydraulic properties.

The study area is located in National Yunlin University of Science and Technology (NYSUT) campus in Taiwan. The sequential pumping test is carried in 2010 and 2012 were used for the inverse modeling effort to estimate the hydraulic properties. The boundary condition is applied to the HT method using the sensitivity equation method (SEM) to calibrate the time-variable heads. Then, the reproducibility of estimates and prediction were analyzed in two different years. The results show that the more heterogeneity of hydraulic properties. The HT method can be improved using the time-variable boundary conditions.

Keywords: Sensitivity equation method, Boundary condition, Hydraulic tomography, Sequential pumping test, Heterogeneity, Hydraulic property

©2019. Japan Geoscience Union. All Right Reserved.

Applying river pollution index and QUAL2K model for water quality assessment and management in Ke-Ya river, Taiwan

*Hong-Syuan Li[1], Yu-Chih Lin[1]

1. Department of Environmental Engineering & Health, Yuanpei University of Medical Technology

Waste water from hundreds of factories in Hsiang-Shan industrial park, Hsinchu Science Park, animal husbandry, metal surface electroplating industries, and domestic sewage are discharged into Keiya River HshinChu, Taiwan. In this study, monitoring data of the Keya River was collected, the river pollution index (RPI) and QUAL2K models were utilized for analysis and assessment of water quality. The divide of pollution collection area and evaluation of the assimilative capacity were also discussed.
The results indicated that the main pollutant in the water quality of Keiya River was ammonia nitrogen, which was contained in wastewater discharged from residential areas and Hsinchu Science Park etc., the second was biochemical oxygen demand (BOD). In order to improve the problem of ammonia nitrogen in the rivers, the Taiwan Environmental Protection Agency has tightened the emission limits of ammonia and nitrogen concentrations in wastewater discharges from 2012. The ammonia nitrogen wastewater treatment modules were also installed in the Hsinchu Science Park to reduce ammonia nitrogen emissions into rivers. In addition, the Hsinchu City Environmental Protection Bureau has strengthened the control of the copper standard for discharge water upto 1.5mg/L from 2017, so that the copper concentration in the current river water was maintained at <0.001-0.03mg/L, which was compliance with the environmental standards related to human health protection.

Keywords: river pollution index, assimilative capacity, ammonia nitrogen

©2019. Japan Geoscience Union. All Right Reserved.

Environmental assessment at CDW disposal sites in Vietnam: Case study in Thanh Tri landfill, Hanoi

*Thanh Ha Ngo[1], Akihiro Matsuno[1], Ken Kawamoto[1]

1. Graduate School of Science and Engineering, Saitama University

In the last recent decade, Vietnam has become one of most developing countries within South East Asia. Due to a rapid increasing of economic and industrial, the amount of construction and demolition waste (CDW) in Vietnam also increasing fast and becoming one of the biggest issue for the surrounding environment. According to MONRE, in 2015, Vietnam produced 1.9 million tons of CDW, while the recycling rate was only accounted for 1 −2%. In particularly, 30% of total solid waste generated in Hanoi was reported as CDW during the period of 2010 −2014. Currently, most of generated CDW from construction and demolition sites is reused on-/off sites without any quality control of materials and dumped at disposal sites along with collected waste from town cleaning (e.g., sludge and soil). At CDW disposal site, there is a potential risk of accepting hazardous and scheduled waste together with non-hazardous waste due to lack of management and control of waste acceptance. Therefore, in order to have environmental risk assessment of CDW disposal sites in Vietnam, it is important to identify the current environmental status of CDW dumping sites according to an appropriate monitoring program. In this study, we assessed qualities of water, gas, and fine residues (soil and fines of dumped CDW) inside the disposal site and its surrounding at Thanh Tri Landfill CDW disposal site in Hanoi as a case study. The final goal of study is to develop a standard monitoring/operating procedure for environmental assessment of CDW disposal sites in Vietnam. The field monitoring of surface gas emission and the sampling of internal gas, water, and fine residues, and investigation of dumped scheduled waste at the site were carried out on December 2018. The internal gas samples were collected at six different points from 0.5 - 1m depth and a flux chamber method applied to determine surface gas emission. The groundwater sample was taken from a well inside the disposal site. Results showed very low concentration of methane (CH4) and Carbon Dioxide (CO2). In the meantime, groundwater quality showed that the amount of Ferrous and Arsenic became higher than Vietnam technical regulation on drinking water (QCVN 01:2009/BYT) and Vietnam technical regulation on domestic water (QCVN 02:2009/BYT).

Keywords: Environmental assessment, CDW disposal sites

©2019. Japan Geoscience Union. All Right Reserved.

Modeling Study on the Impacts of Groundwater Pumping to Regional Hydroclimatology in 37 World Major Aquifers

*Pat J.-F. Yeh[1]

1. Monash University Malaysia

Groundwater pumping (GWP) introduces dormant fossil waters into the active hydrologic cycle and alters the mand and atmosphere water budgets, but its effects are poorly understood due to the lack of large-scale GWP information and hydrometeorological data to estimate these changes. In this study, two sets of global-scale model simulations by a fully-coupled climate-hydrologic model, one with GWP and the other one without, are conducted for the 1900-1999 period. The effects of GWP in affecting the land and atmospheric water budgets are investigated over the selected 37 major aquifers worldwide by analyzing the output data from both sets of simulations. The entire set of the internally-consistent water budget components, includ precipitation (P), evaporation (E), runoff (R), atmospheric vapor convergence (C), and changes in land, ocean and atmosphere water storages, are analyzed, and their differences between tow simulations are considered the effects due to GWP. The contribution of GWP to global sea level rise (GSLR) as a result of the changes in the land and atmospheric water budgets is also estimated via (1) the direct R contribution from land to ocean and (2) the indirect C contribution via atmospheric interactions.

Keywords: groundwater, water budget, sea level rise, model simulations

©2019. Japan Geoscience Union. All Right Reserved.

CHRATERIZING BURIED WASTE COMPOSITION AT CONSTRUCTION AND DEMOLITION WASTE (CDW) DISPOSAL SITE IN VIETNAM: A CASE STUDY IN THANH TRI LANDFILL IN HANOI

*Tselmeg Aldarjav[1], Akira Kato[1], Akihiro Matsuno[1], Ken Kawamoto[1,2]

1. Graduate School of Science and Engineering, Saitama University, Japan , 2. International Institute for Resilient Society, Saitama University, Japan

In recent years building and construction work has been growing rapidly in Vietnam, as construction sector expanded simultaneously the waste generated have increased as well. Due to increasing cost and handling availability of CDW disposal the landfilling approach is the most common and cost-efficient way of disposal in developing countries, including Vietnam. On the other hand, due to lack of technical and management abilities, it is very difficult to collect the data on amount and composition of CDW dumped to the landfilling site. The data on amount and composition of dumped CDW is necessary to evaluate the remaining lifetime of present CDW landfills and to examine the possible recycling strategy and method of CDW fills in future. Besides, the waste composition data contributes to classify the type of CDW landfills. The data on the ratio of each amount is currently not available. In this study, a field survey including pit sampling of buried waste, size grading, weighting of graded fractions, and categorization of waste has been done at Thanh Tri landfill site located on the south-eastern side of Hanoi, Vietnam. The final goals of study are 1) to develop a technical manual to investigate buried CDW at disposal sites, and 2) to characterize waste composition, physical and chemical characteristics of dumped waste in Vietnam. The overall procedure of the manual includes 5 parts: 1. Preliminary survey work, 2. Design of CDW composition survey, 3. Set-up of CDW composition survey, 4. Excursion of CDW composition survey, and 5. data analysis. The proposed manual enables not only to measure the waste composition but also to characterize particle size distribution of buried waste.

Keywords: Construction and Demolition Waste , Waste composition, Landfill, Survey, Manual, Vietnam

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Kentaroh Suzuki

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick
up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG34-07] GCOM-C “Shikisai” FIRST YEAR OBSERVATIONS

★Invited Papers

*Hiroshi Murakami[1], Masahiro Hori[1], Risa Miyazaki[1], Toshiyuki Kobayashi[1], Takashi M. Nagao[1], Kazunori Ogata[1], Rigen Shimada[1], Junichi Takaku[2] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.Remote Sensing Technology Center of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG34-08] Algorithm improvement for GCOM-C/SGLI Above Ground Biomass Standard product.

*KAJIWARA Koji[1], Yoshiaki HONDA[1] (1.Chiba University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG34-09] Common retrieval of Atmospheric Aerosol Properties for geostationary and polar-orbital Satellite Imaging Sensors: Himawari8/AHI and GCOM-C/SGLI results

*Yoshida Mayumi[1], Maki Kikuchi[1], Takashi M. Nagao[1], Hiroshi Murakami[1], Keiya Yumimoto[2] (1.Japan Aerospace Exploration Agency, 2.Kyusyu University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG34-10] Cloud optical properties from various ground and satellite instruments evaluated during an intensive campaign

*Alessandro Damiani[1], Hitoshi Irie[1], Takashi Horio[1], Tamio Takamura[1], Rei Kudo[2], Pradeep Khatri[3], Hironobu Iwabuchi[3], Ryosuke Masuda[3], Takashi M. Nagao[4] (1.CEReS, Chiba University, 2.Meteorological Research Institute, Japan Meteorological Agency, 3.Graduate School of Science, Tohoku University, 4.Earth Observation Research Center, JAXA)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG34-11] Issues in aerosol-cloud-climate interaction: Needs for future satellite mission

★Invited Papers

*Kentaroh Suzuki[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG34-12] Impact of aerosol vertical profile and optical parameters on the accuracy of satellite AOD retrieval

*Jing Li[1], Chong Li[1] (1.Peking University)

GCOM-C “Shikisai” FIRST YEAR OBSERVATIONS

*Hiroshi Murakami[1], Masahiro Hori[1], Risa Miyazaki[1], Toshiyuki Kobayashi[1], Takashi M. Nagao[1], Kazunori Ogata[1], Rigen Shimada[1], Junichi Takaku[2]

1. Earth Observation Research Center, Japan Aerospace Exploration Agency, 2. Remote Sensing Technology Center of Japan

One-year observation results of Global Change Observation Mission-Climate (GCOM-C) called “SHIKISAI” are introduced.

JAXA polar-orbit satellite, GCOM-C, which carries Second-generation Global Imager (SGLI), has been launched on 23 Dec. 2017, and operated in orbit during 2018. The key characteristics of the SGLI are (1) 250-m spatial resolution with 1150 km or 1400 km swath, and (2) nineteen bands in 0.38-12 um including two polarimetry bands (at 672 nm and 866 nm) with +/- 45 degree along-track tilt.

The SGLI radiometric gain was evaluated by the on-board calibration functions (solar, lamp, lunar, and electric calibrations) and vicarious calibration over the land, ocean and ice sheet. The radiometric gain was stable during the first year except for slight degradation (<2 %/year) in 380-565 nm bands. The geometric correction accuracy was evaluated by the Ground Control Point (GCP) matching. The deviation from the GCPs was stable and kept less than about 0.3 pixels.

The SGLI 250-m bands could capture seasonal change of the vegetation and the snow cover, the large-scale red tide, and the fine structures of land-surface temperature and coastal sea-surface temperature. Especially, unique functions of SGLI, the 380-nm band and polarimetry revealed the fine-mode aerosol distribution around wild fires (e.g., California, Africa, and Siberia) and Asian city areas (e.g., North India, and East China). The polarimetry seemed to improve estimation of the aerosols emitted densely from the fires. Difference of the 250-m land-surface temperature between the day and nighttime may give us information about the heat budget in the various land covers including city and crop areas. The GCOM-C standard products have been evaluated and open to public freely through JAXA data portal, G-portal, since Dec. 2018. The re-process of the 2018 data will be completed in the early summer 2019. The accumulating GCOM-C data products are expected to be used in the wide areas of the earth environment researches.

Keywords: GCOM-C, SGLI, remote sensing

©2019. Japan Geoscience Union. All Right Reserved.

Algorithm improvement for GCOM-C/SGLI Above Ground Biomass Standard product.

*KAJIWARA Koji[1], Yoshiaki HONDA[1]

1. Chiba University

On 23rd Dec., 2017, Japan Aerospace Exploration Agency (JAXA) has launched new Earth observation satellite GCOM-C . GCOM-C equips Second-generation Global Land Imager (SGLI) as core sensor. Since SGLI can observe nadir and off-nadir angle with along-track direction simultaneously, it is expected to retrieve forest Above Ground Biomass (AGB) using bi-directional spectral data.

For the estimation of forest AGB, difference of bi-directional reflectance of each observation angle caused by forest canopy structure will be key information.

Authors have been developed basic AGB estimation algorithm for SGLI AGB standard product. This algorithm is based on the empirical model related to the relationship between reflectance shift on the Red-NIR plane for different viewing angle and AGB. The algorithm requires optimum approximation coefficients directly related AGB amount in observed area for each forest type. In 1st stage product algorithm, we have decided these coefficients using AGB in-situ dataset collected from literature survey which work has been conducted by JAMSTEC. While the AGB estimation results using SGLI reflectance data achieved success criteria for initial stage, it is required for getting better accuracy to achieve the full success criteria.
In this paper, development of algorithm for aimed at improving accuracy was discussed. The improved algorithm which adopting the rasterized AGB existed data base and change the zoning method, has been tested. The result of the trial, the accuracy of estimation has been confirmed.

Keywords: Second Generation Global Imager (SGLI), Multi-angular observation, Forest canopy, Biomass Estimation

©2019. Japan Geoscience Union. All Right Reserved.

Common retrieval of Atmospheric Aerosol Properties for geostationary and polar-orbital Satellite Imaging Sensors: Himawari8/AHI and GCOM-C/SGLI results

*Yoshida Mayumi[1], Maki Kikuchi[1], Takashi M. Nagao[1], Hiroshi Murakami[1], Keiya Yumimoto[2]

1. Japan Aerospace Exploration Agency, 2. Kyusyu University

Aerosols influence the energy budget of the earth’ s climate system through scattering and absorbing solar radiation. The Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC, 2014) reported that the radiative forcing of the total aerosol effect in the atmosphere, which includes cloud adjustments due to aerosols, is −0.9 W m^{-2} and results from a negative forcing from most aerosols with a positive contribution from black carbon absorption of solar radiation. However, the range of the uncertainties remains large (−1.9 W m^{-2} to −0.1 W m^{-2}).

For a more precise estimation of the impact of aerosols on climate systems, investigation of the behavior of aerosols on a global scale is essential but challenging because aerosol amounts and characteristics vary over space and time.

Aerosol remote sensing studies have been carried out using polar-orbital Earth observation satellites. JAXA has launched Global Change Observation Mission-Climate (GCOM-C)/Second-generation GLobal Imager (SGLI) at the end of 2017, and Greenhouse gases Observing SATellite- 2 (GOSAT-2)/Cloud and Aerosol Imager 2 (CAI-2) in 2018. In several years, Earth Clouds Aerosols and Radiation Explorer (EarthCARE)/ Multi-Spectral Imager (MSI) will be launched.

In addition, the next-generation geostationary satellite of the Japan Meteorology Agency (JMA), Himawari-8, was launched on October 7, 2014. It carries the Advanced Himawari Imager (AHI), which has six bands from visible to near-infrared wavelengths. It is significantly different from the previous Himawari-6/7 having only one channel in the wavelengths, which made the estimation of aerosol difficult because the assumption of aerosol type is necessary. Himawari-8/AHI observes the top of atmosphere (TOA) visible and near-infrared radiance at a resolution of 0.5–2.0 km over Asia and Oceania at every 10 min, which enables frequent aerosol estimation over the same ground targets.

The synergistic uses of these various imaging sensors on both geostationary and polar-orbital satellites are helpful to understand a complete picture of aerosol distribution in the global scale. For this purpose, we developed the common retrieval algorithm of the atmospheric aerosol properties for various satellite sensors and over both land and ocean.

The algorithm is based on the method developed by Higurashi and Nakajima (1998) and Fukuda et al. (2013). The three main features in the concept of this algorithm are as follows: (1) automatic selection of the optimum channels for aerosol retrieval by introducing a weight for each channel to the object function, (2) setting common candidate aerosol models over land and ocean, and (3) preparation of lookup tables for every 1 nm in the range of 300 to 2500 nm of wavelength and weighting the radiance using the response function for each sensor.

The method was applied to Himawari-8/AHI and GCOM-C/SGLI. The validation study indicated that

©2019. Japan Geoscience Union. All Right Reserved.

aerosol optical thickness estimated from our algorithm was generally consistent with the products from Moderate Resolution Imaging Spectro-radiometer (MODIS) and Aerosol Robotic Network, and SKYNET.

In addition, the utilization of the aerosol properties forecasted by a global aerosol transport model for the retrieval are discussed.

Keywords: earosol, remote-sensing, Himawari, SGLI

©2019. Japan Geoscience Union. All Right Reserved.

Cloud optical properties from various ground and satellite instruments evaluated during an intensive campaign

*Alessandro Damiani[1], Hitoshi Irie[1], Takashi Horio[1], Tamio Takamura[1], Rei Kudo[2], Pradeep Khatri[3], Hironobu Iwabuchi[3], Ryosuke Masuda[3], Takashi M. Nagao[4]

1. CEReS, Chiba University, 2. Meteorological Research Institute, Japan Meteorological Agency, 3. Graduate School of Science, Tohoku University, 4. Earth Observation Research Center, JAXA

An intensive campaign to monitor the atmospheric environment (i.e., aerosols, clouds, and gases) has been carried out at the SKYNET station of Chiba University in November 2018. The station is equipped with a broad range of meteorological instruments as well as sky radiometers and is part of various international research networks. Due to their challenging estimation from ground observations and the typical discrepancy between satellite and surface-based estimates, here we focus on cloud optical properties taking a particular interest in cloud optical depth (COD). First, we conducted a careful evaluation of four COD datasets retrieved from surface observations of i) zenith radiance recorded by a sky-radiometer (based on two independent algorithms), ii) solar radiation taken by a pyranometer and iii) spatial distribution of radiance recorded by a camera system equipped with fisheyes lens. Then, we assessed satellite-based estimations of COD retrieved from AHI/Himawari-8 and SGLI/GCOM-C observations trying to explain the differences between satellite and ground data in term of atmospheric conditions, acquisition geometry and COD spatial distribution. Preliminary results achieved from this activity will be presented.

Keywords: satellite, clouds, solar radiation

©2019. Japan Geoscience Union. All Right Reserved.

Issues in aerosol-cloud-climate interaction: Needs for future satellite mission

*Kentaroh Suzuki[1]

1. Atmosphere and Ocean Research Institute, University of Tokyo

The aerosol forcing is the largest source of uncertainty in determining climate forcing that drives global climate change. The aerosol forcing consists of the so-called direct (aerosol-radiation interaction) and indirect (aerosol-cloud interaction) effects, both of which are subject to significant uncertainty. This uncertainty arises from our lack of understanding on key processes that govern interactions between aerosol, cloud and climate. Precipitation, among those processes, is central to the aerosol-cloud-climate interaction through its effect of depleting both clouds and aerosols. The aerosol-induced precipitation change influences the cloud lifetime and amount, whereas the precipitation change also modulates the wet removal of aerosols. This underscores a fundamental role of precipitation in shaping the aerosol-cloud-climate interaction. Recent advance in satellite observations by multiple sensors and platforms enabled us to observationally diagnose the precipitation processes on the global scale particularly, which also offers a process-level constraint on model representation of the processes. Such a “bottom-up” model constraint, however, turned out to be inconsistent with “top-down” energy balance requirement on model performance, exposing error compensations in state-of-the-art climate models at a fundamental level. This proposes that there is still a gap in our understanding of the aerosol-cloud-climate processes that hampers their reliable modeling. This presentation discusses what is required to observe in future satellite missions for filling the gap in understanding and modeling the aerosol-cloud-climate interaction. In particular, observational needs for aerosol, cloud and precipitation will be argued to better quantify aerosol-induced climate forcing in the context of recent Aerosol-Cloud-Convection-Precipitation (A-CCP) discussion emerging from the US Decadal Survey and multiple community efforts for process-oriented model diagnostics in an attempt to advance climate modeling.

Keywords: Aerosol, Cloud and precipitation, Climate modeling, Satellite observation

©2019. Japan Geoscience Union. All Right Reserved.

Impact of aerosol vertical profile and optical parameters on the accuracy of satellite AOD retrieval

*Jing Li[1], Chong Li[1]

1. Peking University

Satellite sensors are widely used to monitor large scale aerosol variability from space. However, current aerosol retrieval algorithm used by passive sensors still suffers from uncertainties in a series of assumptions, with two important ones being aerosol vertical distribution and scattering/absorbing parameters. In this study, we investigate the effect of these two assumptions on the accuracy of retrieved aerosol optical depth (AOD) using both sensitivity experiments and actual retrieval practices. Using the 6S and Modtran radiative transfer model, we find that the retrieved AOD is very sensitive to the height of absorbing aerosols, and the effect increases with surface albedo. In extreme cases, the error can be as large as 80%. The retrieval results are also quite sensitive to aerosol single scattering albedo, compared to other parameters such as asymmetry parameter and effective radius. Using the aerosol profiles and optical parameters measured by lidar and sunphotometer at the PKU site, we find that the retrieval accuracy can be greatly improved by ~50%. Our results highlight the necessity to refined aerosol profile and optical parameters in the passive retrieval algorithms, possibly through space born lidars and ground based observations.

Keywords: aerosol satellite retrieval, aerosol vertical profile, aerosol single scattering abledo, lidar

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick
up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG34-13] Statistical validation of drop size distribution estimated by GPM/DPR

*Nobuhiro Takahashi[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG34-14] Impact study of DPR SLH nudging method for data assimilation in the JMA Local NWP system

★Invited Papers

*Yasutaka Ikuta[1] (1.Japan Meteorological Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG34-15] Precipitation Extremes Monitoring using Global Satellite Mapping of Precipitation (GSMaP) Product

*Takuji Kubota[1], Tashima Tomoko[1], Riko Oki[1], Tomoaki Mega[2], Tomoo Ushio[2] (1.Earth Observation Research Center,Japan Aerospace Exploration Agency, 2.Department of Aerospace Engineering, Tokyo Metropolitan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG34-16] Estimation of cloud water content over land using satellite-based passive microwave observations with a coupled land and atmosphere assimilation method

*Rie Seto[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG34-17] Ensemble-Based Data Assimilation of GPM/DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

*Shunji Kotsuki[1], Koji Terasaki[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG34-18] **An ecohydrological land reanalysis by integrating simulation and satellite observations**

*Yohei Sawada[1], Tosiyuki Nakaegawa[1], Kozo Okamoto[1], Takeshi Iriguchi[1], Hideyuki Fujii[2] (1.Meteorological Research Institute, 2.Japan Aerospace Exploration Agency)

Statistical validation of drop size distribution estimated by GPM/DPR

*Nobuhiro Takahashi[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

The dual-frequency precipitation radar (DPR) onboard Global Precipitation Measurement (GPM) core satellite provides the information of the model parameter of the drop size distribution (DSD) assuming the Gamma type DSD model by using Ku-band (KuPR) and Ka-band (KaPR) radar observations. In the current DPR algorithm introduces ε (epsilon) as a DSD parameter that is constant in the vertical profile. The ε is defined as a control parameter in k-Z relationship as $k=\varepsilon \alpha Z^{\wedge}\beta$, where k is specific attenuation in (dB/km) and, α and β is constant value, respectively. Therefore, once ε and Z are determined, DSD (and then R) and Z(Ku) - Z (Ka) relationship are determined.

The purpose of this study is to evaluate ε estimated from DPR algorithm by statistical approach. In this study, two methods are implemented: 1) Histogram matching between Z from KuPR and KaPR, and 2) Estimation of ε from PIA-zeta relationship that can be calculated both KuPR and KaPR individually (single frequency method).

Data used in this study are DPR level-2 (Matched swath) in 2015, 2016 and 2017. Before applying the methods, backscattering database for Ku, Ka and W band using Mie theory and Z(Ku)-Z(Ka), Z(Ku)-Z(W) table for various ε ranging from 0.3 to 2.0 with 0.05 intervals, are prepared.

The histogram method compares histograms of Z (Ku) and Z (Ka). In this analysis, the average ε at a certain area (e.g. 10 x 10 degrees box in latitude and longitude) represent the typical value of the area. Since the difference in the histograms of Z both from the KuPR and KaPR reflects the difference in Mie effect between KuPR and KaPR and therefore ε represents the corresponding DSD model. In other words, if we know the ε, we can reproduce the KaPR histogram from KuPR histogram. In this analysis, starting from KuPR histogram, the most appropriate KaPR histogram is tried to find by changing the ε. The advantage of this approach is that ε can be estimated various height (e.g. 1 km, 2 km) if the both KuPR and KaPR data exist. This method, however, is not independent estimation of ε from the standard algorithm of DPR because this method uses the attenuation corrected Z by the standard algorithm that implicitly include the ε. For the calculation of ε, exceedance probability of Z histogram is used. This method can be utilized for different orbital sensors such as the comparison between CloudSat and TRMM/PR.

The next method is to utilize the path integrated attenuation (PIA)- zeta(ζ) relationship (regression method). According to Iguchi et al. (2000),
$1-10^{\wedge}(-PIA\beta/10)=\varepsilon\zeta$, where ζ is the integral of specific attenuation using the observed Z(Zm) instead of attenuation corrected Z multiplied by $0.2\ln(10)\beta$. PIA is estimated by the observation of the surface echo (surface reference method). By making a scatter plot of $1-10^{\wedge}(-PIA\beta/10)$ and ζ, ε corresponds to the slope of this plot. The slope in Ku-band corresponds to the ε in this study. Ka-band epsilon is calculated using the same k-Z relationship with Ku-band.

The ε estimated by these two methods are compared with the average value of ε from standard algorithm. Basically ε from both methods correlate well with the ε from the standard algorithm. Note that the variance ε from the regression method is twice large as the standard algorithm. This result may be

©2019. Japan Geoscience Union. All Right Reserved.

caused by that the standard algorithm not to determine the ε under less attenuated situation. The regression method can be utilized to assess the k-Z relationship between Ku and Ka and the histogram method of various height indicates the constant ε of the throughout the profile may not be valid.

Keywords: Precipitation, radar, drop size distribution

©2019. Japan Geoscience Union. All Right Reserved.

Impact study of DPR SLH nudging method for data assimilation in the JMA Local NWP system

*Yasutaka Ikuta[1]

1. Japan Meteorological Agency

GPM DPR Spectral Latent Heating (GPM-SLH) profile is a very valuable product with three-dimensional latent heating information of precipitation system. The data assimilation of this GPM-SLH is expected to improve the precipitation prediction in numerical weather prediction. The impact of SLH data assimilation is investigated in the Local NWP system which includes the high-resolution numerical prediction model called Local Forecast Model (LFM) of Japan Meteorological Agency.

The purpose of the operation of LFM is to provide information on very-short range precipitation forecast and aviation weather forecasting. The initial condition for the LFM is created by hourly data assimilation in the Local NWP system because the forecast immediacy is important for the achievement of the LFM's aims. Thus the forecast of LFM from the initial condition has latest information of real atmosphere by the hourly assimilation. However, this data assimilation system consists of simple 3D-VAR combined with prediction which is capable of performing speedy calculation for rapidly updating the forecast.

GPM-SLH nudging method corrects the latent heating in cloud microphysics scheme while the numerical prediction model is running in the assimilation window. It is a very efficient method that can input SLH information into the model with keeping immediacy of forecast. In the Local NWP system, the nudging method was implemented and impact studies of SLH assimilation were conducted in typical cases of mid-latitude precipitation system. In this presentation, I will show the result of impact study of GPM-SLH assimilation and the problems to be addressed.

©2019. Japan Geoscience Union. All Right Reserved.

Precipitation Extremes Monitoring using Global Satellite Mapping of Precipitation (GSMaP) Product

*Takuji Kubota[1], Tashima Tomoko[1], Riko Oki[1], Tomoaki Mega[2], Tomoo Ushio[2]

1. Earth Observation Research Center,Japan Aerospace Exploration Agency, 2. Department of Aerospace Engineering, Tokyo Metropolitan University

Natural hazards caused by weather and climate tend to increase in recent years, and it is recognized that there is a need to better utilize and improve the monitoring of extreme weather and climate events from space. Recently, satellite-based precipitation datasets have been developed to achieve higher spatial and temporal resolutions using combined data from passive microwave (PMW) sensors in low Earth orbit and infrared (IR) radiometers in geostationary Earth orbit. Global Satellite Mapping of Precipitation (GSMaP) is a blended PMW–IR precipitation product and has been developed in Japan for the Global Precipitation Measurement (GPM) mission. In this study, detections of drought and heavy precipitation events are examined using standardised precipitation index (SPI) and a statistical value, to demonstrate a capability of the GSMaP. Such efforts will contribute to precipitation extremes monitoring activities using satellite data, such as the World Meteorological Organization (WMO) Space-based Weather and Climate Extremes Monitoring Demonstration Project (SEMDP) with focus on monitoring drought and heavy precipitation in countries of the South-East Asia and the Pacific.

In this study, GSMaP Near-real-time Gauge-adjusted Rainfall Product (GSMaP_Gauge_NRT) for algorithm version 6 is used. This product is adjusted using an optimization model with parameters calculated from data during the past 30 days. As for weather and climate extremes, here it is defined as an extreme precipitation, when a mean rainfall for a specified period is higher than a threshold based on the percentiles (ex. 95th, 99th percentile). Whereas, drought is diagnosed based on SPI over 1, 2 and 3 months. Percentiles and SPI are calculated in 0.1x0.1 grid at lat/lon resolution from the dataset during 18 years from April 2000 to March 2018. To demonstrate feasibilities of GSMaP_Gauge_NRT (v6) for climate extremes monitoring, we evaluated past cases of drought and heavy rainfall.

The first case is drought in south-eastern Australia during July-September 2007. A drought area where 3-month SPI is less than -1.2 spreads widely around the south of Australia. The detected drought area is roughly consistent with an area above 9th decile (Very Much Below Average) shown by the Bureau of Meteorology (BoM) in Australia. However, because there are few rain gauges in Western Australia’s eastern part, distributions between both are different. The second case is heavy rainfall events in western and eastern Australia in December 2010. Monthly mean precipitation exceeds 95th percentile in western and eastern Australia. These detected heavy rainfall area roughly corresponds to an area below 2nd decile (Very Much Above Average) shown by the BoM. The last case is heavy rainfall events in Malay Peninsula in December 2014, which extreme rainfall caused widespread flooding over Thailand and the east coast of Peninsular Malaysia. Time-fluctuation of GSMaP_Gauge_NRT (v6) daily precipitation averaged over these areas is roughly in good agreement with that of CPC Gauge Analysis. A series of heavy rainfall events beginning on 14 December 2014 can be confirmed from space-based observations. Especially, pentad precipitation for 22-26 December 2014, is higher than 99th percentile over large portion of Peninsular Malaysia. Actually, floods caused by heavy rain hit in this area.

Keywords: Precipitation, Satellite, Extreme

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Estimation of cloud water content over land using satellite-based passive microwave observations with a coupled land and atmosphere assimilation method

*Rie Seto[1], Shinjiro Kanae[1]

1. Tokyo Institute of Technology

We proposed a method to estimate the cloud water content (CWC) over land at multiple-kilometer resolutions and to concurrently assimilate the estimated CWC into the model by using multi-frequency satellite-based passive microwave brightness temperatures (TBs) and coupled land and atmosphere assimilation.
The need for a better understanding and more accurate representation of clouds in atmospheric models has been apparent for decades. However, a lack of sufficient observations and reanalysis products is a major obstacle. The use of TBs is an effective way to retrieve CWC of extensive and heterogeneous cloud systems all at once, but it is challenging to estimate CWC over land due to complexities of cloud processes and uncertainties in strong and heterogeneous land emissions. Our method overcomes the difficulty of retrieving clouds over land from TBs and representing them in models by simultaneously optimizing land emissions and CWC over land, and assimilating the estimations into models.
The estimated CWC was in good accordance with vertical two-dimensional products of CloudSat in terms of cloud water path and the vertical distribution of CWC. In addition, we examined the uncertainties of this method by sensitivity analysis of CWC estimates of TBs and cloud top height. The results suggested that the error in TBs is not large, and that cloud top height affects the estimated CWC more sensitively than TBs. The addition of cloud top height information from other satellite observations as a constraint of optimization allows further improvement of the vertical distributions of CWC.
This study revealed that the proposed method has great potential to provide unprecedented data for CWC with adequate accuracy, which are continuously distributed over land and ocean.

Keywords: estimation of cloud water content over land, satellite-based passive microwave brightness temperature, coupled assimilation of land and atmosphere

©2019. Japan Geoscience Union. All Right Reserved.

Ensemble-Based Data Assimilation of GPM/DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

*Shunji Kotsuki[1], Koji Terasaki[1], Takemasa Miyoshi[1]

1. RIKEN Center for Computational Science

This study aims to improve the precipitation forecasts from numerical weather prediction models through effective assimilation of satellite-observed precipitation data. The assimilation of precipitation data is known to be difficult mainly due to highly non-Gaussian statistics of precipitation-related variables. We have been developing a global atmospheric data assimilation system NICAM-LETKF, which comprises the Nonhydrostatic ICosahedral Atmospheric Model (NICAM) and Local Ensemble Transform Kalman Filter (LETKF). Using the NICAM-LETKF system, Kotsuki et al. (2017, JGR) successfully improved the weather forecasts by assimilating the Japan Aerospace eXploration Agency (JAXA)' s Global Satellite Mapping of Precipitation (GSMaP) data into the NICAM at 112-km horizontal resolution. However, assimilating space-borne precipitation radar data remains to be a challenging issue.

This study pioneers to assimilate radar reflectivity measured by the Dual-frequency Precipitation Radar (DPR) onboard the Global Precipitation Measurement (GPM) core satellite into the NICAM. We conduct the NICAM-LETKF experiments at 28-km horizontal resolution with explicit cloud microphysics of a single-moment 6-class bulk microphysics scheme. To simulate GPM/DPR reflectivity from NICAM model outputs, the joint-simulator (Hashino et al. 2013; JGR) is used. Our initial tests showed a better match with the observed reflectivity by assimilating GPM/DPR reflectivity into NICAM forecasts. However, the results from a 1-month data assimilation cycle experiment showed general degradation by assimilating GPM/DPR reflectivity. For better use of GPM/DPR reflectivity data, we are exploring to estimate model cloud physics parameters by assimilating them. This presentation will include the most recent progress up to the time of the meeting.

Keywords: GPM, Data Assimilation, NICAM-LETKF, Precipitation, Radar Reflectivity, Ensemble Kalman Filter

©2019. Japan Geoscience Union. All Right Reserved.

An ecohydrological land reanalysis by integrating simulation and satellite observations

*Yohei Sawada[1], Tosiyuki Nakaegawa[1], Kozo Okamoto[1], Takeshi Iriguchi[1], Hideyuki Fujii[2]

1. Meteorological Research Institute, 2. Japan Aerospace Exploration Agency

Monitoring terrestrial water, energy, and ecosystem is crucially important to understand global environmental changes. Land reanalysis, in which a land surface model (LSM) is driven by bias-corrected atmospheric forcing based on an atmospheric reanalysis dataset, has greatly contributed to generating the long-term and spatiotemporally homogeneous dataset of terrestrial environmental condition. Here we propose a new land reanalysis called ECoHydrological Land reAnalysis (ECHLA). Compared with the other existing land reanalyses, the characteristics of ECHLA are: (1) ECHLA can simulate not only water and energy, but also vegetation dynamics; (2) ECHLA is generated by sequential data assimilation of satellite microwave observation, which is sensitive to soil moisture and vegetation water content, into a LSM; (3) ECHLA can quantify the uncertainty in its simulated variables by an ensemble method. In this presentation, we will show the concept of ECHLA and the preliminary results of the validation of the ECHLA’ s prototype and its application to drought quantification.

Sawada, Y. (2018), Quantifying drought propagation from soil moisture to vegetation dynamics using a newly developed ecohydrological land reanalysis, ***Remote Sensing****, 10,* 1197

Keywords: land reanalysis, microwave remote sensing, satellite data assimilation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 302 3F

[A-CG34] Satellite Earth Environment Observation

convener:Riko Oki(Japan Aerospace Exploration Agency), Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Tsuneo Matsunaga(Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies), Chairperson:Tsuneo Matsunaga

In recent years, we cannot avoid facing issues on global environmental changes that occur in various spatiotemporal scales. The earth environmental observation data by satellites became the necessary basic data to tackle and solve those issues. Due to the recent advancement in the observation sensor technique and the data processing technique, the satellite observation has been showing rapid progress, and the time is changing from examining the accuracy of the observation sensor data to the advancement of the data application, leading to broaden potential users. In these days application became synergetic, so we comprehensively pick
up this topic in the Atmospheric and Hydrospheric Sciences Session of this Union Meeting that enables to comprise the atmospheric, oceanic and land sciences; by combining the intelligence and the knowledge of the party, we propose a session that aims to prompt further studies towards the issues on earth environmental change, the advancement in the data application and future plans of Earth Observation missions.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG34-19] How GOSAT has survived in-orbit anomalies and calibrated radiance spectra for 10 years.

★Invited Papers

*Akihiko Kuze[1], hiroshi Suto[1], Kei Shiomi[1], Nobuhiro Kikuchi[1], Makiko Hashimoto[1], Fumie Kataoka[2] (1.Japan Aerospace Exploration Agency, 2.RESTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG34-20] Estimating regional anthropogenic methane emissions with GOSAT satellite retrievals and ground-based observations

*Shamil Maksyutov[1], Aki Tsuruta[2], Rajesh Janardanan[1], Fenjuan Wang[1], Akihiko Ito[1], Motoki Sasakawa[1], Toshinobu Machida[1], Isamu Morino[1], Yukio Yoshida[1], Johannes Kaiser[3], Greet Janssens-Maenhout[4], Ed Dlugokencky[5], Tsuneo Matsunaga[1] (1.National Institute for Environmental Studies, 2.Finnish Meteorological Institute, 3.Deutscher Wetterdienst, 4.European Commission, Joint Research Centre , 5.National Oceanic and Atmospheric Administration, Global Monitoring Division)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG34-21] The Status and the Future Plan of GOSAT-2 Level 2 and 4 Products

★Invited Papers

*Tsuneo Matsunaga[1], Isamu Morino[1], Yukio Yoshida[1], Makoto Saito[1], Hibiki M Noda[1], Hirofumi Ohyama[1], Akihide Kamei[1], Fumie Kawazoe[1], Ryoichi Imasu[2], Teruyuki Nakajima[4], Takashi Nakajima[5], Naoko Saitoh[3], Makiko Hashimoto[4] (1.Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies, 2.The University of Tokyo, 3.Chiba University, 4.Japan Aerospace Exploration Agency, 5.Tokai University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG34-22] A preliminary initial check of the cloud discrimination products by CAI-2 onboard GOSAT-2

*Yoshiaki Ishihara[1], Yu Oishi[2], Haruma Ishida[3], Takashi Nakajima[4] (1.NIES, 2.NARO, 3.JMA, 4.Tokai Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG34-23] Drought monitoring and evaluation performance of temperature vegetation drought index (TVDI) over Eurasia

*Fengmei Yao[1], Siqi Shi[1], Jiahua Zhang[2] (1.UCAS University of Chinese Academy of Sciences, 2.Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG34-24] **IMPACT OF CHANGE IN LAND USE AND LAND COVER PATTERN ON LAND SURFACE TEMPERATURE AND THERMAL COMFORT USING MICRO-SCALE AREA MODEL: CASE STUDY OF AN EDUCATIONAL CAMPUS.**

*DILJIT KUMAR NAYAK[1], MANJU MOHAN[1] (1.IIT DELHI)

How GOSAT has survived in-orbit anomalies and calibrated radiance spectra for 10 years.

*Akihiko Kuze[1], hiroshi Suto[1], Kei Shiomi[1], Nobuhiro Kikuchi[1], Makiko Hashimoto[1], Fumie Kataoka[2]

1. Japan Aerospace Exploration Agency, 2. RESTEC

Since 2009 Thermal And Near infrared Sensor for carbon Observation Fourier-Transform Spectrometer (TANSO-FTS) onboard the Greenhouse gases Observing SATellite (GOSAT) TANSO-FTS onboard GOSAT has provided 0.2 cm-1-step radiance spectra from solar reflected light in shortwave infrared (SWIR) to thermal infrared (TIR) light using the FTS multiplex-advantage.
The SWIR light passes from the top of the atmosphere to the Earth’ s surface providing column-averaged dry air mole fractions of carbon dioxide (CO2) and methane (CH4). TIR light is the thermal emission from the Earth’ s atmosphere and surface. By combining these wide spectral data, GOSAT can extract the partial column density of lower troposphere, which shows enhanced density from local anthropogenic emission sources.
For SWIR data analysis, we use robust algorithm of differential optical absorption spectroscopy and optical path modification by thin clouds and aerosol can be calibrated by simultaneously observed oxygen (O2) data. On the other hand, thermal emission measurements need absolute radiometric calibration. Furthermore, the PC-MCT detector for TIR is less linear than the Si and InGaAs detectors for SIWR.
During the 10-year operation in orbit, TANSO-FTS had system-shut-down in May 2014, May 2018, and November 2018 due to satellite anomalies and cryo-cooler shutdown in August 2018. Every time TANSO-FTS restarted, the thermal condition of the TIR detector and optics had changed and parameters for non-linearity corrections had to be updated. We present how we can calibrate SWIR and TIR spectra for 10 years for decade-long uniform quality.

Keywords: Green House Gases, Fourier Transform Spectrometer, CO2, CH4, Thermal Infrared, Shortwave Infrared

©2019. Japan Geoscience Union. All Right Reserved.

Estimating regional anthropogenic methane emissions with GOSAT satellite retrievals and ground-based observations

*Shamil Maksyutov[1], Aki Tsuruta[2], Rajesh Janardanan[1], Fenjuan Wang[1], Akihiko Ito[1], Motoki Sasakawa[1], Toshinobu Machida[1], Isamu Morino[1], Yukio Yoshida[1], Johannes Kaiser[3], Greet Janssens-Maenhout[4], Ed Dlugokencky[5], Tsuneo Matsunaga[1]

1. National Institute for Environmental Studies, 2. Finnish Meteorological Institute, 3. Deutscher Wetterdienst, 4. European Commission, Joint Research Centre , 5. National Oceanic and Atmospheric Administration, Global Monitoring Division

GOSAT satellite observations of methane are being used for regional and national methane emission estimates in a number of studies using either high resolution regional inverse models or global medium resolution models. We perform global high-resolution methane flux inversion to estimate global methane emissions using atmospheric methane data collected at global in-situ network, which is archived at WDCGG and NIES, and GOSAT satellite retrievals. High resolution tracer transport is implemented by coupling Lagrangian model FLEXPART to a global atmospheric tracer transport model (NIES-TM) and its adjoint. Prior fluxes at 0.1˚ resolution were prepared for anthropogenic emissions (EDGAR 4.3.2), biomass burning (GFAS), and wetlands (VISIT). The inverse model based on NIES-TM-FLEXPART applies variational optimization to two categories of fluxes: anthropogenic and natural (wetlands). Bi-weekly emissions are estimated for years 2009 to 2017. To reduce GOSAT retrieval biases, the monthly mean difference between GOSAT data and the inversion-optimized forward simulation is estimated for each 5˚ latitude band and it is subtracted from GOSAT retrievals (NIES Level 2 retrievals, v. 02.72) before including them in the inversion. The bias correction is designed to remove large scale biases in GOSAT retrievals, while retaining local scale variability that contains most information on anthropogenic emissions from intense sources such as megacities. Estimated anthropogenic emissions over large regions (US, China, India) are compared to GCP-CH4 top-down estimates. The sensitivity of the estimated emissions to prior fluxes is tested by adjusting the prior fluxes to match UNFCCC reports for selected large countries.

Keywords: methane , inverse model, GOSAT, anthropogenic emissions

©2019. Japan Geoscience Union. All Right Reserved.

The Status and the Future Plan of GOSAT-2 Level 2 and 4 Products

*Tsuneo Matsunaga[1], Isamu Morino[1], Yukio Yoshida[1], Makoto Saito[1], Hibiki M Noda[1], Hirofumi Ohyama[1], Akihide Kamei[1], Fumie Kawazoe[1], Ryoichi Imasu[2], Teruyuki Nakajima[4], Takashi Nakajima[5], Naoko Saitoh[3], Makiko Hashimoto[4]

1. Center for Global Environmental Research and Satellite Observation Center, National Institute for Environmental Studies, 2. The University of Tokyo, 3. Chiba University, 4. Japan Aerospace Exploration Agency, 5. Tokai University

GOSAT-2 (Greenhouse Gases Observing Satellite 2), launched in October, 2018, is the second Japanese Earth observation satellite for greenhouse gas observation from space. It is a joint mission promoted by Ministry of the Environment, JAXA (Japan Aerospace Exploration Agency), and NIES (National Institute for Environmental Studies) as similar to the first satellite, GOSAT, launched in and operated since 2009. Both satellites are designed to measure atmospheric concentrations of carbon dioxide (CO_2) and methane (CH_4) using Fourier transform spectrometers, FTS and FTS-2, with a help of moderate resolution imagers, CAI and CAI-2, for aerosol and cloud observation. The design lifetime of GOSAT-2 is five years and the 15-year record of atmospheric $CO_2$and $CH_4$is now expected from these two satellites.

NIES is responsible for the generation of GOSAT-2's Level 2 and Level 4 standard products which are

1) GOSAT-2 TANSO-CAI-2 L2 Cloud Discrimination Product
2) GOSAT-2 TANSO-CAI-2 L2 Aerosol Property Product
3) GOSAT-2 TANSO-FTS-2 SWIR L2 Chlorophyll Fluorescence and Proxy-method Product
4) GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product
5) GOSAT-2 TANSO-FTS-2 TIR L2 Cloud and Aerosol Property Product
6) GOSAT-2 TANSO-FTS-2 TIR L2 Temperature and Gas Profile Product
7) GOSAT-2 L4A Global CO2 Flux Product
8) GOSAT-2 L4A Global CH4 Flux Product
9) GOSAT-2 L4B Global CO2 Distribution Product
10) GOSAT-2 L4B Global CH4 Distribution Product

The public release of GOSAT-2 Level 2 and Level 4 products will start by the end of October 2019 and 2020, respectively.

In this presentation, the latest status and the future plan of these products will be introduced.

Keywords: greenhouse gas, climate change, satellite

©2019. Japan Geoscience Union. All Right Reserved.

A preliminary initial check of the cloud discrimination products by CAI-2 onboard GOSAT-2

*Yoshiaki Ishihara[1], Yu Oishi[2], Haruma Ishida[3], Takashi Nakajima[4]

1. NIES, 2. NARO, 3. JMA, 4. Tokai Univ.

GOSAT-2, which is a successor of Japanese GOSAT (Greenhouse Gases Observing Satellite) which was launched in January 2009 and has been operated for about ten years, is successfully launched on Oct. 29, 2018. Both satellites are jointly developed and operated by Ministry of the Environment, Japan Aerospace Exploration Agency, and National Institute for Environmental Studies. GOSAT-2 carries two mission instruments, Fourier Transform Spectrometer 2 (FTS-2) and Cloud and Aerosol Imager 2 (CAI-2). They are successors of GOSAT FTS and CAI.

Several publicly available standard products will be generated from GOSAT-2 FTS-2 and CAI-2 data. One of these is CAI-2 Level 2 Cloud Discrimination Product and will be used for the detection of clouds within the field of view of FTS-2. CAI-2 cloud discrimination product is generated by one of two different algorithms. One of those is CLAUDIA1 used for GOSAT CAI Level 2 cloud mask product and the other is newly developed CLAUDIA3. And CLAUDIA3 is default algorithm for CAI-2 cloud discrimination product generation.

In this presentation, we will present a very preliminary initial check results of CAI-2 Level 2 cloud discrimination products, including comparison of cloud discrimination results by CLAUDIA1 and CLAUDIA3.

Keywords: GOSAT-2, Cloud Discrimination

©2019. Japan Geoscience Union. All Right Reserved.

Drought monitoring and evaluation performance of temperature vegetation drought index (TVDI) over Eurasia

*Fengmei Yao[1], Siqi Shi[1], Jiahua Zhang[2]

1. UCAS University of Chinese Academy of Sciences, 2. Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences

Drought has been a common concern recent years as it is one of the high frequent nature disasters in Eurasia that is included in the Belt and Road Initiative under the background of global warming. Thus, it is of great significance to study the drought monitoring and assessment in the region to develop effective plans to mitigate the effects of disasters. This study explored applicability of Temperature Vegetation Drought Index (TVDI) derived from MODIS normalized difference vegetation index (NDVI) and land surface temperature (LST) data as an index for drought monitoring in Eurasia in growing season (April - September) from 2005 to 2014. Three methods were used to compare TVDI against Standardized Precipitation Evapotranspiration Index in three time scales (SPEI-01, SPEI-03, SPEI-06) and the Essential Climate Variable surface soil moisture product (ECV-SM) at continental scales and Land Cover scales, as well as records of drought events from Emergency Events Database (EM-DAT) and relative literatures. The results indicated acceptable correlations between TVDI and SPEIs, ECV-SM in most areas, and TVDI had higher coefficients of correlation with ECV-SM than SPEIs at continental scale. Then we found that the correlation coefficient maps at continental scales were visually consistent with the land cover types, thus correlations between TVDI and SPEIs, ECV-SM were analyzed at Land Cover scales. TVDI showed strong correlation with SPEIs and ECV-SM in evergreen Needle leaf forest, deciduous broad leaf forest and grasslands. However, the accuracy of TVDI in open shrub lands that mainly distributed at high-latitudes remains to be further validated in the future. Finally, a comparison with typical drought-year and typical drought events also demonstrated TVDI could be used as a drought index to monitor drought events in study area over study time.

Keywords: drought monitoring, Temperature Vegetation Drought Index, growing season, continental scale, land cover, drought records

©2019. Japan Geoscience Union. All Right Reserved.

IMPACT OF CHANGE IN LAND USE AND LAND COVER PATTERN ON LAND SURFACE TEMPERATURE AND THERMAL COMFORT USING MICRO-SCALE AREA MODEL: CASE STUDY OF AN EDUCATIONAL CAMPUS.

*DILJIT KUMAR NAYAK[1], MANJU MOHAN[1]

1. IIT DELHI

The influence of change in Land Use Land Cover pattern of an area due to rapid urbanization, over the increment in the Land Surface Temperature (LST) has always been a challenging area for research. This study covers the analysis of the influence of freshly built structure and the storey increment on the thermal comfort of the outdoor environment and Land Surface Temperature with a periodic remotely sensed observation for every three years at IIT Delhi (an educational institute campus). Numerical modelling approach using a 3D microclimate model ENVIMET is implemented for simulating the surface temperature in the presence of hostel residences and in the absence of hostel residences during a summer month of May during the period from 2002 to 2018. The effect of the Sky View Factor on Mean Radiant Temperature is likely to play a key role in influencing the thermal comfort of the residents of the campus. The entire IIT Delhi was classified under open high-rise as per Local Climate Zone (LCZ) categories. It was classified into 17 classes which included eight types of building classification from 4m to 36m and the rest of the nine classes included soil layer, asphalt roads, vegetation cover like trees, dense and light bushes, concrete roads, granite concrete and swimming pool PVC liner. The building class was sub-divided into different classes based on their height to study the effect of high rise buildings on the surface temperature. The model validation is carried out with the LST values obtained from the satellite observation of LANDSAT thermal band. The model estimated the surface temperature giving a correlation of (r=0.95) with the observed values. The RMSE value was found to be 1.28 for the student residence and 2.34 for the non-building structures. Temperature difference over the years as built structure influence was assessed approximately to the tune of 10 degrees. The model performed well in estimating the surface temperature with an accuracy of 94.97 per cent.

Keywords: ENVI-met, 3D microclimate model, Land surface temperature(LST), Land Use Land Cover(LULC), Local Climate Zone(LCZ), Landsat

©2019. Japan Geoscience Union. All Right Reserved.

IMPACT OF CHANGE IN LAND USE AND LAND COVER PATTERN ON LAND SURFACE TEMPERATURE AND THERMAL COMFORT USING MICRO-SCALE AREA MODEL: CASE STUDY OF AN EDUCATIONAL CAMPUS

DILJIT KUMAR NAYAK AND MANJUMOHAN

Centre for Atmospheric Sciences,

Indian Institute of Technology Delhi, Hauz Khas,

New Delhi, India 110016

ABSTRACT

The influence of change in Land Use Land Cover pattern of an area due to rapid urbanization, over the increment in the Land Surface Temperature (LST) has always been a challenging area for research. This study covers the analysis of the influence of freshly built structure and the storey increment on the thermal comfort of the outdoor environment and Land Surface Temperature with a periodic remotely sensed observation for every three years at IIT Delhi (an educational institute campus). Numerical modelling approach using a 3D microclimate model ENVIMET is implemented for simulating the surface temperature in the presence of hostel residences and in the absence of hostel residences during a summer month of May during the period from 2002 to 2018. The effect of the Sky View Factor on Mean Radiant Temperature is likely to play a key role in influencing the thermal comfort of the residents of the campus. The entire IIT Delhi was classified under open high-rise as per Local Climate Zone (LCZ) categories. It was classified into 17 classes which included eight types of building classification from 4m to 36m and the rest of the nine classes included soil layer, asphalt roads, vegetation cover like trees, dense and light bushes, concrete roads, granite concrete and swimming pool PVC liner. The building class was sub-divided into different classes based on their height to study the effect of high rise buildings on the surface temperature. The model validation is carried out with the LST values obtained from the satellite observation of LANDSAT thermal band. The model estimated the surface temperature giving a correlation of (r=0.95) with the observed values. The RMSE value was found to be 1.28 for the student residence and 2.34 for the non-building structures. Temperature difference over the years as built structure influence was assessed approximately to the tune of 10 degrees. The model performed well in estimating the surface temperature with an accuracy of 94.97 per cent.

***Key Words*:** ENVI-met, 3D microclimate model, Land surface temperature(LST), Landsat, Land Use Land Cover, Local Climate Zone(LCZ)

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 301B 3F

[H-TT19] Geographic Information Systems and Cartography

convener:Takashi Oguchi(Center for Spatial Information Science, The University of Tokyo), Yuji Murayama(Graduate School of Life and Environmental Sciences), Yoshiki Wakabayashi(Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University), Chairperson:Yuji Murayama, Yoshiki Wakabayashi

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, and GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in English.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HTT19-01] **A study on geographical changes in main roads and coastlines in the 200 years in Japan**

*Yuki IWAI[1], Yuji Murayama[1] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HTT19-02] Comparative analysis of foreign tourists' spatial behavior in Tokyo using locational data from the photo-sharing service of Flickr

*Bochra Bettaieb[1], Yoshiki Wakabayashi[1] (1.Tokyo Metropolitan University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HTT19-03] Neighborhood Walkability and its Potential Associations with Residents' Walking Habits

★Invited Papers

*Ikuho Yamada[1], Keiichiro Sanada[2] (1.Faculty of Science and Engineering, Chuo University, 2.Graduate School of Science and Engineering, Chuo University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HTT19-04] **THE STUDY OF USING PARTICLE FILTER METHOD COMBINED INDOOR MAGNETIC MAP AND PEDESTRIAN DEAD RECKONING FOR INDOOR POSITIONING.**

*Yu-Chun Chen[1] (1.Department of Land Economics, National Chengchi University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HTT19-05] Assessing the Agriculture Sustainability based on Geospatial Technique in a Tropical Mountain Area : A Case Study in Kotmale Catchment in Sri Lanka.

*DM Sanjeewa Lasantha Bandara[1], Takehiro Morimoto [2] (1.Division of Spatial Information Science, Graduate School of Life and Environmental Sciences, University of Tsukuba, 2.Faculty of Life and Environmental Sciences, University of Tsukuba)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HTT19-06] **Spatial Evaluation of Potential Tsunami Vertical Evacuation: A Case Study of the Western Coastal Belt in Sri Lanka**

*Ranagalage Mahinda Manjula[1], Yuji Murayama[1] (1.Division of Spatial Science, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan)

A study on geographical changes in main roads and coastlines in the 200 years in Japan

*Yuki IWAI[1], Yuji Murayama[1]

1. Graduate School of Life and Environmental Sciences, University of Tsukuba

This study analyzed the changes in the spatial distribution of main roads and coastlines and its determining factors between 1818 and 2018. These changes are important social and natural foundations for the Japanese national land formation, and the knowledge of the spatial changes is useful for promoting the sustainable society. Previous studies have focused on the regional transformation using aerial photographs, drilling surveys, and some old paper maps. They used the geographical data after modernization and targeted the specific region. In our study, an attempt is made to compare the long term of 200 years on the national scale by using INŌ's digital map.
Digital data of main roads and coastlines on the INŌ's map are included in the “Digital INŌ's Map, Professional Edition”. This is digitized by using the INŌ's large paper map which is the largest scale in the INŌ's map. In the analysis of the changes in main roads, we used the attribute information of Digital INŌ's Map. The changes in coastlines were derived by overlay analysis with coastlines of Digital INŌ's Map and the present national land. In the overlay analysis, each section of coastlines which did not overlap with the present national land was defined as the section changed by the backward movement of the coastline. On the other hand, each section of coastlines which overlapped with the present national land contained both the section changed by the reclamation and the section almost unchanged. In analyzing the determining factors, land use data (100m gridded area) and coastal ocean data (1km gridded area) were mainly used.
As a result, it was found that the route changes in main roads were 18.3% of the total (Fig.1), and the changes in coastlines were 28.9% of the whole length. In the changed coastlines, the changed section by the backward movement was 66.3% (Fig.2A), and the changed section due to the reclamation was 33.7% (Fig.2B). Main roads drawn on the INŌ's large map had different density depending on the region, because only main roads surveyed by INŌ's team were drawn on the INŌ's large map. Therefore, the distance of the changed section was summarized at the regional level. The rate of the change was the largest in Kyushu region (27.8%), and the smallest in Shikoku region (2.8%). On the other hand, coastlines drawn on the INŌ's large map distribute uniformly at the national scale. The rate of the change was the largest in the eastern Japan (Fig.2A) and the industrial areas (Fig.2B). Details on determining factors of changes will be discussed on the day of the presentation.

Keywords: Changes in Roads, Changes in Coastlines, INŌ's Map , GIS, Japan

©2019. Japan Geoscience Union. All Right Reserved.

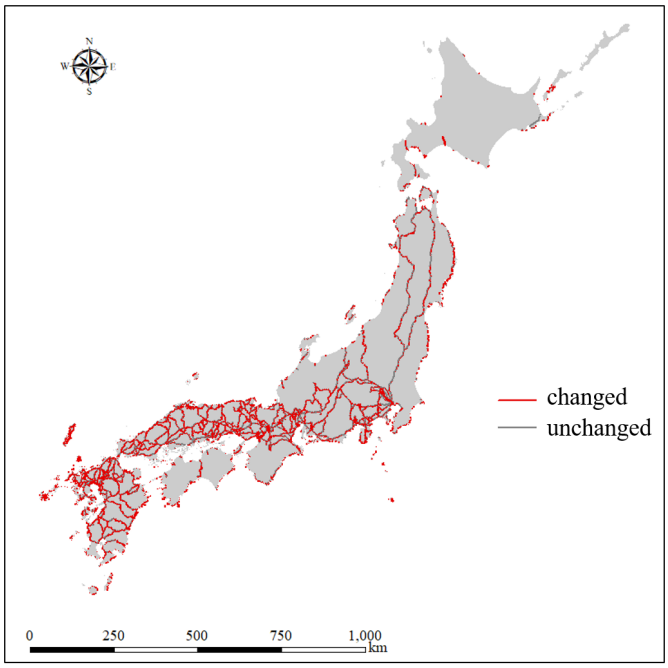


Figure 1 The main roads drawn in the INŌ's large map

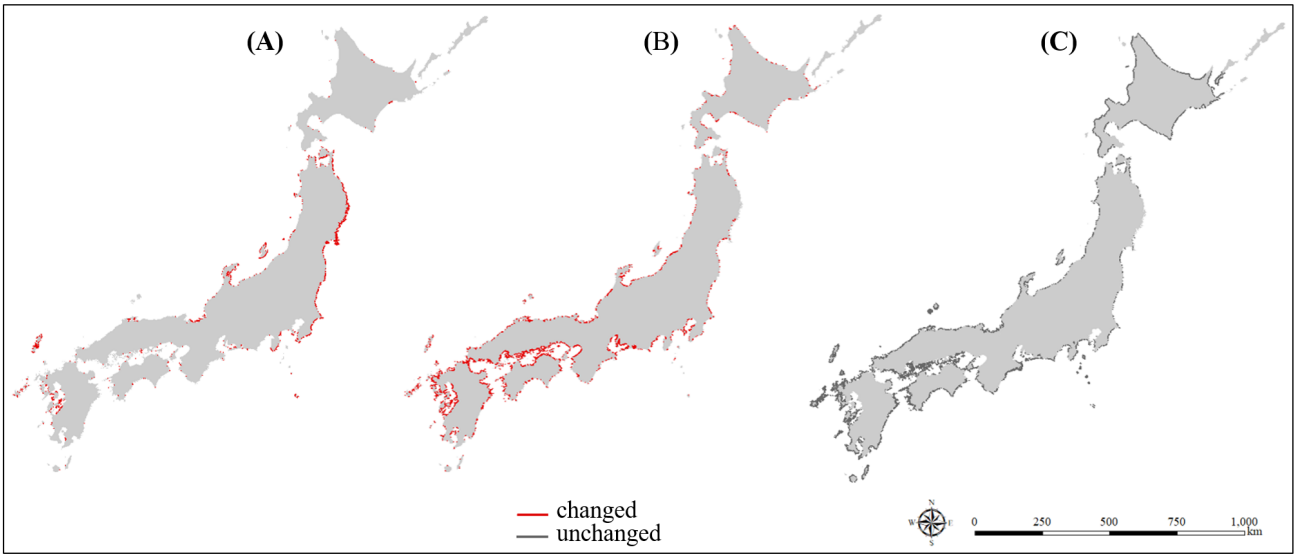


Figure 2 The coastlines drawn in the INŌ's large map; (A) coastlines occurred by backward movement, (B) coastlines occurred by reclamation, (C) coastlines unchanged

©2019. Japan Geoscience Union. All Right Reserved.

Comparative analysis of foreign tourists' spatial behavior in Tokyo using locational data from the photo-sharing service of Flickr

*Bochra Bettaieb[1], Yoshiki Wakabayashi[1]

1. Tokyo Metropolitan University

These new sources of geospatial data, such as smartphones, global positioning systems, and travel cards, provide the possibility of analyzing high-resolution big data to capture patterns of human spatial behavior across space and time. This study analyzes the geocoded photos from a photo-sharing service to make a comparison of the tourist behavior in Tokyo between countries of foreign visitors.

We selected three places (Shinjuku, Asakusa, and Ginza) as study districts. The data were downloaded from Flickr, one of the most popular online platforms for people to share their travel experiences by uploading photos. We used the data of geocoded photos from 2014, taken within 1.5 km from Shinjuku, Ginza, and Asakusa stations. Information on the nationality of contributors recorded in the Flickr data was used to compare the tourist spots of foreign visitors. To summarize the distribution of the points of photos, we aggregated the point features into a rectangular polygon feature with 100 meter grid square, then we made dot maps and mesh maps to capture the overall distribution of the photos.

The obtained results showed that some tourist spots common to foreign visitors in three study areas, namely, places close to railroad stations. However, spatial patterns of tourist spots varied with the study district in question. In Shinjuku and Ginza, there are differences in tourist spots between Asians and Europeans. Particularly, European tourists' hot spots tend to be more scattered than Asians. However, such differences are not observed in Asakusa, where tourists' hot spots are concentrated around Sensoji Temple and Tokyo Sky Tree. The reason for this is that tourist attractions are concentrated in and around specific facilities in the Asakusa district. Hence, the variations of tourist spots obtained by analyzing the geotagged photographs on Flickr can be explained by the difference in behavior and interest of foreign tourists between countries, as well as the spatial distribution of tourist attractions.

Keywords: social media, Flickr, spatial behavior, mesh map, Tokyo

©2019. Japan Geoscience Union. All Right Reserved.

Neighborhood Walkability and its Potential Associations with Residents' Walking Habits

*Ikuho Yamada[1], Keiichiro Sanada[2]

1. Faculty of Science and Engineering, Chuo University, 2. Graduate School of Science and Engineering, Chuo University

Walkability is a concept that embraces various aspects of physical neighborhood environments that may support and promote walking in a neighborhood. Walkable neighborhoods are expected to improve residents' physical activity level and thus health because such environments may be able to implicitly encourage residents to choose walking over driving as a daily transportation mode. While research on walkability originated in western countries, where obesity and lifestyle-related illnesses has been a longstanding public health problem, such research in Japan is also useful and necessary because improving healthy life expectancy among the elderly in an undemanding way is critical in our super-aging society. The concept of walkability is also closely related to that of the compact city, which is considered to be a promising form of sustainable cities in the field of urban planning, as walking is expected to be a major transportation mode in such cities.

This research therefore aims to investigate potential associations between neighborhood walkability and residents' walking habits with specific consideration to characteristics of Japanese cities. Here, we consider two types of walking, namely walking for transportation and walking for leisure, separately because they may relate to neighborhood walkability in different ways. Moreover, we assess neighborhood walkability both subjectively and objectively so as to capture the neighborhood situations in a more comprehensive manner.

An Internet-based questionnaire survey was conducted in January 2018 in order to collect information about residents' walking habits, subjective evaluations of neighborhood environments, and health in selected 49 municipalities in Tokyo. The survey was implemented via an Internet research company, and about 4000 individuals who had registered as a panel of the ompany responded. Questions related to the residents' subjective evaluations of neighborhoods were based on an internationally used standard questionnaire named ANEWS (Abbreviated Neighborhood Environment Walkability Scale). In addition, objective measures of neighborhood walkability were computed using various GIS datasets such as the small area statistics of 2015 Population Census, road network data, and facility location data. Then, statistical analysis was conducted to assess potential associations between residents' walking habits and both subjectively and objectively measured neighborhood walkability.
Results indicated that the two types of walking habits related to different aspects of neighborhood walkability. For example, neighborhood community was found to have positive association with walking for leisure, but no such association was found with walking for transportation. Further, it was suggested that the associations between residents' walking habits and neighborhood walkability would potentially vary depending on neighborhood settings such as urban and suburban regions. Our results also suggested that subjective and objective measures of walkability might have different associations with the two types of walking even when they were assumed to measure the same aspect of neighborhood environments.

Keywords: walkability, neighborhood environments, walking for transportation, walking for leisure, ANEWS (Abbreviated Neighborhood Environment Walkability Scale)

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

THE STUDY OF USING PARTICLE FILTER METHOD COMBINED INDOOR MAGNETIC MAP AND PEDESTRIAN DEAD RECKONING FOR INDOOR POSITIONING.

*Yu-Chun Chen[1]

1. Department of Land Economics, National Chengchi University

In the past, we often needed a map to find out the destination in an unfamiliar environment. With the appearance of Global Positioning System, the outdoor positioning performance has approached perfection. However, due to the environment obstruction, the indoor signal will reduce the positioning accuracy. Therefore, indoor positioning technology has become the focus of research and development in recent years.
In the history of indoor positioning technology, target positions were detected by sensors, radio signals and image or Pedestrian Dead Reckoning (PDR). All the technologies above have their own advantages and disadvantages, like costly or low accuracy. It is necessary to combine the different technologies to achieve a comprehensive consideration of cost, efficiency and accuracy. This study used the built-in magnetometer of the smart phones to build the magnetic field maps of the floor and also accelerometer as an aid to achieve indoor positioning. This study effectively improved the accuracy and efficiency of indoor positioning by using the particle filter method combine PDR with the magnetic positioning.

Keywords: Indoor positioning, Magnetic field map, Pedestrian Dead Reckoning, Particle filter

©2019. Japan Geoscience Union. All Right Reserved.

THE STUDY OF USING PARTICLE FILTER METHOD COMBINED INDOOR MAGNETIC MAP AND PEDESTRIAN DEAD RECKONING FOR INDOOR POSITIONING.

Yu-Chun Chen , Fang-Shii Ning

Department of Land Economics, National Chengchi University,
NO.64, Sec.2, ZhiNan Rd., Wenshan District,Taipei City 11605, Taiwan (R.O.C)
Email: 106257031@nccu.edu.tw; fsn@nccu.edu.tw

Abstract: In the past, we often needed a map to find out the destination in an unfamiliar environment. With the appearance of Global Positioning System, the outdoor positioning performance has approached perfection. However, due to the environment obstruction, the indoor signal will reduce the positioning accuracy. Therefore, indoor positioning technology has become the focus of research and development in recent years.

In the history of indoor positioning technology, target positions were detected by sensors, radio signals and image or Pedestrian Dead Reckoning (PDR). All the technologies above have their own advantages and disadvantages, like costly or low accuracy. It is necessary to combine the different technologies to achieve a comprehensive consideration of cost, efficiency and accuracy. This study used the built-in magnetometer of the smart phones to build the magnetic field maps of the floor and also accelerometer as an aid to achieve indoor positioning. This study effectively improved the accuracy and efficiency of indoor positioning by using the particle filter method combine PDR with the magnetic positioning.

Keywords: Indoor positioning, Magnetic field map, Pedestrian Dead Reckoning, Particle filter

©2019. Japan Geoscience Union. All Right Reserved.

Assessing the Agriculture Sustainability based on Geospatial Technique in a Tropical Mountain Area : A Case Study in Kotmale Catchment in Sri Lanka.

*DM Sanjeewa Lasantha Bandara[1], Takehiro Morimoto [2]

1. Division of Spatial Information Science, Graduate School of Life and Environmental Sciences, University of Tsukuba,
2. Faculty of Life and Environmental Sciences, University of Tsukuba

Sustainable agricultural systems aim at developing new farming practices that do not degrade the environment. It should be catering to the future societal needs for food and feed, ecosystem services and human health, maximizing the net benefit for people, without compromising the ability of future generations to meet their own needs. The agricultural land where located in the tropical mountain area has been becoming a dilapidated situation due to the unplanned agricultural practices coupled with the physical properties of the area and socioeconomic factors. The Kotmale catchment area is located in the central highland of Sri Lanka and covers 572 km^2 with altitude ranges from 681 to 2,505 meters above mean sea level. It is extended from latitude 7˚6'32.80"N to 6˚47'33.12"N and from longitude 80˚ 50'21.26"E to 80˚34'31.34"E which encompasses in the south-central mountainous. The primary objective of this study is to assess the sustainability of agriculture based on the environmental and socioeconomic indicators in the Kotmale catchment using geospatial techniques. The Analytic Hierarchy Process (AHP) combined with Multi-Criteria Decision Making (MCDM) methods was used as data computation method, and both spatial and non-spatial data were used under the three main criteria, such as environment, social and economic. The results of the analysis show that soil erosion is one of the major issues and it is reported as mean erosion is 9.8 t ha^{-1} yr^{-1}. The mean annual rainfall in this area has decreased over the study period (1986-2016) while temperature has increased up to 2-3 ^{0}C. In view of socioeconomic factors, education level of the farmers, lack of labor force, fluctuation of the unit price of the agricultural production, insufficient income of the farmers was negatively affected to the current agricultural activities of the research area. The result would be an aid and sources for assessing the sustainability of agricultural land and decision makers will be able to use this result for future planning.

Keywords: Kotmale watershed, Soil erosion, Agriculture land sustainability , MCDA , AHP

©2019. Japan Geoscience Union. All Right Reserved.

Spatial Evaluation of Potential Tsunami Vertical Evacuation: A Case Study of the Western Coastal Belt in Sri Lanka

*Ranagalage Mahinda Manjula[1], Yuji Murayama[1]

1. Division of Spatial Science, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan

On December 26, 2004, a massive tsunami resulted to recode extensive damages in the Indian Ocean. The recorded death toll was more than 35,000, and approximately one million people were affected in Sri Lanka. Lack of awareness was the main reason for massive damage. After this tsunami incident, Sri Lanka was also categorized as a tsunami-vulnerable country. Several past studies have contributed to introducing proper mechanisms that would minimize the damages from the next tsunami incident. Most tsunami-vulnerable areas have been covered by horizontal tsunami evacuation after 2004, and people need to travel great distances to reach tsunami evacuation centers due to the lower elevation profile of the coastal area. The purpose of this study was to spatially evaluate the potential for tsunami vertical evacuation in the western coastal belt in Sri Lanka. The western coastal belt selected by considering the existing urban structure and tsunami vulnerability. Several criteria and assumptions have been computed to achieve the goal of the study. In this analysis, three tsunami scenarios 4 m, 8 m, and 12 m were used to identify potential vertical evacuation sites. According to the results of the inundation ratio, the category of critical buildings can be increased to 1.7% and 67.0% in 4 m and 12 m scenarios, respectively. It was indicated that the 12 m scenario consisted of more damage than the other two scenarios. Tsunami evacuation sites were selected based on the three tsunami scenarios and 220, 232 and 122 sites were selected for the 4 m, 8 m and 12 m tsunami scenarios, respectively. According to the calculations of the capacity of each site, the selected 220 sites will facilitate 17,594 people during the 4 m tsunami scenario. The selected 232 sites will accommodate 25,677 people during the 8 m scenarios. All selected sites are capable of accommodating the affected population in both the 4 m and the 8 m scenarios. However, the selected evacuation sites are not sufficient for accommodating the affected population in the 12 m scenario. In the 12 m scenario, 12,221 people are affected. However, the evacuation sites can only accommodate 10,165 people. The finding of vertical evacuation by considering the existing urban structure of the city is essential to save human lives during the next tsunami incident. The adopted methodology can be used as an example for other lowland coastal cities to select vertical evacuation to protect human life.

Keywords: tsunami scenario, building volume, vertical evacuation, tsunami , Sri Lanka

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 301B 3F

[H-TT19] Geographic Information Systems and Cartography

convener:Takashi Oguchi(Center for Spatial Information Science, The University of Tokyo), Yuji Murayama(Graduate School of Life and Environmental Sciences), Yoshiki Wakabayashi(Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University), Chairperson:Takashi Oguchi, Ikuho Yamada(Chuo University)

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, and GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in English.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HTT19-07] A Framework for Assessing the Spatial Distribution of Vulnerability of Communities to Landslides in Tropical Mountainous Region: A Case study from Kegalle District – Sri Lanka.

★Invited Papers

*Nimala Chinthake Perera[1] (1.SANASA CAMPUS - SRI LANKA, IHRA - UNIVERSITY OF COLOMBO - SRI LANKA)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HTT19-08] Applications of WebGIS to Educating Disaster Risk Reduction for Chinese and Japanese Students

*Jiali SONG[1], Takashi Oguchi[2], Hiroyuki Yamauchi[2], Takuro Ogura[1] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Center for Spatial Information Science, The University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HTT19-09] Solar System Treks - GIS that provides interactive visualization and analysis for planetary science and exploration

★Invited Papers

*Emily Law[1], Brian Hamilton Day[2] (1.NASA Jet Propulsion Laboratory, 2.NASA Ames Research Center)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HTT19-10] **Landslide Recognition using Remote Sensing Images and PCANet**

*Yimei Wei[1], Takashi Oguchi[1] (1.Graduate School of Frontier Science, the University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HTT19-11] Estimating the fractional vegetation cover using fixed-wing drone and multiple vegetation indices

★Invited Papers

*Kotaro Iizuka[1] (1.Center for Spatial Information Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HTT19-12] Topographic surveys in Ny-Alesund, Svalbard, and improvement of mapping methods

*Jaeyong Lee[1], Takashi Oguchi[2] (1.Department of Environmental Studies, Graduate School of Frontier Sciences, The University of Tokyo, 2.Center for Spatial Information Science, The University of Tokyo)

A Framework for Assessing the Spatial Distribution of Vulnerability of Communities to Landslides in Tropical Mountainous Region: A Case study from Kegalle District –Sri Lanka.

*Nimala Chinthake Perera[1]

1. SANASA CAMPUS - SRI LANKA, IHRA - UNIVERSITY OF COLOMBO - SRI LANKA

Landslide vulnerability refers to the degree of loss to a given element at risk due to the occurrence of a landslide event. The concept of vulnerability is difficult to quantify due to the involvement of some social and physical indicators to determine vulnerability to a landslide in a given location. Therefore, limited research has been carried out to determine the spatial distribution of landslide vulnerability. This study attempt to map the spatial distribution of vulnerability to landslide using vulnerability index developed by entropy method abstracting information from fourteen indicators. The study was based on primary sources of data, obtained from 402 elements including associated human capital from Kegalle District-Sri Lanka. Then the Entropy method was used to estimate the level of vulnerability in sample locations (elements). Computed vulnerably vales were imported into Geodatabase which was used to evaluate element at vulnerability and map the spatial distribution of vulnerability. The spatial distribution of vulnerability was obtained from interpolating vulnerability values of sample locations (elements) by using Kriging interpolation method. Results were expressed on maps on which different spatial patterns of levels of vulnerability were found for the study area. According to the map, landslide vulnerabilities in the study area demonstrate notable regional specification. In general, vulnerability reflects expected degree of damage to the considered element or location by the adjacent to occurred landslides. Also, the spatial distribution of vulnerability has shown a close relationship with the rural-urban divide. According to landslide vulnerability analyses, 14.6% (247 sq Km) of the entire area is found to be the highest vulnerable zone for a landslide.

Further, 32% (544 sq Km) of the total land area categorized under very high or high vulnerable zones. Moderately vulnerable zones take part 13.4% (227 sq Km) of the total area. However, 26.4% (448 sq Km) of land area categorized as low or very low vulnerability, while 13.4% (227 sq Km) area categorize under the lowest zone it can be concluding that entropy method has a sufficient level of capacity to defined weigh for indicators which use for vulnerability assessment

Keywords: Element at risk , Entropy method, Spatial distribution, Vulnerability

©2019. Japan Geoscience Union. All Right Reserved.

Applications of WebGIS to Educating Disaster Risk Reduction for Chinese and Japanese Students

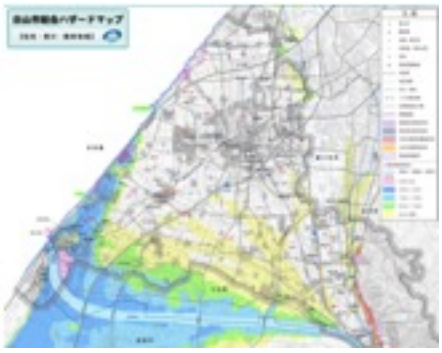
*Jiali SONG[1], Takashi Oguchi[2], Hiroyuki Yamauchi[2], Takuro Ogura[1]

1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Center for Spatial Information Science, The University of Tokyo

In this world of globalization and information explosion, WebGIS (Web Geographic Information Systems) can effectively support education in natural and social sciences. We should utilize this technology and for better human life. Research on mortality due to natural disasters has shown that nations with higher levels of education experience lower levels of mortality. This suggests that young students are knowledgeable and will contribute to future disaster risk reduction (DRR) if they are well educated. Hence, it is important to introduce DRR into high school education such as classes of geography. At present Chinese researchers are preparing disaster-related compulsory curricula for high school DDR education, and are designing special textbooks for this purpose. In Japan, some researchers have already constructed online WebGIS systems for DRR education using hazard maps available on the Internet. However, such DRR activities tend to be insufficient because of limited cognition of citizens about information related to hazards and risks. This study aims to construct an improved online DRR system for high school education using WebGIS technology along with hazard information including maps for China and Japan. In August 2018, Japanese students used the system in an event funded by the Japan Society for the Promotion of Science. After that, a similar educational event was held in a high school in China. During these activities, students compared paper hazard maps with electronic hazard maps and used both of them for consideration. At the end of each event, the feasibility and effectiveness of the system were surveyed by questionnaires to evaluate the understanding of students about WebGIS and relevant knowledge. The results indicate that students in both countries prefer teaching materials like the constructed DRR system for school classes. However, there are some differences between the two countries. For example, the Chinese students thought that analysis of dangerous areas using the layer of flooding areas was more difficult than the Japanese students, reflecting differences in DDR knowledge. To improve the applicability of the system, further educational activities will be conducted in the near future.

Keywords: WebGIS, Disaster risk reduction, Geography education





©2019. Japan Geoscience Union. All Right Reserved.

Solar System Treks - GIS that provides interactive visualization and analysis for planetary science and exploration

*Emily Law[1], Brian Hamilton Day[2]

1. NASA Jet Propulsion Laboratory, 2. NASA Ames Research Center

Meeting the challenges of space exploration has resulted in new knowledge that has kept NASA and JPL world leaders in big data science and technology. We, NASA’s Solar System Treks Project (SSTP – https://trek.nasa.gov) development team at JPL, under the management of Solar System Exploration Virtual Research Institute (SSERVI, https://sservi.nasa.gov/), have developed a Geographic Information Sysetms (GIS) based system that includes a set of web-based portals that provide a suite of interactive visualization and analysis tools to enable mission planners, scientists, and engineers to access a large volume of cartographic products and models from a growing number of spacecraft. Currently, various web-based portals are available for discovering and exploring the Moon, Mars, Vesta, Ceres, Titan and Icy Moons of Saturn, and hydrology on Earth. This presentation will provide an overview of this GIS-based system highlighting its high level architecture, technologies and capabilities that was designed and developed specifically for exploration of any Solar System bodies. We will also describe its uses, features and capabilities, highlighting visualization and analysis innovations.

Keywords: GIS, Visualization, Analysis, Solar System

©2019. Japan Geoscience Union. All Right Reserved.

Landslide Recognition using Remote Sensing Images and PCANet

*Yimei Wei[1], Takashi Oguchi[1]

1. Graduate School of Frontier Science, the University of Tokyo

Landslides are complex geological phenomena that can cause serious damage to the natural and social environments and may result in a significant loss of lives and properties. Consequently, landslide recognition, mapping, and monitoring are important for the prevention of secondary disasters and post-disaster relief. Since various remote sensing images have become more accessible in recent years, the use of satellite and aerial imagery for geological disasters has become a hot research topic. When remote sensing images are used to recognize landslides, image feature extraction is the main technical issue, and inefficiency in extracting ground object features has been a major challenge. This study explores the use of a simplified deep learning network structure, PCANet, to learn image features from post-disaster remote sensing images and train the classifier. This approach reduces the computation time of feature extraction and improves the efficiency of landslide recognition. The materials for training PCANet are image data sets for several areas in Japan including both landslide and non-landslide samples. They were collected from vertical aerial photographs and orthophotographs provided by the Geospatial Information Authority of Japan (GSI). In addition, post-disaster landslide distribution maps provided by the National Institute of Geosciences and Disaster Recovery (NIED) and GSI were utilized in the selection of sample images. As the analyzed remote sensing images were taken in a short time after a serious geological disaster, this research also contributes to future rapid responses to landslide hazards.

Keywords: Landslide recognition, Image feature extraction, PCANet, Machine learning

©2019. Japan Geoscience Union. All Right Reserved.

Estimating the fractional vegetation cover using fixed-wing drone and multiple vegetation indices

*Kotaro Iizuka[1]

1. Center for Spatial Information Science, The University of Tokyo

Fractional vegetation cover (percentage of vegetation cover) plays a key role in characterizing the conditions of the terrestrial environment. To analyze the distribution of the vegetation conditions, several methods and models can be found for estimating its coverage. Remote sensing techniques, especially utilizing the satellite imagery is one of the major approaches due to its applicability in larger spatial extent and multiple channels observed from different electromagnetic spectra. Although, in cases of high frequent cloud covering regions such as the tropical regions, usually this is difficult to conduct. Thus, in this work, we seek in alternatively collecting a remotely sensed imagery from a fixed-wing drone and analyze to estimate the fractional vegetation cover of the study site. Normal RGB camera and multispectral sensors were carried onboard the fixed-wing drone, and multiple images were collected. The Structure from Motion method was implemented to develop an ortho image of the whole study site. The imageries were used to further develop a general land use/land cover (LULC) map of the site, and within the determined gridded area, the fraction of each LULC types were examined with different vegetation indices (VIs) computed from the multispectral data. Clear positive trend was found with increasing VIs and increasing fractional cover of healthy trees, and clear negative trend was found with decreasing VIs and increasing fractional cover of soils. This approach demonstrates that it is possible to analyze the coverage information through the utilization of drones, which can be also used as ground truthing, moreover, the findings would play an important role in further simulating such as the water cycles.

Keywords: Drone, Forests, Remote Sensing, Vegetation Index, Land Cover, Structure from Motion

©2019. Japan Geoscience Union. All Right Reserved.

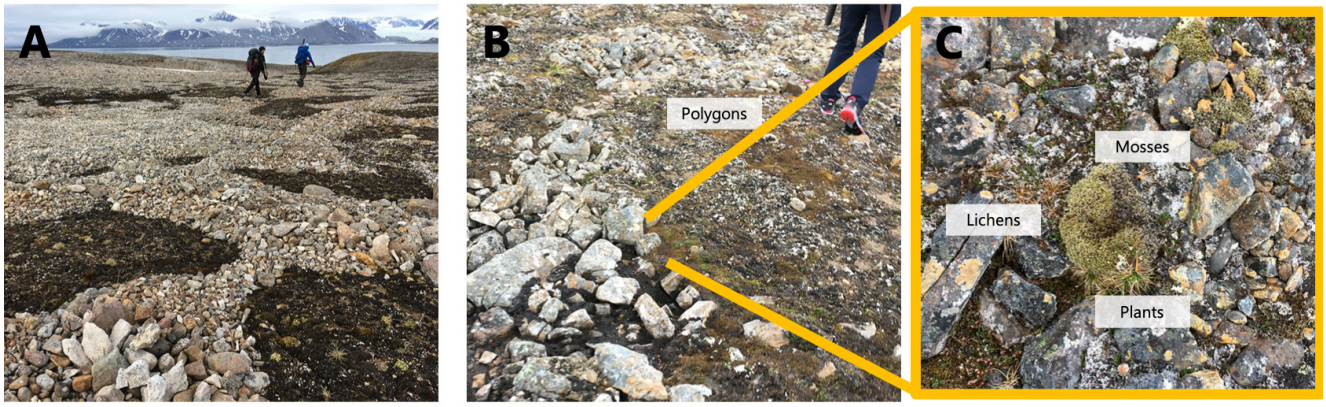
Topographic surveys in Ny-Alesund, Svalbard, and improvement of mapping methods

*Jaeyong Lee[1], Takashi Oguchi[2]

1. Department of Environmental Studies, Graduate School of Frontier Sciences, The University of Tokyo, 2. Center for Spatial Information Science, The University of Tokyo

In Ny-Alesund, Svalbard in the Arctic, frozen layers with the active layer that melts only in the summer and the impermeable permanently frozen layer distribute widely. The vertical structure affects the distribution of groundwater as well as the surface environment and sediment movement. In addition, patterned-ground formed by repeated freezing and thawing and associated vegetation are the basis of polar ecosystems. Recent global warming alters the surface environments especially the expansion of the active layer and increased groundwater flow. In order to quantitatively understand such changes in the surface environment, we developed the technique of high-resolution mapping in Ny-Alesund. As field surveys in the polar regions have limitations in terms of site accessibility and duration, we utilized data from not only our fieldwork but also past fieldwork, along with satellite/aerial images and other geospatial data.
We analyzed altitude slope, aspect, curvature, and solar radiation for the area near the Ny-Alesund Science Village using DEMs produced by the Norwegian Polar Institute. We evaluated the reliability of the terrain analysis using TopoSvalbard satellite images and aerial photographs. We also utilized ground photographs and high-resolution ground mapping with the SfM-MVS method to produce a topographic map of the area. Since legal restrictions on the use of radio frequency in Ny-Alesund limit the use of UAVs, we made a pole camera with stabilizer function, which provides photographs with about 3 mm resolution. Such photographs are useful for very high-resolution mapping for small areas.

Keywords: Ny-Alesund, Permafrost, High-resolution mapping



The images of frozen layer taken in field survey in Ny-Alesund, 2017.
A) Well-developed polygon shape patterned ground., **B)**, **C)** Vegetation on the polygons.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT25] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Graduate School of Science, Osaka University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), William F McDonough(University of Maryland College Park), George Helffrich(Earth-Life Science Institute, Tokyo Institute of Technology), Chairperson:George Helffrich(ELSI, Tokyo Institute of Technology), Hidenori Terasaki

There are fundamental links between the formation and evolution of planets and their satellites to that of their cores. Defining the physical and chemical properties of the cores of these terrestrial bodies are fundamental for understanding their internal structures and thermal profile. Recent advances in experimental and theoretical studies provide new insights and applications to the Earth's cores and other terrestrial bodies. Near-future exploration missions will obtain data on the internal structure of terrestrial planets (e.g., Mars and Mercury) and planet-satellite systems. We anticipate presentations on recent advances on the physical and chemical properties of cores and discussions regarding the latest views of their formation and evolution. We welcome contributions from mineral/rock physics, geophysics, geochemistry, geodynamics, and planetary science.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT25-01] High-pressure Equation of State of Schreibersite $Fe_{2.15}Ni_{0.85}P$: Implications for the Martian Core

*Xuejing He[1], Jiazeng Guo[2], Xiang Wu[3], Shengxuan Huang[1], Fei Qin[1], Xiangping Gu[4], Shan Qin[1] (1.Peking Univ., 2.Nanyang Normal Univ., 3.China Univ. of Geosciences, 4.Central South Univ.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT25-02] Bottom-up solidification versus top-down solidification of the liquid core of the relatively small planetary bodies

*Satoru Urakawa[1], Hidenori Terasaki[2] (1.Department of Earth Sciences, Okayama University, 2.Department of Earth and Space Science, Osaka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT25-03] P-wave velocity of Fe_3S under high pressure and temperature

*Seiji Kamada[1,2], Hidenori Terasaki[3], Hiroshi Fukui[4,5], Tatsuya Sakamaki[2], Hiroshi Uchiyama[6], Satoshi Tsutsui[6], Eiji Ohtani[2], Alfred Q.R. Baron[5] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.Department of Earth and Space Science, Graduate School of Science, Osaka University, 4.Graduate School of Material Science, University of Hyogo, 5.RIKEN, 6.JASRI)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT25-04] The sound velocity of liquid Fe-Ni-S-Si alloys under Mercury's core condition

*Iori Yamada[1], Hidenori Terasaki[1], Asaka Kamiya[1], Ryo Tsuruoka[1], Yuji Higo[2], Akihiko Machida[3] (1.Graduate School of Science, Osaka University, 2.Japan Synchrotron Radiation Research Institute, 3.National Institute for Quantum and Radiological Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT25-05] In situ observation of Rayleigh–Taylor instability growth of liquid Fe-Si using laser shock

*Hidenori Terasaki[1], Tatsuhiro Sakaiya[1], Keisuke Shigemori[2], Hiroki Kato[2], Yoichiro Hironaka[2], Tadashi Kondo[1] (1.Graduate School of Science, Osaka University, 2.Institute of Laser Engineering, Osaka University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC
Discussion

High-pressure Equation of State of Schreibersite $Fe_{2.15}Ni_{0.85}P$: Implications for the Martian Core

*Xuejing He[1], Jiazeng Guo[2], Xiang Wu[3], Shengxuan Huang[1], Fei Qin[1], Xiangping Gu[4], Shan Qin[1]

1. Peking Univ., 2. Nanyang Normal Univ., 3. China Univ. of Geosciences, 4. Central South Univ.

Phosphorus is thought to be an important light element existing in planetary cores. The phosphorus abundance is evaluated to be ~0.20 wt% in the Earth's core, and ~0.32 wt% in the Martian core. To fully understand its existence in planetary cores, structural and physical properties of iron-nickel phosphides should be investigated under high pressure and high temperature. $(Fe,Ni)_3P$-schreibersite is observed as a common accessory in the veinlet of iron and stony-iron meteorites, so that it is of significance to discuss and constrain the properties of planetary cores. The equation of state of a natural single-crystal schreibersite, $Fe_{2.15}Ni_{0.85}P$, has been studied up to ~50 GPa at room temperature in a diamond anvil cell using *in situ* synchrotron-radiation X-ray diffraction. The sample kept its tetragonal structure ($I\bar{4}$) up to the highest pressure with no observation of phase transition. Experimental results have shown that the magnetic collapse of $Fe_{2.15}Ni_{0.85}P$ is weakened because of the substitution of nickel, leading to an isotropic axial compressibility. The pressure-volume data were fitted by the third-order Birch-Murnaghan equation of state, yielding K_0 = 184(4) GPa, K_0' = 4.1(2), V_0 = 365.9(1) $Å^3$. The density of $Fe_{2.15}Ni_{0.85}P$, along with several iron sulfides and iron phosphides has been calculated under relative pressure-temperature conditions of the Martian core. The comparison with that of γ-Fe and a density model of the Martian core evidences that nickel and phosphorus dopant would result in density reduction of iron sulfides, suggesting that $(Fe,Ni)_3(S,P)$ might be a possible compound existing in the Martian core.

Keywords: schreibersite, high pressure, equation of state, Martian core

©2019. Japan Geoscience Union. All Right Reserved.

Bottom-up solidification versus top-down solidification of the liquid core of the relatively small planetary bodies

*Satoru Urakawa[1], Hidenori Terasaki[2]

1. Department of Earth Sciences, Okayama University, 2. Department of Earth and Space Science, Osaka University

Some planetary bodies, such as Mercury and Ganymede, have their own magnetic fields and other bodies, such as the Moon and Mars, once had a magnetic field. These magnetic fields of the relatively small bodies are thought to be originated from core dynamo driven by compositional convection. Compositional convection is related to the density fluctuation due to partial crystallization of liquid core. The phenomenon that iron solidified at the upper part of the core settles is called ‘Fe snowing’ and it is considered as the main cause of compositional convection in the core of the small planetary bodies. However, crystallization of iron occurs from the top of the core in some cases and from the bottom of the core in another case, due to the complexity of melting relationships of iron-light element system under pressure. Whether the top-down freezing occurs or the bottom-up freezing occurs depends on the adiabat in the liquid core and the melting slope of the constituent substance of the core. We have investigated the adiabatic temperature gradient of the Fe-S liquid core based on the thermal expansivity which is determined by X-ray absorption density measurements at high pressures. Then, we divided the pressure-composition space for the Fe-FeS system into the bottom-up solidification field and the top-down solidification field at the pressures up to 10 GPa. These would contribute to understand the generation of magnetic field in the relatively small bodies.

Keywords: Planetary magnetic field, planetary core, compositional convection, adiabat, Fe-S liquid

©2019. Japan Geoscience Union. All Right Reserved.

P-wave velocity of Fe_3S under high pressure and temperature

*Seiji Kamada[1,2], Hidenori Terasaki[3], Hiroshi Fukui[4,5], Tatsuya Sakamaki[2], Hiroshi Uchiyama[6], Satoshi Tsutsui[6], Eiji Ohtani[2], Alfred Q.R. Baron[5]

1. Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2. Department of Earth Science, Graduate School of Science, Tohoku University, 3. Department of Earth and Space Science, Graduate School of Science, Osaka University, 4. Graduate School of Material Science, University of Hyogo, 5. RIKEN, 6. JASRI

Martian cores have been thought to include a certain amount of sulfur as a light element. Sohl and Spohn (1997) proposed seismic wave velocity and density profiles of the interior of Mars based on equations of state of core matrials although seismic wave velocities of core materials are needed for presice estimation. However, there have been only a limited number of works for V_P of Fe alloys with sulfur. In the Fe-FeS system, V_P of FeS and FeS_2 have been studied (e.g. Badro et al. 2007) but these compounds are not appropriate for the core materials of Mars because Fe_3S is a stable phase above 20 GPa corresponding to Martian core conditions (Fei et al., 1997, 2000) up to at least 200 GPa (Kamada et al., 2010, 2012). Therefore, Fe_3S is a subsolidus phase together with ε -Fe in the Fe-Fe_3S system at Martian core conditions and it is essential to study V_P of Fe_3S to understand seismic properties of the Martian core. We have measured sound V_P of Fe_3S under high temperature and pressure at BL35XU of SPring-8.
In this study, a synthesized Fe_3S was used as a starting material. A symmetric diamond anvil cell was used to generate high pressures. IXS(Inelastic X-ray Scattering) and XRD experiments were performed at the beamline 35XU of SPring-8, Japan (Baron et al., 2000). V_P of Fe_3S were measured up to 100 GPa and 2000 K. We will discuss temperature effect on the V_P of Fe_3S and the Birch's law and seismic wave velocity profile of the Martian core.

Keywords: Inelastic X-ray scattering, diamond anvil cell, laser heateting

©2019. Japan Geoscience Union. All Right Reserved.

The sound velocity of liquid Fe-Ni-S-Si alloys under Mercury’s core condition

*Iori Yamada[1], Hidenori Terasaki[1], Asaka Kamiya[1], Ryo Tsuruoka[1], Yuji Higo[2], Akihiko Machida[3]

1. Graduate School of Science, Osaka University, 2. Japan Synchrotron Radiation Research Institute, 3. National Institute for Quantum and Radiological Science and Technology

Mercury has a large liquid core and it mainly consists of Fe-Ni and possibly contains some light elements. The X-ray spectroscopy measurements by the MESSENGER spacecraft indicates that surface on Mercury contains 1-4wt% S (Nittler et al. 2011). When silicate containing 1-4 wt%S coexists with liquid metal, S and Si tend to dissolve into liquid metal based on partitioning of S and Si between metal and silicate melts. This suggests that both S and Si are likely to be included in the outer core of Mercury (Chabot et al. 2014). Thus, elastic properties of liquid Fe-Ni-S-Si at BL04B1 and BL22XU beamlines, SPring-8 Facility. High pressure was generated using 1500ton Kawai-type or 180 ton cubic multianvi press. The sound velocity was measured using the pulse-echo overlap method. We used two kinds of compositions (Fe-11wt%Ni-6wt%S-4wt%Si and Fe-11wt%Ni-3wt%S-8wt%Si) for Fe-Ni-S-Si sample. The P-wave velocity (V_P) was measured up to 16 GPa and 2000 K and it increases with pressure. Temperature dependence on the V_P of liquid Fe-Ni (Kuwabara et al. 2016), the V_P of liquid Fe-Ni decreases approximately 1.6 % by addition of 6 wt%S and 4 wt%Si and increases approximately 3.1 % by addition of 3wt%S and 8wt%Si. This suggests that the effect of S reduces the V_P effectively also in the Fe-Ni-S-Si system.

Keywords: Mercury, Core, Sound velocity, Light element

©2019. Japan Geoscience Union. All Right Reserved.

In situ observation of Rayleigh–Taylor instability growth of liquid Fe-Si using laser shock

*Hidenori Terasaki[1], Tatsuhiro Sakaiya[1], Keisuke Shigemori[2], Hiroki Kato[2], Yoichiro Hironaka[2], Tadashi Kondo[1]

1. Graduate School of Science, Osaka University, 2. Institute of Laser Engineering, Osaka University

Rayleigh–Taylor instability occurs at the interface between two fluids with different densities when a heavy fluid overlies a light one in a gravitational field. The RT instability is considered as one of the important core formation mechanism beneath the magma ocean. This mechanism has been discussed from simulations (e.g., Honda et al. 1993, Ricard et al. 2009) and analog experiment (e.g., Olson and Weeraratne, 2008). However, experimental approach using liquid Fe-alloys for this mechanism has never been performed under high pressure. In this study, we applied the laser-shock technique to observe *in situ* the Rayleigh–Taylor instability of liquid Fe-Si alloy under high pressure. The growth of the Rayleigh–Taylor instability was successfully observed using *in situ* x-ray radiography under shock compression. The growth rate of the Rayleigh–Taylor instability was estimated to 0.3 ns^{-1}. The present results provide useful information to constrain the time scale of the Earth’ s and planetary core formation.

Keywords: Core formation, Rayleigh–Taylor instability, liquid Fe-alloy

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT25] Planetary cores: Structure, formation, and evolution

convener:Hidenori Terasaki(Graduate School of Science, Osaka University), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), William F McDonough(University of Maryland College Park), George Helffrich(Earth-Life Science Institute, Tokyo Institute of Technology), Chairperson:William McDonough(University of Maryland / Tohoku University), Eiji Ohtani(Tohoku University)

There are fundamental links between the formation and evolution of planets and their satellites to that of their cores. Defining the physical and chemical properties of the cores of these terrestrial bodies are fundamental for understanding their internal structures and thermal profile. Recent advances in experimental and theoretical studies provide new insights and applications to the Earth's cores and other terrestrial bodies. Near-future exploration missions will obtain data on the internal structure of terrestrial planets (e.g., Mars and Mercury) and planet-satellite systems. We anticipate presentations on recent advances on the physical and chemical properties of cores and discussions regarding the latest views of their formation and evolution. We welcome contributions from mineral/rock physics, geophysics, geochemistry, geodynamics, and planetary science.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SIT25-06] *P-V-T* equation-of-state of liquid Fe from *ab-initio* simulations to the TPa regime

*Gerd Steinle-Neumann[1], Fabian Wagle[1] (1.Bayerisches Geoinstitut, University of Bayreuth, Germany)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SIT25-07] ***Ab initio* study of Iron-Nickel alloys in Super-Earths cores**

*Francois Soubiran[1], Razvan Caracas[1] (1.Ecole normale superieure de Lyon, Laboratoire de Géologie de Lyon, Université Lyon 1, CNRS UMR 5276, Lyon, France)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT25-08] **Impurity effect on the iron's transport properties at Earth's core conditions: A key constraint for the evolution of the Earth's core**

*Youjun Zhang[1], Mingqiang Hou[2], Nilesh Salke[2], Jung-Fu Lin[3] (1.Sichuan University, 2.HPSTAR, 3.University of Texas at Austin)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SIT25-09] Melting in the Fe-FeO system to 214 GPa

*Kenta Oka[1], Yuto Kidokoro, Kei Hirose[1], Yoichi Nakajima[2], Guillaume Morard[3], Guillaume Fiquet[3], Nicolas Coudurier[3] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Priority Organization for Innobation and Excellence, 3.Sorbonne Université)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SIT25-10] B2 phase in the inner core: constraints from high pressure experiments

*Eiji Ohtani[1], Daijo Ikuta[1], Seiji Kamada[2], Tatsuya Sakamaki[1], Naohisa Hirao[3] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2.Frontier Institute for Interdisciplinary Research, Tohoku University, 3.SRring-8, Japan Synchrotron Research Institute)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

P-V-T equation-of-state of liquid Fe from *ab-initio* simulations to the TPa regime

*Gerd Steinle-Neumann[1], Fabian Wagle[1]

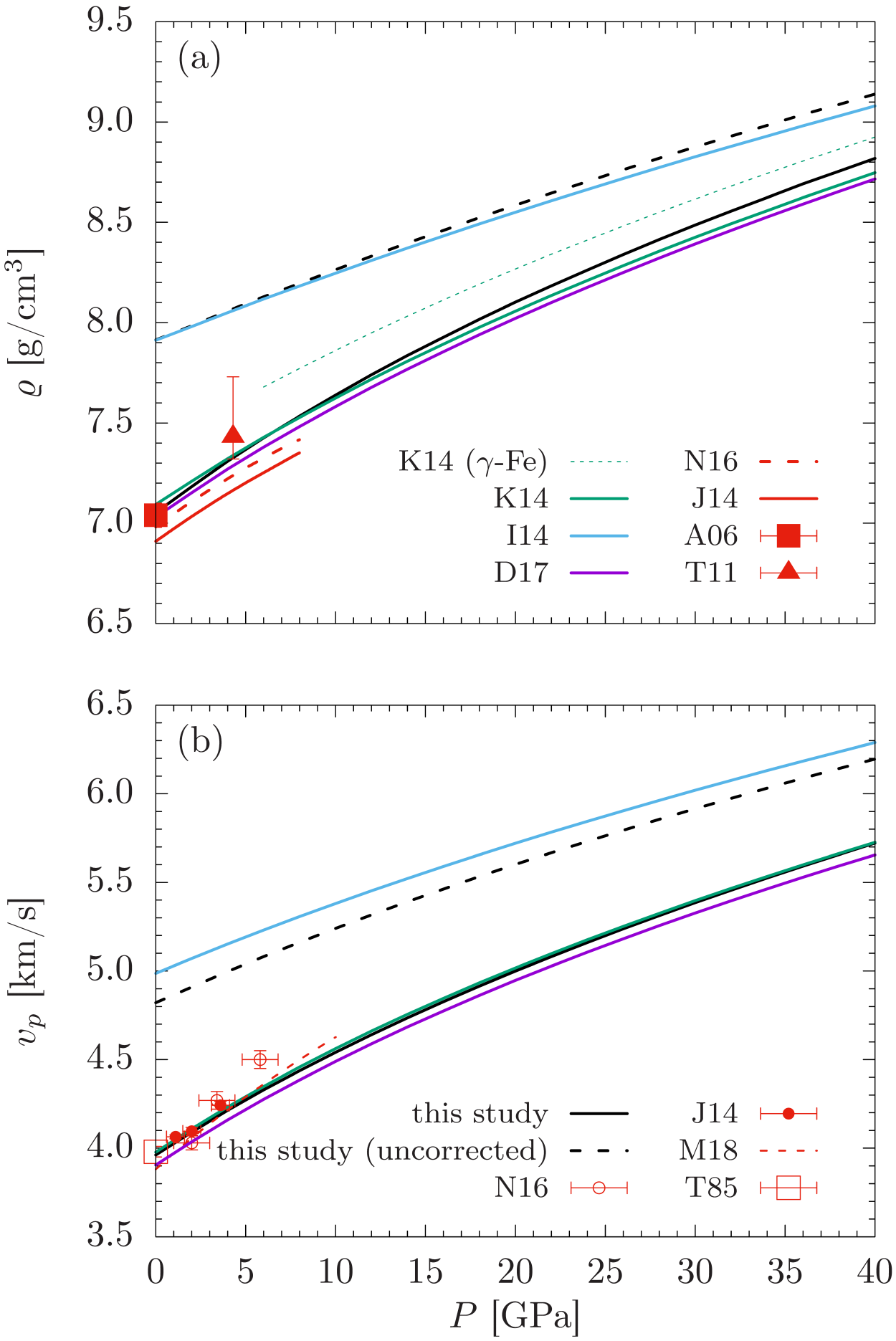
1. Bayerisches Geoinstitut, University of Bayreuth, Germany

The pressure-volume-temperature (*P-V-T*) equation-of-state (EoS) of liquid iron provides important information (reference adiabat, density ρ, and higher order thermodynamic parameters) in the modelling of the internal structure of planetary bodies with Fe-based cores. Relevant P-conditions range from a few GPa (Moon, Mercury) through the Mbar range (Earth) to several TPa (super-Earth exoplanets). Experimental data on ρ in the liquid stability field are scarce and a thermodynamic assessment of ρ depends on matching Gibbs energy along the melting line which remains controversial to this day. The alternative determination of a *P-V-T* EoS based on ab-initio simulations, on the other hand, suffer from the fact that ρ at ambient P is predicted too large by as much as 20% in the simulations [e.g., 1]. Here, we have fitted *P-V-T* triplets from *ab-initio* molecular dynamics simulations with an EoS formulation that is thermodynamically self-consistent [2] and combined it with a correction formalism that accounts for the known ρ-mismatch at ambient *P* [3]. As the correction is additive to the Helmholtz potential and shows the correct limiting behavior at high and low ρ, the thermodynamic self-consistency of the results is not affected. Using this combination, the EoS we have developed reproduces ρ from shock-wave experiments as well as previous models, but shows a significantly improved agreement at ambient *P*, the critical point and the sole low ρ measurement at 4.3 GPa [4] (T11 in Figure). We explore the performance of our thermodynamic potential and various previously published models [1,5,6] for liquid iron over a wide range of conditions: (i) at ambient pressure as a function of temperature, (ii) along the melting curve of Fe to 40 GPa, relevant for the cores of smaller terrestrial bodies in our solar system (Figure), (iii) along isentropes in the Earth's outer core and (iv) for the core of super-Earth Kepler-36b. The correction term significantly improves the agreement of computed properties with experiments and other thermodynamic models that are based on an assessment of the phase diagram at ambient and moderate pressure, showing how *ab-initio* molecular dynamics simulations can be used at par with other thermodynamic techniques. For the Earth's core, densities from the various models are similar, but higher-order derivatives (acoustic velocities and Grüneisen parameter) show significant differences. Evaluated along a core-temperature profile in Kepler-36b, differences in density from various models are negligible, for core mass they do not exceed 2%, showing robust extrapolation of all equation of state models.

[1] Ichikawa et al., JGR 119, 240 (2014) (I14); [2] Vlček et al., PRB 85, 184201 (2012); [3] French & Mattsson, JAP 116, 013510 (2014); [4] Tateyama et al., PCM 38, 801 (2011) (T11); [5] Komabayashi, JGR 119, 4164 (2014) (K14); [6] Dorogokupets et al., SciRep 7, 41,863 (2017) (D17); [7] Nishida et al., PEPI 257, 230 (2016) (N16); [8] Jing et al., EPSL 396, 78 (2014) (J14); [9] Assael et al., JPCRD 35, 285 (2006) (A06); [10] Morard et al., AmMin 103, 1770 (2018) (M18); [11] Tsu et al., BRIMDM 41, 1 (1985) (T85).

Keywords: planetary cores, iron, equation of state

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Ab initio study of Iron-Nickel alloys in Super-Earths cores

*Francois Soubiran[1], Razvan Caracas[1]

1. Ecole normale superieure de Lyon, Laboratoire de Géologie de Lyon, Université Lyon 1, CNRS UMR 5276, Lyon, France

Iron-nickel alloys are considered the main components of Earth and Super-Earth cores, which make them crucial systems in order to comprehend the properties of these planets. While the relative nickel content is anticipated to be around 10% in the Earth, this value could differ slightly in other planets because of different host star metallicity and formation history. It is thus important to understand the properties of iron-nickel systems with various compositions in the multi-megabar regime.

While pure iron is anticipated to have hexagonal close packing at high pressure, nickel is expected to have face-centered cubic packing. This means there is a structural change as the composition is modified, which can also mean a limited stability of the solid solutions of iron-nickel.

We will discuss the properties of iron-nickel alloys in the megabar regime as predicted by *ab initio* simulations. We will examine the relative stability of different iron-nickel solid solution compositions and the interplay of the spin states. After characterizing the properties of these alloys at pressure-temperature conditions relevant for Super-Earth, we will discuss possible consequences their cores.

Keywords: Super-Earth, iron core, Ab initio simulations

©2019. Japan Geoscience Union. All Right Reserved.

Impurity effect on the iron’s transport properties at Earth’s core conditions: A key constraint for the evolution of the Earth’s core

*Youjun Zhang[1], Mingqiang Hou[2], Nilesh Salke[2], Jung-Fu Lin[3]

1. Sichuan University, 2. HPSTAR, 3. University of Texas at Austin

The Earth’s core is mainly composed of Fe-Ni alloyed with some light elements, such as Si, S, O and C [1]. The transport properties of Fe alloys at Earth’s core conditions constrain the heat flow from the core into mantle, which governs the geodynamo, dynamics and thermal evolution of Earth’s core [2,3]. While, this property is still not well understood and remains controversial in previous work due to the experimental challenging at very high pressure and temperature [4,5]. Here, we directly measure the electrical resistivity of hcp-Fe-Ni and hcp-Fe-Si alloys at the relevant conditions of Earth’s core using double-side laser-heated Diamond Anvil Cells. Our results show a quasi-linear relation between temperature and resistivity in hcp-Fe-Ni and hcp-Fe-Si at the core pressures. Compared with hcp-Fe [6], the impurities like Ni and Si can elevate iron’s resistivity but they show different magnitude. Thermal conductivity of an Fe-Ni-Si alloy as a candidate core composition was modelled via the Wiedemann-Franz law based on our measured resistivity. Our results show that the core’s thermal conductivity could be strongly reduced by impurities, supporting a Mesoproterozoic inner core age and a self-consistent convection-driven geodynamo.

Refs:
[1] Li and Fei. Treat. Geochem., 527-557 (2014)
[2] Davies et al. Nat. Geosci. 8, 678-685 (2015)
[3] Williams. Annu. Rev. Earth Planet. Sci. 46: 47-66 (2018)
[4] Ohta et al. Nature 534, 95-98 (2016)
[5] Konôpková et al. Nature 534, 99-101 (2016)
[6] Zhang et al. Submitted, (2019)

Keywords: Fe alloys, Transport properties, High pressure-temperature, Geodynamo, Thermal evolution of the core

©2019. Japan Geoscience Union. All Right Reserved.

Melting in the Fe-FeO system to 214 GPa

*Kenta Oka[1], Yuto Kidokoro, Kei Hirose[1], Yoichi Nakajima[2], Guillaume Morard[3], Guillaume Fiquet[3], Nicolas Coudurier[3]

1. Department of Earth and Planetary Science, The University of Tokyo, 2. Priority Organization for Innobation and Excellence, 3. Sorbonne Université

Oxygen is one of the likely candidates as the light elements in the Earth’ s core. If oxygen is the primary one, the oxygen content in the outer core should be less than that of the eutectic liquid composition in the Fe-FeO system, which is required to explain the dense solid inner core compared to the liquid outer core. The eutectic liquid composition in the Fe-FeO system has been estimated under high pressures, on the basis of thermodynamic calculations and high-pressure experiments. However, large inconsistency is found among these previous studies, especially below 100 GPa.
In this study, we have conducted high-temperature and high-pressure experiments up to 214 GPa and 3650 K. Liquidus phase relations were determined from textural and chemical characterizations of recovered samples using FIB/FE-EDS/FE-EPMA. Liquid-liquid immiscibility reported below 21 GPa in previous multi-anvil studies (Tsuno et al., 2007) was not observed above 42 GPa in the present DAC experiments. Our results demonstrate that the eutectic liquid composition in the Fe-FeO binary system changed largely from Fe+1.3wt.%O at 15 GPa (Tsuno et al., 2007) to >8 wt.% O at 42 GPa. It then further increased gradually to ~13 wt.% O with increasing pressure to 214 GPa.
These results are in reasonably good agreement with the previous DAC experiments by Seagle et al. (2008) based on XRD measurements and the earlier thermodynamic model by Komabayashi (2014) that considered non-ideal mixing between liquid Fe and FeO. Our data also showed contamination by variable amounts of carbon in liquid, which may explain the difference from the results by Morard et al. (2017) below 80 GPa. The large change in the liquidus phase relations in the Fe-FeO system observed between 15 and 42 GPa is likely related to the disappearance of liquid-liquid immiscibility.
The outer core may include 5.5 wt.% O if oxygen is a sole light element (Badro et al., 2014). When extrapolating our data to 330 GPa, the eutectic liquid in the Fe-FeO binary system includes about 15 wt.% O, which is much higher than the 5.5 wt.% O and therefore allows the outer core liquid containing oxygen as one of important light elements to crystallize solid Fe at the ICB. These results support the presence of oxygen in the core.

Keywords: outer core, light elements, melting experiment, Fe-FeO System

©2019. Japan Geoscience Union. All Right Reserved.

B2 phase in the inner core: constraints from high pressure experiments

*Eiji Ohtani[1], Daijo Ikuta[1], Seiji Kamada[2], Tatsuya Sakamaki[1], Naohisa Hirao[3]

1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2. Frontier Institute for Interdisciplinary Research, Tohoku University, 3. SRring-8, Japan Synchrotron Research Institute

The Earth inner core is considered to be composed of hcp-iron alloy with small amounts of light elements, and intensive efforts have been made to clarify the physical properties of hcp-iron. On the other hand, there are many seismological observations on existence of heterogeneities, layering, and anisotropy in the inner core, which cannot be accounted for only by hcp-iron.

It has been suggested that B2 or bcc phase can exit in the inner core mainly by theoretical calculations (e.g., Belonoshko et al., 2003). Therefore, it has been a debated matter on the existence of a stable B2 structure of iron alloys in the inner core. There is experimental reports suggesting existence of B2 phase in Fe-Si alloy (Fischer et al., 2013). Coexistence of hcp+B2 is observed by Fishcer et al. (2013) in the Fe-Si system with silicon greater than 6 wt. %.

Nickel is an important metallic component in meteorites, and it can modify the phase relations of iron alloy systems significantly. In order to clarify the stability of B2 phase in the inner core, we studied the phase relations of the Fe-Ni-Si system at high pressure and temperature relevant in the core. The in-situ X-ray observations of the Fe-Ni-Si alloys at high pressure and temperature were conducted at BL10XU of SPring-8 by using the double sided laser heating diamond anvil cell. We observed a wide stability field of coexistence of B2 phase and hcp at high pressure and temperature above 100 GPa and 2500 K in the composition of Fe7wt%Ni5wt%Si alloy.

The nickel and silicon contents in the inner core were estimated to be 0~8 wt% and 3-6 wt% respectively in order to account for the PREM inner core based on the equation of state of hcpFe-Ni-Si alloy (Asanuma et al., 2013) and the sound velocity of hcpFe-Si alloy (Sakairi et al., 2018). Combined with the phase relations together with the sound velocity measurements, we can suggest that the inner core is mainly composed of hcp-iron with a small amount of B2 phase. Coexistence of B2 phase with hcp-Fe alloy in the inner core can explain the heterogeneity and fine structure of the inner core reported in seismology.

Reference: Belonoshki et al. (2003) Nature, 466, 744-747. Fischer et al. (2015) Am Min, 100, 2718-2724. Asanuma et al. (2011) EPSL, 310, 113-118. Sakairi et al. (2018), Am Min., 102, 85-90.

Keywords: inner core, bcc, hcp, Fe-Ni-Si alloy, phase relation, sound velocity

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC34] Connecting magma dynamics in vent-conduit system with surface expression of volcanic eruption

convener:Takahiro Miwa(National research institute for earth science and disaster prevention), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Takahiro Miwa, Jacopo Taddeucci

Magma dynamics within a shallow conduit system control the diversity of behavior of volcanic eruptions. Recent advancements in geophysical, airborne and ground-based observation techniques provide quantitative data about the dynamic behavior of volcanic eruptions. New analytical methods of the macro and microtextures of eruptive products also open new insights on detailed dynamics of magmas within conduit. The aim of this session is the integration of these new techniques to approach the dynamics of magma ascending from a shallow part of conduit to vent. This session seeks submissions that explore magma dynamics controlling the behaviors of volcanic eruption by integrated investigation of 1) degassing, outgassing, crystallization, and fragmentation of ascending magma, 2) emission and recycling of eruptive product, and 3) morphological characterization of the vent-conduit system. We encourage contributions based on textural-petrological analyses of eruptive product, experimental study reproducing magma in the conduit, geophysical observation on surface expression of volcanic eruption, and related numerical modeling.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC34-01] An experimental basis for estimating particle properties following volcanic ash emissions

★Invited Papers

*Adrian Hornby[1], Ulrich Kueppers[1], Hanna Horsch[2], Paul Ayris[1], Nick Varley[3], Daniele Andronico[4], Boris Behncke[4], Yan Lavallée[5], Jackie E Kendrick[5], James Utley[5], Amy Hughes[5], David Damby[6], Benedikt Maurer[1], Marlin Juchem[1], Donald B Dingwell[1] (1.Ludwig-Maximilians-Universität München, DE, 2.Hazen Research, Golden, USA, 3.University of Colima, MX, 4.INGV Catania, IT, 5.University of Liverpool, UK, 6.USGS Cascades Volcano Observatory, USA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC34-02] Vapor transport in shallow intruded magmas: insights from diktytaxitic texture

*Ryosuke Sakurai[1], Michihiko Nakamura[2], Satoshi Okumura[2], Mayumi Mujin[2], Takayuki Nakatani[2] (1.Division of Earth and Planetary Materials Science, Faculty of Science, Tohoku University, 2.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC34-03] First observation of nanolites and ultrananolites in alkaline volcanic glasses (Eifel, Germany)

*Marija Putak Juricek[1], Michihiko Nakamura[2], Mayumi Mujin[2], Hans-Ulrich Schmincke[3], Mari Sumita[3], Nobuyoshi Miyajima[1] (1.BGI, 2.Tohoku Univ., 3.GEOMAR)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC34-04] Textural Study of Pumice Clasts from The Youngest Toba Tuff Eruption

*Gabriela Nogo Retnaningtyas Bunga Naen[1], Atsushi Toramaru[1], Tomoharu Miyamoto[1], Haryo Edi Wibowo[2] (1.Department Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Nishiku, 744, Motooka, Fukuoka, 819-0395, Japan, 2.Geological Engineering Department, Universitas Gadjah Mada, 55284, Yogyakarta, Indonesia)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC34-05] **Oomurodashi volcano: Past effusive and phreatomagmatic activity revealed by submarine and subaerial deposits**

*Iona McIntosh[1], Kenichiro Tani[2], Alexander Nichols[3], Qing Chang[1], Jun-Ichi Kimura[1] (1.Japan Agency for Marine-Earth Science and Technology, Yokosuka, 2.National Museum of Nature and Science, Tsukuba, 3.University of Canterbury, Christchurch, New Zealand)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC34-06] Mechanism of volatile transport from mafic to silicic magma upon mixing

*Shumpei Yoshimura[1], Akiko Matsumoto[1], Mitsuhiro Nakagawa[1] (1.Department of Earth and Planetary Sciences, Hokkaido University)

An experimental basis for estimating particle properties following volcanic ash emissions

*Adrian Hornby[1], Ulrich Kueppers[1], Hanna Horsch[2], Paul Ayris[1], Nick Varley[3], Daniele Andronico[4], Boris Behncke[4], Yan Lavallée[5], Jackie E Kendrick[5], James Utley[5], Amy Hughes[5], David Damby[6], Benedikt Maurer[1], Marlin Juchem[1], Donald B Dingwell[1]

1. Ludwig-Maximilians-Universität München, DE, 2. Hazen Research, Golden, USA, 3. University of Colima, MX, 4. INGV Catania, IT, 5. University of Liverpool, UK, 6. USGS Cascades Volcano Observatory, USA

In recent years, mitigating the impact of volcanic ash emissions has risen up political and research agendas. Despite intense research efforts, challenges remain as to the detection and forecasting of emissions, and subsequent interactions in the earth system. Monitoring instruments and ash dispersal models usually require the input of volcanic ash properties in order to operate effectively, however forensic methods are poorly suited to volcanic eruptions where near-real-time data is required, and default values are commonly used. Here, we take an experimental approach to demonstrate that the surface composition and the initial size and shape distribution of volcanic ash particles depends upon (i) the initial rock texture, chemistry and mineralogy and (ii) the fragmentation processes that produced the particles.

We compare natural pyroclasts produced during recent eruptive activity at Volcán de Colima, Mt Etna, Santiaguito, Mt Agung and Tungurahua, with particles produced in fragmentation experiments using fresh rock samples from Volcán de Colima and Mt Etna. Sets of experiments were conducted under varying conditions in shock tube, tumbling and fault friction apparatuses to simulate natural eruption processes. Using QEMSCAN, an SEM-based automated mineralogy technique, we produce micron-scale maps showing the size, shape and phase distribution of thousands of ash particles in each sample. We measure particle size-, shape- and phase distribution in each sample and show that particle sizes and shapes show characteristic variation between different experimental methods and eruptive activity. Some phases, particularly groundmass glass (or tachylite), feldspars and pyroxenes are found to vary significantly at particles boundaries compared to the bulk. The pattern of enrichment and depletion of phases is shown to relate to the fragmentation mechanism and the rock texture at the macro- and micro-scale, and correlations between experimental and natural samples indicate a robust signal.

Volcanic ash presents unique hazards to aviation, health and the environment and better constraints on ash particle properties immediately following activity may improve estimations of the intensity and spatial extent of ash-related hazards. Our results may benefit local hazard management, monitoring and forecasting efforts at the case study volcanoes.

Keywords: Volcanic ash, Fragmentation processes, Experimental volcanology, Hazards, Ash dispersal and monitoring, QEMSCAN

©2019. Japan Geoscience Union. All Right Reserved.

Vapor transport in shallow intruded magmas: insights from diktytaxitic texture

*Ryosuke Sakurai[1], Michihiko Nakamura[2], Satoshi Okumura[2], Mayumi Mujin[2], Takayuki Nakatani[2]

1. Division of Earth and Planetary Materials Science, Faculty of Science, Tohoku University, 2. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University

Volcanic ashes from Vulcanian explosions derived from shallow-intruded magmas and dome lavas often include microporous and glass-free groundmass in which lath-shaped plagioclase microlites form angular voids. Such texture, generally described as diktytaxitic texture, is known to control the permeability of bulk rock significantly when the connected porosity of bubbles and cracks is small (Kushnir et al., 2016). How and under what conditions diktytaxitic texture is formed is, however, not precisely known. In this study we simulated the formation of diktytaxitic groundmass through a series of isobaric-isothermal (IBIT) crystallization experiments in order to clarify its formation kinetics. As a result, diktytaxitic texture was formed at 850 and 900℃ and at 10 and 20 MPa, and almost entire groundmass became diktytaxitic (i.e. glass-free) in the experiment kept at 850℃ and 20 MPa for 189 h. At 850℃ and 10 MPa for >24 h, interstitial melt completely disappeared to form the groundmass composed of feldspar microlites with angular voids. Cristobalite crystals were found in the groundmass and on the interior walls of capsules. The glass compositions form liner trends between the plagioclase microlites and the precipitated silica on the SiO_2-Al_2O_3 diagram. These observations indicate that evaporation of SiO_2-rich melt and condensation of cristobalite are the dominant process for the formation of microporous groundmass characteristic of dixtytaxitic texture. The wide range of K_2O contents in the glass can be explained as a result of vapor-phase growth of ~10 μm K-feldspar microlites in the diktytaxitic groundmass. Hence, we conclude that diktytaxitic texture is formed through (1) enrichment of silicon and potassium in the melt by microlite crystallization, (2) evaporation of SiO_2-rich constituents from the melt accompanied by breakage of Si-O covalent bond, and (3) precipitation of cristobalite and K-feldspar from vapor. The present study indicates that the late stage magma crystallization in shallow intrusions and lava domes proceeds dominantly through a vapor phase.

Keywords: crystallization experiment, evaporation-condensation, cristobalite, diktytaxitic texture, vapor-phase growth, lava dome

©2019. Japan Geoscience Union. All Right Reserved.

First observation of nanolites and ultrananolites in alkaline volcanic glasses (Eifel, Germany)

*Marija Putak Juricek[1], Michihiko Nakamura[2], Mayumi Mujin[2], Hans-Ulrich Schmincke[3], Mari Sumita[3], Nobuyoshi Miyajima[1]

1. BGI, 2. Tohoku Univ., 3. GEOMAR

Nanolites are the smallest, less than <1 μm wide, crystals observed in groundmass of volcanic rocks. They are believed to be the last solid phases that crystallize from the melt during eruptions. Understanding mechanisms of nucleation and subsequent growth of nanolites could potentially provide information about the physiochemical conditions of magma just prior to eruption.

Since nanolite studies are scarce in literature and experimental observation of crystal nucleation and growth is challenging, few constraints on kinetics of nanolite crystallization are available at present. Furthermore, previous studies have investigated nanolites from exclusively calc-alkaline volcanic products. Since melt composition may have a significant effect on crystal nucleation and growth, detailed and systematic descriptions of nanolites occurring in eruptive products of different magma series are required.

The purpose of this study is to present a preliminary overview of nanolite nucleation and growth mechanisms in alkaline melts. Due to high concentrations of network modifying Na and K atoms and considerable volatile budgets, alkaline magmas have very low viscosities. As chemical diffusion is highly dependent on viscosity, nucleation and growth of nanolites in alkaline melts may be governed by different mechanisms from those observed in previous studies.

Variously differentiated samples produced by different eruption styles were collected from West and East Eifel Volcanic Fields (Germany). Samples were observed using a combination of polarized microscopy, FE-SEM and TEM.

Preliminary observation suggests that average nanolite nucleation density in mafic and ultramafic Eifel samples is noticeably higher in comparison to calc-alkaline rocks. In general, nanolites in alkaline eruptive products display a wide range of morphologies with a tendency towards acicular and dendritic habits. Examples of both homogeneous and heterogeneous nucleation were observed. The most abundant phase in the nanolite population of mafic and ultramafic samples is magnetite. The only highly differentiated sample, a phonolitic glass, contained very few nanolites.

In a recently published experimental study it was suggested that precipitation of magnetite nano-crystals may increase magma viscosity by modifying the melt composition. Considering the abundance of magnetite nanolites in Eifel scoria fragments, these magmas may have experienced a severe viscosity increase at shallow crustal levels. We suspect that the presence of extensive interconnected networks of acicular and dendritic magnetite nanolites may have mechanically impeded magma flow as well, contributing to the explosive nature of Eifel eruptions that was previously attributed to magma-water mixing.

Keywords: nanolites, alkaline, nucleation, dendrites

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Textural Study of Pumice Clasts from The Youngest Toba Tuff Eruption

*Gabriela Nogo Retnaningtyas Bunga Naen[1], Atsushi Toramaru[1], Tomoharu Miyamoto[1], Haryo Edi Wibowo[2]

1. Department Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Nishiku, 744, Motooka, Fukuoka, 819-0395, Japan, 2. Geological Engineering Department, Universitas Gadjah Mada, 55284, Yogyakarta, Indonesia

Toba Caldera Complex, North Sumatra, Indonesia is well known as the largest Quaternary caldera (87×33 km) that formed by four major eruptions with magnitude of VEI 8 among which the biggest one is the latest eruption of the Youngest Toba Tuff (YTT) about 74,000 years ago. The conduit dynamics of Toba caldera forming eruption is still poorly understood. Bubbles in pumice, which are produced by an explosive eruption possibly record dynamic processes in the conduit during eruption. This textural study aims to estimate the decompression rate of the biggest event of Toba eruption (YTT) by using textural data from Bubble Number Density (BND) together with geochemical, petrographical, grain size distribution (GSD), and bulk density data. In general, only a few data of decompression rate from caldera forming eruption events are available because the products were mostly welded and the original texture has been erased. Meanwhile, Toba eruption produced non-welded to welded deposit. Therefore, we focus on the nonwelded part of the biggest Quaternary caldera forming eruption localized on the northern part of the caldera in order to extract the original condition of the bubble formation. Samples from three different locations were employed for the analyses. Whole rock geochemical data of pumices were obtained by XRF. Petrography analysis for 21 thin sections were conducted using optical microscope. Bulk density measurement for 338 individual pumices with the size range of 4-8 mm and 8-16 mm were conducted using Laser 3D scanner. Textural analysis was carried out for 6 particles of 3 selected thin sections using microphotographs taken by SEM and further analyzed using image processing software. Geochemical data showed that the YTT magma is rhyodacitic to rhyolitic in whole rock compositions with the narrow range of SiO_2 (69.15 - 72.17 wt. %). Phenocrysts are plagioclase, biotite, quartz, and sanidine, most of which are fractured. The vesicle has a variety in size from 2.5 μm to 97 μm and in shape from rounded, elongated, to complex. GSD for each location are dominated by fine size (phi=1). Bulk density of individual pumice ranges from 0.4 to 1.1 gcm^{-3}. BND calculation were done in carefully selected area where is uniform in size of bubbles to represent samples in estimating the decompression rate in the conduit. BND value ranges from 10^5 - 10^7 mm^{-3} showing a wide range of BND magnitude. Qualitatively, higher magnitude of BND is correlated with higher silica content, higher frequency of crystal fracture, complex vesicle shape, smaller vesicle size, and lower bulk density, and vice versa . The decompression rate was calculated using the BND decompression rate meter from Toramaru (2006). The result showed that Toba caldera forming eruption has high decompression rate ranging from 10^7 –10^8 Pa/s. Those fact shows that Toba experienced with rapid decrease of pressure in the conduit. Moreover, this idea could be an important factor to reveals the conduit dynamic system of YTT super eruption.

Keywords: Toba Caldera, Pumice of the Youngest Toba Tuff (YTT), Textural Study, Conduit Dynamics, Bubble Number Density, High Decompression Rate

©2019. Japan Geoscience Union. All Right Reserved.

Oomurodashi volcano: Past effusive and phreatomagmatic activity revealed by submarine and subaerial deposits

*Iona McIntosh[1], Kenichiro Tani[2], Alexander Nichols[3], Qing Chang[1], Jun-Ichi Kimura[1]

1. Japan Agency for Marine-Earth Science and Technology, Yokosuka, 2. National Museum of Nature and Science, Tsukuba, 3. University of Canterbury, Christchurch, New Zealand

Oomurodashi is a recently discovered active, shallow (~140 mbsl), silicic submarine volcano in the northern Izu-Bonin arc, only 60 km from the entrance to Tokyo Bay. Past activity at Oomurodashi spans a wide range of eruption styles and includes small lava effusions, submarine pumice, and subaerial tephra deposits on nearby Izu-Oshima and Toshima islands. Here we present volatile and textural data that reveal contrasting degassing, quench and fragmentation processes occurring in the shallow conduit and overlying water column.

H_2O data for pumiceous pyroclasts and lavas were obtained using new Fourier Transform Infrared spectroscopy (FTIR) analytical techniques for vesicular and hydrated glasses. Although the Oomurodashi glasses are extensively hydrated, the interconversion of H_2O species (i.e. molecular water, H_2O_m, and hydroxyl groups, OH) stops at the glass transition temperature, and low temperature hydration occurs via diffusive addition of H_2O_m only, leaving OH contents unchanged. OH data can therefore be interpreted according to the known pressure-dependence of H_2O solubility and temperature dependence of H_2O speciation.

Pumice clasts within the subaerial tephra layer have OH contents that are consistent with quench fragmentation at depths of ~60 –150 m depth within the shallow edifice. Moreover, the majority of this tephra deposit consists of ‘mosslike’ particles formed by annealing of extremely fine-grained material, which are typically formed by explosive phreatomagmatic activity. We therefore propose that this tephra represents the distal deposits from the explosive formation of the shallow (~100 m depth) summit crater by a shallow submarine, phreatomagmatic maar-type eruption.

By contrast, two in situ submarine lavas have lower OH contents than expected for their current water depths. Comparison with past sea level variation suggests that these effusive eruptions occurred at ~8-9 and ~12 ka during times of lower sea level. Loose submarine pumice also sampled from the edifice has a range of OH contents and vesicularities, reflecting different quench depths and dispersal histories within the water column.

Keywords: Submarine volcanism, FTIR, Volatiles, Magma fragmentation

©2019. Japan Geoscience Union. All Right Reserved.

Mechanism of volatile transport from mafic to silicic magma upon mixing

*Shumpei Yoshimura[1], Akiko Matsumoto[1], Mitsuhiro Nakagawa[1]

1. Department of Earth and Planetary Sciences, Hokkaido University

Introduction
Deep-derived, high-temperature mafic magma often injects into shallow-stored, low-temperature silicic magma, producing either well-mixed intermediate magma or mafic enclaves floating in host magma. Volatile transport from mafic to silicic magma accompanies magma mixing, and it may control volcanic activity (e.g., Roberge et al., 2009). However, the detailed mechanism of such volatile transport is unclear. In this study, we investigated how the gas was generated in mafic magma and transported to the silicic magma based on S and Cl analysis of Atchiyama rhyolitic lava that contains abundant basaltic enclaves.

Method
We observed Atchiyama biotite-rhyolite lava that erupted 1600 BP in Niijima Island (Isshiki, 1997), and analysed compositions of host rhyolite and basaltic enclaves. Cl mapping analysis was also performed on the area of enclave-host boundary to track the volatile transfer paths.

Results and discussion
Basaltic enclaves exhibited fine-grained groundmass composed of dendritic crystals, rhyolitic interstitial melt, and bubbles. The interstitial melt, which was compositionally distinguishable from the host rhyolite, was S-free (<50 ppm) and Cl-rich (1200 ppm). Melt inclusion analysis showed that the initial basaltic melt before mixing was S-rich (~4000 ppm) and Cl-poor (~430 ppm). These observations indicate that the basaltic magma cooled and crystallised rapidly upon injection, and the interstitial rhyolitic melt was produced as a result of crystallisation fractionation. Crystallisation-induced vesiculation (second boiling) occurred and S degassed completely, while Cl was concentrated in the interstitial melt.
Groundmass glass of host rhyolite was S-free and Cl-poor (~800 ppm). However, Cl mapping analysis revealed that the Cl content increased to 1200 ppm near the enclave margin. In addition, finger-like veins containing vapour-phase crystals developed from the enclave to far afield in host rhyolite, and the Cl content was also high near such veins. All these observations indicate that S- and Cl-rich gas was generated in crystallising enclave, and it was transported to the host rhyolitic magma via gas flow and diffusion.

Keywords: magma, mixing, volatile

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC34] Connecting magma dynamics in vent-conduit system with surface expression of volcanic eruption

convener:Takahiro Miwa(National research institute for earth science and disaster prevention), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Nobuo Geshi(GSJ/AIST), Adrian Hornby(Ludwig-Maximilians-University Munich)

Magma dynamics within a shallow conduit system control the diversity of behavior of volcanic eruptions. Recent advancements in geophysical, airborne and ground-based observation techniques provide quantitative data about the dynamic behavior of volcanic eruptions. New analytical methods of the macro and microtextures of eruptive products also open new insights on detailed dynamics of magmas within conduit. The aim of this session is the integration of these new techniques to approach the dynamics of magma ascending from a shallow part of conduit to vent. This session seeks submissions that explore magma dynamics controlling the behaviors of volcanic eruption by integrated investigation of 1) degassing, outgassing, crystallization, and fragmentation of ascending magma, 2) emission and recycling of eruptive product, and 3) morphological characterization of the vent-conduit system. We encourage contributions based on textural-petrological analyses of eruptive product, experimental study reproducing magma in the conduit, geophysical observation on surface expression of volcanic eruption, and related numerical modeling.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC34-07] The in-flight grain size distribution of lapilli and bombs from Strombolian explosions

*Jacopo Taddeucci[1], Piergiorgio Scarlato[1], Elisabetta Del Bello[1], Tullio Ricci[1], Ulrich Kueppers[2], Bruce Houghton[3] (1.Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, 2.Department of Earth and Environmental Sciences. Ludwig-Maximilians-Universität (LMU). Munich, Germany, 3.Department of Earth Sciences, University of Hawai‘i at Mānoa, Honolulu, USA)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC34-08] **Pyrrotite oxidation as a proxy for air entrainment in eruption columns**

*Keiko Matsumoto[1], Michihiko Nakamura[2] (1.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology, 2.Faculty of Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC34-09] **Thermal signals in volcano monitoring: combining MODIS-MIROVA data with ground-based measurements at Aso Volcano, Japan**

*Corrado CIGOLINI[1], Akihiko Yokoo[2], Diego Coppola[1], Marco Laiolo[1] (1.Department of Earth Sciences, University of Torino, Italy, 2.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Kyoto University, Japan)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC34-10] Magma transfer processes in the NE Japan arc: insights from crustal ambient noise tomography combined with volcanic eruption records

*Georg F Zellmer[1], Kai-Xun Chen[2], Yuancheng Gung[2], Ban-Yuan Kuo[3], Takeyoshi Yoshida[4] (1.Massey University, Palmerston North, New Zealand, 2.National Taiwan University, Taipei, Taiwan, 3.Academia Sinica, Taipei, Taiwan, 4.Tohoku University, Sendai, Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC34-11] **STRATIGRAPHY RENEWAL, MAGMA CHAMBER STRATIFICATION, AND CONDUIT PROCESS OF THE 1815 TAMBORA CALDERA FORMING ERUPTION**

*Indranova Suhendro[1], Atsushi Toramaru[1], Yasuo Miyabuchi[2], Tomoharu Miyamoto[1] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Japan, 2.Faculty of Advanced Science and Technology, Kumamoto University, Kurokami 2-40-1, Chuo-ku, Kumamoto 860-8555, Japan)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

The in-flight grain size distribution of lapilli and bombs from Strombolian explosions

*Jacopo Taddeucci[1], Piergiorgio Scarlato[1], Elisabetta Del Bello[1], Tullio Ricci[1], Ulrich Kueppers[2], Bruce Houghton[3]

1. Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, 2. Department of Earth and Environmental Sciences. Ludwig-Maximilians-Universität (LMU). Munich, Germany, 3. Department of Earth Sciences, University of Hawai ʻi at Mānoa, Honolulu, USA

Grain size distribution is one of the fundamental physical parameters of pyroclastic deposits, key to understanding both magma fragmentation and tephra emplacement processes during an explosive eruption. Most commonly, the grain size distribution of pyroclasts from one eruption is obtained from field sampling and analysis of the resulting tephra deposit; integration of multiple analyses gives a total grain size distribution. In this process it is often assumed that the grain size distribution of the deposit reflects that of the assemblage of pyroclasts that left the eruptive vent. However, observations suggest that multiple processes may act to change the size of erupted pyroclasts during their emplacement, so that the grain size distribution of a deposit may differ, to a variable degree, from that at the vent. Here, we use high-speed imaging to measure the in-flight grain size distribution of pyroclasts for the first tens of meters above an eruptive vent.

We focus on lapilli and bombs from Strombolian- explosions at Stromboli volcano (Italy) in September 2018. At that time, multiple, well-collimated jets with incandescent pyroclasts and no visible ash erupted from a vent about one meter in diameter and in plain view. The activity was recorded by using a high-speed camera filming with a temporal and spatial resolution of 500 frames per second and 0.012 m/pixel, respectively. The high-speed videos were pre-processed for background subtraction, then thresholded for gray level intensity, and finally the individual particles measured for their 2-D size and shape by using image processing. Particle velocity and size was also measured using particle tracking algorithms.

In a parametric study, the effect of different thresholding levels and frame sampling has been investigated. The results define the best parameters and the most effective truncation limits of the measured grain size distributions. Modal values of the grain size are broadly centered around the phi -4 to -5 size classes (16-32 mm) by particle number and the phi -5 to -6 size classes (32 to 64) by particle mass, respectively. The grain size distribution of erupted pyroclasts shifts considerably over time, with smaller clasts being ejected at the beginning of an explosion, and larger median diameters recorded at instants of higher pyroclast volume fluxes.

These results highlight the complexity and variability of the erupted size distributions at the vent, but also the need for a careful assessment of analytical error and methodological limitations.

Keywords: strombolian, explosion, grain size distribution

©2019. Japan Geoscience Union. All Right Reserved.

Pyrrotite oxidation as a proxy for air entrainment in eruption columns

*Keiko Matsumoto[1], Michihiko Nakamura[2]

1. Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology, 2. Faculty of Science, Tohoku University

Entrainment of air by turbulent mixing into eruption columns is a primary control of explosive eruption styles. Pyrrhotite (Po; $Fe_{1-x}S$) in erupted materials is oxidized to form magnetite (Mt) and hematite (Hm) at the oxygen fugacity (fO_2) on the Earth's surface and at magmatic temperature. Degree of Po breakdown has been proposed as a proxy for magma oxidation and cooling by entrained air through examination of the Plinian pumice and lavas from the 1914 eruption at Sakurajima volcano (VEI4). To verify and further investigate the potential use of Po oxidation for estimating eruption intensities from pyroclasts, we have examined the pumice clasts from three andesitic explosive eruptions with similar magmatic temperature and different eruption intensity: the 1783 Plinian eruption of the Asama volcano (VEI4), the 2011 sub-Plinian eruption of the Shinmoedake volcano (VEI2) and the 2010 Vulcanian explosion of the Sakurajima volcano (VEI1).

Mineral phases of magmatic sulfide and occurrence of pseudomorph (Mt and Hm) are different among the three eruption samples. Po is observed in the groundmass of the pumice from the Asama 1783 eruption and the Sakurajima 2010 eruption, whereas the sulfide in the Shinmoedake 2011 groundmass is intermediate solid solution (iss; $Cu_{1-x}Fe_{2+y}S_{2-z}$). Po is sometimes replaced to form pseudomorph, while iss shows no replacement. The porous texture of the Po pseudomorph, which indicates a reaction of Po with air, is similar to that observed for the oxidation product having columnar microstructure reported in the pumice from the Sakurajima 1914 eruption (Matsumoto and Nakamura, 2017). Approximately half of the Po grains are partly or entirely replaced by the pseudomorph in the Asama 1783 pumice, as observed in the Sakurajima 1914 samples. On the other hand, proportion of the pseudomorphic Po grains is less than 20% in the Sakurajima 2010 pumice. This difference indicates that the Asama 1783 pumice, together with the Sakurajima 1914 pumice, has been more efficiently oxidized than the Sakurajima 2010 pumice. The preservation of iss in the Shinmoedake 2011 pumice is probably due to the difference in oxidation mechanism between iss and Po. The efficient oxidation of Po during the two Plinian eruptions (i.e., the Asama 1783 and the Sakurajima 1914 eruptions) can be attributed to the longer duration in which temperature of pumice were kept high in the eruption columns than that in the Vulcanian column. These results underscore the potential use of Po oxidation for the purpose of constraining the temperature and fO_2 of eruption columns that reflect eruption intensity of explosive eruptions.

Keywords: pyrrhotite, oxidation, explosive eruption, eruption column

©2019. Japan Geoscience Union. All Right Reserved.

Thermal signals in volcano monitoring: combining MODIS-MIROVA data with ground-based measurements at Aso Volcano, Japan

*Corrado CIGOLINI[1], Akihiko Yokoo[2], Diego Coppola[1], Marco Laiolo[1]

1. Department of Earth Sciences, University of Torino, Italy, 2. Aso Volcanological Laboratory, Institute for Geothermal Sciences, Kyoto University, Japan

Active volcanoes bearing crater lakes are rather challenging targets for thermal monitoring since their anomalies are rather small when compared to lava flows and/or domes. Thus, we have combined satellite data with ground-based measurements at Aso Volcano during its recent activity.
The thermal signals of Aso Volcano (Nakadake) during unrest episodes have been analyzed by means of the MODIS-MIROVA data set and high resolution images (LANDSAT 8 OLI and Sentinel 2) cross-checked with ground-based thermal observations. The Volcanic Radiative Power (VRP) detected by nighttime satellite data during the time span considered was mainly below 3 MW. This value is a thermal threshold that marks the transition from high fumarole activity (HFA) to Strombolian eruptions (SE). Periods with the occurrence of sporadic phreatic eruptions (PE, eventually bearing phreatomagmatic episodes), is the dominant phase during unrest episodes, with VRP values around 0.5 MW. However, during sustained Strombolian phases (November-December 2014) the radiative power was higher than 4 MW, reaching peak values up to 15.6 MW (on December 7, 2014, 10 days after the major Strombolian explosion of November 27). Ground-based measurements, recorded by FLIR T440 Thermo-camera on the fumarole field of the South Area, shows that the heat-flux stabilized around 2 MW until February 2015. Apparent temperatures measured on the fumarole field were around 490-575˚C before the major Strombolian explosive event, whereas those recorded at the active vent (Central Pit) reached their maxima around 600 ˚C. In the following days they both exhibited a decreasing trend. However, during the Strombolian phase the crater lake dried out and was then replenished by early July, 2016. Then volcanic activity shifted back to phreatic-phreatomagmatic and the eruptive cycle was completed; in this period ground measurements were fluctuating around 1 MW. Following the major phreatic explosion of October 8, 2016 satellite VRP were moderately above 2 MW and then progressively decreased. During 2018, they were essentially below 1 MW (with a mean of 0.75 Mw and few peaks above 1 MW).
We estimated the total amount of Magma Equivalent Volume (MEV) responsible for satellite thermal anomalies during the Strombolian phase (from the end of November 2014 to May 2015). The cumulative volume involved in this phase reached 4.5 x 10^5 m^3, which is two order of magnitude lower than the total volume of magma undergoing degassing (estimated by means of the petrologic models based on SO_2 degassing). This indicates that thermal anomalies during the Strombolian phases detect the magma that is reaching the surface and through a feeder dike, or conduit, connected at depth with a major reservoir.

Keywords: Aso Volcano, unrest episodes, thermal anomalies, Strombolian activity, major explosions

©2019. Japan Geoscience Union. All Right Reserved.

Magma transfer processes in the NE Japan arc: insights from crustal ambient noise tomography combined with volcanic eruption records

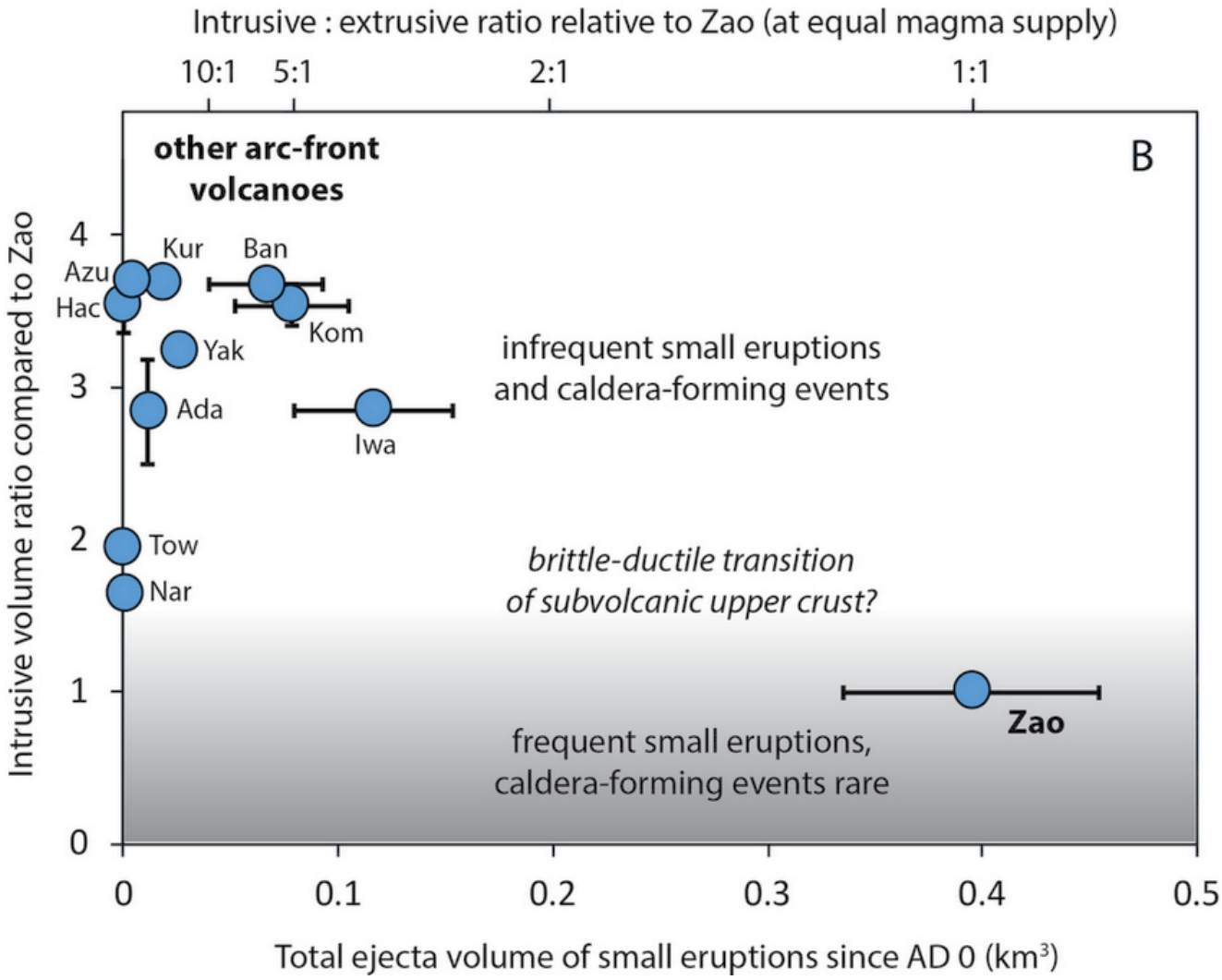
*Georg F Zellmer[1], Kai-Xun Chen[2], Yuancheng Gung[2], Ban-Yuan Kuo[3], Takeyoshi Yoshida[4]

1. Massey University, Palmerston North, New Zealand, 2. National Taiwan University, Taipei, Taiwan, 3. Academia Sinica, Taipei, Taiwan, 4. Tohoku University, Sendai, Japan

Subduction zone magmatic budgets and crustal growth processes depend on poorly constrained intrusive : extrusive ratios of arc magmas. Published ambient noise tomography data from northeast Japan reveal upper crustal low-V_S bodies, indicating elevated temperatures of plutonic rocks, beneath most sites of active arc-front volcanoes, with the exception of Zao volcano. Strikingly, when small eruptions (VEI 1 to VEI 3) from arc-front volcanoes in the last 2 kyr are considered, Zao has erupted most frequently and has produced a more than three times greater tephra volume than any of the other volcanoes. We propose that the frequent low-volume volcanism at Zao is fed by dikes that traverse the crustal section rapidly, fracturing through brittle lithologies. Beneath the other volcanoes, hotter and more ductile plutonic bodies have developed through repeated intrusive activity, hindering magma transport to the surface. This positive feedback mechanism ultimately results in cataclysmic caldera-forming events. We show that the number of late Cenozoic calderas is higher above the imaged low-V_S crust, consistent with this interpretation. We propose that generation of plutonic bodies is facilitated by volcaniclastic materials buried in a Miocene rift graben, which dampen fracture propagation and promote repeated sill intrusion. In contrast, transcurrent faulting has moved cold Cretaceous basement of the fore-arc range into the arc-front beneath Zao. These brittle rocks instead provide fracture pathways explored by magmas rapidly rising to the surface. The combined data imply that millions of years of crustal growth and tectonic history have a direct control on present-day volcanic eruption style.

Keywords: heat incubation, crustal magma ascent, crustal growth history, volcanic eruption style, Tohoku volcanism, brittle-ductile transition

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

STRATIGRAPHY RENEWAL, MAGMA CHAMBER STRATIFICATION, AND CONDUIT PROCESS OF THE 1815 TAMBORA CALDERA FORMING ERUPTION

*Indranova Suhendro[1], Atsushi Toramaru[1], Yasuo Miyabuchi[2], Tomoharu Miyamoto[1]

1. Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, Japan, 2. Faculty of Advanced Science and Technology, Kumamoto University, Kurokami 2-40-1, Chuo-ku, Kumamoto 860-8555, Japan

The 1815 eruption of Tambora volcano was initiated by two precursory Plinian falls and terminated by pyroclastic density current (PDC) deposits. Although the occurrence of fall deposits and pumice rich PDC has been well-described by previous researchers, we discover scoria rich PDC deposits. However, the presence and relationship of scoria rich PDC with another well-described 1815 eruption deposit has never been discussed in detail. Moreover, several aspects of the magma chamber and conduit dynamics are still poorly understood. In order to that, we conducted petrography by optical microscope, chemical anlyses by XRF, SEM-EDS, and FE-EPMA, and textural analyses of BND and MND. Systematic change in the phenocryst, vesicle, microlite, and chemical compositions also observed through the stratigraphic position. Plinian fall units are characterized by relatively low crystal abundance and small average phenocryst size (0.44 - 0.52 mm) with higher silica content (56.8-58.05 wt.% SiO_2). In contrast, PDC deposits are characterized by relatively higher crystal abundance and greater average phenocryst size (0.53 - 0.59 mm) with lower silica content (56.5-57.5 wt.% SiO_2). There is no evidence of magma mixing because no bimodal distribution in anorthite content and no reverse zoning pattern in plagioclase phenocryst. Large phenocrysts (>1 mm) have less variation than small phenocrysts (<1 mm) in chemistry. Core compositions of large phenocrysts are An_{70}-$_{90,}$ while those of small phenocrysts are An_{40}-$_{95}$. The correlation between crystal size, chemical composition, and stratigraphic position suggests that stratification of crystals and chemical compositions in the magma chamber was established prior to 1815 eruption. Juveniles from Plinian eruption are composed of higher BND and lower MND value, compared to juveniles from PDC. As a result, we explained negative correlation of BND and MND by the control of decompression rate (dP/dt). Namely, high decompression rate will induce high nucleation rate of bubble thus facilitate magma to ascent rapidly and limiting the growth of microlite. The increase of lithic population from precursory Plinian towards PDC can be regarded as vent-widening process. Therefore, the decrease of decompression rate accompanied by conduit widening during the early to later phase has shifted the eruption style, from buoyant Plinian column to PDC. Finally, rapid and voluminous magma withdrawal from the chamber has led to the formation of caldera.

Keywords: Tambora, caldera forming eruption, textural analyses, detailed stratigraphy, bubble number density, microlite number density

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Kimihiro Mochizuki(Earthquake Research Institute, University of Tokyo), Ryuta Arai

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG48-17] Three-dimensional seismic structure of the shallow plate boundary in the northern Hikurangi margin from NZ3D OBS data

*Ryuta Arai[1], Shuichi Kodaira[1], Richard Kellett[2], Valerie Stucker[2], Dan Bassett[2], Stuart Henrys[2], Koichiro Obana[1], Nathan Bangs[3], Dan Barker[2], Rebecca Bell[4], Kimihiro Mochizuki[5], Gou Fujie[1], Seiichi Miura[1], Bill Fry[2], team NZ3D (1.Japan Agency for Marine-Earth Science and Technology, 2.GNS Science, 3.University of Texas Institute for Geophysics, 4.Imperial College London, 5.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:45 AM JST | 12:15 AM - 12:45 AM UTC

[SCG48-18] **Using earthquake focal mechanisms to investigate slow slip driving forces in the northern Hikurangi**

★Invited Papers

*Emily Warren-Smith[1], Bill Fry[1], Laura Wallace[1] (1.GNS Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG48-19] Seismological structural changes around source regions of slow earthquakes in Nankai subduction zone inferred from broadband receiver functions

*Yasunori Sawaki[1], Yoshihiro Ito[2], Kazuaki Ohta[2], Takuo Shibutani[2], Tomotaka Iwata[2] (1.Graduate School of Science, Kyoto University , 2.Disaster Prevention Research Institute, Kyoto University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG48-20] Slip tendency maps for compressional and extensional stress states on a shallow decollement in Nankai Trough

*Yoshitaka Hashimoto[1], Shigeyuki Sato[1], Gregory F Moore[2], Masataka Kinoshita[3], Gaku Kimura[4], Ayumu Miyakawa[5], Kazuya Shiraishi[6], Yasuhiro Yamada[6] (1.Kochi University, 2.University of Hawaii, 3.University of Tokyo, 4.Tokyo University of Marine Science and Technology, 5.AIST, 6.JAMSTEC)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG48-21] Permeability and its anisotropy on creeping Chihshang Fault, Taiwan

*Tyas Dwi Aprilniadi[1], Wen-Jie Wu[1], Li-Wei Kuo[1], Jian-Cheng Lee[2], Jia-Jyun Dong[3] (1.Department of Earth Sciences, National Central University, 2.Institute of Earth Sciences, Academia Sinica, 3.Graduate Institute of Applied Geology, National Central University)

Three-dimensional seismic structure of the shallow plate boundary in the northern Hikurangi margin from NZ3D OBS data

*Ryuta Arai[1], Shuichi Kodaira[1], Richard Kellett[2], Valerie Stucker[2], Dan Bassett[2], Stuart Henrys[2], Koichiro Obana[1], Nathan Bangs[3], Dan Barker[2], Rebecca Bell[4], Kimihiro Mochizuki[5], Gou Fujie[1], Seiichi Miura[1], Bill Fry[2], team NZ3D

1. Japan Agency for Marine-Earth Science and Technology, 2. GNS Science, 3. University of Texas Institute for Geophysics, 4. Imperial College London, 5. Earthquake Research Institute, University of Tokyo

Slow earthquakes occur around the seismogenic zones of the plate boundary faults and they have so far been largely studied on the deep portions of the plate interface based on land-based geophysical observations. On the other hand, recent marine studies reveal that shallow slow earthquakes at the up-dip portions of seismogenic zones are also common in subduction zones. These shallow slow earthquakes have been found to occur from near the trench to ~10 km depth of the plate interface and their genesis is thought to be closely linked to fluid pressures and effective stresses at the fault. However, primary controls on seismogenesis at these depths, such as fault structures and stratigraphic/hydrogeologic properties around the subduction megathrust faults, are highly complex in three dimensions and poorly understood.

In order to refine our understanding of structural characteristics regulating slow earthquakes occurring at shallow plate boundaries, we collected 3-D seismic refraction/wide-angle reflection data from offshore Gisborne at the northern Hikurangi subduction margin, New Zealand, as part of an international collaborative project, NZ3D. The dataset covers an area of 60 km x 14 km ranging from the northern Tuaheni landslide complex and the easterly forearc slope to the subduction trench and was recorded on 97 ocean bottom seismographs deployed with an average spacing of 2 km on 4 parallel lines with over 140,000 airgun sources. In the study area, shallow slow slip events and tectonic tremor have been well documented (Wallace et al., 2016; Todd et al., 2018). Previous 2-D seismic reflection studies also show that the subduction of large-scale seamounts facilitates the transport of fluid-rich sediments deep into the subduction zone and produces conditions of high fluid pressures along the plate interface and pathways for fluid migration into the overriding plate (Bell et al., 2010; Barker et al., 2018).

Using the very dense airgun-OBS data, we constructed a preliminary three-dimensional P-wave velocity structure model of the accretionary forearc and the plate boundary from first arrival tomography. The velocity images from over 250,000 first arrivals revealed a thick low-velocity (Vp < 5.0 km/s) volume along the plate interface down to a depth of at least ~10 km. This velocity structure may represent a thick subduction channel filled with fluid-rich sediments associated with seamount subduction.

Keywords: Shallow plate boundary, Hikurangi margin, 3-D seismic structure

©2019. Japan Geoscience Union. All Right Reserved.

Using earthquake focal mechanisms to investigate slow slip driving forces in the northern Hikurangi

*Emily Warren-Smith[1], Bill Fry[1], Laura Wallace[1]

1. GNS Science

Understanding the processes that drive slow slip events (SSEs) may assist in improving our understanding of the physics of both slow and fast earthquakes. Recent work has shown that the stress ratio, R, retrieved by focal mechanism inversion systematically decreases prior to SSEs in New Zealand's northern Hikurangi subduction zone, and subsequently increases during the evolution of each SSE. These R fluctuations are proposed to represent slow, precursory increases and fast concurrent decreases in fluid pressure within overpressured subducting oceanic crust during the SSE cycle.

These observations represent an exciting opportunity to improve forecasts of SSE occurrence via monitoring of R changes. Thus far, this cyclic behaviour has only been observed over a short time-period (9 months, 4 SSE cycles) when ocean-bottom seismographs were deployed.

Here we present the results of a waveform cross-correlation study that aims to extend the catalogue in time and reduce the magnitude of completeness for focal mechanisms of northern Hikurangi seismicity. This enables improved temporal coverage and statistical analysis of stress tensor changes across multiple SSE cycles. By using well constrained focal mechanisms of events recorded on >30 OBS and land stations as templates, we automatically assign correlation-derived relative polarities to waveforms and subsequently invert for focal mechanisms and R using many more earthquakes complete to a lower magnitude. This approach offers an important step towards accurate SSE forecasting and an improved understanding of the physical processes leading to slow rupture nucleation.

Keywords: slow slip, seismology, focal mechanisms, stress inversions, Hikurangi, fluid pressure

©2019. Japan Geoscience Union. All Right Reserved.

Seismological structural changes around source regions of slow earthquakes in Nankai subduction zone inferred from broadband receiver functions

*Yasunori Sawaki[1], Yoshihiro Ito[2], Kazuaki Ohta[2], Takuo Shibutani[2], Tomotaka Iwata[2]

1. Graduate School of Science, Kyoto University , 2. Disaster Prevention Research Institute, Kyoto University

Coupled phenomena of tremors accompanying short-term slow slip events and very low frequency earthquakes (Ito et al., 2007) have been detected at deeper parts of seismogenic regions on the Nankai Subduction Zone in southwestern Japan. Elucidating detailed seismological structures on plate interfaces hosting slow earthquakes is very important to understand mechanisms and relationships of slow earthquakes and megathrust earthquakes. Few studies, however, have proposed detailed velocity structure models and their spatio-temporal variations with high resolution receiver functions (RFs) on plate interfaces. In this study, we calculate broadband RFs around source regions with slow earthquake events in the Nankai Subduction Zone. We also investigate frequency dependency of RFs to constrain detailed physical features near the plate interface.
RF method is one of the best approaches to estimate the velocity structure beneath seismic stations by extracting P-to-S phases converted on velocity discontinuity from teleseismic waveforms. In southwestern Japan, Shiomi et al. (2008) confirmed the oceanic Moho discontinuity in the Philippine Sea Slab. In usual cases, high cut filter (e.g. 0.6Hz: Shiomi et al., 2008) is used when deconvoluting vertical component waveforms from horizontal ones in order to avoid instability on calculation. Akuhara et al. (2017) recently calculated high frequency RFs up to 4 Hz using ocean bottom seismometers equipped off the Kii peninsula, and confirmed the existence of a thin low velocity zone composed of a fluid-rich sediment layer along the Nankai trough megathrust fault. In this study, we calculate RFs applying the Extended-Time Multitaper method modified by Shibutani et al. (2008) and the frequency dependency of RFs is examined by taking different frequency ranges up to 0.5, 1, 2, 3 and 4 Hz.
We have used Hi-net and F-net seismograms provided by National Research Institute for Earth Science and Disaster Resilience in Japan. We confirm that spectra of teleseismic waveforms have sufficient SN ratios up to 3 or 4 Hz. Fig.1 shows an example of the RFs at NKTH located on the Kii peninsula. The RFs at most of the stations contain positive and negative phases around 3-4 s after P-wave arrival, which correspond to oceanic Moho discontinuity and the plate interface, respectively. The amplitude and the arrival time of these phases depend on backazimuth, suggesting that dependency on the incident angle of a ray to the subducting plate interface. In case of a downdip for the subducting slab, incoming P-waves have lower incident angles and generate smaller convert S-waves. On the contrary, an updip case, incoming P-waves have higher incident angles and generate larger convert S-waves.
At higher frequency RFs (Fig.1, right), the phases from the plate interface are generally sharper than those at lower frequency, whereas the phases corresponding to oceanic Moho seems to tend to be broader or split into several phases, suggesting that the oceanic Moho is not a simple velocity discontinuity but would consists of several layers. The split positive phase just after the negative phase from the plate interface may relate to the thin low velocity zone inferred from Akuhara et al. (2017).

Keywords: Receiver function, Broadband receiver function, Slow earthquake, Nankai subduction zone

©2019. Japan Geoscience Union. All Right Reserved.

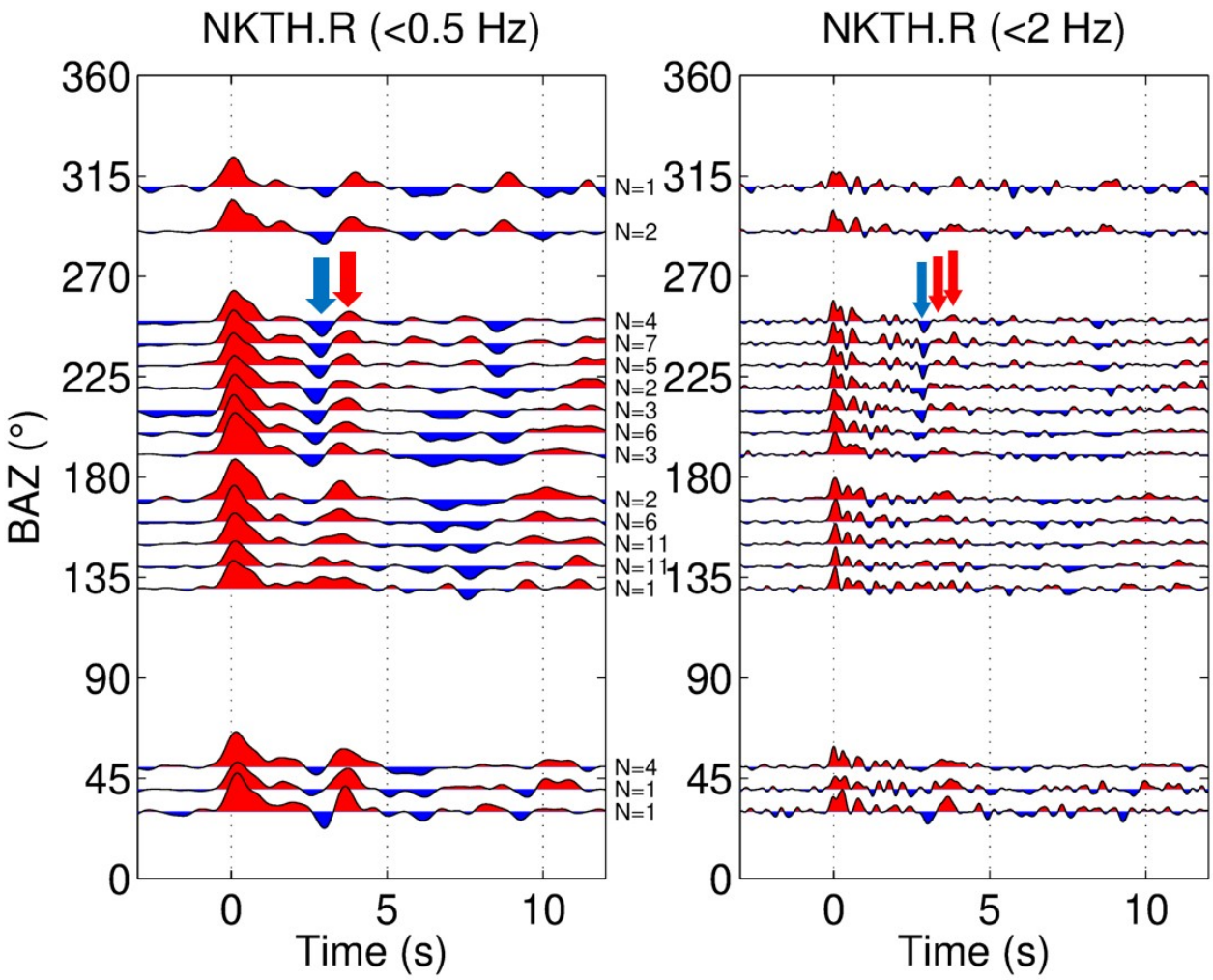


Fig. 1 Radial receiver functions (RFs) on NKTH with frequency ranges up to (left) 0.5 Hz and (right) 2 Hz. The vertical and horizontal axes denote delay time from P-wave arrival [s] and backazimuth [degree], respectively. Areas colored in red and blue show the positive and negative amplitudes, respectively. N is the number of RFs stacked every 10 degrees. Red and blue arrows indicate later phases from the oceanic Moho and the plate interface, respectively.

©2019. Japan Geoscience Union. All Right Reserved.

Slip tendency maps for compressional and extensional stress states on a shallow decollement in Nankai Trough

*Yoshitaka Hashimoto[1], Shigeyuki Sato[1], Gregory F Moore[2], Masataka Kinoshita[3], Gaku Kimura[4], Ayumu Miyakawa[5], Kazuya Shiraishi[6], Yasuhiro Yamada[6]

1. Kochi University, 2. University of Hawaii, 3. University of Tokyo, 4. Tokyo University of Marine Science and Technology, 5. AIST, 6. JAMSTEC

Stress state along a subduction plate interface is one of important controls for wedge architectures, fault activations and seismogenic behaviors. In a shallow portion of a subduction plate interface, a large displacement along decollement could be expected for tsunamigenic events (Fujiwara et al., 2012) as well as slow earthquakes such as very low frequency earthquakes and slow slips have been observed (Araki et al., 2017, Nakano et al., 2018). Paleo-stress state has been estimated using micro-fault inversion method from exhumed accretionary complexes and oceanic accretionary wedges, which shows the stress state changes between compression and extension states with almost horizontal and vertical principal stress axes. The stress change could be related to seismic cycle.

In this study, we examined geographical features of a shallow decollement using 3D seismic profiles and mapped slip tendencies on the decollement with compressional and extensional stress state to discuss an effect of distribution of slip tendency on the fault slip behaviors. Slip tendency is a shear stress ratio to normal stress on a fault surface when a regional stress state is applied on a fault surface.

The target transect of the 3D seismic profiles is located at the Nankai Trough off Kii Peninsula, SW Japan where Philippine Sea Plate subducted into Eurasian Plate, and IODP NantroSEIZE project has been operated. The 3D seismic profiles had been reprocessed to make reflectors clear using an updated technology. We traced the shallow decollement to make geographic features (3D surface) by Petrel. We analyzed dip angle and dip azimuth for 50 m mesh of the surface. The characteristics of geographic features of the shallow decollement are 1) almost horizontal with dip angle ranging 5-15, 2) dip azimuth directing 300-350˚ (NW-NWN) in average. In addition, some narrow zones with dip azimuth directing 50-150˚ (SE-SES) are identified, which shows a relatively high frequency reliefs striking NE-SW direction. Some of these are related to the geography of oceanic basement.

Compressional and extensional stress states were applied on the surface to examine a change in slip tendency with change in stress state. We assumed that compressional one has (150, 0) sigma 1 and (90, 90) sigma 3 and others has (150, 0) sigma 3 and (90, 90) sigma 1. The 0.6 of friction coefficient was assumed as the maximum value. We calculated differential stresses for compressional and extensional stress states to make a plane with idealized attitude to applied stress state reactivated. This assumption implies that the estimated slip tendency is the maximum value.

Resulted slip tendency represents a strong relationship with geomorphic features. In compressional stress state, large slip tendency (0.4-0.5) distributes on the surface with dip azimuth directing 300-350˚ whereas small slip tendency (0.1-0.2) corresponds to the surface with dip azimuth directing 50-150˚. In extensional stress state, the similar distribution with that in compressional stress state is identified but the difference between the dip azimuths is very small; slip tendency ranges 0.1-0.2. The differences between slip tendencies in compressional and extensional stress states is almost similar to that for compressional stress state because slip tendency for extensional stress state is almost 0.1-0.2.

©2019. Japan Geoscience Union. All Right Reserved.

If we take the difference in slip tendency as a kind of stress drop, relatively small stress drop are observed on the surface with dip azimuth directing 50-150˚, which is distributed in NE-SW zones. Nakano et al. (2018) found that VLFs in the region migrates toward NE, which is consistent with the directions of zones with stress drop is small. The area for VLFEs could be limited in these zones where the slip tendency is small both in compressional and extensional stress states, implying that the material with very low friction coefficient and/or high pore fluid pressure are expected to make a plane reactivated with small slip tendency.

Keywords: Slip tendency, seismic cycle, Nankai Trough, very low frequency earthquake

©2019. Japan Geoscience Union. All Right Reserved.

Permeability and its anisotropy on creeping Chihshang Fault, Taiwan

*Tyas Dwi Aprilniadi[1], Wen-Jie Wu[1], Li-Wei Kuo[1], Jian-Cheng Lee[2], Jia-Jyun Dong[3]

1. Department of Earth Sciences, National Central University, 2. Institute of Earth Sciences, Academia Sinica, 3. Graduate Institute of Applied Geology, National Central University

The Chihshang Fault in eastern Taiwan is a 20-km-long segment of the Longitudinal Valley Fault that a plate-suture boundary fault between the Eurasian continental margin and the Philippine Sea Plate has fastest shallow creep in the world and infrequently occurs earthquakes (Magnitude greater than 6). Here we performed permeability measurements on Lichi Mélange and conglomerate with an intra-vessel oil pressure apparatus (YOKO2) at room temperature at isotropic confining pressure, using helium as pore fluid. We made samples, with dip and normal direction of fault, from retrieved rock cores in WAN-2 borehole and attempted to build the permeability structure across creeping Chihshang Fault. Generally, intrinsic permeabilities of Lichi Mélange were lower than that of conglomerate and intrinsic permeabilities in dip direction were higher than that in normal direction. But the permeability differed in rock type and was associated with shear structures that fault zone architecture is not typical as simple mode suggested by Caine et al. (1996). The results show Lichi Mélange was a natural aquifuge blocking the fluid flow that may be responsible for fluid-rock interaction and seasonal fluctuation on creeping Chihshang Fault. The heterogeneous Lichi Mélange has complicated composition as other Mélange that the microstructural observation would be conducted for investigating the relationship between microstructures and permeability in creeping Chihshang Fault. Taking microstructures, permeability anisotropy and the fault zone architecture into consideration, we may depict the permeability structures of Chihshang Fault and further provide the information of matrix permeability for hydraulic properties in the field.

Keywords: creeping Chihshang Fault, Lichi Mélange, permeability anisotropy

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Simon Wallis(Nagoya University)

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG48-22] Short fluid infiltration events in the low permeable metamorphic rocks triggered by crustal fracturing at amphibolite–granulite facies conditions

*Diana Mindaleva[1], Masaoki Uno[1], Fumiko Higashino[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1] (1.Graduate school of environmental studies, Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG48-23] Generation of high fluid pressure at the base of the shallow mantle wedge—evidence from serpentinite of the Sanbagawa belt, SW Japan

*Simon Richard Wallis[1], Yui Kouketsu[2], Mari Yokota[1,2] (1.University of Tokyo, 2.Nagoya University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG48-24] **Overpressured subduction plate boundary caused by infiltration of mantle-derived fluids: Evidence from helium isotope analysis on veins in subduction mélange**

*Naoki Nishiyama[1], Kohtaro Ujiie[1], Hirochika Sumino[2] (1.University of Tsukuba, 2.The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG48-25] **Geological and rheological conditions of subduction plate boundary between the seismogenic zone and the ETS zone in warm-slab environments**

*Kohtaro Ujiie[1], Kazuya Noro[1], Norio Shigematsu[2], Ake Fagereng[3], Naoki Nishiyama[1], Christopher Tulley[3], Haruna MASUYAMA[1], Yasushi Mori[4] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, 2.Research Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, Japan, 3.Cardiff University, 4.Kitakyushu Museum of Natural History and Human History)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG48-26] Temperature variation in tectonic mélanges of the Shimanto Belt, SW Japan

*Tsai-Wei Chen[1], Donald M Fisher[1], Andrew J Smye[1], Yoshitaka Hashimoto[2] (1.Penn State Univ., 2.Kochi Univ.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG48-27] Frictional properties of opal gouge at low-temperature hydrothermal conditions and their implications for seismogenic faulting along subduction-zone megathrusts

*Kyuichi Kanagawa[1], Tomoya Nakanishi[2], Morito Kuwana[3], Michiyo Sawai[1], Takehiro Hirose[4] (1.School of Science, Chiba University, 2.Graduate School of Science and Engineering, Chiba University, 3.Faculty of Science, Chiba University, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology)

Short fluid infiltration events in the low permeable metamorphic rocks triggered by crustal fracturing at amphibolite–granulite facies conditions

*Diana Mindaleva[1], Masaoki Uno[1], Fumiko Higashino[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1]

1. Graduate school of environmental studies, Tohoku University

Aqueous fluids flow could be responsible for changing hydrologic and thermodynamic properties of rocks. It is generally accepted that fluids play a key role in the generation of earthquakes, tremors, and slow slip events. For example, it was suggested that tremors are related to fluids released during dehydration processes in the subduction slab (e.g., Abers et al., 2009; Katsumata and Kamaya, 2003; Obara et al., 2004). Hydrous minerals in subducting slabs release H_2O due to dehydration reactions. Released water increases fluid pressure rapidly. However, fluid pressure gradients within the crust remain poorly constrained due to their heterogeneity. Therefore, it is important to constrain timescales of fluid infiltration to understand fluid pressure gradient, permeability, and tectonic evolution.

We have investigated fluid-rock reaction zones in mafic granulite and amphibolite samples from Mefjell, south-central part of the Sør Rondane Mountains (SRM), East Antarctica, and constrained pressure gradient and permeability. Mafic granulite and amphibolite samples are cut by numerous randomly-oriented veins. Samples are partially hydrated along veins associated with mm-scale hydration reactions zones. Reaction zones fingerprint relationship between fluid infiltration and rock response. We divide samples into several reaction zones increasing distance from the vein center by modal amount of minerals, reaction textures, and trace elements concentrations distributions profiles in apatite. The P-T conditions for the fluid infiltration in mafic granulite were estimated to be 0.65 GPa, 650˚C , and that for peak P-T conditions were 850˚C, 0.55-1.0 GPa. On the other hand, P-T conditions for the fluid infiltration in amphibolite were estimated to be around 500˚C.

Trace elements concentrations (Cl, Sr, and some REE) measured by EPMA and LA-ICP-MS in several apatite grains were gradually decreasing with distance from the vein. Cl distributions profiles were analyzed by a reactive-transport model to define transport mechanism by fitting to Peclet number (Pe#=vL/D, where v is pore velocity, L is length of reaction zone, D is self-diffusion coefficient) and time-scales of fluid infiltration. For mafic granulite Pe# is 0.025, for amphibolite is 90. Whereas diffusion transport is revealed to be dominant for mafic granulite, advection transport is likely for amphibolite. Duration of fluid infiltration was estimated to be 5.5 h for mafic granulite and 1-3 h for amphibolite, which is very short in geological timescales. This suggests rapid and intense fluid flux through the mantle wedge and onto overlying crust. Short timescales of fluid infiltration may reflect linkage to the seismic events.

To estimate permeability, the pressure gradient for the reaction zones was calculated from the water and other elements activities constrained by pseudosection analysis for different reaction zones. Bulk compositions at each reaction zone were used to create pseudosections. Permeability was calculated from the estimated pressure gradient and total flux $q=-\kappa(\partial P/\partial x)/\eta$, where q is total flux, k is permeability, η is viscosity, and $(\partial P/\partial x)$ is pressure gradient. Results suggest low and contrasting permeability between mafic granulite dominated by diffusion and amphibolite dominated by advection mass transport mechanisms. This difference may be explained by different P-T conditions for fluid infiltration and heterogeneity of the pressure gradients. Therefore, it suggest that fluid infiltration in low

©2019. Japan Geoscience Union. All Right Reserved.

permeable rocks caused fracturing and formed narrow reaction zones, which released fluid pressure in a short time. Above results of our study suggest importance of fluid transport phenomena in relation to the evolution of rocks hydrological properties.

Abers G. A. et al. Geology 37.12 (2009): 1119-1122.

Katsumata A., Kamaya N. Geophysical Research Letters 30.1 (2003): 20-1.

Obara K. et al. Geophysical Research Letters 31.23 (2004).

Keywords: Pressure gradient, Permeability, Water-rock interaction

©2019. Japan Geoscience Union. All Right Reserved.

Generation of high fluid pressure at the base of the shallow mantle wedge—evidence from serpentinite of the Sanbagawa belt, SW Japan

*Simon Richard Wallis[1], Yui Kouketsu[2], Mari Yokota[1,2]

1. University of Tokyo, 2. Nagoya University

Serpentinite units derived from the mantle wedge in the Sanbagawa subduction-type metamorphic belt record interaction between the shallow mantle-wedge and the flow of SiO2-bearing fluids at two different depths in the paleo subduction zone. The mineralogy and geochemistry of two units indicate there was a major increase in the fluid flow perpendicular to the subduction boundary with decreasing pressure. The rate of flow can be related to the presence or absence of a thick shear zone. Estimates of fluid flux from subducted slabs combined with experimentally determined permeability of serpentinite suggests that the presence of a zone of gently dipping strongly foliated serpentinite is a key component of developing high fluid pressures at depths of 30–50 km in subduction zones—a key requirement for the development of slow earthquakes. Most of the SiO2 in these subduction fluids will be absorbed in the serpentinite and is unlikely to be available for precipitation and formation of an impermeable cap at higher levels in the system.

Keywords: Fluid pressure, Deep slow earthquakes, Serpentinite, Sanbagawa belt

©2019. Japan Geoscience Union. All Right Reserved.

Overpressured subduction plate boundary caused by infiltration of mantle-derived fluids: Evidence from helium isotope analysis on veins in subduction mélange

*Naoki Nishiyama[1], Kohtaro Ujiie[1], Hirochika Sumino[2]

1. University of Tsukuba, 2. The University of Tokyo

Fluid overpressures have been invoked as one of the key factors controlling slow earthquakes in subduction zones. The generation of fluid overpressures has been thought to occur by in-situ processes such as compaction disequilibrium and mineral dehydration in sediment and oceanic crust. To determine the origin of fluid responsible for overpressured subduction plate boundary, we examined noble gas and microthermometric analyses on quartz-calcite veins in the subduction mélange deformed at ~10–15 km depth.

The analyzed veins are sigmoidal extension vein arrays and shear veins. The former represents Riedel shear zones formed during subduction under vertical σ_1. The latter records the numerous low-angle brittle thrusting at very small shear strength with recurrence time comparable to that of slow earthquakes, which could account for the generation of tectonic tremors [1]. Homogenization and ice melting temperatures of fluid inclusions indicate that the both types of veins recorded the fluids with salinity of 3–7 wt% and near-lithostatic fluid pressures at 10–15 km depth. The measured $^{3}He/^{4}He$ range 1.6–2.5 Ra (Ra is the $^{3}He/^{4}He$ of air) regardless of types of veins, indicating the presence of mantle helium. The ratios of non-radiogenic heavy noble gas isotopes (^{36}Ar, ^{84}Kr, and ^{130}Xe) are similar to those of seawater and serpentinite in slab mantle [2]. Because porosity in sediments already decreased to <1 % at depths of 4–5 km [3], seawater captured in the pores would be completely expelled from the subducting sediments before reaching to 10–15 km depth, and thus the serpentinized slab mantle is the likely origin of the ^{36}Ar, ^{84}Kr, and ^{130}Xe. The measured $^{3}He/^{4}He$, non-radiogenic heavy noble gas ratios, and salinity are consistent with those of slab-derived fluids observed in mantle wedge peridotites from subduction zones [4, 5], suggesting that fluids released from subducted serpentinite to the mantle wedge migrate toward shallow depths along subduction boundary. From a mixing calculation using ^{36}Ar, ^{84}Kr, and ^{130}Xe data, more than 64% of vein-forming fluids were originated from the subducted serpentinite. Therefore, the migration of mantle-derived fluids has a potential to induce brittle failures in plate boundaries via increasing fluid pressures.

[1] Ujiie *et al.* (2018) *Geophys. Res. Lett.* **45**, 5371–5379. [2] Kendrick *et al.* (2013) *Earth Planet. Sci. Lett.* **365**, 86–96. [3] Kato *et al.* (2004) *Geophys. Res. Lett.* **31**, L06602. [4] Sumino *et al.* (2010) *Earth Planet. Sci. Lett.* **294**, 163–172. [5] Kobayashi *et al.* (2017) *Earth Planet. Sci. Lett.* **457**, 106–116.

Keywords: Fluid overpressure, Mantle-derived fluids, Helium isotopes, Crack-seal vein

©2019. Japan Geoscience Union. All Right Reserved.

Geological and rheological conditions of subduction plate boundary between the seismogenic zone and the ETS zone in warm-slab environments

*Kohtaro Ujiie[1], Kazuya Noro[1], Norio Shigematsu[2], Ake Fagereng[3], Naoki Nishiyama[1], Christopher Tulley[3], Haruna MASUYAMA[1], Yasushi Mori[4]

1. Graduate School of Life and Environmental Sciences, University of Tsukuba, 2. Research Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, Japan, 3. Cardiff University, 4. Kitakyushu Museum of Natural History and Human History

In subduction zones particularly under warm-slab environments, the transition zone between the locked seismogenic zone and the deeper, stably sliding zone is the site of slow earthquakes such as episodic tremor and slip (ETS) and long-term slow slip events (L-SSEs). Exhumed subduction mélanges on Kyushu Island, Japan, were deformed at depths of ~15–30 km and temperatures of ~370–500 ˚C under warm-slab environments and thus provide an invaluable opportunity to examine geological and rheological conditions that may responsible for slow earthquakes. The mélanges record low-angle thrust sense, viscous shear associated with metasomatic reactions. The metasomatism is caused by the infiltration of sodium-bearing fluid between pelitic schist and mafic to ultramafic rocks, resulting in albitization of pelitic schist. Microstructural observations and electron backscatter diffraction analysis show that viscous shear was accommodated by dislocation creep, mechanical rotation, and possible diffusion creep, resulting in dynamic recrystallization of quartz, strong shape and crystal preferred orientations of actinolite and chlorite, and random orientation of albite, respectively. Strain rate of viscous shear zones, estimated from the recrystallized grain size piezometer and flow law for quartz, increases with depth from ~$10^{-13}s^{-1}$to ~$10^{-10}s^{-1}$. The upper value of strain rate is consistent with the strain rate of L-SSEs in subduction zones, when the thickness of viscous shear zone is orders of 10–100 m, compatible with our field observation. Lattice-preferred orientation patterns of quartz c-axes also changes with depth from Type I crossed girdle to c-axis maximum subparallel to shear direction, showing a shear sense consistent with low-angle thrust faulting. Albitized pelitic schist formed by metasomatic reactions and associated viscous shear zones are absent in the mélange deformed at temperatures less than ~330 ˚C. In total, viscous shear associated with metasomatic reactions may account for strain rate, kinematics, and lower limit temperature of L-SSEs zone.

Keywords: subduction mélange, metasomatism, viscous shear

©2019. Japan Geoscience Union. All Right Reserved.

Temperature variation in tectonic mélanges of the Shimanto Belt, SW Japan

*Tsai-Wei Chen[1], Donald M Fisher[1], Andrew J Smye[1], Yoshitaka Hashimoto[2]

1. Penn State Univ., 2. Kochi Univ.

Silica redistribution along plate interfaces is a fault zone aging process likely to affect the slip behavior of subduction interfaces. Numerical modeling for slip according to the rate law based on silica kinetics reproduces the characteristics of real-world subduction zones, such as an updip limit to the seismogenic zone, earthquake clustering, and a power-law size distribution of earthquake magnitudes. In the field, the structure of subduction fault zones is typically marked by veined sandstone blocks within mudstones with scaly fabric, with mudstones providing a local source of silica and other elements that precipitate as minerals veins, which act as a sink for mobile elements. The silica kinetics related to diffusion from shearing mudstones to cracking sandstone blocks in mélange provides a temperature dependent mechanism for fault zone aging whereby the contact area across the fault zone increases in the time between slip instabilities. In the Shimanto belt of Japan, scaly fabric and vein microstructures show textural variability as a function of temperature. There is a gradient in the age of paleosubducting oceanic crust from north to south within the inner Shimanto belt, from the Yokonami mélange, with a thick pelagic chert section and older basalt and younger mélanges in the south (Okitsu, Hyuga, and Mugi) with little or no chert section, suggesting younger subducting crust. Thus, the mélanges of the Shimanto belt were accreted at different temperatures and depths along the interface, and there also may have been differences in the subduction geotherm. We suggest that these variations in temperature are likely to lead to different silica kinetics and rates of mineral redistribution, recorded in microstructural variations that may reflect different frictional properties along the plate interface. The slip behavior of the plate interface depends on temperature as evidenced by down dip variations in slip mode and differences in earthquake size distributions for subduction zones with different age crust. We therefore have undertaken a study of oxygen isotope thermometry using coexisting mineral pairs of quartz-albite-calcite observed in the tectonic mélanges from the Shimanto belt at a variety of estimated temperatures. This data provides an independent method for evaluating the temperature during mineral redistribution that can be compared with current estimates based on vitrinite reflectance and fluid inclusion analyses.

Keywords: Subduction zone processes, Shimanto Belt , Silica redistribution, Oxygen isotope thermometry

©2019. Japan Geoscience Union. All Right Reserved.

Frictional properties of opal gouge at low-temperature hydrothermal conditions and their implications for seismogenic faulting along subduction-zone megathrusts

*Kyuichi Kanagawa[1], Tomoya Nakanishi[2], Morito Kuwana[3], Michiyo Sawai[1], Takehiro Hirose[4]

1. School of Science, Chiba University, 2. Graduate School of Science and Engineering, Chiba University, 3. Faculty of Science, Chiba University, 4. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology

We conducted a series of triaxial friction experiments on opal gouge at low-temperature (≦200˚C) hydrothermal conditions, in order to address the change in frictional stability along subduction-zone megathrusts. The results revealed frictional properties of opal gouge dependent on temperature (T), displacement (V) or pore water presure (P_p), as described below.

When fitted by the rate- and state-friction constitutive law, friction parameter a does not change much with T, V or P_p, while friction parameter b increases, and resultantly ($a-b$) value decreases with increasing T, decreasing V or increasing P_p. Microstructural observations revealed that densification and coalescence of gouge particles occurred at higher T, suggesting the operation of pressure solution. Thus increasing activity of thermally activated pressure solution with increasing T, decreasing V or increasing P_p promotes gouge lithification to increase frictional strength, by which ($a-b$) value decreases to <0, and thereby the transition from aseismic faulting to seismic faulting along subduction-zone megathrusts. Our results also imply that increasing P_p at that transition region where ($a-b$) ≈0 would decrease ($a-b$) value to <0, and hence promote slow seismic faulting with small negative ($a-b$) values, which is consistent with high V_P/V_S ratios observed in the regions of slow earthquakes.

Keywords: frictional properties, opal gouge, low-temperature hydrothermal conditions

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Takahiro Hatano, Takehito Suzuki

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG48-28] **Rate and State Dependent Friction Law and Static Friction Force**

*Hiroshi Matsukawa [1] (1.Aoyama Gakuin University)

2:00 PM - 2:30 PM JST | 5:00 AM - 5:30 AM UTC

[SCG48-29] **Stable sliding, slow and silent slip events and laboratory earthquakes across the brittle ductile transition**

★Invited Papers

*Alexandre Schubnel[1], Aubry Jérôme[1], François Passelègue[2] (1.Laboratoire de Géologie, ENS, PARIS, France, 2.EPFL, Switzerland)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG48-30] Dramatic velocity weakening of dry quartz friction at relatively slow slip velocities

*Akito Tsutsumi[1], Hirotaka Iida[2], Yuko Onoe[1] (1.Graduate School of Science, Kyoto University, 2.Geothermal Engineering. Co. Ltd.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG48-31] Rupture nucleation processes accompanying tremor and slow slip in gel friction experiments

*Tetsuo Yamaguchi[1] (1.Graduate school of Engineering, Kyushu University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG48-32] Solution Orbit for k and epsilon Model for Turbulent Flow in Porous Media

*Takehito Suzuki[1] (1.Department of Physics and Mathematics, Aoyama Gakuin University)

Rate and State Dependent Friction Law and Static Friction Force

*Hiroshi Matsukawa [1]

1. Aoyama Gakuin University

It is well known that the Rate and State Dependent Friction Law (RSF) plays an important role in the study of earthquake including slow-earthquake [1, 2]. RSF was introduced by Dietrich [3] and Ruina [4] based on the laboratory experiments and describes the sliding velocity and state-variable dependences of the friction coefficient. The dependences are analyzed by the thermal activation process of the deformation and detachment of actual contact points [5-7]. The thermal activation of the deformation of actual contact points, which is called the indirect process, cause the increase of the actual contact area and then the friction force with increasing contact time of actual contact point, which is inversely proportional to the sliding velocity. The thermal activation of the detachment of actual contact points, which is called the direct process, cause the increase of the friction force with increasing sliding velocity. Such analysis discuss the change of friction coefficient depending on the sliding velocity and state-variable. Here we extend the analysis and discuss the absolute value of the friction coefficient. In the case that the direct process overwhelm the indirect process, the friction coefficient can vanish in the limit of vanishing sliding velocity, that means the vanishing static friction force. The vanishing static friction force results from the thermal activation of the detachment of the actual contact points. The velocity dependence of the friction coefficient in the low velocity regime is investigated. It is also shown that even in the case that the indirect process overwhelm the direct process in the usual velocity regime, the direct process overwhelm the indirect process in the law velocity limit. In this case the steady state friction coefficient once increase from zero in the low velocity regime, shows a peak and then decreases with increasing sliding velocity. The relations with the laboratory experiment [8] and slow earthquake are discussed.

References

1, Scholz, C., “*Earthquakes and friction laws*”, Nature **391**, 37 (1998).

2, Saito, T., Ujiie, K., Tsutsumi, A., & Kameda, J., “*Geological and frictional aspects of very-low-frequency earthquakes in an accretionary prism*”, Geophysical Research Letters **40**, 703 (2013).

3, Dieterich, J., “*Modeling of rock friction 1. Experimental results and constitutive equations*” and “*Modeling of rock friction 2. Simulation of preseismic slip”*, Journal of Geophysical Research **80,** 2161 and 2169 (1979).

4, Ruina, A. , “*Slip instability and state variable friction law*”, Journal of Geophysical Research: Solid Earth **88,** 10359 (1983).

5, Heslot, F., Baumberger, T., Perrin, B., Caroli, B., & Caroli, C. *“Creep, stick-slip, and dry-friction dynamics: Experiments and a heuristic model”*, Physical Review E **49**, 4973 (1994).

6, Hatano T., “*Rate and state friction law as derived from atomistic processes at Asperities*”, arXiv:1512.05078v1 (2015).

©2019. Japan Geoscience Union. All Right Reserved.

7. Aharonv, E., & Scholz, C.H., “*A physics based rock friction constitutive law: Steady state friction*”, Journal of Geophysical Research: Solid Earth **123**, 1591 (2018).

8. Yamaguchi, T., private communication.

Keywords: Rate and State Dependent Friction Law, Static Friction Force

©2019. Japan Geoscience Union. All Right Reserved.

Stable sliding, slow and silent slip events and laboratory earthquakes across the brittle ductile transition

*Alexandre Schubnel[1], Aubry Jérôme[1], François Passelègue[2]

1. Laboratoire de Géologie, ENS, PARIS, France, 2. EPFL, Switzerland

The transition from brittle to plastic deformation corresponds to the regime where brittle fracturing and plastic flow co-exist. This transition is of fundamental importance to understand how natural faults behave differently at the bottom of the seismogenic zone, at PT conditions where the deformation regime is not fully brittle anymore.

Here, we reproduced the complete spectrum of natural faulting at laboratory scale, from stable slip to slow earthquakes and up to fast instabilities, on samples of dolostones and carbonates. Transitions from creep to slow ruptures and from slow to fast ruptures, are obtained by increasing both pressure and temperature up to conditions encountered at 3 km depth (i.e. 100 MPa confining pressure and 100 ˚C), which corresponds to the onset of seismicity in nature. Increasing confining pressure and temperature augments the fault elastic stiffness, which decreases the nucleation length and enhances the slip velocities during the nucleation to values allowing flash weakening and decarbonation processes.

From our experimental results, we conclude that: (i) laboratory earthquakes may nucleate on inherited fault interfaces at brittle-ductile transition conditions; (ii) in this regime where plastic deformation of the bulk and dynamic fault slip may co-exist, laboratory earthquakes are promoted when the interface is smooth, or when the loading rate is slow; (iii) stable sliding tends to produce mirror-like surface, while stick-slips is associated with matte surfaces, on which the size of the asperities grows with increasing confining pressure, (iv) slower loading rates and higher confining pressures promote the occurrence of laboratory earthquakes associated with increasing plastic deformation, while increasing initial roughness promotes stable sliding and slow stick-slip.

Keywords: slow and silent earthquakes, stick slip, brittle ductile transition

©2019. Japan Geoscience Union. All Right Reserved.

Dramatic velocity weakening of dry quartz friction at relatively slow slip velocities

*Akito Tsutsumi[1], Hirotaka Iida[2], Yuko Onoe[1]

1. Graduate School of Science, Kyoto University, 2. Geothermal Engineering. Co. Ltd.

Understanding the frictional properties of subduction-zone fault materials is crucial to understanding subduction-zone seismogenesis. Previous experimental studies have demonstrated that fault weakening in siliceous rocks occurred at relatively low slip velocities ($V > 0.01$ mm/s) [Goldsby and Tullis, 2002; Di Toro et al., 2004; Hayashi and Tsutsumi, 2010], under which conditions transformation reactions are unable to proceed because of low temperatures. Formation of a silica gel layer has been suggested as a possible cause of the weakening behavior [Goldsby and Tullis, 2002]. However, there exists only limited information on the frictionally generated material and little is known about the weakening mechanism. To study the effect of moisture on the fault zone process in siliceous material, we have performed friction experiments on a synthetic quartz sample under two different humidity conditions: in room humidity (relative humidity RH = 20 to 75%) and in dry (RH < 3%) conditions. to

Three types of friction experiments were performed using a rotary-type testing machine on a pair of hollow-cylindrical specimens of quartz with outer and inner diameter of 25 and 5 mm, respectively, at a constant normal stress of 1.5 MPa. Constant velocity tests and velocity stepping tests were conducted under a range of slip velocities from 0.005 to 105 mm/s. In slide-hold-slide (SHS) tests, samples were first slid at $v = 105$ mm/s, by which sliding friction coefficient f decreases to attain a steady-state value of about $f = 0.2$. Then, rotation of the sample was stopped for periods of 1 to 10000s, after which rotation of the sample at the same rate was restarted.

In room humidity conditions, steady state friction shows velocity weakening at $v > 0.01$ mm/s, which is consistent to the previous studies. We find that steady-state friction values measured at the dry condition are almost constant at $f = 0.2$ for slip velocities v from 0.1 to 100 mm/s. SHS tests show that time-dependent frictional healing is observed for hold time duration $t > 10$s in room humidity condition. On the contrary, the time-dependent frictional healing is negligible when tested in the dry condition.

Our results imply that the moisture-absorption strengthening, which has been proposed to be an effective mechanism for time-dependent healing of high-velocity friction of gabbro (Mizoguchi et al. 2006) is an important underlying mechanism of the frictional weakening of quartz rocks observed in ambient humidity conditions.

Keywords: high-velicity friction, velocity weakening, gel lubrication

©2019. Japan Geoscience Union. All Right Reserved.

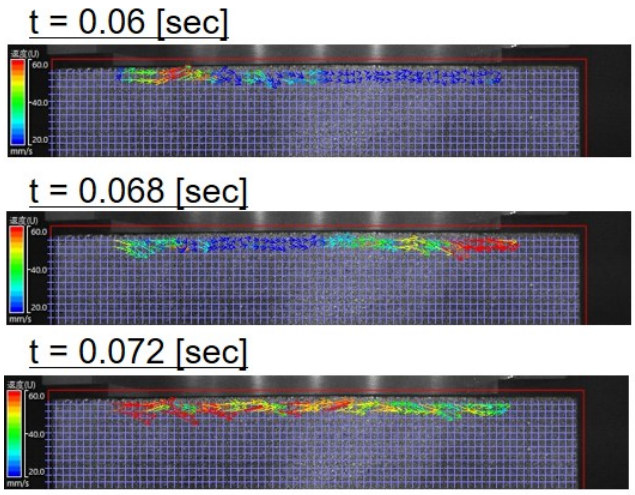
Rupture nucleation processes accompanying tremor and slow slip in gel friction experiments

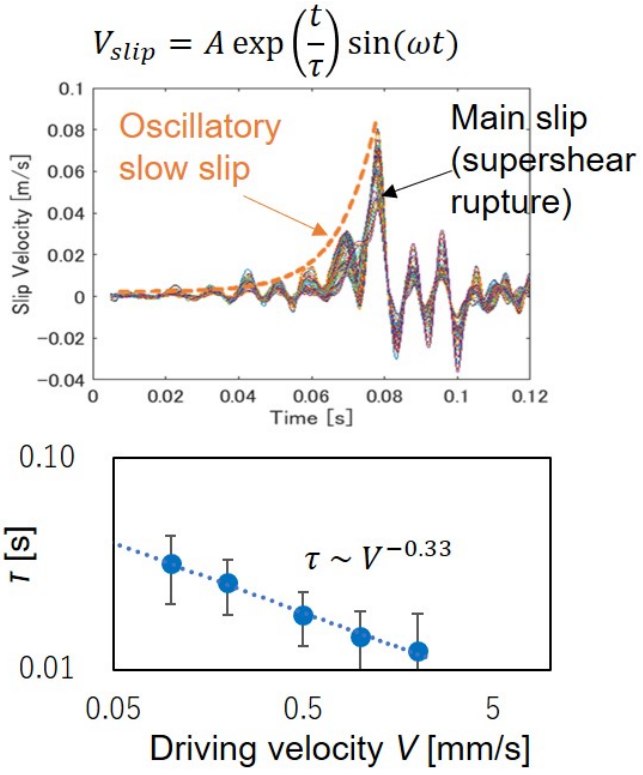
*Tetsuo Yamaguchi[1]

1. Graduate school of Engineering, Kyushu University

We have been elucidating similarities between our analogue experiments and earthquakes through some examples, such as coexistence of fast and slow slip, GR relation, size-duration scaling, and supershear rupture. In this study, we observed rupture nucleation processes for large events. As a result, we found the occurrence of tremor in coincident with slow slip. We also found that the duration of a slow event is proportional to the minus one-third power to the driving velocity. This power law behavior suggests that the slow slip process is determined independently of the characteristic velocity scale of the system. We will elucidate the relationship between frictional constitutive law and the macroscopic behavior. We will also discuss the realistic geological setup for our lab systems.

Keywords: Slow slip, Tremor, Analogue experiment, Gel





©2019. Japan Geoscience Union. All Right Reserved.

Solution Orbit for k and epsilon Model for Turbulent Flow in Porous Media

*Takehito Suzuki[1]

1. Department of Physics and Mathematics, Aoyama Gakuin University

Turbulent flow within porous media such as fault rocks can affect dynamic earthquake rupture processes and has attracted interests of many researchers. Among models treating the turbulent flow, the k-epsilon model has widely been employed, where k is the turbulent kinetic energy and epsilon is the dissipation rate of k. However, analytical treatment associated with the effect of the initial values of k and epsilon on the final state has not been performed.

We assume a one-dimensional homogeneous porous medium and isotropic turbulence. We also assume that the density of the fluid, rho, and the porosity, phi, are constant, and the ensemble averages of phi k and phi epsilon will be written as k and epsilon below, respectively. With these assumptions, it should be emphasized that exactly the same straight line given by the equation epsilon=c_k u_D k /\sqrt{*K*} is a nullcline common to both variables on the k-epsilon phase space, where c_k is a constant number, u_D is averaged Darcy velocity, and *K* is permeability. We can regard this line as a line attractor or repeller as observed in other systems such as Suzuki (2017). Moreover, the straight line epsilon=0 (k axis) is also a nullcline for epsilon.

Actually, the analytical form of solution orbits is given by epsilon=epsilon$_0$ (k/k_0)^C_2, where C_2 is a constant, 1.9. Using this, we show below that the common nullcline epsilon=c_k phi u_D k/\sqrt{*K*} is a line attractor for this solution orbit. First, we define Region I as the region 0< epsilon < c_k u_D k /\sqrt{*K*} on the phase space, and Region II as the region epsilon > c_k u_D k/\sqrt{K}>0. We also define the point (k_f, epsilon$_f$) as the point where the solution orbit passing the point (k_0, epsilon$_0$) crosses the nullcline. With these definitions, we have relations k_0f and epsilon$_0$f if (k_0, epsilon$_0$) is in the Region I. This occurs because epsilon is proportional to k on the nullcline, while epsilon is proportional to k^C_2 on the solution orbit and C_2 >1. We can also conclude k_0>k_f and epsilon$_0$>epsilon$_f$ if (k_0, epsilon$_0$) is in the Region II. Second, we should emphasize that k and epsilon increase (decrease) with increasing time in the Region I (II), since \partial k/\partial t and \partial epsilon/\partial t are positive (negative). Therefore, if (k_0, epsilon$_0$) is in the Region I (II), the solution moves to the upper right (lower left), and is absorbed into the nullcline with the limit t \to \infty. We can conclude that the nullcline is a line attractor, not a repeller. The steady stable solution is given by (k, epsilon)=(k_f, epsilon$_f$).

Note that k and epsilon vanish with the limit t \to \infty for usual isotropic turbulent flow, even though the solution orbit for such flow is the same as one obtained here. Actually, the usual turbulent flow is described by the limit *K* \to \infty in the present model. The nullcline is k axis in such a case, and the Region I vanishes. Therefore, all the solutions are absorbed into the origin. The finite *K* enables the turbulence to be survive with t \to \infty for the homogeneous state.

Keywords: porous media, k-epsilon model, solution orbit

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-CG48] Science of slow earthquakes: Toward unified understandings of whole earthquake process

convener:Satoshi Ide(Department of Earth an Planetary Science, University of Tokyo), Hitoshi Hirose(Research Center for Urban Safety and Security, Kobe University), Kohtaro Ujiie(Graduate School of Life and Environmental Sciences, University of Tsukuba), Takahiro Hatano(Earthquake Research Institute, University of Tokyo), Chairperson:Naofumi Aso, Takahiro Hatano

Accumulating observational studies on various types of slow deformation events, such as tectonic tremors, very low frequency events, and slow slip events, portrays some universal characteristics in generally complex behavior, including interaction among events and influence by various outer loadings. Some of these phenomena seem to have causal relation with the occurrence of very large earthquakes. A unified understanding of these slow and fast earthquake processes requires an approach integrating geophysics, seismology, geodesy, geology, and non-equilibrium statistical physics. We welcome presentations based on, but not limited to, geophysical observation, data analysis, analytical theory, numerical simulation, field study, and laboratory experiments.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SCG48-33] **Modelling precursory seismicity in the laboratory using a roughness derived rate and state friction model**

★Invited Papers

*Paul A Selvadurai[1], Percy Galvez[2], Stefan Wiemer[1], P. Martin Mai[2] (1.Swiss Seismological service, ETH Zurich, Switzerland, 2.King Abdullah University of Science and Technology, Thuwal, Saudi Arabia)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG48-34] Exponential dependence on perturbation stress of earthquake nucleation

*Saito Takuya[1], Takahiro Hatano[1] (1.The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG48-35] Stochastic modeling of slow earthquakes comparable to observations

*Naofumi Aso[1], Ryosuke Ando[2], Satoshi Ide[2] (1.Tokyo Institute of Technology, 2.University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG48-36] Migration of aqueous fluid near the subducting plate interface

*Manabu Morishige[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG48-37] EnKF estimation of frictional properties and slip evolution on a LSSE fault and the changing slip deficit rate on a megathrust fault

*Kazuro Hirahara[1,2] (1.Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University , 2.Riken, AIP center)

Modelling precursory seismicity in the laboratory using a roughness derived rate and state friction model

*Paul A Selvadurai[1], Percy Galvez[2], Stefan Wiemer[1], P. Martin Mai[2]

1. Swiss Seismological service, ETH Zurich, Switzerland, 2. King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

Growing amounts of seismologic observations appear to be capturing a larger diversity in slip behavior along natural faults. One such behavior is the appearance of localized high-frequency events occurring within a larger preparatory region of accelerated preslip. A mechanism explaining this phenomenon is that fault zones have contrasting strength, which may affect the spatial variability of seismic coupling. Recent numerical studies of faults governed by rate-and-state (RS) friction, show that systematic variations in the strength heterogeneity could explain diverse slip behaviors, such as, stable sliding without spontaneous slip transients, or unstable with spontaneous rupture [Liu and Ampuero, 2017].

Here we detail results from a direct shear friction experiment where a well-instrumented fault was formed by pressing together mature (worn) surfaces of poly(methyl methacrylate), then subjecting it to shear, until gross ‘stick-slip’ failure occurred. Prior to failure, spontaneous ruptures were found to nucleate within a region of accelerated slip, but *arrested locally within a seismogenic section* of the interface. Seismic waves produced by these high-frequency events were measured by an array of calibrated piezoelectric transducers. The seismogenic section was found to form where a slow slip front propagated into a relatively locked region [Selvadurai and Glaser, 2015].

To model the behavior of this lab-scale seismogenic region, we use multi-cycle simulations and linear stability analysis in the open source software QDYN, which utilizes boundary element method and adaptive time-stepping [Luo et al., 2017]. We studied the postmortem surfaces and found that the worn fault displayed a clear bimodal Gaussian distribution of surface height. This unique distribution of surface roughness was determined to be a proxy for a heterogeneous description of the critical slip distance D_c used in numerical calculation that modelled the seismogenic region as a VW section with constant normal stress that obeyed the slip law in terms of RS friction.

Our model showed that it was capable of producing the same diversity in slip behaviors from stable sliding to unstable with localized spontaneous ruptures and this was dependent on parameter selection. Preferentially smooth (polished) sections of fault exhibited low D_c and were susceptible to rupture nucleation. However, the extent to which they propagated along the fault depended on the level strength heterogeneity. Wearing of the fault also led to a natural periodicity in the spatial distribution of strength, which produced numerical estimates of source characteristics that matched those made from an independent analysis of seismic waves. Matching numerical and experimental estimates of source characteristics (seismic moment, source length scale and stress drop) was used a calibration tool to accurately tune the model behavior and better understand conditions leading to the production of seismicity attributed to the interaction of a slow slip front into a relatively locked section of fault.

References:

Luo, Y., Ampuero, J.-P. (2017), Stability of faults with heterogeneous friction properties and effective normal stress, *Tectonophysics*, doi:10.1016/j.tecto.2017.11.006

©2019. Japan Geoscience Union. All Right Reserved.

Luo, Y., Ampuero, J.P., Galvez, P., Ende, M., Idini, B., (2017). *QDYN: a Quasi-DYNamic Earthquake simulator (V1.1).* http://dx.doi.org/10.5281/zenodo.322459.

Selvadurai, P. A., and S. D. Glaser (2015), Laboratory-developed contact models controlling instability on frictional faults, *J. Geophys. Res. Solid Earth*, 120, doi:10.1002/2014JB011690.

Keywords: Foreshocks, Linear stability analysis, Strength heterogeneity, Laboratory studies

©2019. Japan Geoscience Union. All Right Reserved.

Exponential dependence on perturbation stress of earthquake nucleation

*Saito Takuya[1], Takahiro Hatano[1]

1. The University of Tokyo

Recent observations have reported that some tremors in slow earthquake are sensitive to stress perturbations caused by ocean tides [1]. According to the preceding studies [1], occurrence frequencies of the susceptible tremors display exponential dependence on the stress magnitude. This study numerically investigates effects on earthquake nucleation growths of the periodic stress perturbations to see if the nucleation developed under the rate-and-state friction law reproduces the stress dependence. The numerical results suggest the exponential dependence on the perturbation stress magnitudes even in the presence of superimposed sinusoidal waves with the different periods. In addition, the exponential rates are found not to be sensitive to a change in the perturbation period or the superposition components of the sinusoidal perturbations, which implies the critical stresses magnitude are independent of a variety of the perturbations.

[1] S. Ide and Y. Tanaka, Geophys. Res. Lett. 41, 3842 (2014); S. Ide, S. Yabe, H.-J. Tai, and K. H. Chen, Geophys. Res. Lett., 42, 3248 (2015).

©2019. Japan Geoscience Union. All Right Reserved.

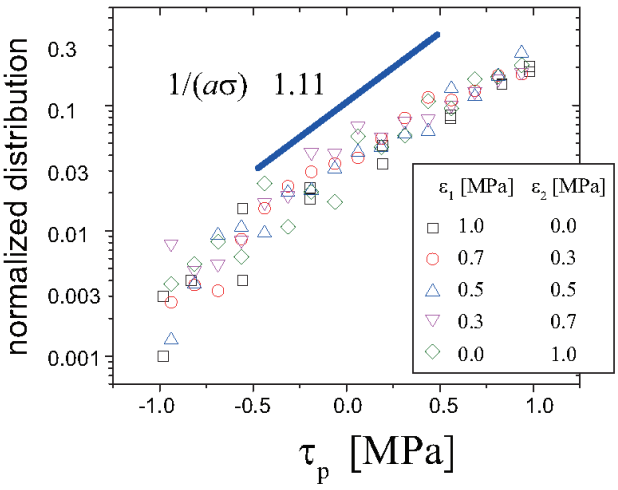


FIG. 1: Numerical results of stress dependence of the nucleation growth under the perturbation $\tau_p = \epsilon_1 \sin(\omega_1 t) + \epsilon_2 \sin(\omega_2 t + \phi_{2,ini})$. Horizontal or vertical axes represents stress magnitude or the normalized distribution, respectively. For each parameter condition, we measured the stresses of 1000 nucleation samples, which grow from randomly generated initial conditions, when the nucleation slip reaches the threshold velocity $V_{thr} = 1.0$ mm/s.

©2019. Japan Geoscience Union. All Right Reserved.

Stochastic modeling of slow earthquakes comparable to observations

*Naofumi Aso[1], Ryosuke Ando[2], Satoshi Ide[2]

1. Tokyo Institute of Technology, 2. University of Tokyo

Slow earthquakes are often modeled using rate-and-state friction law with heterogeneously distributed parameters. However, we never know the exact friction law nor the perfect distribution of frictional parameters. Also, other physics are also proposed to contribute to the slow process, including pore fluid. Since any deterministic approaches cannot adequately capture the temporal stress change at a specific site because of the inherent unpredictability caused by various nonlinear processes, we instead focus on the stochastic approach to model slow earthquakes.
In stochastic modeling, we artificially add stochastic fluctuations in numerical simulations. When the result agrees with observations, the stochastic fluctuations are found to represent underlying physics. Then, we can make some predictions that could be evaluated by further observations. After capturing many characteristics of the stochasticity, we could finally approach physics. Although the deductive approach based on specific physics is often taken in earthquake source physics, the experimental approach has the potential to fill the gap between modeling and observations.
Here, we demonstrate that the consideration of stochastic stress fluctuations in ordinary crack simulations can reproduce a variety of observations of slow earthquakes, including burst-like tremor initiation, the existence of tremor front, decelerating tremor migration, and precursory slow earthquakes. The identical model can also reproduce both crack-like and pulse-like ordinary earthquakes by simply changing the strength drop and initial stress level.

©2019. Japan Geoscience Union. All Right Reserved.

Migration of aqueous fluid near the subducting plate interface

*Manabu Morishige[1]

1. Japan Agency for Marine-Earth Science and Technology

At least in several subduction zones including Tohoku, Japan, and Cascadia, low surface heat flow has been observed in the forearc, which suggests the existence of a cold fore-arc mantle. This low heat flow has been explained by a thin, low-viscosity layer (LVL) on top of the subducting slab that decouples the movement between the slab and the overriding mantle wedge. Although the formation mechanism of the LVL remains unclear, hydrous minerals such as serpentine may play an essential role in it. The effects of the LVL on solid (or rock) velocity have been extensively investigated. However, little is known of aqueous fluid migration in and around the LVL, despite its importance to our understanding of seismic activity along the subducting plate interface which includes slow earthquakes. In this presentation, I propose a mechanism of fluid flow through the LVL based on a numerical modeling of two-phase flow.

It has been shown that the equations for the solid and fluid phases can be decoupled if porosity is small. I therefore take the following two-step approach based on this assumption. I first solve for solid velocity and the dynamic pressure gradient in and around the LVL. These results are then used to solve for the porosity and compaction pressure in this region.

Preliminary results show that a large amount of fluid is trapped within the LVL by the effects of compaction, that is, the fluid cannot easily flow into the overriding mantle wedge with high viscosity. Dynamic pressure gradient within the LVL becomes large when a thin LVL or high solid viscosity within the LVL is assumed, which leads to a faster fluid flow in the updip direction. These findings suggest that the effects of compaction and dynamic pressure gradient are critical to understand the fluid flow near the subducting plate interface. I also find that the fluid tends to stay near the basal region of the LVL when a non-linear solid viscosity is applied.

Keywords: slow earthquakes, aqueous fluid, subduction zones, low-viscosity layer

©2019. Japan Geoscience Union. All Right Reserved.

EnKF estimation of frictional properties and slip evolution on a LSSE fault and the changing slip deficit rate on a megathrust fault

*Kazuro Hirahara[1,2]

1. Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University , 2. Riken, AIP center

With EnKF(Ensemble Kalman Filter), we are developing a system of real-time estimation of frictional properties and slip evolution on LSSE(long-term slow slip event) faults together with the slip deficit rate of the megathrust existing at the up-dip portion of the LSSE faults from the observed GNSS data, through numerical experiments. In the present system, the state vector to be forecasted and updated includes slip rates, state variables and frictional parameters on a LSSE fault, and the slip deficit rate in the megathrust fault. The first 3 parameters are constrained by a RSF(rate and state friction) law and data, but the last one is only by data in a kinematic way. Nishikiori and Hirahara (2017) have shown that the system with EnKF has successfully estimated the slip deficit rate together with frictional properties and slip evolution on the assumed Bungo-Channel LSSE fault for the station distribution corresponding to the GEONET one. So far, we have mainly examined the case of the constant slip deficit rate of the locked megathrust fault, assuming a short and stationary period in the Nankai earthquake cycle.
Several simulation studies have suggested the activity of LSSE is changing during the megaquake cycle, and the real-time monitoring of LSSE activity is important for understanding the stress state of the megaquake fault. Hirahara and Nishikiori (2018) have preliminarily examined the effect of changing deficit rate of the locked region. This study is an extension of theirs. A time series of slip deficit rate derived from a simple simulation of the Nankai earthquake cycle with a RSF law produces shorter reoccurrence time and larger slip rate of the Bungo-Channel LSSE fault toward the occurrence of Nankai megaquake. Based on this simulation model, we produce the simulated deformation rate data at GEONET stations. Then we try to estimate the changing slip deficit rate of the Nankai earthquake fault together with frictional parameters and slip evolution on the LSSE fault. Here, we define v_lock=V_lock -Vpl, and assign Vpl=6.5cm/yr. We can correctly trace the v_lock around -6cm/y during almost locked period. However, when v_lock is larger than -4 cm/yr, our system can not trace v_lock and underestimate the value. Then other parameters become to be also estimated as values deviated from the true ones. Therefore, we try to apply covariance inflation to enlarge the error covariance of the forecast state vector. There are two types of covariance inflation to enlarge the error covariance of the forecast vector. One is multiplicative inflation, where the forecast vector is artificially enlarged. Another is additive inflation, where we add random perturbation to the analysis vector in the previous time step, and obtain the forecast one in the next time step. In the latter one, the perturbation is not added directly to the forecast vector but to the analyzed one in the previous time step, so that the dynamical balances are kept when the next forecast is obtained. We use the approach of additive inflation of covariance. Then, we can correctly estimate the value of v_lock as well as other parameters up to a high value of v_lock around 25 cm/yr. We discuss such problems of abrupt breaks when we encounter in applying our system in numerical experiments.

Keywords: Ensemble Kalman Filter, Slow Slip Events, Rate and State Friction, Megaquake, Covariance Inflation

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-CG50] Intraslab and intraplate earthquakes

convener:Saeko Kita(International Institute of Seismology and Earthquake Engineering, BRI), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(Bavarian Geoinstitute, University of Bayreuth), Ryo Okuwaki(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Saeko Kita(Building Research Insitute), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(University of Bayreuth), Ryo Okuwaki(筑波大学), Thomas Ferrand(UC San Diego)

The purpose of this session is to share recent advances of geo-scientifical studies for intraslab and shallow-depth intraplate earthquakes. We seek to formulate future directions of the interdisciplinary study of the occurrence of intermediate-depth and deep earthquakes from the viewpoint of seismology, geodynamics and mineral physics. We welcome presentations from a wide variety of scientific disciplines, including seismology, seismotectonics, geodynamics, mineral and rock physics, other geophysics, geology, and numerical modeling.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG50-01] On a reversely-dipping low-velocity layer in the Tohoku-slab beneath the forearc: unbending induced fluid pathway?

★Invited Papers
Cancelled

*Hitoshi Kawakatsu[1], HyeJeong Kim[1] (1.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG50-02] Evidence for transient fluid pathways in the mantle of the subducting Nazca slab from seismological observations and modeling of the Poisson's ratio

★Invited Papers

*Wasja Bloch[1,2], Timm John[2], Jörn Kummerow[2], Bernd Schurr[1], Pablo Salazar[3,4], Serge A. Shapiro[2] (1.GeoForschungszentrum GFZ, Potsdam, Germany, 2.Freie Universität Berlin, Germany, 3.Universidád Católica del Norte, Antofagasta, Chile, 4.National Research Center for Integrated Natural Disasters Management (CIGIDEN), Santiago, Chile)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG50-03] Numerical simulation of water transportation along subducting slabs and implications for intraslab earthquakes

★Invited Papers

*Atsushi Nakao[1], Hikaru Iwamori[1,2,3], Tomoeki Nakakuki[4], Yujiro Suzuki[1], Takashi Nakagawa[5], Hitomi Nakamura[2,3,6,7] (1.Earthquake Research Institute, University of Tokyo, 2.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.Department of Earth and Planetary Systems Science, Hiroshima University, 5.Department of Earth Sciences, The University of Hong Kong, 6.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 7.Ocean Resource Research Center for Next Generation, Chiba Institute of Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG50-04] Subduction of serpentinized fracture zone and intraslab earthquakes in southern Mexico

★Invited Papers

*Marina Manea[1,2] (1.Computational Geodynamics Laboratory, Geosciences Center, National Autonomous University of Mexico, 2.Institute of Astronomy, Romanian Academy)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG50-05] Reaction-induced embrittlement of the lower continental crust

*Alexandre Schubnel[1], Sarah Incel[2], Julien Gasc[1], Nadège Hilairet[5], Yanbin Wang[3], Feng Shi[3], Loic Labrousse[4] (1.Laboratoire de Géologie, ENS, 2.University of Oslo, 3.GCECARS, University of Chicago, 4.ISTEP, Sorbonne Université, 5.UMET, Université de Lille)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG50-06] **Transformation-induced, melt-enhanced faulting in orthoenstatite: implications for global intermediate-depth earthquakes**

Feng Shi[1], Jianguo Wen[2], Tony Yu[1], Lupei Zhu[3], *Yanbin Wang[1] (1.Center for Advanced Radiation Sources, University of Chicago, Chicago, IL, USA, 2.Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, USA, 3.Department of Earth & Atmospheric Sciences, Saint Louis University, St. Louis, MO, USA)

On a reversely-dipping low-velocity layer in the Tohoku-slab beneath the forearc: unbending induced fluid pathway?

*Hitoshi Kawakatsu[1], HyeJeong Kim[1]

1. Earthquake Research Institute, University of Tokyo

Kawakatsu & Kim (2018, SSJ) have recently updated the receiver function reflectivity images beneath the Japanese islands reported earlier in a series of papers by Kawakatsu and others(e.g., Kawakatsu & Watada, 2007, Science). We collected data from recent 14 years (April 2004 to April 2018) of Hi-net recordings; the resulting new dataset is 2.4, 6.4 and 4.8 times larger in terms of the time period, the number of earthquakes, and the number of RF waveforms compared to the earlier works. New images obtained are generally consistent with the previous ones; as the data quantity increases, the covered area widens and images tend to be clearer and smoother. One exception is that there is a glimpse of reversely-dipping low-velocity layer (LVL) within the slab beneath the forearc region dipping toward the Japan trench. When compared with the recent tomographic model that incorporates data from a seafloor cable seismic network S-net, the LVL appears to correspond to a strong P-wave LVL dipping also toward the trench that is imaged from the slab surface at around a depth of 40km to at least 60km. As this LVL is observed along the entire Tohoku Japan arc, it might be a representation of some mechanical process associated with subduction, unless some systematic bias is introduced in tomography (e.g., mis-location of off-shore earthquake depths). We speculate that this structure may continue to the bottom of the slab as imaged by the tomography though not resolved, and be related with the slab unbending that straightens the slab in the mantle (e.g., Kawakatsu, 1986, JGR). Tensile stress caused by unbending near the slab bottom may open a pathway for the sub-slab fluid to migrate upwards all the way to the slab top to further supply fluids around the slab surface, as well as to hydrate the lower-layer of the double seismic zone as suggested by Seno & Yamanaka (1996, AGU Monograph). Geophysical and geochemical consequences of this hypothesis that might be testable via various ways may be discussed.

Keywords: unbending, slab, fluid

©2019. Japan Geoscience Union. All Right Reserved.

Evidence for transient fluid pathways in the mantle of the subducting Nazca slab from seismological observations and modeling of the Poisson's ratio

*Wasja Bloch[1,2], Timm John[2], Jörn Kummerow[2], Bernd Schurr[1], Pablo Salazar[3,4], Serge A. Shapiro[2]

1. GeoForschungszentrum GFZ, Potsdam, Germany, 2. Freie Universität Berlin, Germany, 3. Universidád Católica del Norte, Antofagasta, Chile, 4. National Research Center for Integrated Natural Disasters Management (CIGIDEN), Santiago, Chile

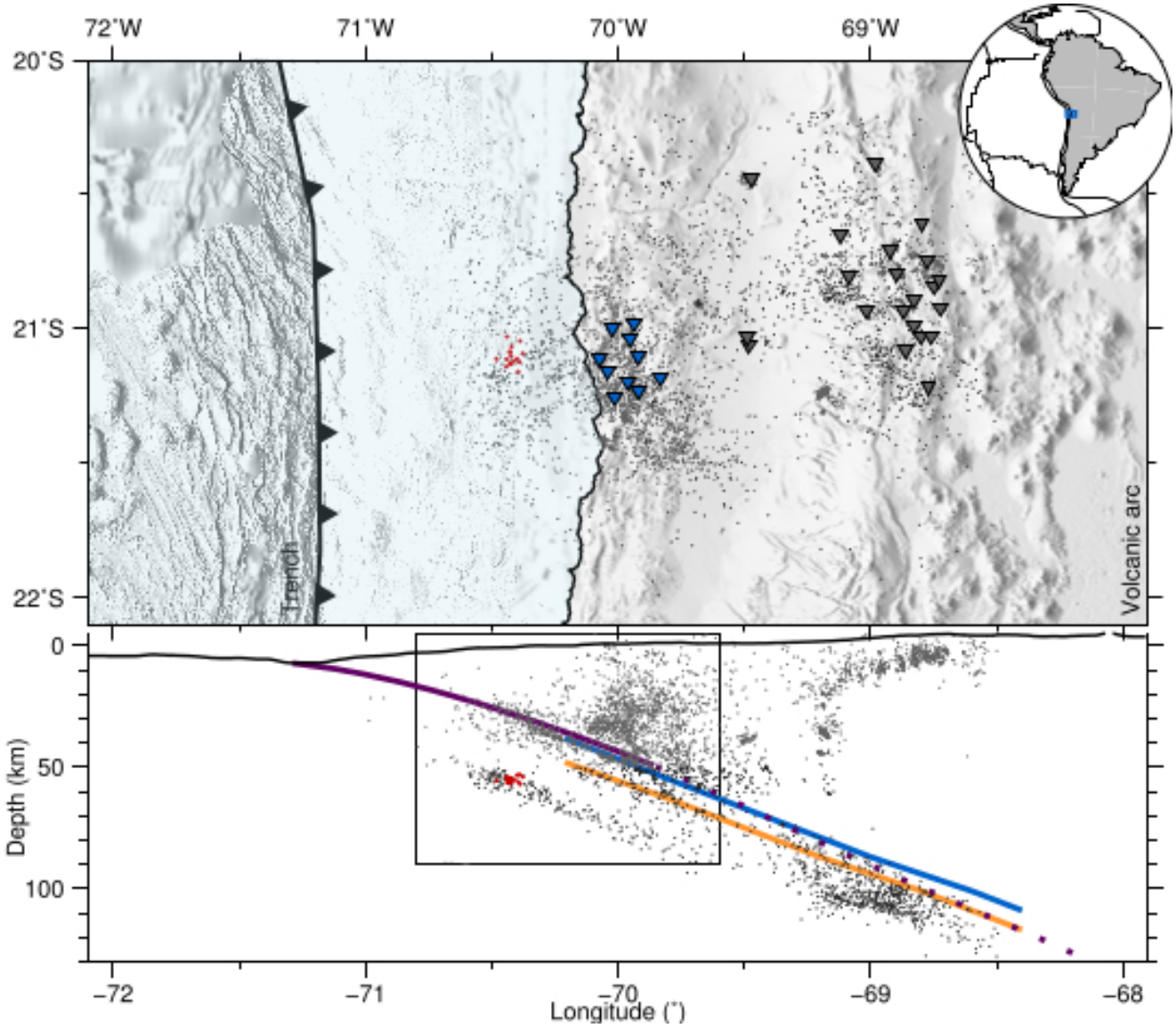
Subduction zones worldwide show the common pattern of a lower seismicity plane, where earthquakes occur at intermediate depth within the mantle of the subducting slab. In order to explain the occurrence of these earthquakes different earthquake nucleation mechanisms have been proposed. Some of them attribute seismicity to different transient phenomena that accompany the metamorphic breakdown of water bearing mineral phases. Event though such mechanisms can well explain the distinct shape of the lower seismicity plane and can well be reproduced in laboratory experiments, they are based on the assumption that the subducting plate is hydrated tens of kilometers below the oceanic Moho. Direct evidence for this assumption is scarce.

To detect the possible presence of fluids in the slab mantle, as predicted by the dehydration hypotheses, we estimated the Poisson's ratio of a small rock volume that hosts intra-slab earthquakes by employing a non-tomographic seismic method that has its greatest sensitivity in the direct vicinity of the earthquakes and delivers unique results. We interpret our results by means of a state-of-the-art coupled thermodynamic-poroelastic model. We additionally determine focal mechanisms in the lower seismicity plane to gain information about the prevailing stresses.

The joint interpretation yields a picture in which seismicity occurs at a low rate at 50km depth in a dehydrating but not over-pressured environment at low, overall tensile differential stresses. The modeling results indicate that the fluid occupies a minor volume fraction in the order of only 0.1% and constitutes an interconnected, vein-shaped and therefore transient pore network. These findings are in agreement with results from laboratory experiments, numerical simulations and outcrop studies. They imply that the oceanic mantle of the subducting Nazca slab must be at least weakly hydrated to a depth of 20-30km below the seafloor. Our interpretation can also be applied to tomographic images of other lower seismicity planes, e.g. in Japan.

Keywords: Mantle dehydration, Fluid processes, Seismology

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Numerical simulation of water transportation along subducting slabs and implications for intraslab earthquakes

*Atsushi Nakao[1], Hikaru Iwamori[1,2,3], Tomoeki Nakakuki[4], Yujiro Suzuki[1], Takashi Nakagawa[5], Hitomi Nakamura[2,3,6,7]

1. Earthquake Research Institute, University of Tokyo, 2. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 3. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4. Department of Earth and Planetary Systems Science, Hiroshima University, 5. Department of Earth Sciences, The University of Hong Kong, 6. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 7. Ocean Resource Research Center for Next Generation, Chiba Institute of Technology

It has been argued that water is abundant enough across subducting slabs to trigger lower seismic planes (i.e., >40-km-thick hydrous mantle; Peacock, 2001). Geodynamic modeling, however, suggests that the Pacific slab has a low water content beneath Northreast Japan (NEJ) (Nakao et al., 2018), despite presence of the clear lower seismic plane. The model shows that the thickly serpentinized slab mantle (>10 km for 100-Ma slab) causes slow plate convergence, stationary trenches, and slab penetration into the 660-km boundary, in contrast to the case of NEJ (Lallemand et al., 2008; Fukao & Obayashi, 2013). Moreover, seismic velocity and anisotropy structures also indicate a small amount of water around the lower plane in the Pacific slab (Zhang et al., 2004; Reynard et al., 2010). To address this discrepancy, we performed numerical simulations of water transport within and along the subducting slab of a variable age and initial water content. It is demonstrated that the loci of fluid liberation from the subducted slab of an old age (130 Ma) broadly correspond to the upper seismic plane beneath NEJ. On the other hand, loci of any dehydration reaction within the old slab may not explain the lower seismic plane. Instead, the loci of chlorite breakdown for a 36-Ma slab correspond to the lower plane beneath NEJ. In this case, the breakdown and formation of chlorite repeatedly occur, and liberated fluid forms a long curved-linear locus similar to the shape and extent of lower seismic plane in the Pacific slab beneath NEJ. We suggest that the repeated chlorite breakdown which effectively reutilizes a small amount of water contained initially in the slab may trigger the long lower seismic plane beneath NEJ.

Keywords: Wadati-Benioff zone, intermediate-depth earthquake, plate tectonics, phase relation, thermal structure

©2019. Japan Geoscience Union. All Right Reserved.

Subduction of serpentinized fracture zone and intraslab earthquakes in southern Mexico

*Marina Manea[1,2]

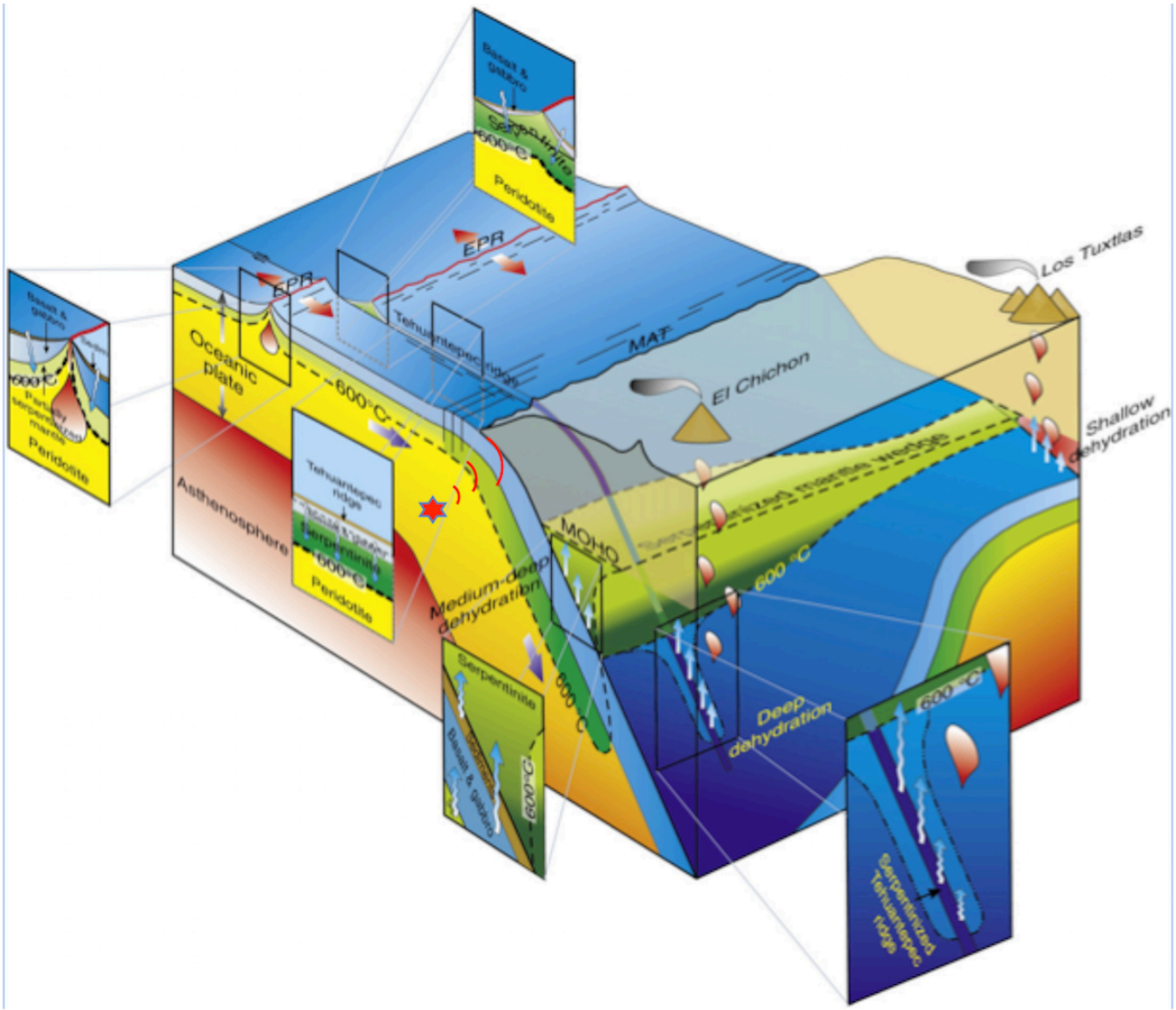
1. Computational Geodynamics Laboratory, Geosciences Center, National Autonomous University of Mexico, 2. Institute of Astronomy, Romanian Academy

Oceanic fracture zones are born where spreading centers are offset, creating strong gradients in oceanic floor age and vertical offsets in the oceanic lithosphere. Several lines of evidence, such as tectonic uplift and localized volcanic activity distributed along fracture zones, suggest that oceanic fracture zones represent zones of weakness where seawater can infiltrate several kilometers down into the lithosphere and transform mantle peridotites into serpentinites. Such major serpentinized fracture zones are often consumed into subduction zones where they release large quantities of fluids. The southern Mexican subduction zone is similarly characterized by the presence of a large fracture zone, the Tehuantepec fracture zone (TFZ), which presumably is serpentinized. Moreover, the region where TFZ enters into subduction is marked by a relatively low intraplate seismic activity and a large seismic gap where no large megathrust occurred in the last 100 years or more.

In general the physical processes associated with such seismic gaps are not well understood. However, the presence of TFZ in this area can provide a unique opportunity to advance our knowledge into earthquake mechanics linked to mantle thermal structure. The peculiar 2017 M8.2 Tehuantepec intraslab earthquake nucleated in the vicinity of TFZ, and, from analyses of regional geophysical observations, it is demonstrated that this large normal faulting event ruptured the entire ~26 Ma Cocos slab right beneath the megathrust region. The faulting most likely reactivated a bend fault fabric and ruptured to a depth well below the predicted brittle-ductile transition for the Cocos slab, including regions where temperature is expected to exceed 1000˚C, at far greater P-T conditions than previously considered. Additionally, since the rupture area also propagated laterally along the trench and stopped abruptly when encountered the subducted TFZ, we propose that large and serpentinized fracture zones can act as barriers for intraslab earthquakes. I have to acknowledge that all numerical computations were performed at the National Laboratory for Advanced Scientific Visualization at UNAM (LAVIS).

Keywords: intraslab earthquakes, fracture zone, serpentinization , southern Mexico

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Reaction-induced embrittlement of the lower continental crust

*Alexandre Schubnel[1], Sarah Incel[2], Julien Gasc[1], Nadège Hilairet[5], Yanbin Wang[3], Feng Shi[3], Loic Labrousse[4]

1. Laboratoire de Géologie, ENS, 2. University of Oslo, 3. GCECARS, University of Chicago, 4. ISTEP, Sorbonne Université, 5. UMET, Université de Lille

Field observations and geophysical data reveal a causal link between brittle seismic failure and eclogitization of the lower continental crust. We present results from experimental deformation of plagioclase-rich samples at eclogite-facies conditions and quantify the link between rock rheology and the kinetics of the eclogitization reactions. The deformation was ductile both in the absence of reaction and when the progress of eclogitization was fast compared to the imposed strain rate. However, when the reaction rate was relatively slow, the breakdown of plagioclase into nanocrystalline reaction products induced a weakening that triggered seismic failure. Fluid-induced plagioclase breakdown under eclogite-facies conditions is an exothermic reaction accompanied by a negative change in solid volume. This is similar to other mineral transformations that are known to trigger transformational faulting. We demonstrate that mineral reactions lead to brittle deformation in situations where reaction rates are slow compared to the deformation rate. This reaction-induced instability may provide a generic mechanism for embrittlement at depths beyond the normal seismogenic zone.

Keywords: lower crust, Eclogitisation, Granulite

©2019. Japan Geoscience Union. All Right Reserved.

Transformation-induced, melt-enhanced faulting in orthoenstatite: implications for global intermediate-depth earthquakes

Feng Shi[1], Jianguo Wen[2], Tony Yu[1], Lupei Zhu[3], *Yanbin Wang[1]

1. Center for Advanced Radiation Sources, University of Chicago, Chicago, IL, USA, 2. Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL, USA, 3. Department of Earth & Atmospheric Sciences, Saint Louis University, St. Louis, MO, USA

Intermediate-depth earthquakes, which occur at ~50-300 km depths and account for ~90% of all deep earthquakes between 50 and 700 km, are ubiquitously observed along convergent plate margins and post great hazards in many regions of the world. Earthquake-depth distribution in oceanic subduction zones exhibits a prevalent secondary seismicity peak between 180 and 240 km, where major dehydration reactions are expected to have completed [1, 2]. This secondary seismcity peak is a direct manifestation of earthquake activities in the lower plane of the double seimic zone [3]. One of the main constituents of oceanic slabs is harzburgite, which consists mainly of olivine and orthoenstatite (OEn) [4]. The latter transforms to high-pressure clinoenstatite (HP-CEn) at ~120 –210 km depths, depending on aluminum content and slab temperature [5, 6]. We conducted deformation experiments on OEn at conditions corresponding to ~ 40 –250 km depths. Within its stability field, OEn deforms plastically; no brittle failure is detected with acoustic emission (AE) monitoring. In the HP-CEn stability field, metastable OEn generates numerous AEs generated, and fails by macroscopic faulting between ~773 and 1373 K. Outside this temperature range, metastable OEn flows plastically again with no AEs detected. Recovered failed samples contain large conjugated faults, with ultrafine-grained gouge layers containing melts that are more Al-rich. OEn grain boundaries are decorated with fine grained (grainsize < 1 micron) garnet and clinoenstatite (CEn). The latter is interpreted as back-transformed HP-CEn upon pressure release. Within large OEn grains, finer-grained garnet forms thin lamellae preferentially parallel to the OEn (100) twin planes. These results suggest that micro-ruptures start in metastable OEn by syn-deformational transformation, which, aided by exothermic latent heat production, results in exsolution lamellae of garnet and CEn, both along the OEn (100) planes, associated with intragranular ruptures. These micro-ruptures conglomerate along weakened grain boundaries to form intergragular faults consisting of ultrafine grained reaction and shear zones, which, through adiabatic heating and local melting, self-organize into macroscopic faults. We propose that in harzburgite, the observed OEn instability triggers shear localization in olivine, resulting in adiabatic instability, a mechanism hypothesized on theoretical grounds [7, 8] and recently observed in laboratory experiments [9].

References:
[1] Hacker, B.R., Peacock, S.M., Abers, G.A., Holloway, S.D., 2003. J Geophys Res 108, 2019.
[2] Syracuse, E.M., van Keken, P.E., Abers, G.A., 2010. Phys Earth Planet In 183, 73–90.
[3] Brudzinski, M.R., C.H. Thurber, B. R. Hacker, E.R. Engdahl, Science, 316, 1472-1474.
[4] Ringwood, A.E., Irifune, T., 1988. Nature 331, 131–136.
[5] Gasparik, T., 2003. Phase diagrams for geoscientists. An Atlas of the Earth's Interior.
[6] Akashi, A.,et al., 2009. J Geophys Res 114, 322.
[7] Ogawa, M., 1987. J Geophys Res 92, 13801-13810.
[8] Hoobs, B.E., Ord, A., 1988. J. Geophys Res 93, 10521-10540.
[9] Ohuchi, T., et al., 2017. Nature Geoscience 10, 771.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-CG50] Intraslab and intraplate earthquakes

convener:Saeko Kita(International Institute of Seismology and Earthquake Engineering, BRI), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(Bavarian Geoinstitute, University of Bayreuth), Ryo Okuwaki(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Saeko Kita(Building Research Insitute), Tomohiro Ohuchi(Geodynamics Research Center, Ehime University), Marcel Thielmann(University of Bayreuth), Ryo Okuwaki(筑波大学), Thomas Ferrand(UC San Diego)

The purpose of this session is to share recent advances of geo-scientifical studies for intraslab and shallow-depth intraplate earthquakes. We seek to formulate future directions of the interdisciplinary study of the occurrence of intermediate-depth and deep earthquakes from the viewpoint of seismology, geodynamics and mineral physics. We welcome presentations from a wide variety of scientific disciplines, including seismology, seismotectonics, geodynamics, mineral and rock physics, other geophysics, geology, and numerical modeling.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG50-07] The Isolated M7.9 Deep Earthquake of 30 May 2015 Under the Present Bonin Wadati-Benioff Zone: Evidence from the New ISC-EHB Earthquake Catalogue (1930-2015) and CMT Focal Mechanisms

*Stephen Kirby[1], E. Robert Engdahl[2], Emile Andre Okal[3] (1.United States Geological Survey, Menlo Park, 2.University of Colorado, 3.Northwestern University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG50-08] What Can M_W –4 Lab-Quakes Teach Us About Deep-Focus Earthquakes?

★Invited Papers

*Julien Gasc[1], Julien Fauconnier[1], Clémence Daigre[1], Arefeh Moarefvand[1], Damien Deldicque[1], Blandine Gardonio[1], Alexandre Schubnel[1], Pamela Burnley[2] (1.Laboratoire de Géologie, ENS-CNRS, Paris, FRANCE, 2.University of Nevada Las Vegas, Las Vegas, USA)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG50-09] Deep intraslab earthquake rupture due to grain size assisted thermal runaway

*Marcel Thielmann[1], Thibault Duretz[2] (1.Bavarian Geoinstitute, University of Bayreuth, Germany, 2.Université de Rennes, Rennes, France)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG50-10] Fault model of the 2012 off-Miyagi intraslab earthquake doublet and its implication for rheological signature of incoming Pacific plate

*Tatsuya Kubota[1], Ryota Hino[2], Syuichi Suzuki[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Graduate School of Science, Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG50-11] Source-rupture process of the intraplate earthquake; its diversity related to the fault geometry and damaged fault zone

*Ryo Okuwaki[1], Yuji Yagi[1] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG50-12] Aftershocks of the NEXT Cascadia Intraslab Earthquake

*Paul Bodin[1,2] (1.University of Washington Seattle, 2.Pacific Northwest Seismic Network)

The Isolated M7.9 Deep Earthquake of 30 May 2015 Under the Present Bonin Wadati-Benioff Zone: Evidence from the New ISC-EHB Earthquake Catalogue (1930-2015) and CMT Focal Mechanisms

*Stephen Kirby[1], E. Robert Engdahl[2], Emile Andre Okal[3]

1. United States Geological Survey, Menlo Park, 2. University of Colorado, 3. Northwestern University

The M7.9 deep earthquake of 30 May 2015 at a depth of about 680 km was surprising in that it occurred more that 150 km distant from any event in the main Bonin sector Wadati-Benioff Zone (WBZ) above it and more than 120 km deeper than any well-recorded event in the Bonin subduction system. We applied the recently developed ISC-EHB methodology (GJI, 2018, v. 214, 474-484) to produce a comprehensive catalogue of hypocenters for the Izu-Bonin-Marianas region from 1904 to 2015. This methodology, which utilizes only events well-recorded telesesismically along with reported depth phases, ensures that the hypocenters in any given region are relatively well constrained in both location and depth. Individual trench-normal cross sections though the Southern-Bonin/Northern-Marianas subduction systems (including the transition through the Ogasawara Plateau collision zone) display a very sharply defined Bonin inclined seismic zone with no ISC-EHB events at depths and positions between the 2015 deep event and the Izu-Bonin Wadati Benioff Zone (WBZ) above it. Moreover the 2015 deep event occurred at least 200 km north of a possible tear in the main slab at about latitude about 25-26 ˚N where the deep WBZ bends back under the intermediate-depth segment. Most of the CMT focal mechanisms deeper than 300 km within the Bonin WBZ have normal-faulting mechanisms. Some published papers have claimed that the 2015 deep Bonin earthquake occurred in a steeply-dipping sector of the Bonin slab based largely on seismic tomography, but none of these studies have demonstrated sufficient resolution for convincing evidence of high-wave-speed slab material clearly linking the 2015 hypocenter with the main Bonin WBZ. Other published papers show independent evidence that the 2105 event occurred below the Bonin WBZ. We are left with the interpretation that the 2015 event occurred in a slab fragment separated from the main Bonin WBZ. We offer a possible fragmentation scenario involving a oceanic plateau collision, a consequent slab detachment, and an eastward trench stepback. Isolated deep earthquakes in slab fragments can rupture by transformational faulting in metastable olivine (MO) where stresses can originate by the residual stresses caused by heterogeneous volume changes associated with the MO->Spinel transformation (Okal and Kirby, PEPI, 1998).

Keywords: Deep earthquakes, Bonin seismic zone, 2015 Ultra-deep earthquake, Metastable olivine

©2019. Japan Geoscience Union. All Right Reserved.

What Can M_w −4 Lab-Quakes Teach Us About Deep-Focus Earthquakes?

*Julien Gasc[1], Julien Fauconnier[1], Clémence Daigre[1], Arefeh Moarefvand[1], Damien Deldicque[1], Blandine Gardonio[1], Alexandre Schubnel[1], Pamela Burnley[2]

1. Laboratoire de Géologie, ENS-CNRS, Paris, FRANCE, 2. University of Nevada Las Vegas, Las Vegas, USA

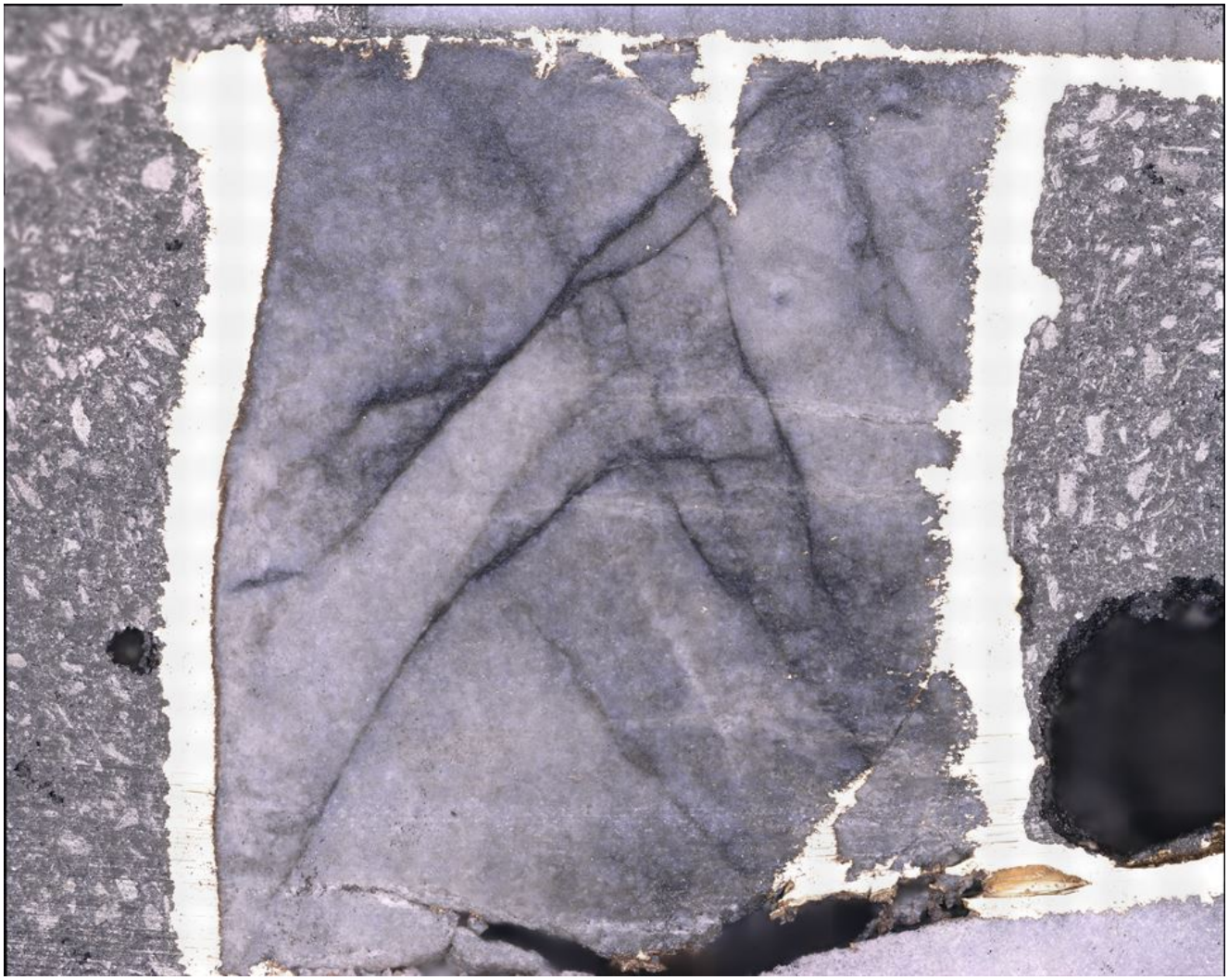
In recent years, several experimental studies have shed new light on possible faulting mechanisms responsible for intermediate and deep-seated earthquakes. These studies rely not only on the traditional analysis of mechanical data and recovered microstructures, but also on the in situ collection of acoustic data –in the form of Acoustic Emissions (AEs)– used to identify possible co-seismic faulting, i.e., brittle failure.

I will give an overview of this recent work and detail how, recently, deep-focus earthquakes mechanisms could be investigated at 1.5 GPa and 750-900˚C, in a new-generation Griggs-type apparatus using sintered Mg_2GeO_4 samples. This compound is an analogue of natural olivine for which the transition towards the high pressure phase (spinel structure) occurs at atmospheric pressure, instead of ~14 GPa for the silicate. This transition induces a mechanical instability –the so-called *transformational faulting*– that leads to macroscopic failure of the samples in a narrow temperature window. The boundaries of this brittle window, as for other reactions (quartz-coesite, antigorite dehydration, plagioclase breakdown and so on), are defined by the reaction kinetics. Here, faulting only occurs in cases where spinel nucleates but hardly grows, i.e., when reaction rates are slow.

At 900˚C mechanical data show a softening, indicative of ductile plastic flow, whereas large amounts of hardening followed by rapid stress drops (and audible stick slips) are recorded at 750˚C. AEs were detected in both cases and differences between P and S waves arrival times suggest that the majority of AEs originate inside the sample. Coherence analysis of the AEs seems to suggest that some bursts of events have similar sources. Surprisingly, AEs are more numerous (~600) at higher temperature, where deformation takes place in a ductile way, accommodated by the development of a wide mylonitic shear band. However, at 750˚C, far more energy is released acoustically upon brittle faulting despite a lower number of AEs (~100). Therefore, higher temperatures favor larger reaction rates, which, in turn, allow the growth of ductile fine-grained spinel. Our results confirm that the brittle temperature window (1) is a function of both equilibrium overstep (reaction kinetic) and strain rate and (2) seems to shift towards lower temperatures with decreasing strain rates, which may explain how earthquakes can occur in a slowly reacting metastable olivine wedge at strain rates orders of magnitude lower than in the lab.

Keywords: deep focus earthquakes, high pressure deformation experiments, transformational faulting, olivine spinel transition, acoustic emissions

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Deep intraslab earthquake rupture due to grain size assisted thermal runaway

*Marcel Thielmann[1], Thibault Duretz[2]

1. Bavarian Geoinstitute, University of Bayreuth, Germany, 2. Université de Rennes, Rennes, France

The rupture of the 2017 Mw 8.2 Tehuantepec earthquake has been shown to extend to temperatures above 1,000 ˚C. Ruptures penetrating to regions of such temperatures are highly unusal and raise the question whether the governing rupture mechanisms at these temperatures are comparable to shallow earthquakes. It has been suggested that dehydration embrittlement could result in deep intraslab earthquakes. However, dehydration embrittlement requires the presence of fluids. In the case of the Tehuantepec earthquake, this means that fluids would have to infiltrate the slab to depths that have not been observed.
An alternative mechanism that may lead to failure at these temperatures and depths is thermal runaway, in particular in conjunction with grain size reduction. Due to the conversion from mechanical work to heat during irreversible deformation, this mechanism weakens the rock. In certain conditions, it then results in zones of highly localized viscous creep along which a significant amount of displacement can be accumulated.
Here, we investigate the onset and formation of a ductile shear zone nucleating a cold temperatures and then propagating to regions of higher temperature using 2D numerical models with a nonlinear viscoelastic rheology. We show that it is indeed possible to form a ductile shear zone through the combined action of grain size reduction and shear heating and determine the parameter ranges where this feedback loop may result in ductile shear zone formation and thus also deep earthquake rupture.

Keywords: intraslab earthquakes, deep earthquakes, thermal runaway, grain size evolution

©2019. Japan Geoscience Union. All Right Reserved.

Fault model of the 2012 off-Miyagi intraslab earthquake doublet and its implication for rheological signature of incoming Pacific plate

*Tatsuya Kubota[1], Ryota Hino[2], Syuichi Suzuki[2]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Graduate School of Science, Tohoku University

An Mjma 7.3 earthquake composed of a deep reverse-faulting subevent (~60km, Mw 7.2; subevent 1) and a shallow normal-faulting subevent (~20km, Mw 7.1; subevent 2) occurred on 7 December 2012, within the Pacific Plate near the Japan Trench. Since the fault mechanisms of two subevents are consistent with the stress field within the incoming plate near the trench, characterized by the deep compressional and shallow tensile stresses due to the bending of the subducting plate (bending stress, e.g., Chapple and Forsyth, 1979 JGR), we have estimated the finite fault model of this earthquake to discuss the intraplate stress field in this region (Kubota, 2017 PhD thesis, Tohoku Univ). In this study, we conducted more comprehensive discussions for the intraplate stress state, the physical properties, and the relationship between the 2012 earthquake and the Tohoku-Oki earthquake.

We first estimated the initial sea-surface height distribution by inverting the tsunami records and compared it with the vertical deformation expected from the Global CMT solution, to find that the subsided area was generated only by subevent 2 and the uplift area was by both subevents. Then we estimated the optimum fault model for subevent 2, which explains the subsided area of the initial height distribution and the aftershock distribution determined by Obana et al. (2015 AGU FM). Finally, based on the the teleseismic records and the residual displacement between the initial height and the vertical displacement expected from the subevent 2 fault model, we estimated the subevent 1 fault model. We also evaluated the estimation error of our fault model based on the models which had relatively good reproductivity of the sea-surface deformation. As a result, the depth range of the faults of subevents 1 and 2 fell into ~ 45 –70 km and ~ 5 (seafloor) –35 km, respectively.

The down-dip edge of the shallow normal-faulting seismicity in 2012 (~35 km) significantly deepened compared to that in 2007 (~25 km, Hino et al., 2009 G3). However, consideringthe vertical stress gradient of the bending stress (~15 MPa/km), the coseismic stress change by the 2011 Tohoku-Oki earthquake around the normal-faulting seismicity (~20 MPa) is too small to cause normal-faulting earthquakes in that depth range, suggesting that the plate down to ~ 35 km is required to have been already yielded before the Tohoku-Oki earthquake and the frictional strength in the normal-faulting depth range is required to be significantly weaker than the empirical relationship (e.g., Byerlee, 1978). Accounting for the result of the active seismic survey of Fujie et al. (2018 Nature Comm), who suggested the existence of the pore fluid at the shallow part of the subducting plate (< ~ 5 km), the strength reduction is caused by the pore fluid infiltration down to ~ 35 km, along the bending faults (e.g., Faccenda et al., 2009 Nature Geo).

We also obtained the down-dip depth of the deep reverse-faulting subevent at ~70 km, which obviously below the brittle-ductile transition depth expected for the age of the plate. The deep penetration of the fault is explained by the viscoelastic relaxation following the Tohoku-Oki earthquake (e.g., Tomita et al., 2017 Science Adv), which increases the strain rate in the deeper part of the plate. Since the increase of the strain rate makes the brittle-ductile transition depth (e.g., Scholtz, 1988), the depth range of the brittle rupture are extended deeper than that before the Tohoku-Oki earthquake. This result suggests that deep reverse-faulting earthquake in the incoming plate can grow larger after the massive interplate

©2019. Japan Geoscience Union. All Right Reserved.

earthquake than in the interseismic period.

Keywords: The 2011 Tohoku-Oki earthquake, Intraplate earthquake, Rheology, Stress, Tsunami

©2019. Japan Geoscience Union. All Right Reserved.

Source-rupture process of the intraplate earthquake; its diversity related to the fault geometry and damaged fault zone

*Ryo Okuwaki[1], Yuji Yagi[1]

1. Graduate School of Life and Environmental Sciences, University of Tsukuba

Supershear rupture is one of the features that characterizes the earthquake-rupture complexity. Both the theoretical analyses and the laboratory experiments suggests that the rupture-front propagation can exceed the shear wave velocity of the medium due to the excess of the energy flux into the rupture tip. However in real earthquakes, extrinsic factor that controls the manner of supershear rupture has yet been well captured and a relationship between the geometric complexity of the fault and the supershear rupture propagation has been elusive. Geometrical complexity of the fault system is a challenging feature against a reliable estimate of kinematic slip evolution on the basis of finite-fault inversion, since the presumed, fixed rectangle-fault plane or even configuration of the multiple rectangles may not necessarily, fully represent a real fault geometry. Especially for the strike-slip (mode-II rupture) earthquake, the radiation pattern of the wave is sensitive around nodal-shear planes, and if the earthquake involves the geometric complexity in the fault system, the radiation pattern at a certain location on a fault cannot be reproduced when the presumed model fault geometry deviates from the real one. Although supershear-rupture propagation has often been observed in the large strike-slip earthquake (e.g. Mw 7.8 2001 Kunlun, Tibet and Mw 7.9 2002 Denali, Alaska earthquakes), such limitations of finite-fault modeling has prevented us to discuss a relationship between supershear rupture and the fault geometry.

Here we present a kinematic rupture model for the intraplate, Mw 7.5 2018 Palu, Indonesia, earthquake. The 2018 Palu earthquake occurred along the strike-slip Palu-Koro fault zone, which is located around the triple junction of the Australia, Eurasia, and Philippines sea plates. The trace of the surface rupture of the 2018 Palu earthquake, mapped by the Interferometric Synthetic Aperture Rader (InSAR), shows the geometric complexity around the epicenter and south of the Palu bay. We inverted the teleseismic waveforms to resolve both the spatiotemporal evolution of shear slip and the variation of fault geometry by representing slip with five-basis potency-density tensors, without forcing a shear plane to be consistent with a pre-fixed model plane. A possibility of supershear rupture was taken into account by resolving slip in a wide parametric-model space with longer duration of slip-rate function and faster maximum rupture velocity.

The resultant model showed that a rupture front persistently propagated at a high speed (~5 km/s) that exceeds the local shear wave velocity throughout 200-km long within 40 s, but also showed the transient deceleration and acceleration of slip migration, which can be seen as an inchworm walking. The transient deceleration and acceleration of the slip migration was resolved in the area where the strike angle was rotated from the reference-model strike (358˚), which also coincides with the geometric discontinuity of the surface rupture resolved by the InSAR analyses. We will then discuss possible roles of geometric discontinuity that develops inchworm-like slip evolution and damaged fault zone that enables long-lived supershear rupture propagation, which may be characteristic factors that control diverse rupture process of the intraplate earthquake.

Keywords: Intraplate earthquake, Waveform inversion, Fault geometry, Supershear rupture, source rupture process

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Aftershocks of the NEXT Cascadia Intraslab Earthquake

*Paul Bodin[1,2]

1. University of Washington Seattle, 2. Pacific Northwest Seismic Network

In 1949, 1965, and 2001 damaging (M6.5-M6.8) deep (~60 km) earthquakes ruptured faults within the Juan de Fuca slab beneath the Puget Sound region of the Cascadia subduction zone in the Pacific Northwest of the U.S.. Each had only a few and very small (approximately M<4) aftershocks. Immediately after the *next* such damaging intraslab earthquake shall we tell the public and first responders that there will likely be no damaging aftershocks? While this low likelihood of aftershocks seems probable based on the historical record, there is no compelling well-agreed-upon physical reason to expect this behavior. For example, recent deep intraslab earthquakes in Japan, Alaska, and Mexico have been followed by strong aftershock sequences. Is the lack of aftershocks following Cascadian intraslab earthquakes unique or extreme? And is it expected and explainable? Possible explanations for regulating the production rate of aftershocks include physical environmental characteristics such as pressure and temperature, geological differences like rock types and faulting geometry, dynamic frictional factors like slip rates, afterslip, and stress drop, and possible roles of fluids. We survey aftershock occurrence following recent smaller Cascadian intraslab earthquakes and following recent large intraslab earthquakes in a number of subduction zones and attempt to classify and distinguish between hypotheses for the lack of Cascadian deep earthquake aftershocks. Is this another possibly unique feature of Cascadia, like the nearly complete lack of instrumentally observed interface earthquakes of any size?

Keywords: intraslab, aftershock, Cascadia, intraplate

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-CG51] Role of volatiles on Earth and planetary dynamics

convener:Takayuki Ishii(Bavarian Research Institute, University of Bayreuth), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), Michihiko Nakamura(Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University), Bjorn Mysen(Geophysical Laboratory, Carnegie Inst. Washington), Chairperson:Michihiko Nakamura, Eiji Ohtani(Tohoku University)

This session addresses how volatile species affect dynamics of the
Earth and planets from natural observations, laboratory experiments, and
numerical modeling in the temperature, pressure, and oxygen activity
range from the early stage of the planet formation to the present. The
volatiles can be critical in zones of magma storage and ascent, mantle
upwelling and melting in the fluid-enriched subduction zones, in the
mantle transition zone, in the lower mantle, in the core-mantle boundary,
and in Earth and planetary cores. However, volatiles affect properties
and processes differently depending on their pressure, temperature, and
redox conditions, which vary in time and space.
 This session aims to address how volatiles control the dynamic
processes of the Earth and planets, governed by their geophysical and
geochemical properties. We welcome papers dealing with geological and
laboratory observations coupled with numerical modeling on the role of
volatiles. The topics include (1) Stability relations, chemical and
physical properties of crystalline, molten and fluid phases,
partitioning of volatiles among these phases, (2) Rheological and other
physical properties of minerals, and the effects of intergranular fluid
on the properties, (3) Volatiles and dehydration induced seismicity and
volcanism in various tectonic regions including subduction zones, and (4)
Effects of volatiles in numerical simulation of geo-tectonics, and (5)
Magma outgassing and its control of volcanic eruption dynamics.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG51-01] Constraining the degassing rate of the mantle since 3 Ga using the deficit of xenon-129 in the ancient atmosphere

★Invited Papers

*Bernard Marty[1], David Bekaert[1], Michael Broadley[1] (1.Centre de Recherches Pétrographiques et Géochimiques/ CNRS - Universite de Lorraine France)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG51-02] Investigating volatile cycles in the terrestrial mantle by incorporating He and Ar isotopes into geodynamical models of mantle convection

★Invited Papers

*Rosie Ellen Jones[1], Peter van Keken[2], Jonathan M Tucker[2], Chris J Ballentine[1] (1.Department of Earth Sciences, University of Oxford, Oxford, UK, 2.Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, USA)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG51-03] Fluid circulation in the forearc mantle wedge inferred from the dihedral angle in an olivine-H_2O-NaCl system

*Yongsheng HUANG[1], Takayuki Nakatani[1], Michihiko Nakamura[1], Catherine McCammon[2] (1.Graduate School of Science, Tohoku University, 2.Byerisches Geoinstitut, University of Bayreuth)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG51-04] The oxygen fugacity of serpentinites: implications for subduction zone redox evolution

*Lisa Eberhard[1], Dan Frost[1], Catherine McCammon[1] (1.BGI)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG51-05] Experimental study of the effect of composition on water solubility in natural silicate melts

*Shigeru Yamashita[1] (1.Institute for Planetary Materials, Okayama University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG51-06] Deep mantle volatile cycle and plate tectonics: Impact to the climate evolution

*Takashi Nakagawa[1], Shintaro Kadoya[2], Eiichi Tajika[3] (1.Department of Earth Sciences, The University of Hong Kong, 2.Department of Earth and Space Sciences, University of Washington, 3.Department of Earth and Planetary Sciences, The University of Tokyo)

Constraining the degassing rate of the mantle since 3 Ga using the deficit of xenon-129 in the ancient atmosphere

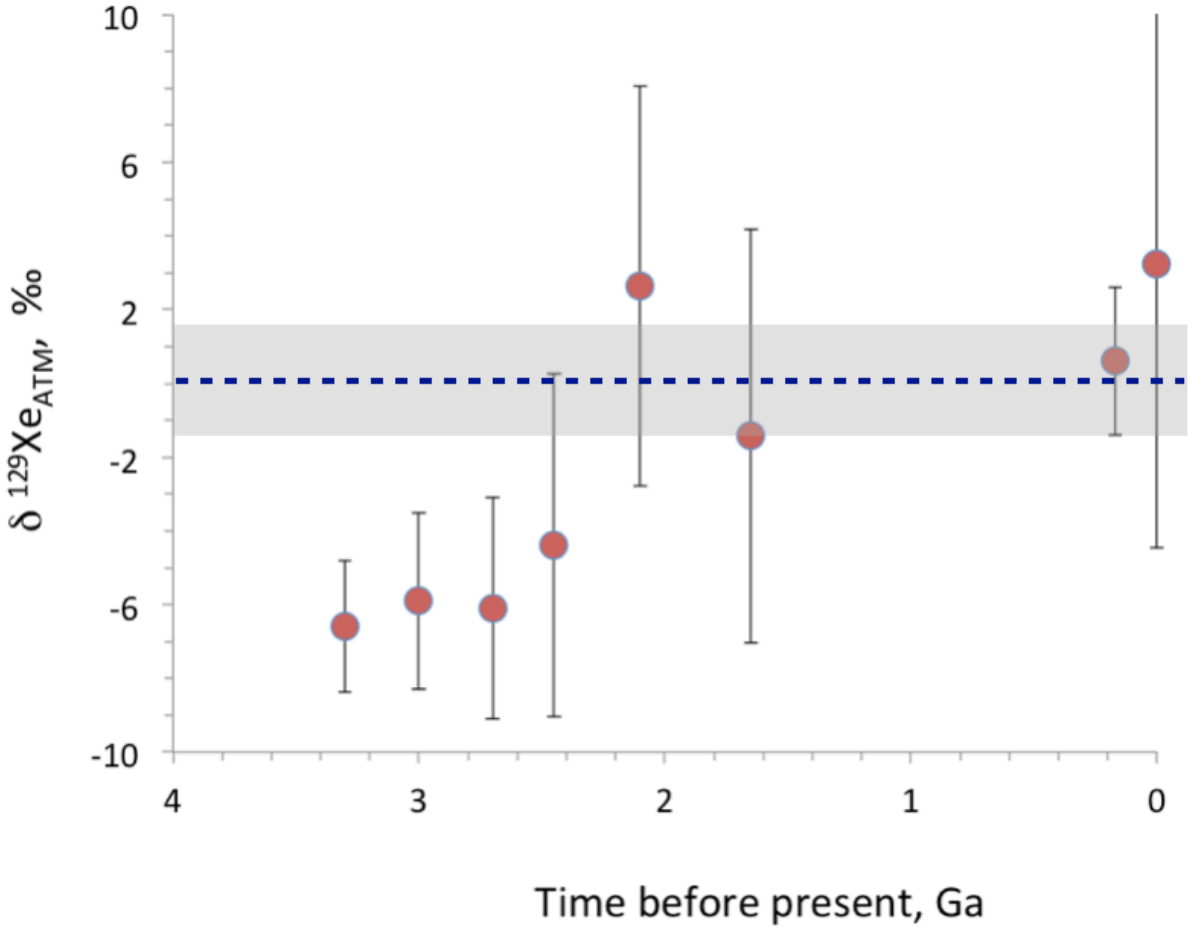
*Bernard Marty[1], David Bekaert[1], Michael Broadley[1]

1. Centre de Recherches Pétrographiques et Géochimiques/ CNRS - Universite de Lorraine France

Degassing of volatile elements from the mantle to the atmosphere requires decompression melting, magma generation and degassing, and is therefore linked to mantle convection. Mantle convection is a physical process that tends to minimize temperature contrasts between the Earth's surface and the deep regions of the mantle. Hence its strength was variable through geological periods of time as it depended on heat generation within the Earth as well as heat dissipation to space. Convection of planetary mantles is a key driver of the evolution of planets and on Earth has been modulating the generation and stabilization of the continental crust. Still the thermal regime of the Earth, and notably the radiogenic/total heat production ratio (the Urey number) are not precisely known. It is related to the distribution of radioactive isotopes (mainly ^{238,235}U, ^{232}Th, ^{40}K) among Earth's reservoirs which varied through time, on the latent heat of core crystallization, on the residual energy of accretion, and on the heat dissipation from the Earth's interior, which depends on mantle convection, a self-regulating process. Geological and geochemical observations have the potential to set constraints on variations of mantle convection in the distant time. Atmospheric xenon presents excesses in ^{129}Xe, an isotope contributed by the decay of extinct iodine-129 ($T_{1/2}$ = 16 Ma). Part of this excess resulted from early degassing of the mantle and, possibily from contributions of comet to early Earth. Mantle degassing also contributed ^{129}Xe to the atmosphere through time since the solid Earth is rich in ^{129}Xe compared to the atmosphere. In agreement with this possibility, remnants of the Archean atmosphere trapped in fluid inclusions (Avice et al *Nature Comm*, 2017, GCA 2018) and in organic matter (Bekaert et al Science Adv 2018) show that xenon in Archean air was depleted in ^{129}Xe compared to the modern composition (see Figure; error bars at 2 s; the grey area represents the reproducibility of air standards at the 2 slevel). However, this deficit cannot be accounted for by the modern degassing rate (as estimated from noble gas fluxes from the mantle), and requires degassing rates two orders of magnitude larger in the distant past than at present. This discrepancy implies a more vigorously convecting Archean-Proterozoic Earth, and suggests a potential impact on the composition of the Archean atmosphere. It also leads credence to models advocating a magmatic origin for drastic environmental changes like the great oxidation event.

Keywords: mantle degassing, Archean, noble gases

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Investigating volatile cycles in the terrestrial mantle by incorporating He and Ar isotopes into geodynamical models of mantle convection

*Rosie Ellen Jones[1], Peter van Keken[2], Jonathan M Tucker[2], Chris J Ballentine[1]

1. Department of Earth Sciences, University of Oxford, Oxford, UK, 2. Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, USA

The dichotomy in $^{3}He/^{4}He$ isotopes ratios between mid ocean ridge and ocean island basalt samples (MORB and OIB) has provided a fundamental cornerstone in defining the need for a long-lived, volatile rich, and possibly primordial, geochemical reservoir within the deep mantle. However, this is somewhat at odds with evidence from other radiogenic isotope systems (e.g., U-Th-Pb, Lu-Hf, Sm-Nd, Rb-Sr), as well as geophysical evidence, for recycled surficial/crustal material in the deep mantle. Geodynamic models of mantle convection have been developed to incorporate earth-like phase and viscosity changes and can reproduce earth-like surface heat flow and plate motion. When such models take into account the higher density of the subducting oceanic crust, compared to the surrounding mantle, it provides a mechanism of retarding convection in the deepest mantle and reproduces observed geochemical distributions in multiple isotope systems (U-Th-Pb, Rb-Sr, Sm-Nd, Lu-Hf and Re-Os) that define the DMM, HIMU and EMI mantle endmembers (Brandenburg et al., 2008, Jones et al., 2017). Here we use a geodynamical model of mantle convection (Brandenburg et al., 2008), and combine it with geochemical input parameters, to investigate whether the subduction of dense eclogite can retard lower mantle convection sufficiently to explain the observed differences in $^{3}He/^{4}He$ obtained for MORB and OIB. We go on to analyse the effect of ^{3}He outgassing from the Earth's core and early recycling of extra-terrestrial material containing high ^{3}He (e.g., interplanetary dust particles (IDPs)) into the mantle. The K-Ar system is also incorporated into the model and earth-like ^{40}Ar planetary degassing from the mantle is reproduced. We explore the impact of ^{36}Ar recycling on the $^{40}Ar/^{36}Ar$ compositions of MORB and OIB. The results suggest recycling of atmospheric Ar can produce the observed $^{40}Ar/^{36}Ar$ compositions of the upper and lower mantle.

Brandenburg, J.P., Hauri, E.H., van Keken, P.E., Ballentine, C.J., 2008. Earth and Planetary Science Letters 276, 1-13.

Jones, R., van Keken, P. E., Hauri, E., Vervoort, J. D., & Ballentine, C. J., 2017. AGU Fall Meeting Abstracts.

Keywords: He isotopes, Ar isotopes, Mantle convection, Geodynamic model, Geochemistry, Volatiles

©2019. Japan Geoscience Union. All Right Reserved.

Fluid circulation in the forearc mantle wedge inferred from the dihedral angle in an olivine-H_2O-NaCl system

*Yongsheng HUANG[1], Takayuki Nakatani[1], Michihiko Nakamura[1], Catherine McCammon[2]

1. Graduate School of Science, Tohoku University, 2. Byerisches Geoinstitut, University of Bayreuth

In subduction zones, the circulation of slab-released aqueous fluids is crucial to understand the generation of arc magma and recycle of materials, and further to constrain the global geodynamics. The infiltration of aqueous fluids plays an important role in controlling geophysical properties of the mantle wedge such as elasticity, permeability and electrical conductivity. Recently, magnetotellulic studies found a high electrical conductor beneath the fore-arc region which was interpreted as a storage of voluminous slab-derived fluid, implying the presence of permeable mantle wedge at fore-arc depths. By contrast, experimental constraints on dihedral (wetting) angle (θ) in the olivine-H_2O system indicated the fluid is once trapped in isolated pores ($\theta > 60^\circ$) within the down-dragging mantle matrixat fore-arc depths and finally released just beneath the arc volcano where $\theta < 60^\circ$. Here we present the precisely determined dihedral angles in the olivine and NaCl-bearing aqueous fluid (5–27.5 wt% NaCl) system at 1–4 GPa and 800–1100˚C to reveal the influence of NaCl on the fluid connectivity because the NaCl is now recognized to be an important constituent of subduction zone fluids. We found that NaCl significantly decreases θ down to below 60˚ at all the investigated temperature and pressure conditions even at 5 wt% NaCl. Our results suggest that released NaCl-bearing aqueous fluid begins to form an interconnected network in the mantle at relatively shallow depths of ~80 km and can partly penetrate the fore-arc crust without causing mantle melting, which could account for the high electrical conductivity anomalies beneath the for-are region. Our model also emphasizes that partial melting of peridotite triggered by the addition of aqueous fluid can occur more widely than that previously thought, and implies that the release depth of aqueous fluid is not a primary control on the volcanic front position. This work was supported by the JSPS Japanese-German Graduate Externship.

Keywords: dihedral angle, NaCl-bearing, fluid network, mantle wedge, subduction zone

©2019. Japan Geoscience Union. All Right Reserved.

The oxygen fugacity of serpentinites: implications for subduction zone redox evolution

*Lisa Eberhard[1], Dan Frost[1], Catherine McCammon[1]

1. BGI

At subduction zones H_2O and CO_2 are returned to the Earth’ s mantle, bound within hydrous and carbonate minerals. Serpentinites are considered to be major carriers of H_2O into the mantle but natural exposures indicate that some sections of serpentinized mantle also contain significant amounts of carbonate minerals. Determining the fate of so called ophicarbonate rocks presents an important challenge because it involves the interaction between both H_2O- and CO_2- bearing fluids. A further aspect however is that serpentine minerals also contain ferric in addition to ferrous iron. Natural serpentinites record in fact a very wide range of Fe^{3+}/Fe^{tot} ratio but the effect of this ratio on the high pressure stability of serpentine and the relationship with the speciation of coexisting C-O-H fluid phases is unknown.

We have examined the stability of the serpentinite mineral antigorite within ophicabonate assemblages at subarc conditions as a function of P, T and fO_2. Multi-anvil experiments were performed both inside the stability field of antigorite, but also at conditions where antigorite starts to dehydrate. Natural serpentinites are used as starting materials with initially high and low Fe^{3+}/Fe^{tot} ratios. Calcium carbonate was then added to these assemblages to simulate ophicarbonate composition. Iridium metal was added to some nominally unbuffered experiments to allow the oxygen fugacity to be determined, whereas in other experiments the oxygen fugacity was fixed using powders of Ru + RuO_2 and Re + ReO_2 distributed throughout the sample. Ferrous Fe is located in the octahedral site of antigorite whereas ferric Fe may additionally occupy the tetrahedral site of the trioctahedral 1:1 sheet silicates, providing charge balance. We have determined the location and speciation of the Fe atoms in serpentinites as a function of fO_2, P and T by using Mössbauer spectroscopy to examine the run products of the multi-anvil experiments.

The experiments were run for approximately 3 days during which it was possible to change the Fe^{3+}/Fe^{tot} ratios of the starting materials to both higher and lower ratios depending on the redox buffers employed. We found that the relationship between the Fe^{3+}/Fe^{tot} ratio of antigorite and the oxygen fugacity is very temperature dependent with antigorite Fe^{3+}/Fe^{tot} ratios decreasing sharply at the same oxygen fugacity as dehydration commences. This behaviour should cause the oxygen fugacity within subducting lithosphere to increase as dehydration takes place, which will have important implications for fluid speciation. On the other hand the stabilisation of ferric iron in antigorite at high oxygen fugacities appears to have a minimal effect on the temperature of dehydration.

Keywords: Serpentine, subduction zone, f(O2), Multi-anvil, Mössbauer spectroscopy

©2019. Japan Geoscience Union. All Right Reserved.

Experimental study of the effect of composition on water solubility in natural silicate melts

*Shigeru Yamashita[1]

1. Institute for Planetary Materials, Okayama University

Water is the first dominant volatile dissolved in magmas. Oversaturation and exsolution of the water in magmas affects the buoyancy and excess vapor pressure of the system, and hence the water solubility in silicate melts is fundamental in controlling magma transport beneath volcanoes. Many experimental studies of the solubility for water in natural silicate melts are now available, but most of them were performed over a limited range of composition. For example, published solubility data for water are rather sparse for the natural silicate melts having moderate SiO_2 contents. This has resulted in insufficient data coverage of composition space, which makes difficult to precisely model if a melt is subject of compositional change due to partial crystallization, assimilation, or magma hybridization. This study presents results from experimental determinations of the solubility for water in a natural dacitic melt at near-the liquidus and the superheated conditions.

The starting material for the experiments was the natural subalkaline dacite JA1 (GSJ standard reference material, ~65 wt% SiO_2). A nominally anhydrous glass was prepared from the starting material, and the glass was equilibrated with water in an internally heated pressure vessel for ~24 hours at 1000-1200 °C and 100-200 MPa. Double capsule technique was employed to control the oxygen fugacity in the sample along Ni-NiO buffer during the experiments. The water content in the quenched glass was determined from the near infrared absorption intensities of the hydroxyl groups band at ~4500 cm^{-1} and the molecular water band at ~5200 cm^{-1} using the molar absorption coefficients of Ohlhost et al. (2001).

Results of this study are overall consistent with previous determinations of pressure- and temperature-dependence of water solubility in rhyolitic melts. Water solubility in the dacitic melt increases with pressure at a fixed temperature, and decreases with temperature at a fixed pressure. On the other hand, the water solubility in the dacitic melt was found to be 10-20 % (relative, on the mole fraction basis) greater than those previously determined by Holtz et al. (1992; 1995) and Yamashita (1999) for the rhyolitic melts when compared at the same pressure and temperature condition. This advocates that the effect of melt composition play a noticeable role in controlling the degree of water oversaturation during magmatic processes. When a hotter basaltic magma is injected to a colder rhyolitic magma body, a purely thermal effect on water solubility enhances formation of vapor bubbles in the rhyolitic magma (e.g., Yamashita, 1999). Once hybridization between the melt portions of the two magmas proceeds, the effect of melt composition on water solubility becomes important, i.e., already present, sub-millimeter size bubbles (thus their buoyant separation is limited) can be resorbed by the hybridized melt which has an intermediate composition.

References: Holtz et al., Chem. Geol., 96, 289-302, 1992; Holtz et al., Amer. Mineral., 80, 94-108, 1995; Ohlhost et al., Chem. Geol., 174, 5-20, 2001; Yamashita, J. Petrol., 40, 1497-1507, 1999.

Keywords: magma, water solubility, composition dependence

©2019. Japan Geoscience Union. All Right Reserved.

Deep mantle volatile cycle and plate tectonics: Impact to the climate evolution

*Takashi Nakagawa[1], Shintaro Kadoya[2], Eiichi Tajika[3]

1. Department of Earth Sciences, The University of Hong Kong, 2. Department of Earth and Space Sciences, University of Washington, 3. Department of Earth and Planetary Sciences, The University of Tokyo

We investigate the deep mantle volatile (water and carbon) cycle and its impact to plate tectonics and climate evolution in the numerical mantle convection simulations couping with the energy balance model of the surface climate model. To calculate the mantle water cycle, the storage capacity model of water in each mantle minerals as functions of temperature and pressure is incorporated into numerical mantle convection simulations so that the dehydration process can be included in the numerical model of mantle water cycling as well as the regassing and degassing processes. However, the decarbonation process cannot be included because the storage capacity model of carbon is not well-established. In three migration processes of mantle volatiles, the volcanic degassing plays a significant role because the volatile composition of the atmosphere-ocean system can be described as a balance between degassing flux and silicate weathering effects as uptake of the volatile components. As a result, the optical properties of the atmosphere-ocean system such as the Albedo and planetary radiation are changed with the volcanic degassing. Other two migration processes may be worked for regulating the volatile content stored in the deep planetary interior and inventory of surface volatile reservoir. The style of plate tectonics driven by mantle convection may strongly affect the style of climate evolution and inventory of surface volatile reservoir. In the stagnant lid mode of mantle convection, the snowball climate is dominated for over a few billion years because the strong radiative cooling is controlled due to less amount of volcanic degassing associated with the stagnant lid convection. Whereas, the continuous carbon degassing is expected in the continuous surface plate motions so that the mild climate can be found, which allows having the liquid water over a few billion years on the planetary surface. In order to preserve the amount of surface seawater on the planetary surface as the present-day amount of surface seawater on the Earth, the required amount of the water in the entire planetary system may be around 10 to 12 Ocean Masses of present-day Earth's water ocean. Therefore, the mantle volatile cycle concerning with the plate tectonics driven by mantle convection may control the habitability of the rocky planets such as the Earth.

Keywords: plate tectonics, volatile cycle, climate evolution

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-CG51] Role of volatiles on Earth and planetary dynamics

convener:Takayuki Ishii(Bavarian Research Institute, University of Bayreuth), Eiji Ohtani(Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University), Michihiko Nakamura(Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University), Bjorn Mysen(Geophysical Laboratory, Carnegie Inst. Washington), Chairperson:Takayuki Ishii(Bavarian Research Institute, University of Bayreuth), Bjorn Mysen(Carnegie Institution of Washington)

This session addresses how volatile species affect dynamics of the
Earth and planets from natural observations, laboratory experiments, and
numerical modeling in the temperature, pressure, and oxygen activity
range from the early stage of the planet formation to the present. The
volatiles can be critical in zones of magma storage and ascent, mantle
upwelling and melting in the fluid-enriched subduction zones, in the
mantle transition zone, in the lower mantle, in the core-mantle boundary,
and in Earth and planetary cores. However, volatiles affect properties
and processes differently depending on their pressure, temperature, and
redox conditions, which vary in time and space.
 This session aims to address how volatiles control the dynamic
processes of the Earth and planets, governed by their geophysical and
geochemical properties. We welcome papers dealing with geological and
laboratory observations coupled with numerical modeling on the role of
volatiles. The topics include (1) Stability relations, chemical and
physical properties of crystalline, molten and fluid phases,
partitioning of volatiles among these phases, (2) Rheological and other
physical properties of minerals, and the effects of intergranular fluid
on the properties, (3) Volatiles and dehydration induced seismicity and
volcanism in various tectonic regions including subduction zones, and (4)
Effects of volatiles in numerical simulation of geo-tectonics, and (5)
Magma outgassing and its control of volcanic eruption dynamics.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG51-07] The nature of water induced small degree melts in the deep mantle

★Invited Papers

*Daniel James Frost[1], Pierre Condamine[3], Davide Novella[2], Rong Huang[1] (1.University of Bayreuth, 2.University of Cambridge, 3.Université de Lorraine)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG51-08] Phase separation of hydrous Vesuvius melt: vesicle nucleation or spinodal decomposition?

★Invited Papers

*Anja Allabar[1], Marcus Nowak[1] (1.University of Tuebingen)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG51-09] Role of water on dynamics in the lower mantle and core-mantle boundary regions

*Eiji Ohtani[1], Takayuki Ishii[2], Liang Yuan[1], Daijo Ikuta[1], Tomoo Katsura[2], Dan Frost[2] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2.Bavarian Research Institute, University of Bayreuth)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG51-10] Stability of Fe-bearing hydrous phases and element partitioning in the system MgO-Al_2O_3-Fe_2O_3-SiO_2-H_2O in Earth's lowermost mantle

*Hongsheng Yuan[1], Li Zhang[1], Eiji Ohtani[2], Yue Meng[3], Eran Greenberg[4], Vitali B. Prakapenka [4] (1.Center for High Pressure Science and Technology Advanced Research, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.HPCAT, X-Ray Science Division, Argonne National Laboratory, 4.Center for Advanced Radiation Sources, University of Chicago)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG51-11] **Laboratory Micro-Seismicity during Serpentinite Deformation as a Potential Analogue for Lower Wadati-Benioff Plane Seismicity**

*Julien Gasc[1,3], Nadège Hilairet[2], Tony Yu[3], Yanbin Wang[3], Thomas P. Ferrand[1], Alexandre Schubnel[1] (1.Laboratoire de Géologie, CNRS - ENS, Paris, FRANCE, 2.Unité Matériaux et Transformations, CNRS - Lille University, Villeneuve d'Ascq, FRANCE, 3.GeoSoilEnviro-CARS, University of Chicago, Argonne IL, USA)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG51-12] Water transport and mixing in the whole-mantle scale convection

*Takeo Kaneko[1], Tomoeki Nakakuki[1], Masanori Kameyama[2], Hikaru Iwamori[3] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.Geodynamics Research Center, Ehime University, 3.Earthquake Research Institute, University of Tokyo)

The nature of water induced small degree melts in the deep mantle

*Daniel James Frost[1], Pierre Condamine[3], Davide Novella[2], Rong Huang[1]

1. University of Bayreuth, 2. University of Cambridge, 3. Université de Lorraine

Slow S-wave velocities in the deep mantle have been used to argue for the presence of hydrous silicate melts. Small degree partial melts could potentially be formed due to a reduction in the H_2O storage capacity of mantle minerals due to pressure induced phase transitions or as a result of redox processes. Hydrous melt layers could accumulate at certain depths in the mantle due to neutral buoyancy. Water concentrations in the ambient mantle are at most likely to lead to only small degrees of melting. Such incipient melts would be in equilibrium with a peridotite assemblage containing minerals that would be practically identical in major elements as the unmelted assemblage. The compositions of such melts are important because their water contents constrain the relationship between melt fraction and the bulk water content. Furthermore, the water content and the iron content would mainly determine their buoyancy. To assess if neutrally buoyant small degree hydrous melt layers exist in the mantle and to determine how much water would need to be present to create them requires experimental determination of their compositions.

Determining the chemical composition of low degree melts and particularly their water contents is experimentally very challenging. At pressures higher than 2 GPa melts no longer quench to form glasses and can therefore not be analyzed to determine water contents. Small melt fractions are very hard to analyze due to their very small volume and due to modification through reaction with solid phases during quenching. One way to overcome these problems and produce an analyzable portion of incipient melt composition is by performing sandwich experiments. In this method an initial first guess melt composition is equilibrated with a sub-equal proportion of peridotite. The resulting melt is then re- equilibrated with peridotite in a series of iterative experiments until a composition is obtained that is in equilibrium with the entire peridotite assemblage.

We have used this procedure to determine the compositions of incipient melts at depths equivalent to around 200 and 400 km in the mantle at adiabatic temperatures. The sandwich technique has to be modified in a number of ways when used at very high pressures, mainly to ensure that water contents can be accurately determined through mass balance. The resulting melts have affinities with the major classes of kimberlite magmas and their compositions can be used to assess their buoyancy in the deep mantle.

Keywords: Pressure, Transition zone

©2019. Japan Geoscience Union. All Right Reserved.

Phase separation of hydrous Vesuvius melt: vesicle nucleation or spinodal decomposition?

*Anja Allabar[1], Marcus Nowak[1]

1. University of Tuebingen

The phase separation of H_2O fluids from supersaturated hydrous silicate melts determines the starting point of explosive volcanic eruptions. The number of fluid vesicles per unit volume of silicate melt (*VND*) is a basic property that controls the efficiency of fluid-melt separation and as a result the acceleration of magma ascent. To simulate the phase separation of single phase hydrous silicate melts during ascent, continuous decompression experiments were performed at superliquidus temperatures with AD79 Vesuvius white pumice composition. This pumice buried Herculaneum and Pompeii and is representative of other catastrophic phonolitic and trachytic explosive eruptions like the violent 39 ka Campi Flegrei and the 1815 AD Tambora eruption.
Experiments were conducted in an internally heated pressure vessel equipped with a high-pressure valve that facilitates continuous decompression. 5.3 wt% H_2O were dissolved in the melts at 200 MPa and 1523 K for 96 h. Subsequently, the slightly H_2O undersaturated melts were isothermally decompressed at 1323 or 1373 K with rates of 0.024-1.7 MPa·s^{-1}. At final pressures (P_{final}) between 110 and 70 MPa, the samples were isobarically quenched with ~150 K·s^{-1} to room temperature. The *VND* of the vitreous samples were determined with optical microscopy and quantitative backscattered electron image analysis combined with computational 2D to 3D transformation.
Homogeneously dispersed vesicles are observed in the samples decompressed to a P_{final} ≦100 MPa which corresponds to a ΔP of ~95 MPa that is necessary to induce homogeneous phase separation. High log *VND*'*s* of ~5.2 (in mm^{-3}), corresponding to average vesicle distances of 10 μm, are observed irrespective of decompression rate within the investigated range. A nucleation theory based decompression rate meter (Toramaru, 2006), which is commonly used to estimate magma ascent velocity from *VND* of volcanic ejecta, fails to explain the experimentally observed decompression rate independent *VND*. Alternatively, decompression induced H_2O-silicate melt phase separation may be described by the theory of spinodal decomposition (Cahn, 1965) at the limit of thermodynamic stability. Critical behavior of hydrous silicate melt has already been evidenced experimentally by e.g. Shen and Keppler (1997) and is attributed to spinodal decomposition.
Irrespective of the phase separation mechanism, a decompression rate independent *VND* has profound consequences for the degassing dynamics of natural polyphase hydrous magma, that contain crystals and pre-existing fluid vesicles. During ascent, H_2O supersaturation is decreased in melt shells surrounding pre-existing vesicles by H_2O diffusion. Homogeneous phase separation occurs in interstitial melt volumes in which sufficient supersaturation is still preserved. If the decompression rate is fast enough to maintain such supersaturated volumes, the formation of vesicles with high log*VND* of 5.2 inevitably causes efficient melt degassing within seconds due to short H_2O diffusion distances on a 10 μm scale from the melt into fluid vesicles. This causes rapid density decrease accompanied by sudden increase of magma buoyancy required for explosive volcanism.

Cahn, J.W., 1965. J. Chem. Phys. 42, 93–99.
Shen, A.H., Keppler, H., 1997. Nature 385, 710–712.
Toramaru, A., 2006. J. Volcanol. Geotherm. Res. 154, 303–316.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: magma degassing, magma ascent rate, vesicle number density, spinodal decomposition, phase separation

©2019. Japan Geoscience Union. All Right Reserved.

Role of water on dynamics in the lower mantle and core-mantle boundary regions

*Eiji Ohtani[1], Takayuki Ishii[2], Liang Yuan[1], Daijo Ikuta[1], Tomoo Katsura[2], Dan Frost[2]

1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2. Bavarian Research Institute, University of Bayreuth

Recent experimental evidence indicated that the Earth’ s transition zone contains some amount of water at least locally. Subduction of the slabs into the lower mantle can transport water further into the lower mantle. One of the most important candidates of the water carrier into the lower mantle is hydrous phase delta-AlOOH and phase H-$MgSiO_4H_2$ solid solution. Our works on the stability of this solid solution revealed that it coexists with bridgmanite under the lower mantle conditions [1, 2].

We studied the hydrogen and aluminum partitioning between alumina and hydrogen between the delta-H solid solution and aluminous bridgmanite at high pressure and temperature. We observed that bridgmanite under the wet conditions depleted in aluminum, and it contains almost no water under the wet lower mantle conditions at 28 GPa and 800-1400°C. This partitioning of H and Al can provide significant effect on lower mantle dynamics through the change of the garnet-bridgmanite phase boundary, the pressure of the spin transition of both bridgmanite and delta-H solid solution, and bridganite-postperovskite transition.

The supply of water to the core-mantle boundary can create a reaction of water and iron in the core to produce FeO_2H and its reaction product postperovskite Fe_2O_3. These phases together with the delta-H solid solution can play important roles at the bottom of the lower mantle. Physical properties of these phases can account for the sound velocity and density anomalies in the regions such as ULVZ (ultra-low velocity zone) and LLSVP (large low shear velocity province) [3].

References:

[1] Ohira et al. (2014) Earth Planet. Sci. Lett., 401: 12–17, [2] Ohtani et al. (2018) Jour. Asian Earth Sci. 2018, [3] Yuan et al. (2018) Geophys. Res. Lett.,45. doi.org/10.1002/2017GL0757

Keywords: Water, lower mantle, hydrous mineral, phase delta, phase H, bridgmanite

©2019. Japan Geoscience Union. All Right Reserved.

Stability of Fe-bearing hydrous phases and element partitioning in the system MgO-Al_2O_3-Fe_2O_3-SiO_2-H_2O in Earth's lowermost mantle

*Hongsheng Yuan[1], Li Zhang[1], Eiji Ohtani[2], Yue Meng[3], Eran Greenberg[4], Vitali B. Prakapenka [4]

1. Center for High Pressure Science and Technology Advanced Research, 2. Department of Earth Science, Graduate School of Science, Tohoku University, 3. HPCAT, X-Ray Science Division, Argonne National Laboratory, 4. Center for Advanced Radiation Sources, University of Chicago

We performed experiments on a synthetic hydrous gel consisting of a model composition of subducted slabs in the MgO–Al_2O_3–Fe_2O_3–SiO_2–H_2O system and containing ~7 wt.% water. The experiments were conducted in laser-heated diamond anvil cells under high pressure–temperature (*P-T*) conditions corresponding to the lowermost mantle using *in situ* synchrotron X-ray diffraction and *ex situ* transmission electron microscope techniques. The hydrous δ-phase AlOOH–FeOOH–$MgSiO_2(OH)_2$–SiO_2 (with an orthorhombic symmetry and the space group of *Pnnm*) coexists with bridgmanite (Bdg), post-perovskite (pPv), or both in a broad *P-T* range of 104–126 GPa and 1900–2500 K, whereas the pyrite-type (py) $FeOOH_x$ phase was only observed to coexist with the pPv phase by *in situ* XRD. Chemical analysis on recovered samples showed that (i) in the Bdg-bearing assemblage quenched from 104 GPa and 1900 K, the Bdg phase contains ~8 at.% Al and ~11 at.% Fe, and the coexisting hydrous δ-phase contains ~70 at.% Al and ~14 at.% Fe; (ii) in the pPv-bearing assemblage quenched from 117 GPa and 2050 K, the pPv phase contains ~7 at.% Al and ~16 at.% Fe, and the coexisting hydrous δ-phase contains ~81 at.% Al and ~9 at.% Fe. The considerable $Fe_2O_2(OH)_2$ (8–13 mol%) and SiO_2 (9–13 mol%) content in the δ-phase does not reduce its thermal stability; therefore, the Fe-bearing δ-phase can transport water to the lowermost mantle along the mantle geotherm. The dense py-phase may accumulate in the lowermost mantle in the presence of the pPv phase. In a hydrous system, Al_2O_3 depletion in both the Bdg and pPv phases can significantly reduce the width of the Bdg to pPv transition compared with the width in a dry system. On the other hand, significant Fe enrichment in pPv relative to the coexisting Bdg lowers the transition pressure to the depth of the D'' discontinuity. Accordingly, the depth and thickness of the Bdg to pPv transition in subducted hydrous basaltic crustal materials might explain the seismically detected D'' discontinuity. The formation of the dense hydrous py-phase in subducted slabs may contribute to chemical heterogeneities in the lowermost mantle.

Keywords: deep lower mantle, hydrous phase, bridgmanite to post-perovskite transition, synchrotron X-ray diffraction, multigrain analysis

©2019. Japan Geoscience Union. All Right Reserved.

Laboratory Micro-Seismicity during Serpentinite Deformation as a Potential Analogue for Lower Wadati-Benioff Plane Seismicity

*Julien Gasc[1,3], Nadège Hilairet[2], Tony Yu[3], Yanbin Wang[3], Thomas P. Ferrand[1], Alexandre Schubnel[1]

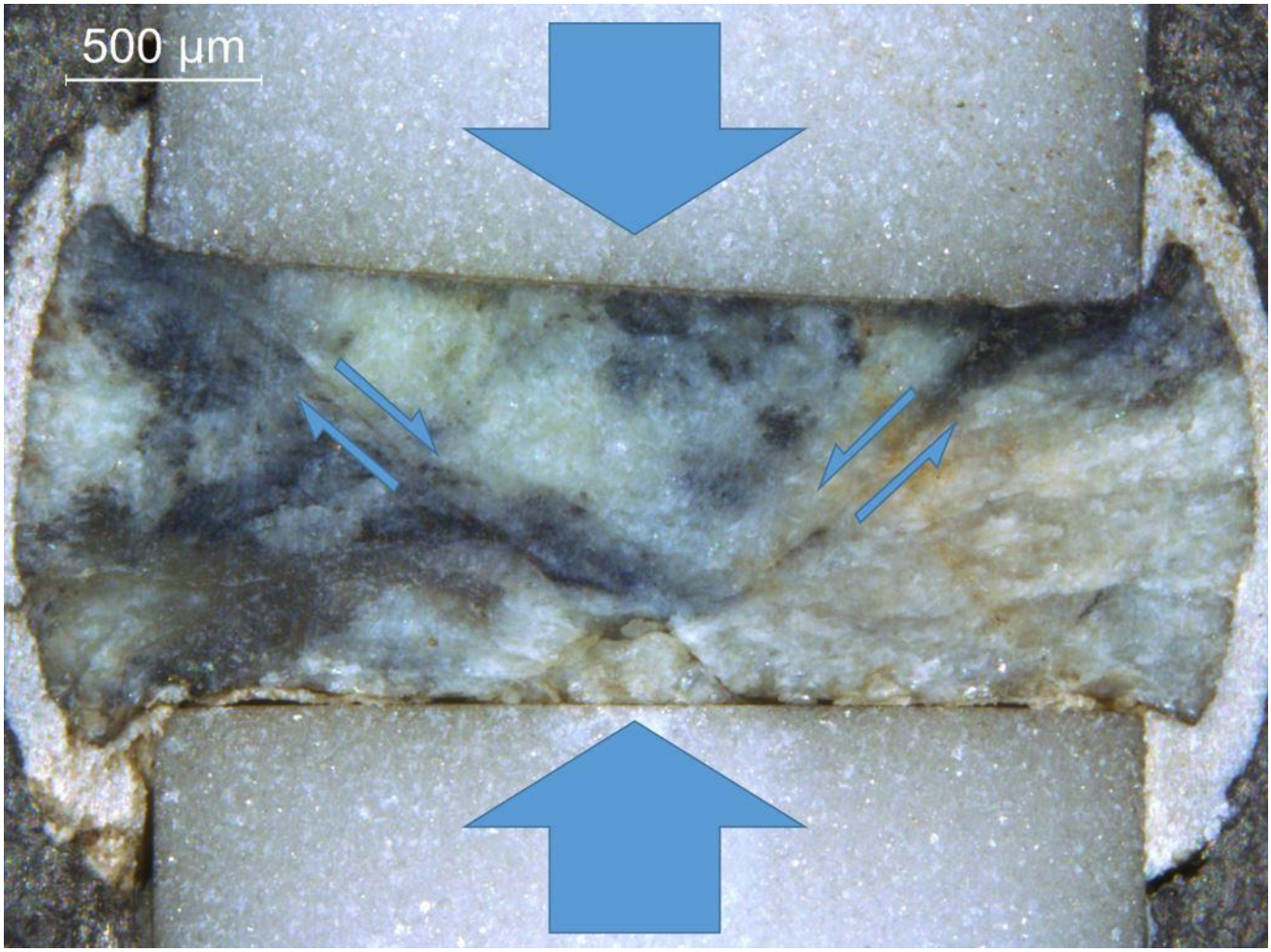
1. Laboratoire de Géologie, CNRS - ENS, Paris, FRANCE, 2. Unité Matériaux et Transformations, CNRS - Lille University, Villeneuve d'Ascq, FRANCE, 3. GeoSoilEnviro-CARS, University of Chicago, Argonne IL, USA

The origin of intermediate-depth earthquakes, which occur at depths of 60-300 km along subducting slabs, remains somehow enigmatic. In the pressure and temperature conditions involved, rocks should indeed deform in a ductile fashion. Dehydration embrittlement, due to serpentine breakdown, was long considered a good candidate to explain lower Wadati-Benioff plane seismicity. However, unlike in the classic dehydration embrittlement theory, dehydration induced volume changes are negative at such depths and cannot trigger instabilities via pore pressure buildup. Accordingly, some experimental studies have shown that faulting of serpentinites related to dehydration, occurs in a stable and aseismic way (Chernak and Hirth, 2011; Gasc et al., 2011). Nevertheless, tremendous progress was recently made in understanding the mechanics of intermediate earthquakes, notably thanks to the combination of high pressure deformation experiments and in-situ synchrotron techniques. In order to assess the seismic potential of serpentinites, micro-seismicity was monitored during high pressure experiments by recording Acoustic Emissions (AE's) –or labquakes. A D-DIA apparatus was used to deform natural antigorite-rich samples at pressures of 1-5 GPa, both within and outside antigorite's stability field.

Below 400˚C, the deformation of fully hydrated serpentinite samples involves aseismic ductile cataclastic flow. Above 600˚C, despite conditions propitious to dehydration embrittlement (i.e., with fast strain rates and reaction kinetics), joint deformation and dehydration also lead to ductile shear, without generation of AE's. However, samples show a brittle temperature window around 500˚C that seems to correlate with the very onset of the mineral's breakdown, and is therefore not associated to significant release of water. In this latter case, AE's are consistently collected upon faulting and extremely sharp strain localization is observed (Gasc et al., 2017). In addition, brittle faulting of partly hydrated samples (a mixture of olivine and antigorite) can also occur with minor amounts of antigorite, due to stress percolation upon antigorite breakdown. Unlike for low-pressure dehydration embrittlement, faulting is also enabled here by the metastability of the solid phase rather than by fluid overpressure and dynamic fault propagation occurs concomitantly with the appearance of pseudotachylites along the fault plane (Ferrand et al., 2017).
Both brittle failure mechanisms identified in these studies share major similarities with the now-classic concept of transformational faulting (Burnley et al., 1991), often invoked for deep-focus earthquakes, and both may be a source of seismicity in subducting slabs. We provide evidence that destabilizing antigorite at mantle depths can initiate faulting and thus be involved in intermediate-depth earthquakes. However, analysis of the acoustic signal shows that it is relatively weaker than its real-earth counterpart, once scaled relative to standard brittle faulting. This suggests that other mechanisms are responsible for large intermediate-depth earthquakes, which may reflect fault propagation in the adjacent peridotitic mantle.

Keywords: intermediate-depth earthquakes, serpentinite, high pressure, deformation experiments, acoustic emissions

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Water transport and mixing in the whole-mantle scale convection

*Takeo Kaneko[1], Tomoeki Nakakuki[1], Masanori Kameyama[2], Hikaru Iwamori[3]

1. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2. Geodynamics Research Center, Ehime University, 3. Earthquake Research Institute, University of Tokyo

The subduction of oceanic plates transports sea water with the basaltic crust to the Earth’ s interior. High-pressures experiments reveal that nominally anhydrous minerals (NAMs) contain the water of a few thousands ppm in the weight fraction. On the other hand, numerical simulations show that the NAMs layer above the subducted slab plays an important role in water transport into the deep mantle. However, the details of the water circulation and distribution processes on the whole mantle has still not been understood well.
We perform numerical simulations of isoviscous mantle convection in a two-dimensional cylinder in which hydrous-mineral phase changes and the hydration-dehydration reaction are considered. We systematically examined the effects of parameters that control activity and mixing efficiency of the mantle convection, i.e., the Rayleigh number, the internal heating rate, and the water storage capacity of the lower mantle, on the water transport into the deep mantle.
The distribution and total amount of the water transported into the mantle strongly depends on the convection style. When the internal heating is absent, stable cellular flow dominates the mantle convection. The stable convection does not mix water well so that the water distributes only near the convection cell boundary. When the mantle has the internal heating, the mantle flow becomes strongly time-dependent by thermal boundary layer instabilities. Migration of the convection cell boundary enhances the mixing of the water into the whole mantle. In addition, mixing efficiency increases with the Rayleigh number, which is an index indicating convective vigor. When the water storage capacity of the lower mantle is much smaller than the NAMs, the ejected water forms the regional hydrous layer with high water content over the 660 km discontinuity near the downwellings. However, these hydrous regions are hindered from globally spreading to the mantle transition zone. The water content in most of the mantle rocks becomes equal to the smaller value among water storage capacities of the NAMs in the upper mantle and the lower mantle finally, though the upper mantle can accommodate more water. The amount of the water stored in the whole mantle rocks is, therefore, smaller than the summation of their capacities. As a result, the equilibrium of the water regassing and degassing is realized more rapidly than the whole mantle rocks are completely saturated.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS03] Evolution and variability of the Asian monsoon in Cenozoic global climate changes

convener:Masanobu Yamamoto(Faculty of Environmental Earth Science, Hokkaido University), Ryuji Tada(Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo), Chairperson:Masanobu Yamamoto(Hokkaido University), Tomohisa Irino, Yoshimi Kubota(National Science Museum), Ryuji Tada(The University of Tokyo)

The Asian Monsoon (AM) is a part of interhemispheric atmospheric phenomena that is driven by the thermal gradient between ocean and land. Contrasts of insolation, heat content and latent heat transfer between ocean and land may have affected the behavior of the AM in the past, but the proxy records are occasionally controversial and do not show a clear picture of the AM variability. Recent proxy and modeling studies suggest that glacial pCO2 cycles could be related to the position of southern westerlies, which is sensitive to interhemispheric heat imbalance. Because monsoon is driven by the heat imbalance, knowledge on the variability of the AM is important to understand the behavior of the global climate system. In this session, presentations on the reconstruction of long-term AM variability from various archives such as IODP expedition cores, discussion on its forcing, and the roles of the AM in global climate changes are welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS03-01] Reconstruction of Indian summer monsoon variability during the last 1,460,000 years

*Masanobu Yamamoto[1], Steven Clemens[2] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Department of Earth, Environmental and Planetary Sciences, Brown University)

2:00 PM - 2:20 PM JST | 5:00 AM - 5:20 AM UTC

[MIS03-02] Pleistocene Seawater $\delta^{18}O$ reconstructions from the Indian and East Asian Monsoon Regions

★Invited Papers

*Steven C Clemens[1], Masanobu Yamamoto[2] (1.Brown University, 2.Hokkaido University)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[MIS03-03] The Monsoon Erosion Pump

★Invited Papers
Cancelled

*Liviu Giosan[1] (1.Woods Hole Oceanographic Institution)

2:40 PM - 3:00 PM JST | 5:40 AM - 6:00 AM UTC

[MIS03-04] East Asian winter monsoon intensity in the Pleistocene based on seasonal land snail shell stable isotope ratios

★Invited Papers

*David L Dettman[1,3], Xin Wang[2], Mi Wang[2], Junhui Zhang[2] (1.University of Arizona, Geosciences Dept., Environmental Isotope Lab., 2.Lanzhou University, Key Laboratory of Western China's Environmental Systems, College of Earth and Environmental Sciences, 3.Shimane University, Estuary Research Center)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS03-05] Reconstruction of ventilation history of the Japan Sea based on physical properties data collected during IODP Exp. 346

*Tomohisa Irino[1], Liviu Giosan[2], Ryuji Tada[3], Ken Ikehara[4] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Woods Hole Oceanographic Institution, 3.Graduate School of Science, University of Tokyo, 4.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

Reconstruction of Indian summer monsoon variability during the last 1,460,000 years

*Masanobu Yamamoto[1], Steven Clemens[2]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Department of Earth, Environmental and Planetary Sciences, Brown University

Monsoon is an atmospheric phenomenon dominant in low and mid-latitudes and determines the temporal and spatial distributions of rainfall that govern vegetation. A classical model assumes that monsoon responds to precession-controlled changes in seasonal insolation. Speleothem records show a precession cycle in oxygen isotope variation consistent with this model, but marine and loess records generally do not show strong precession variation. This mismatch has long been debated. Key approach is the precipitation reconstruction to understand past changes in summer monsoon. In this study, we generated an Indian summer monsoon (ISM) record by evaluating riverine discharge. We used GDGT indices, i.e., CBT and MBT, as a proxy of soil organic matter contribution and generated a 1,700-year resolution record of Mahanadi River soil discharge in IODP Site U1446 to understand changes in the ISM rainfall during the last 1,460,000 years. The CBT and BIT show a similar variation according to glacial-interglacial cycles. Maxima appeared after the peak of interglacial. Minima appeared during deglaciations. Their variations are reversely correlated with the sea water $\delta^{18}O$ obtained based on *G. ruber* $\delta^{18}O$, global $\delta^{18}O$ and TEX_{86}-based SST. The records are consistent with previously-reported ISM records from marine archives and Borneo speleothems in the overlap periods and different from Chinese speleothem records. Spectral analysis indicates that BIT and CBT show 100,000, 41,000, 30,000, 23,000 and 19,000-year cycles during the last 800,000 years, the variation was out of phase with variation in northern hemisphere summer insolation. This suggests that the ISM did not respond directly to orbital forcing, in contrast to the classical hypothesis, but was driven by internal feedback processes. Orbital cycles were not clearly shown prior to 800,000 years ago. This suggests that the strong response of the ISM to orbital forcing was initiated around 800,000 years ago, which coincided with the onset of glacial 100,000 year cycles.

Keywords: Indian summer monsoon, Pleistocene, IODP

©2019. Japan Geoscience Union. All Right Reserved.

Pleistocene Seawater $\delta^{18}O$ reconstructions from the Indian and East Asian Monsoon Regions

*Steven C Clemens[1], Masanobu Yamamoto[2]

1. Brown University, 2. Hokkaido University

The study of orbital-scale climate change during the late Pleistocene is unique in that the signal-to-noise ratio is large, the external forcing (insolation) is known, and the critical internal forcings (greenhouse gases and terrestrial ice volume) are well constrained. As such, it should be possible to assess the underlying mechanisms driving climate change at this time scale, as well as the relative sensitivity to these forcing mechanisms.

We present three reconstructions of local seawater $\delta^{18}O$, including previously published records from the East China Sea (U1429)[*S. C. Clemens et al.*, 2018], the Andaman Sea (NGHP 17)[*Gebregiorgis et al.*, 2018], and our new work from the northeast Indian Margin, Bay of Bengal (U1446). Local seawater $\delta^{18}O$ is based on removal of the SST and global seawater $\delta^{18}O$ from planktonic foraminifer $\delta^{18}O$ and reflects changes in surface salinity driven by rainfall and runoff from surrounding catchment basins. This proxy offers an independent reconstruction for comparison to speleothem $\delta^{18}O$ and other proxies in order to assess driving mechanisms and the extent to which the Indian and East Asian subsystems covary with one another.

In the northern East China Sea, *G. ruber* $\delta^{18}O$ has the same precession- and millennial-scale structure as the onshore speleothem $\delta^{18}O$ record from the Yangtze River Valley[*Cheng et al.*, 2016]. However, after removing the temperature and global seawater $\delta^{18}O$ signals, the offshore seawater $\delta^{18}O$ has almost no precession-scale (23 kyr) variance)[*S. C. Clemens et al.*, 2018]. This result contrasts with the speleothem record, which is almost exclusively dominated by precession-scale variance, and argues against external insolation as the primary driver of East Asian monsoon rainfall in the Yangtze River Valley region.

The Andaman Sea record monitors direct rainfall and runoff from the Irrawaddy and Salween catchment basins. The precession-band timing of low seawater $\delta^{18}O$ (increased rainfall, low mixed-layer salinity) indicates that strong monsoonal rainfall lags maximum northern hemisphere insolation by ~9 kyrs at the precession band[*Gebregiorgis et al.*, 2018]. Our new Indian Margin record resides within the low-salinity East India Coastal Current fed by runoff from the Ganges-Brahmaputra complex, the Mahanadi Basin, and direct rainfall. The Indian Margin seawater $\delta^{18}O$ reconstruction also demonstrates this large lag. The lag in both these records agrees with that of the summer-season (southwest) monsoon wind strength records from the NW Arabian Sea[*S.C. Clemens and Prell*, 2003; *S.C. Clemens et al.*, 1991].

This precession-band timing (lagging minimum precession by 7-9 kyrs) precludes insolation as a direct forcing for Indian monsoon rainfall and wind strength, pointing instead to decreased high-latitude ice volume, increased greenhouse gasses, and latent heat export from the southern hemisphere as the primary drivers of monsoon circulation at these time scales[*S.C. Clemens and Prell*, 2003].

©2019. Japan Geoscience Union. All Right Reserved.

Cheng, H., et al. (2016), The Asian monsoon over the past 640,000 years and ice age terminations, Nature, 534(7609), 640-646, doi: 10.1038/nature18591

Clemens, S. C., and W. L. Prell (2003), A 350,000 year summer-monsoon multi-proxy stack from the Owen Ridge, Northern Arabian Sea, Marine Geology, 201, 35-51.

Clemens, S. C., W. L. Prell, D. Murray, G. Shimmield, and G. Weedon (1991), Forcing mechanisms of the Indian Ocean monsoon, Nature, 353, 720-725.

Clemens, S. C., A. Holbourn, Y. Kubota, K. E. Lee, Z. Liu, G. Chen, A. Nelson, and B. Fox-Kemper (2018), Precession-band variance missing from East Asian monsoon runoff, Nature Communications, 9(1), 3364, doi: 10.1038/s41467-018-05814-0.

Gebregiorgis, D., E. C. Hathorne, L. Giosan, S. Clemens, D. Nürnberg, and M. Frank (2018), Southern Hemisphere forcing of South Asian monsoon precipitation over the past ~1 million years, Nature Communications, 9(1), 4702, doi: 10.1038/s41467-018-07076-2.

Keywords: East Asian Monsoon, Indian Monsoon, East China Sea, Bay of Bengal, Paleoclimate, Greenhouse Gas

©2019. Japan Geoscience Union. All Right Reserved.

The Monsoon Erosion Pump

*Liviu Giosan[1]

1. Woods Hole Oceanographic Institution

Understanding the factors controlling the flux of materials from land to oceans has key implications for global biogeochemical cycling and the links between the sedimentary record and landscape evolution. Monsoonal climates are recognized as prodigious sediment producers but conflicting proxy reconstructions limit assessing their influence on land-sea material transfers at various timescales. Here I discuss the concept of a monsoon erosion pump based on terrestrial and oceanic records reconstructed from recent Indian National Gas Hydrate Program and IODP drilling in the Bay of Bengal, Arabian and Andaman Seas. From millennial to orbital to tectonic timescales, these records suggest that vegetation land cover interacts and modulates the regime of erosion and weathering under perennial but variable monsoonal rain conditions. Under this new proposed interpretation the Indian monsoon exhibits two distinct flavours during the Cenozoic that can be largely explained by its heartbeat, or astronomical forcing. This erosional regime is mediated by the global glacial state and attendant sea level and by limiting conditions imposed by the paleogeography of Asia.

Keywords: monsoon, India, erosion

©2019. Japan Geoscience Union. All Right Reserved.

East Asian winter monsoon intensity in the Pleistocene based on seasonal land snail shell stable isotope ratios

*David L Dettman[1,3], Xin Wang[2], Mi Wang[2], Junhui Zhang[2]

1. University of Arizona, Geosciences Dept., Environmental Isotope Lab., 2. Lanzhou University, Key Laboratory of Western China's Environmental Systems, College of Earth and Environmental Sciences, 3. Shimane University, Estuary Research Center

Monsoon climates are characterized by strong seasonal oscillations between a very wet season and very dry conditions. The study of ancient variation in monsoon climate strength and its impact on regional environments is difficult because geological materials rarely record individual seasons. It is difficult to infer seasonal change through time when working with oxygen isotope records that average multiple years or centuries. One solution is to use high-resolution sampling of land snail shells as monitors of wet-season and dry-season differences. Although land snail fossils are often rare, in many cases they are well preserved and widely distributed across the planet. We subsampled shells along the spiral growth axis, producing 15 to 35 samples per shell to document maximum and minimum oxygen and carbon stable isotope ratios. The most robust signal in land snail shell oxygen isotope records is connected to evaporation. The arid dry-season leads to significant evaporation in the land snail body water, which elevates the δ18O values recorded in the shell. Wet-season oxygen isotope ratios are more negative and can be tied roughly to the δ18O of wet season precipitation and summer temperatures. Carbon isotope ratios are tied to the diet of the animals, and reveal the proportion of C3 and C4 plants in the landscape.

Larger land snail (> 1.5 cm diameter) taxa have behaviors that can lead to significant evaporation of body water, as they are willing to range away from local water sources. Modern samples show that the total amplitude in oxygen isotope variation in a shell can be related to the intensity and duration of the dry season. This suggests that amplitudes in ancient shells are indicators of the winter monsoon strength. Although under extremely arid conditions snail growth occurs only when surface water is available and d18O amplitudes collapse in desert conditions. The most negative δ18O values are not correlated with the intensity of the summer monsoon, suggesting that δ18O values are not good indicators of summer monsoon strength.

Data from one genus of land snail (*Cathaica* species) living on the Chinese loess plateau throughout the late Pleistocene allow us to make some generalizations about monsoon climate in this region. In general, the oxygen isotope amplitude in shells from glacial periods are larger than those from the interglacial periods. This suggests that the East Asian Winter Monsoon was strongest during glacial intervals on the Loess Plateau. The largest δ18O amplitude observed was 19.2 ‰. Marine Isotope Stages 2, 6, and 8 have the largest amplitudes and, by inference, the strongest winter monsoons in our record. Older glacial intervals seem to have weaker winter monsoons. However, glacial amplitudes were not always larger, just as climate undergoes significant short-term variation in glacial intervals (such as D-O cycles and Heinrich events) oxygen isotope amplitudes show large amounts of variability in glacial times. In contrast, interglacial intervals tend to have smaller δ18O amplitudes, pointing to warmer and wetter winters in interglacial times. But like the glacial data, some interglacial amplitudes are larger than some glacial records. These data show that the differences in high frequency climate variability is as large as the differences between glacial and interglacial climates.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Winter Monsoon, Seasonality, Oxygen isotopes, Land Snails

©2019. Japan Geoscience Union. All Right Reserved.

Reconstruction of ventilation history of the Japan Sea based on physical properties data collected during IODP Exp. 346

*Tomohisa Irino[1], Liviu Giosan[2], Ryuji Tada[3], Ken Ikehara[4]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Woods Hole Oceanographic Institution, 3. Graduate School of Science, University of Tokyo, 4. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology

The Japan Sea is a semi-enclosed marginal sea located at the eastern edge of Asian continent and under the influence of east Asian monsoon. The primary production is controlled by nutrient supply from the East China Sea by summer monsoon, while deep water ventilation is promoted by winter monsoon cooling of the surface water of the Japan Sea. Perfectly continuous sediment splice sequences were established at Sites U1422-U1427 and U1430 which have been correlated among others using apparent dark-light cycles. The coverage of water depths are, in ascending order, 330 m at Site U1427, 903 m at Site U1426, 1072 m at Site U1430, 1785 m at Site U1423, 1909 m at Site U1425, 2808 m at Site U1424, and 3429 m at Site U1422, which enable us to reconstruct the temporal variation of depth distribution of organic carbon flux related to the past primary production and deep water ventilation in the Japan Sea.

For calculation of the mass accumulation of organic carbon (OC flux) at each site, we used the perfectly continuous records of dry bulk density (DBD) and total organic carbon content (TOC) calculated from shipboard measurements such as gamma-ray attenuation (GRA) density with grain density and a strong negative correlation between TOC and photo RGB values, respectively. Linear sedimentation rate (LSR) of each site was estimated based on the projection of the age model established at Site U1424 by tuning the GRA variation onto LR04 benthic oxygen isotope curve. Based on the consistent correlation among sites, depth distribution of OC flux was reconstructed for 1 ky step during the last 1.5 million years.

Princple component analysis for depth-temporal OC flux distribuion suggests that three princple component explain 74% of the total variance. Principle component (PC) 1 loading was positively correlated with all the sites except for the U1427 (330 m), while PC2 loading was correlated positively with sites shallower than 1000 m and negatively with those deeper than 2000 m. PC3 loading was correlated negatively with sites around 1000 m and positively with other sites. Such depth dependent patterns suggest that primary production (PC2) and ventilation (PC1) at middle to deeper depth were primary controls on the OC deposition. PC3 may indicate stronger middle depth ventilation or (oppositely) formation of oxygen minimum zone.

We also examined the color variation of these sediments using metric hue. Sediment color varies between dull green (higher hue) and olive (lower hue). Average metric hue is about 88 degree for all the site and variability is smaller for shallower sites. The metric hue at Site U1425 (1909 m) varies in harmony with the score of PC1, and lower metric hue is associated with larger PC1 score. Namely, higher OC flux (a lower oxygenation level) was associated with more olive color, which could be interpreted that dull green background (detritus) color was overridden by olive color reduced iron. Such an agreement between independently estimated variables suggests that the deep water ventilation intensity in the Japan Sea could be independently reconstructed as a proxy of winter monsoon intensity.

Keywords: Japan Sea, Organic carbon flux, Ventilation, IODP Expedition 346

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS03] Evolution and variability of the Asian monsoon in Cenozoic global climate changes

convener:Masanobu Yamamoto(Faculty of Environmental Earth Science, Hokkaido University), Ryuji Tada(Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo), Chairperson:Ryuji Tada(The University of Tokyo), Yoshimi Kubota(National Science Museum), Masanobu Yamamoto(Hokkaido University)

The Asian Monsoon (AM) is a part of interhemispheric atmospheric phenomena that is driven by the thermal gradient between ocean and land. Contrasts of insolation, heat content and latent heat transfer between ocean and land may have affected the behavior of the AM in the past, but the proxy records are occasionally controversial and do not show a clear picture of the AM variability. Recent proxy and modeling studies suggest that glacial pCO2 cycles could be related to the position of southern westerlies, which is sensitive to interhemispheric heat imbalance. Because monsoon is driven by the heat imbalance, knowledge on the variability of the AM is important to understand the behavior of the global climate system. In this session, presentations on the reconstruction of long-term AM variability from various archives such as IODP expedition cores, discussion on its forcing, and the roles of the AM in global climate changes are welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS03-06] The spatial-temporal patterns of Indian monsoonal variations during the past 80 kyr recorded in NGHP-02 Hole 19B, western Bay of Bengal: Implications from chemical and mineral properties

*Yuki Ota[1,2,3,4], Hodaka Kawahata[4], Junichiro Kuroda[4,3], Atsushi Suzuki[2], Daisuke Araoka[2], Asuka Yamaguchi[4], Ayako Abe-Ouchi[4] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

3:45 PM - 4:05 PM JST | 6:45 AM - 7:05 AM UTC

[MIS03-07] **400,000 years millennial scale temperature and rainfall in East Asia deduced from paired Mg/Ca and oxygen isotope of planktic foraminifera from the East China Sea**

★Invited Papers

*Yoshimi Kubota[1], Steven Clemens[2], Kyung-Eun Lee[3], Ann Holbourn[4], Etsuko Wakisaka[5], Keiji Horikawa[5], Ryuji Tada[6], Katsunori Kimoto[7] (1.National Museum of Nature and Science, 2.Brown University, 3.Korea Maritime and Ocean University, 4.Christian-Albrechts-University, 5.University of Toyama, 6.The University of Tokyo, 7.Japan Agency for Marine-Earth Science and Technology)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MIS03-08] Onset and evolution of millennial-scale variability of East Asian Monsoon recorded in the Japan Sea sediments: New data with new interpretation

*Ryuji Tada[1], Tomohisa Irino[2], Arisa Seki[3], Masafumi Murayama[4], Kaz Mitake[1], Masayuki Ikeda[5] (1.Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo, 2.Faculty of Environmental Earth Science, Hokkaido University, 3.Faculty of Science, Shinshu University, 4.Faculty of Agriculture and Marine Science, 5.Shizuoka University)

4:20 PM - 4:40 PM JST | 7:20 AM - 7:40 AM UTC

[MIS03-09] Interhemispheric linkages of Australian and Asian monsoons on a warmer-than-modern Earth

★Invited Papers

*Ann E Holbourn[1], Wolfgang Kuhnt[1], Janika Joehnck[1], Sebastian Beil[1], Julia Luebbers[1], Kenji Marc Raymond Matsuzaki[2], Yair Rosenthal[3], Denise Kulhanek[4], IODP Expedition 363 Scientists (1.University of Kiel, 2.University of Tokyo, 3.Rutgers University, 4.Texas A&M University)

4:40 PM - 5:00 PM JST | 7:40 AM - 8:00 AM UTC

[MIS03-10] **Miocene evolution of the Asian Monsoon from climate and productivity proxies in the Bay of Bengal and South China Sea**

★Invited Papers

*Wolfgang Kuhnt[1], Julia Luebbers[1], Ann Holbourn[1], Karlos GD Kochhann[2], Steven C Clemens[3], Clara T Bolton[4], Yoichi Usui[5] (1.University of Kiel, 2.UNISINOS University, 3.Brown University, 4.Aix-Marseille Université, 5.Japan Agency for Marine-Earth Science and Technology)

The spatial-temporal patterns of Indian monsoonal variations during the past 80 kyr recorded in NGHP-02 Hole 19B, western Bay of Bengal: Implications from chemical and mineral properties

*Yuki Ota[1,2,3,4], Hodaka Kawahata[4], Junichiro Kuroda[4,3], Atsushi Suzuki[2], Daisuke Araoka[2], Asuka Yamaguchi[4], Ayako Abe-Ouchi[4]

1. Department of Earth and Planetary Science, The University of Tokyo, 2. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3. Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4. Atmosphere and Ocean Research Institute, The University of Tokyo

Detailed reconstruction of Indian summer monsoons is necessary to better understand the late Quaternary climate history of the Bay of Bengal and Indian peninsula. We established a chronostratigraphy for a sediment core from Hole 19B in the western Bay of Bengal, extending to approximately 80 kyr BP, and examined major and trace element compositions and clay mineral components of the sediments. Lower lithogenic matter flux, higher $\delta^{18}O$ values, and weaker weathering in the sediment source area during marine isotope stages (MIS) 2 and 4 compared to MIS 1, 3, and 5 are explained by increased Indian summer monsoonal precipitation and river discharge around the western Bay of Bengal. Chemical components indicate a felsic sediment source, suggesting the Precambrian gneissic complex of the eastern Indian peninsula as the dominant sediment source at this site since 80 kyr. Trace element ratios indicate increased sediment contributions from mafic rocks during MIS 2 and 4. We interpret these results as reflecting the changing influences of the eastern and western branches of the Indian summer monsoon, and a greater decrease in rainfall in the eastern and northeastern parts of the Indian peninsula than in the western part during MIS 2 and 4.

Keywords: Indian Monsoon, Bay of Bengal sediments, late Quaternary

©2019. Japan Geoscience Union. All Right Reserved.

400,000 years millennial scale temperature and rainfall in East Asia deduced from paired Mg/Ca and oxygen isotope of planktic foraminifera from the East China Sea

*Yoshimi Kubota[1], Steven Clemens[2], Kyung-Eun Lee[3], Ann Holbourn[4], Etsuko Wakisaka[5], Keiji Horikawa[5], Ryuji Tada[6], Katsunori Kimoto[7]

1. National Museum of Nature and Science, 2. Brown University, 3. Korea Maritime and Ocean University, 4. Christian-Albrechts-University, 5. University of Toyama, 6. The University of Tokyo, 7. Japan Agency for Marine-Earth Science and Technology

Abrupt millennial-scale climate changes during the late Quaternary were widely recognized in the East Asian monsoon region from deep-sea sediments in the Japan Sea and more recently from oxygen isotope ($\delta^{18}O$) variability in Chinese speleothems ($\delta^{18}O_{sp}$). The finely ^{230}Th-dating method on the speleothems enables comparison to climate records from other regions on millennial scale, and there is little doubt that the variability of these $\delta^{18}O_{sp}$ records is synchronized with climate perturbation in the North Atlantic high latitude, known as Heinrich events and with Dansgaard-Oeschger (D-O) oscillations in Greenland. However, mechanisms of the climate response in East Asia remain unclear due to the lack of fundamental agreement on what the $\delta^{18}O_{sp}$ climate signal represents. A primary impediment to interpreting the variability in $\delta^{18}O_{sp}$ is the lack of the means to decompose $\delta^{18}O_{sp}$ into constituent components. By contrast, the $\delta^{18}O$ of calcite planktic foraminifers ($\delta^{18}O_{p}$) from nearshore marine sediments can be quantitatively partitioned into sea surface temperature (SST) and $\delta^{18}O_{w}$ of seawater ($\delta^{18}O_{w}$), a function of sea surface salinity (SSS). In this study, millennial-scale climate variability in East Asia is investigated using 400,000-yr records of SST, $\delta^{18}O_{p}$, and $\delta^{18}O_{w}$ from the East China Sea (IODP Site U1429). $\delta^{18}O_{w}$ can be interpreted as reflecting SSS, hence rainfall, as the monsoonal runoff from the Yangtze River determines summer SSS in the northern East China Sea. As a result, SST and $\delta^{18}O_{w}$ variability accounts for 58% and 35% of the total variability of $\delta^{18}O_{p}$ and the rest (6%) is the ice volume component or noise; the primary contributor to $\delta^{18}O_{p}$ variations is SST, and the secondary is $\delta^{18}O_{w}$. Foraminiferal $\delta^{18}O_{p}$ shows the strongest similarly with Chinese $\delta^{18}O_{sp}$, indicating that $\delta^{18}O_{sp}$ is best interpreted as the combination of changes in surface temperature and monsoon rainfall; it is not indicative of summer monsoon rainfall alone. Partitioning of variance between temperature and rainfall does not change on glacial-interglacial timescales indicating that the hemispheric teleconnection mechanism between the Atlantic and East Asia does not depend on the global climate background status (CO_2, ice volume). In comparison with the millennial scale Greenland temperature, the East China Sea SST decreases and $\delta^{18}O_{w}$ increases (rainfall deceases) in most of the North Atlantic cold events (e.g., Heinrichs). However, SST and $\delta^{18}O_{w}$ exhibit overall poor coherence, revealing that these climate parameters fundamentally behave differently on the millennial scale, but tend to respond in the manner described above (decrease in temperature and rainfall) once a severe cold event occurs in the North Atlantic.

Keywords: Asian Monsoon, East China Sea, Millennial-scale climate variability, oxygen isotope, Mg/Ca, IODP Exp.346

©2019. Japan Geoscience Union. All Right Reserved.

Onset and evolution of millennial-scale variability of East Asian Monsoon recorded in the Japan Sea sediments: New data with new interpretation

*Ryuji Tada[1], Tomohisa Irino[2], Arisa Seki[3], Masafumi Murayama[4], Kaz Mitake[1], Masayuki Ikeda[5]

1. Department of Earth and Planetary Science, Graduate School of Science, The Univeristy of Tokyo, 2. Faculty of Environmental Earth Science, Hokkaido University, 3. Faculty of Science, Shinshu University, 4. Faculty of Agriculture and Marine Science, 5. Shizuoka University

New XRF scanner data from U1426 on Oki Ridge and comparison with those of the deeper sites U1424 and 1425 revealed Br (MOC proxy) profile of deeper sites are significantly influenced by post-depositional oxidation during the early diagenesis while Br profile of shallower site (U1426) better preserve surface productivity signal. Thus we use Br profile of U1426 during the last 3 Ma to analyze past changes in millennial-scale variability of East Asian Summer Monsoon intensity and the response of the Japan Sea to such changes. The result suggests several new information which will be presented at 2019JpGU.

Keywords: East Asian Summer Monsoon, Japan Sea

©2019. Japan Geoscience Union. All Right Reserved.

Interhemispheric linkages of Australian and Asian monsoons on a warmer-than-modern Earth

*Ann E Holbourn[1], Wolfgang Kuhnt[1], Janika Joehnck[1], Sebastian Beil[1], Julia Luebbers[1], Kenji Marc Raymond Matsuzaki[2], Yair Rosenthal[3], Denise Kulhanek[4], IODP Expedition 363 Scientists -

1. University of Kiel, 2. University of Tokyo, 3. Rutgers University, 4. Texas A&M University

The large-scale Asian-Australian monsoon system consists of several regional subsystems that are dynamically linked through the annual migration of the Intertropical Convergence Zone across the equator, but exhibit distinct responses to external (local insolation) and internal (e.g., ice volume, greenhouse gas concentrations) forcings. Here we provide a long-term perspective of regional variability under different mean-state climate conditions. We focus on the 8 to 5 Ma period, which was characterized by warmer-than-modern climate conditions, but was also marked by distinct reversals in climate trends including transient cooling events exhibiting similarities to late Pleistocene Heinrich stadials. Extended sediment archives recovered by the Ocean Drilling Program (ODP) and the International Ocean Discovery Program (IODP) in the South China Sea, Bay of Bengal and off Northwest Australia allow direct comparison of Northern and Southern Hemisphere monsoonal subsystems on orbital timescales. High-resolution XRF-scanner derived estimates of terrigenous discharge, foraminiferal Mg/Ca derived mixed layer temperatures and stable isotopes reveal cooling and strengthening of the Northern Hemisphere winter monsoon starting at ~7 Ma. This intensification occurred synchronously with an increase in monsoonal seasonality in the Southern Hemisphere. In all regions, summer monsoonal precipitation intensified after ~5.5 Ma in tandem with globally rising sea surface temperatures. Our results suggest that changes in latitudinal temperature gradients, greenhouse gas concentrations and moisture budgets strongly influenced the long-term evolution of the Australian and Asian monsoons during the transition from a unipolar to a bipolar glaciated Earth.

Keywords: Asian-Australian Monsoon, late Miocene, International Ocean Discovery Program, Foraminiferal stable isotopes, Foraminiferal Mg/Ca, X-ray fluorescence scanner elemental data

©2019. Japan Geoscience Union. All Right Reserved.

Miocene evolution of the Asian Monsoon from climate and productivity proxies in the Bay of Bengal and South China Sea

*Wolfgang Kuhnt[1], Julia Luebbers[1], Ann Holbourn[1], Karlos GD Kochhann[2], Steven C Clemens[3], Clara T Bolton[4], Yoichi Usui[5]

1. University of Kiel, 2. UNISINOS University, 3. Brown University, 4. Aix-Marseille Université, 5. Japan Agency for Marine-Earth Science and Technology

Export particle flux from primary production and terrigenous input in combination with planktic and benthic foraminiferal isotope records were used to monitor monsoon-related paleoceanographic changes in the Bay of Bengal (Indian Monsoon) and South China Sea (East Asian Monsoon) through the middle to late Miocene. Proxy indicators of carbon export flux to the seafloor and carbonate accumulation rates at International Ocean Discovery Program (IODP) Site U1443 located in 2925 m water depth at the northern end of the Ninetyeast Ridge closely track changes in the carbonate budget of the deep Indian Ocean. Prolonged intervals of low carbonate concentrations and accumulation rates from ~17 to 15 Ma and from ~13.2 to 8.7 Ma indicate episodes of reduced carbonate deposition, which correlate with the globally recognized early to middle Miocene “Carbonate Drought” and the middle to late Miocene “Carbonate Crash”. The global occurrence of these events implies that changes in chemical weathering and in the riverine input of calcium and alkalinity into the ocean reservoir (rather than changes in circulation or inter-ocean carbonate fractionation) drove carbonate accumulation in the deep Indian Ocean. Higher XRF-scanner derived Log(Ba/Ti) together with a change in the redox state of deep sea sediments at ~11.2 Ma indicate a rise in biological production and export flux to the sea floor. A contemporaneous stepwise steepening of the gradient between mixed layer and deep ocean $\delta^{13}C$ starting from a minimum at ~11 Ma also indicates intensification of the biological pump at Ocean Drilling Program (ODP) Site 1146 (2091 m water depth) in the South China Sea. We suggest that the attendant increase in carbonate accumulation in the Indian Ocean was linked to increased nutrient flux and intensification of upper ocean mixing, associated with changes in the seasonality and intensity of the Asian monsoon.

Keywords: Asian Monsoon, Miocene, International Ocean Discovery Program , Foraminiferal stable isotopes, Foraminiferal Mg/Ca, X-ray fluorescence scanning elemental data

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS04] Interdisciplinary studies on pre-earthquake processes

convener:Katsumi Hattori(Department of Earth Sciences, Graduate School of Science, Chiba University), JANN-YENQ Liu(Institute of Space Science, National Central University, Taiwan), Dimitar Ouzounov(Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA), Qinghua Huang(Peking University), Chairperson:Jann-Yenq Liu(National Central University, Taiwan), Toshiyasu Nagao

This session expands the interdisciplinary discussions on preparation process of earthquake and earthquake predictability by presenting the latest progress in studying the physically based pre-earthquake phenomena. New observations from space and ground have provided
evidences, which may enhance better understanding of tectonic activity. The session anticipates talks that include but not limited to observations and analyses of seismic, electrical, electromagnetic, electro-chemical and thermodynamic processes related to stress changes in the lithosphere along with their statistical and physical validation. Presentations on the latest observational results associated with major earthquakes obtained by different methodologies are welcomed. The topics of the session are as follows but not limited.

-General discussion on earthquake preparation process and the physics of pre-earthquake signals

- Theory, modeling, laboratory experiments, computational simulation for generation and propagation of pre-earthquake signals and their connection with seismic cycle

 - Multi-parameter observations, detection, and validation of pre-earthquake signals

 - Cross-disciplinary studies, practical and technical approaches for better understanding of earthquake preparation processes and their connection with seismicity

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS04-01] Application of blind source separation method in seismo-magnetic data analysis

★Invited Papers

*Peng Han[1], Yi Zhong[1], Yuanyuan Zhou[1], Yonghui Ma[2], Chengliang Xie[3], Katsumi Hattori[4], Chie Yoshino[4] (1.Southern University of Science and Technology, Shenzhen, China, 2.Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China, 3.China University of Geosciences (Beijing), Beijing, 100083, China, 4.Chiba University, Chiba, Japan)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS04-02] Rn flux anomaly and local seiemicity around Asahi station,Boso,Japan

*Haruna Kojima[1], Katsumi Hattori[2], Chie Yoshino[2], Michikuni Shimo[3], Toshiharu Konishi[4], Ryuichi Furuya[5] (1.Graduate School of Science and Engineering,Chiba University, 2.Department of Earth Sciences,Graduate School of Science,Chiba University, 3.Fujita Hearth University, 4.OHYO KOKEN KOGYO Co.,Ltd, 5.COM SYSTEM ,INC.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS04-03] Geochemical evidence for the occurrence of 2018 Hualien earthquake triggered by earlier earthquake swarm

*Ching-Chou Fu[1], Lou-Chuang Lee[1], Cheng-Horng Lin[1], Vivek Walia[2], Dimitar Ouzounov[3] (1.Institute of Earth Sciences, Academia Sinica, 2.National Center for Research on Earthquake Engineering, NARL, Taiwan, 3.Chapman University, One University Drive, Orange, CA, USA)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS04-04] Temporal Variation and Statistical Assessment of b value

*weiyun xie[1], Katsumi Hattori[1], Peng Han[2] (1.chiba university, 2. Southern University of Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS04-05] The S-K characteristics of the borehole areal strains associated with the Ms 8.0 Wenchuan and Ms 7.0 Lushan earthquakes

★Invited Papers

*Kaiguang Zhu[1], Zining Yu[1], Chenquan Chi[1], Mengxuan Fan[1], Kaiyan Lii[1] (1.Jilin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS04-06] The Relationship between Earthquakes and Lightning Events of the globe during 2009-2017

*Ching-Chung Cheng[1], JANN-YENQ Liu[1,2,3] (1.Graduate Institute of Space Science, National Central University, TAIWAN, 2.Center for Astronautical Physics and Engineering, National Central University, TAIWAN, 3.Center for Space and Remote Sensing Research, National Central University, TAIWAN)

Application of blind source separation method in seismo-magnetic data analysis

*Peng Han[1], Yi Zhong[1], Yuanyuan Zhou[1], Yonghui Ma[2], Chengliang Xie[3], Katsumi Hattori[4], Chie Yoshino[4]

1. Southern University of Science and Technology, Shenzhen, China, 2. Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China, 3. China University of Geosciences (Beijing), Beijing, 100083, China, 4. Chiba University, Chiba, Japan

Along with the development of urban constructions, artificial disturbances in geomagnetic observations are becoming more and more tremendous. The near-field noises produced by human activities such as vehicles, subway and high-speed railways make it difficult to precisely measure geomagnetic pulsations on the ground, thus reducing the practical application value of geomagnetic data. Therefore, suppressing near-field noises has scientific significance and application value. In this study, by combining remote reference and blind source separation analysis methods, we proposed a new signal processing approach which is able to separate geomagnetic pulsation from near-field noise. First, we demonstrated the effectiveness of the new approach by separating signals of different sources in the simulation analysis. Then, we applied this method to geomagnetic field data observed in Chiba, Japan where DC-driven train noises were intense. The results showed that geomagnetic pulsations and train noises are separated clearly, and near-field train noise could be reduced effectively on that basis. It is concluded that the reference-based blind source separation analysis is useful in extracting geomagnetic pulsations and suppressing near-field noises, and may have potential application value in electromagnetic exploration.

Keywords: blind source separation, seismo-magnetic data analysis, Boso, Japan

©2019. Japan Geoscience Union. All Right Reserved.

Rn flux anomaly and local seiemicity around Asahi station,Boso,Japan

*Haruna Kojima[1], Katsumi Hattori[2], Chie Yoshino[2], Michikuni Shimo[3], Toshiharu Konishi[4], Ryuichi Furuya[5]

1. Graduate School of Science and Engineering,Chiba University, 2. Department of Earth Sciences,Graduate School of Science,Chiba University, 3. Fujita Hearth University, 4. OHYO KOKEN KOGYO Co.,Ltd, 5. COM SYSTEM ,INC.

In recent years, there are many studies reported electromagnetic phenomena preceding earthquakes such as ionospheric anomalies. Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model has been proposed to explain these phenomena. In this study, to explain the possibility of the chemical channel of LAIC, we have installed sensors for atmospheric electric field (AEF), atmospheric ion concentration (AIC), atmospheric Rn concentration (ARC), ground Rn concentration (GRC), and weather elements at Asahi station, Boso Peninsula, Japan. Because the atmospheric electricity parameters could be mainly influenced by weather factors, it is necessary to remove these influences as much as possible. In this sense, we apply the MSSA (Multi-channel Singular Spectral Analysis) to remove these influences from the GRC variation and estimate the Rn flux from the ground. Then, we investigate the correlation between the changes in the Rn flux and seismicity around the station. As a result, we found the correlation between Rn flux and regional cumulative seismic moment and/or Es index, which indicates the daily seismic energy near the station received at the station. It is highly suggestive of the effectiveness of GRC monitoring in regional seismicity around the station. Further researches such as network observations will be required for the detailed consideration on the correlation between Rn flux and seismicity such as magnitude and distance dependences.

Keywords: Lithosphere-Atmosphere-Ionosphere Coupling, atmospheric electric field, atmospheric ion concentration, ground Rn concentration

©2019. Japan Geoscience Union. All Right Reserved.

Geochemical evidence for the occurrence of 2018 Hualien earthquake triggered by earlier earthquake swarm

*Ching-Chou Fu[1], Lou-Chuang Lee[1], Cheng-Horng Lin[1], Vivek Walia[2], Dimitar Ouzounov[3]

1. Institute of Earth Sciences, Academia Sinica, 2. National Center for Research on Earthquake Engineering, NARL, Taiwan, 3. Chapman University, One University Drive, Orange, CA, USA

The continuous observations of soil radon for earthquake studies at the Tapingti station (TPT) have been recorded and are compared with the data from gamma rays observations at the Taiwan Volcano Observation station (YMSG), located north to the TPT station. The previous significant increases of gamma rays and radon were observed at both stations before the earthquakes, which occurred in eastern and northeastern Taiwan, suggest that anomalies in gamma and radon may provide the good indicator for exploring earthquake precursor in eastern Taiwan. A Mw 6.4 Hualien earthquake struck eastern Taiwan on 6 February 2018. Based on seismological studies, this earthquake may be triggered by the earthquake swarm that shook eastern Taiwan on 4 February 2018. In this study, both stations recorded significant changes about two weeks before the Hualien Earthquake. However, we provide the possible evidences from geochemical data for the occurrence of 2018 Hualien earthquake was triggered by earlier earthquake swarm. The continuous monitoring on the multiple parameters can improve our understanding of the relationship between the observed radon and gamma-ray variations and the regional crustal stress/strain in the area.

©2019. Japan Geoscience Union. All Right Reserved.

Temporal Variation and Statistical Assessment of b value

*weiyun xie[1], Katsumi Hattori[1], Peng Han[2]

1. chiba university, 2. Southern University of Science and Technology

The Gutenberg-Richter Law describes frequency-magnitude distribution of earthquakes. A number of studies have shown that the slope (b value) of the relationship between frequency and magnitude decreased before large earthquakes. In this paper, we investigate the temporal variation of the b value in the Hokkaido and Tohoku regions, Japan and the Wenchuan region, China, respectively, where M 8.0+ earthquakes occurred in the new century. The magnitude of completeness (Mc) in the catalog is evaluated by combining the maximum curvature (MAXC) technique and the bootstrap approach. Then, the b value and its uncertainty is computed by using the maximum likelihood estimation. The Akaike Information Criterion (AIC) with the bootstrap approach is introduced to statistically assess the temporal variation of b values and quantify the significance level. The results show decrease trends of the b value prior to the 2003 Tokachi Earthquake (M8.0) in Hokkaido, the 2011 Tohoku Earthquake (M9.0), and the 2008 Wenchuan Earthquake in China. In addition, the decrease of b values shows certain statistical significance few months before the three M8.0+ great earthquakes. It is concluded that the b value with statistical assessment may contain potential information for future large earthquake preparation.

Keywords: b-value, AIC

©2019. Japan Geoscience Union. All Right Reserved.

The S-K characteristics of the borehole areal strains associated with the Ms 8.0 Wenchuan and Ms 7.0 Lushan earthquakes

*Kaiguang Zhu[1], Zining Yu[1], Chenquan Chi[1], Mengxuan Fan[1], Kaiyan Lii[1]

1. Jilin University

The skewness and kurtosis of daily borehole areal strain at Guza station are jointly analysed on the S-K plane for the Wenchuan and Lushan earthquakes. We define a crustal stationary background to distinguish possible anomalies related to the earthquakes on the assumption that the background exhibits a quasi-Gaussian distribution. By calculating the S-K biases of the daily areal strain from the crustal stationary background, we found that before the Wenchuan earthquake, the large S-K bias anomalies were always negative, implying that the crust was compressed near the station. Whereas for the Lushan earthquake, clustered positive bias anomalies appeared within two time periods, revealing tensile changes in the crust. In addition, the S-K distributions of two arthquakes are separated on the S-K plane, further indicating differences in the associated deformation. These results demonstrate that the S-K characteristics of borehole areal strain data are potentially promising as earthquake precursors.

Keywords: borehole areal strain, S-K biases, S-K distributions, Wenchuan and Lushan earthquakes

©2019. Japan Geoscience Union. All Right Reserved.

The Relationship between Earthquakes and Lightning Events of the globe during 2009-2017

*Ching-Chung Cheng[1], JANN-YENQ Liu[1,2,3]

1. Graduate Institute of Space Science, National Central University, TAIWAN, 2. Center for Astronautical Physics and Engineering, National Central University, TAIWAN, 3. Center for Space and Remote Sensing Research, National Central University, TAIWAN

Lightning activities observed by WWLLN (World-Wide Lightning Location Networks) and 95 magnitude greater than 7.0 earthquakes within 30 degrees north and south latitude during 2009 - Nov. 2017 have been statistically examineed. In particular, we investigate how the lightning activities relate to the magnitude, depth, and distance to the epicenter of the earthquakes. Results show that the lightning events 12-22 days before the magnitude greater than 7.9 earthquakes significantly increase around the epicenter. Furthermore, the area size around the epicenter with the statistical significance of lightning activity enhancements is proportional to the earthquake magnitude. These results suggest that lightning activities can be used to find the possible location of forthcoming large earthquakes.

Keywords: Earthquake, Lightning

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS04] Interdisciplinary studies on pre-earthquake processes

convener:Katsumi Hattori(Department of Earth Sciences, Graduate School of Science, Chiba University), JANN-YENQ Liu(Institute of Space Science, National Central University, Taiwan), Dimitar Ouzounov(Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA), Qinghua Huang(Peking University), Chairperson:Peng Han, Katsumi Hattori

This session expands the interdisciplinary discussions on preparation process of earthquake and earthquake predictability by presenting the latest progress in studying the physically based pre-earthquake phenomena. New observations from space and ground have provided
evidences, which may enhance better understanding of tectonic activity. The session anticipates talks that include but not limited to observations and analyses of seismic, electrical, electromagnetic, electro-chemical and thermodynamic processes related to stress changes in the lithosphere along with their statistical and physical validation. Presentations on the latest observational results associated with major earthquakes obtained by different methodologies are welcomed. The topics of the session are as follows but not limited.

-General discussion on earthquake preparation process and the physics of pre-earthquake signals

- Theory, modeling, laboratory experiments, computational simulation for generation and propagation of pre-earthquake signals and their connection with seismic cycle

 - Multi-parameter observations, detection, and validation of pre-earthquake signals

 - Cross-disciplinary studies, practical and technical approaches for better understanding of earthquake preparation processes and their connection with seismicity

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS04-07] 3D-Tomography of the Ionospheric Anomalies Preceding the 2011 Tohoku-Oki (M_W9.0) Earthquake

*Ihsan Naufal Muafiry[1,2], Kosuke Heki[1] (1.Hokkaido University, Japan, 2.Universitas Esa Unggul, Indonesia)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS04-08] Statistical Analysis of Pre-seismic Ionospheric Electron Density Anomalies and Investigation of Precursor

*Sanaka Saito[1], Chie Yoshino[1], Katsumi Hattori[1] (1.Chiba University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS04-09] Spatial clustering of pre-earthquake anomalies as an indicator of the preparation/activation zone

*Dimitar Ouzounov[1], Sergey Pulinets[2], Tiger Liu[3], Katsumi Hattori[4] (1.Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA, 2.Space Research Institute, RAS, Moscow, Russia, 3.National Central University, Taoyuan City, Taiwan, 4. Chiba University, Chiba, Japan)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS04-10] **Application of the ionospheric parameters on the seismic research**- -Seismic-ionospheric effect detected from China Seismo-Electromagnetic Satellite

★Invited Papers

*Rui Song[1], Hattori Katsumi[2], Xuemin Zhang[3] (1.Graduate School of Science and Engeering, Chiba University, 2.Graduate School of Science, Chiba University, 3.Institute of Earthquake Science, China Earthquake Administration)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS04-11] ROC curve analyses on the ionospheric TEC of M>=6.0 earthquakes in Japan during 1998-2015

★Invited Papers

*JANN-YENQ Liu[1], Yuh-Ing Chen[2], Pei-Jung Lee[1] (1.Center for Astronautical Physics and Engineering; Graduate Institute of Space Science, National Central University, Taiwan, 2.Graduate Institute of Statistics, National Central University, Taiwan)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS04-12] FORMOSAT-5/AIP observes seismo-ionospheric precursors

*JANN-YENQ Liu[1], Chi-Kuang Chao[1] (1.Center for Astronautical Physics and Engineering; and Graduate Institute of Space Science, National Central University, TAIWAN)

3D-Tomography of the Ionospheric Anomalies Preceding the 2011 Tohoku-Oki (M_w9.0) Earthquake

*Ihsan Naufal Muafiry[1,2], Kosuke Heki[1]

1. Hokkaido University, Japan, 2. Universitas Esa Unggul, Indonesia

The vertical deformation of solid earth could trigger direct acoustic wave propagating upward and will reach the F-layer of the ionosphere ~10 minutes after earthquakes (Cahyadi & Heki, 2015). Such an acoustic disturbance may also make long-lasting electron depletion (Shinagawa et al., 2013). These phenomena can be studied through Total Electron Content (TEC) data using Global Navigation Satellite System (GNSS) receivers. The GNSS phase difference can be converted to slant TEC (STEC) integrated along its line-of-sight (LoS), which are further converted to absolute vertical TEC (VTEC) by removing inter-frequency biases and multiplying with the cosine of the incidence angle of LoS to the ionosphere.

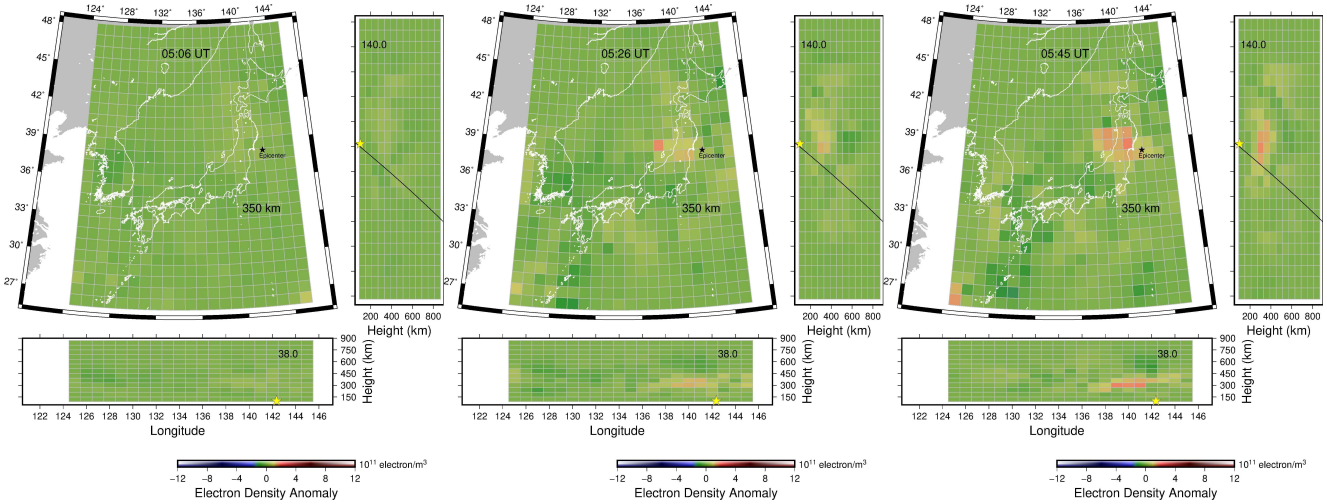
Shortly after the 2011 Tohoku-Oki M_w9.0 earthquake, Heki (2011) reported a significant positive anomaly in TEC starting ~40 minutes before the earthquake above the focal area, and He & Heki (2017) found similar TEC enhancements before 18 earthquakes with M_w 7.3-9.2. He & Heki (2016; 2018) investigated the spatial structure of the electron density anomalies before the 2015 Illapel earthquake, Chile (M_w8.3) using three-dimensional (3D) tomography technique. The result showed that positive electron density anomaly at ~200 km and negative anomalies at high altitudes line up along the geomagnetic field. This suggests their origin by electron redistribution caused by electric field made by surface positive electric charge (e.g. Freund, 2011).

Here, we report the 3D structure of the ionospheric electron density anomalies immediately before the 2011 Tohoku-Oki Earthquake using data from GEONET, a dense GNSS arrays in Japan, and the dense network in South Korea, with the 3D tomography technique similar to He & Heki (2018) and Muafiry et al. (2018). We set up more than 1500 blocks over the region covering the whole Japanese Islands, the Japan Sea, and the Korean Peninsula, with the size of 1.0° (E-W) x 0.9° (N-S) x 60 km (U-D) up to 900 km altitude. By using STEC residuals of pairs of thousand stations and 8 GPS satellites from reference curves, carefully determined by the L-curve method, as the input, we estimated the number of electron density anomalies within individual blocks. To stabilize and regularize the solution, we applied two types of constraints, i.e. continuity constraint and altitude-dependent absolute value constraint assuming the Chapman distribution. Before using the real data, we performed various tests to confirm the reliability of the solution including the checkerboard test, the test assuming realistic preseismic anomaly pattern, and comparing observed STEC anomalies of 10 % of the observation data with those calculated using the electron density anomalies estimated from the remaining 90% of data. These tests showed that our tomography results are robust with its difference is below 0.5 total electron content unit (TECU).

The attached figure shows the map view of our result at a height of 350 km with longitudinal and latitudinal profiles at three different epochs. The results show that positive electron density anomalies occurred at ~300 km altitude. They become large without spatial drifts as the main-shock approaches. Negative anomalies surround this compact and strong positive anomaly. The anomaly is situated just above to the focal area, suggesting its origin as the concentration of ionospheric electrons in response to surface positive electric charges appearing immediately before the 2011 Tohoku-Oki earthquake.

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: Ionosphere-Anomalies, Earthquake Precursor, GPS-TEC, 3D-tomography



©2019. Japan Geoscience Union. All Right Reserved.

Statistical Analysis of Pre-seismic Ionospheric Electron Density Anomalies and Investigation of Precursor

*Sanaka Saito[1], Chie Yoshino[1], Katsumi Hattori[1]

1. Chiba University

Recently, many papers have been published on the earthquake-related ionospheric anomalies. In particular, event studies and statistical studies on Ionospheric electrons using Ionosonde and GPS TEC (total electron content) indicate the pre-seismic anomalies. In Japan region, the previous statistical study during 1998-2010 shows that there is an increase anomaly 1-5 days before the earthquake with M>=6 D<=40 km. In this study, we performed statistical analysis on ionosonde data observed at Kokubunji (35.71N, 139.49E), Japan over 60 years of 1958 ~ 2017 in order to investigate the earthquake-related ionospheric anomalies. The ionosonde is operated by the National Institute of Information and Communication Technology, Japan. The studied parameters are NmF2, which indicates the maximum electron density in the F2 layer, hmF2, which shows the NmF2 altitude, and foEs which is the critical frequency of the Es layer. We select earthquakes occurred within 1000 km and 350 km radius from the ionosonde station, and M >= 6 and D <= 40 km. There are 352 and 148 earthquakes. Ionospheric anomalies are also induced by geomagnetic storm. Therefore, to remove the geomagnetic storm effects, we adopt the Dst index. We divided the values into some classes by onset time and intensity. For each class, we performed statistical processes to calculate duration of ionospheric anomalies triggered by a geomagnetic storm. We found these anomalies last about 1-3 days, and we remove the data based on results. To investigate the correlation between ionospheric anomalies and earthquakes, we perform the Superposed Epoch Analysis (SEA). We define the anomaly as 15 days backward median value ±1.5 IQR and an anomalous day has the anomaly with more than 10 hours. Then, we make up the binary time series data on the earthquake-related anomaly. We extract dataset 30 days before and after the earthquake day for the all selected earthquakes and perform SEA. To evaluate the statistical significance, we compute the random test. SEA results show that there is a significant positive anomalies 1-10 days before the earthquakes in NmF2 data. For hmF2 data, we can find there are no clear correlation. As for foEs, we need further investigation. For NmF2, we checked Molchan’ s Error Diagram (MED). From the results of MED, NmF2 may be precursor for earthquakes. The detailed will be given in the presentation.

©2019. Japan Geoscience Union. All Right Reserved.

Spatial clustering of pre-earthquake anomalies as an indicator of the preparation/activation zone

*Dimitar Ouzounov[1], Sergey Pulinets[2], Tiger Liu[3], Katsumi Hattori[4]

1. Center of Excellence in Earth Systems Modeling & Observations (CEESMO) , Schmid College of Science & Technology Chapman University, Orange, California, USA, 2. Space Research Institute, RAS, Moscow, Russia, 3. National Central University, Taoyuan City, Taiwan, 4. Chiba University, Chiba, Japan

We present an interdisciplinary study of observations of pre-earthquake processes associated with major earthquakes based on integrating space and ground- data. We are exploring the general temporal-spatial and evolution patterns of these pre-earthquake signals as a function of both their type and the earthquake magnitude. We examined the possible correlation between the spatial clustering of pre-Earthquake anomalies and the size of earthquake preparation/activation (Dobrovolsky-Bowman zone) in the framework of the Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) concept. For this analysis we selected six most massive earthquakes from the last decade with differing geographic and seismo-tectonics regions: (1) M9.3, Off the West Coast of Northern Sumatra, Dec 26, 2004; (2) M9.0 Great Tohoku Earthquake, , Japan, March 11, 2011; (3 and (4) M7.8 and M7.3 Gorkha, Nepal, 2015; (5); M8.2 Tehuantepec, Mexico, September 8, 2017 and; (6) M7.1, Puebla central Mexico earthquakes, Mexico, September 19, 2017.
Four physical parameters were measured from ground and satellite were used in the temporal-spatial patterns: 1) Ground Radon variation; 2) Outgoing Long-wavelength Radiation (OLR obtained from NPOESS, NASA/AQUA) on top of the atmosphere (TOA); 3) Atmospheric Chemical Potential (ACP) obtained from NASA assimilation models and; 4) electron density variations in the ionosphere via GPS Total Electron Content (GPS/TEC).

Our preliminary results of temporal-evolution patterns indicate an enhancement of radon (about a week to ten days prior) followed by the increase in the atmospheric chemical potential measured near the epicenter from both satellite and subsequently with an increase of OLR observed on the TOA from NOAA/NASA (a week in advance). Finally, GPS/TEC data indicate an increase in electron concentration 1-4 days before the earthquakes. Although the radon variations, some of satellite OLR and GPS/TEC anomalies were observed far (>2000km) from the epicenter areas, the anomalies were always inside the estimates of the Dobrovolsky-Bowman area of preparation. This finding provides new metrics in the assessment of pre-earthquake signals according to LAIC for both sea and land earthquakes possible only by integrating satellite and ground observations. A detailed summary of our approach to this study of pre-earthquake research has just been published as AGU/Wiley Geophysical Monograph Series No. 234.

Keywords: earthquake forecasting, pre-earthquake, LAIC, GPS/TEC, satellite thermal anomaly, radon

©2019. Japan Geoscience Union. All Right Reserved.

Application of the ionospheric parameters on the seismic research --Seismic-ionospheric effect detected from China Seismo-Electromagnetic Satellite

*Rui Song[1], Hattori Katsumi[2], Xuemin Zhang[3]

1. Graduate School of Science and Engeering, Chiba University, 2. Graduate School of Science, Chiba University, 3. Institute of Earthquake Science, China Earthquake Administration

The ionosphere is located at the altitude of 60 kilometers above the earth surface and the top of the ionosphere is about 500km. Figure 1 shows the basic structure of the ionosphere, where D, E and F layers are all clearly concluded. In addition, F layer can be divided into F1 and F2 layers. F1 layers and D region always disppear in nighttime. The seismic-ionospheric research began in 1960s, when American scientists studied the Alaska M8.5 earthquake in 1964, they first found that the disturbance of plasma density before this earthquake. Since then, many researchers engaged in this field. Based on the promising seismic-ionospheric research, China government launched the Seismo-electromagnetic satellite, CSES for short, on February, 2018 for both the earthquake observation and geophysical research. As the data is available now, in this research we adopt the observed data from CSES. The basic information of this satellite is listed in Table 1. There are four consecutive shallow focus earthquakes in a short period in Indonesia during July to Augst, 2018, where Table 2 shows the detailed information about these four earthquakes, and figure 2 shows the specific locations of four epicenters on the map. As for the data sources, there are mainly three kinds of data. The first kind is the Ionospheric Electron density (Ne for short) from CSES satellite. Figure 3 shows the launch and flight status of CSES satellite where a total of 8 payloads concluded, and we adopted the electron density from Langmuir Probe PayloadIn this research. The second kind of data is Ne corresponding with the observed data from International Reference Ionosphere model 2016 (IRI 2016). The third kind is the global ionosphere map from CODE whose time resolution is 1 hour, spatial resolution is 2.5deg*5deg. We adopt these data to evaluate the reliability of the CSES satellite data. First, we used the following formula to calculate the percent disturbance of electron density from CSES satellite. After calculation, we found that there are mainly four significant anomalies on July 27, 31, August 07, and 14 respectively, shown as figure 3. Compared with the earthquake time listed in table 2, these four disturbances just happened before the four earthquakes, which maybe the seismic-ionospheric effect. And the red star in these figures represent the epicenter. After checking different kinds of space weather index, we can exclude that the disturbance is caused by space weather. As for the IRI 2016 model can be seen as the background data without any seismic factors, so we adopt the corresponding Ne from IRI model to evaluate the reliability of CSES data. From figure 4, it is clear the abnormal orbits in figure 3 also show the similar disturbance. As the orbit revisiting period is 5 days, figure 5 shows the comparison between the revisiting orbits of CSES on July 31 and August 14, the other two orbits go through the same location 5 or 10 days before. From this figure, the electron density shows obvious swelling on the abnormal days while the electron temperature shows the opposite trend. Then we used the grid data from CODE to calculate the disturbance about VTEC. Figure 6 (a) shows the percent disturbance of VTEC on August 1, 2018, from 5:00UT the abnormal around the epicenter is gradually increased, till 15:00UT the abnormal area disappeared. It is worth noting that the anomaly did not change with time, which means it is not triggered by sun activity. The percent disturbance of VTEC on Aug. 14, 2018 also shows the similar results from figure 6 (b). In the following research, we counted all the earthquakes that occurred in Indonesia over a 10-year period during 2007-2017 between 106.45 E-126.45 E and 8.3 S-1.7 N from USGS to check the anomalies of

©2019. Japan Geoscience Union. All Right Reserved.

ionospheric vertical TEC from CODE. After selecting the earthquake accidents whose depth is less than 50km, and magnitude is greater than M5.8, there are a total of 35 earthquakes in the end, shown as figure 7. Figure 8 shows the statistical results of the count of TEC anomalies 15 days before and after these 35 earthquakes. It is obvious that 1-7 days before one earthquake in Indonesian region, the number of ionospheric parameter anomalies is more than other time.

Keywords: Seismic-ionospheric effect, Electron density, Total electron contents, CSES satellite

©2019. Japan Geoscience Union. All Right Reserved.

ROC curve analyses on the ionospheric TEC of M>=6.0 earthquakes in Japan during 1998-2015

*JANN-YENQ Liu[1], Yuh-Ing Chen[2], Pei-Jung Lee[1]

1. Center for Astronautical Physics and Engineering; Graduate Institute of Space Science, National Central University, Taiwan, 2. Graduate Institute of Statistics, National Central University, Taiwan

To verify the pre-earthquake ionospheric anomaly (PEIA), statistical analyses are implemented on the relationship between the total electron content (TEC) of global ionosphere map (GIM) and M>=6.0 earthquakes in Japan during 1998-2018. A median-based method together with z test is employed to find the criteria and/or characteristics of TEC anomalies related to earthquakes. It is found that the GIM TEC over the Japan significantly increases 1-3 days before the earthquakes. The receiver operating characteristic (ROC) curve is used to compare the TEC anomaly-based method with some competitive alternatives for predicting the earthquakes under study. We find, based on possible TEC anomalies, that the observed PEIAs are significantly earthquake-related. Moreover, the results of regression analyses show that the PEIA strength is associated with the magnitude of earthquakes.

Keywords: pre-earthquake ionospheric anomaly (PEIA), total electron content (TEC), earthquake, receiver operating characteristic (ROC)

©2019. Japan Geoscience Union. All Right Reserved.

FORMOSAT-5/AIP observes seismo-ionospheric precursors

*JANN-YENQ Liu[1], Chi-Kuang Chao[1]

1. Center for Astronautical Physics and Engineering; and Graduate Institute of Space Science, National Central University, TAIWAN

FORMOSAT-5 (F5) was launched at 18:51 UT (universal time) on 24 August 2017 with a sun-synchronous orbit at 720 km altitude and 98.28° inclination, which passes at almost the same local time everywhere in the daytime of about 10:30 LT and the nighttime of about 22:30 LT. It carries a primary payload, optical RSI (Remote Sensing Instrument), and a science payload, AIP (Advanced Ionospheric Probe), which are normally operating in the daytime and nighttime, respectively. The AIP mission is to monitor seismo-ionospheric precursors (SIPs) and observe ionospheric space weather. It is basically a multi-grid planar ion probe integrated with a planar Langmuir probe within a 10 cm ×10 cm aperture, which consists of Retarding Potential Analyzer (RPA), and Ion Drift Meter (IDM)/Ion Trap (IT) to maximize the total availability of ionospheric ion concentration (or density), ion velocities, and ion/electron temperatures at a sample rate up to 8192 Hz over a wide range of spatial scales in ionospheric plasma. The electroformed gold grids used has almost no hysteresis in sweeping current-voltage curves, and results in that the AIP can accurately probe plasma quantities in the ionosphere. The RPA and IDM/IT have been alternatively operating on every other orbit since end of October 2017. The RPA probes the ion density, while the IDM/IT derives the ion density and ion drift velocity. This paper combines in situ plasma measurements of F5/AIP and remote sensing of the TEC (total electron content) derived by ground-based GNSS (global navigation satellite system) receivers to three-dimensionally study SIPs of the 12 November 2017 M7.3 Iran-Iraq Border Earthquake and disturbances of ionospheric storms on 1 and 21 November 2017. The F5/AIP ion density is employed to confirm the SIP signatures and storm signatures being observed, while the F5/AIP ion velocity is employed to find electric fields associated with the SIPs and the ionospheric storms.

Keywords: FORMOSAT-5, AIP (Advanced Ionospheric Probe), seismo-ionospheric precursors

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 202 2F

[M-IS06] Conservation of geoparks, natural geosites and cultural heritage: weathering process and damage assessment

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Tetsuya Waragai(Graduate School of Science and Engineering, Nihon University), Kuniyasu Mokudai(Tohoku Gakuin University), Magdalini Theodoridou(School of Engineering, Cardiff University), Chairperson:Tetsuya Waragai(日本大学大学院理工学研究科), Kuniyasu Mokudai(Japan Geoservicee)

Geoparks, world heritage sites, natural geosites and cultural heritage structures are considered important natural and/or cultural heritage properties. They have been exposed to weathering not only in geologic time frame but also in human time scale, thus rocks and geological materials are often facing deterioration. In order to preserve these sites conservation measures should be considered. Several studies have taken place on this topic involving a wide range of research fields, such as geomorphology, engineering geology, geoarchaeology, conservation science, geoconservation, materials science, petrophysics, geochemistry, geotechnical engineering etc. However, our knowledge on many aspects is still limited. The session welcomes contributions, presenting original research, discussions as well as case studies on documentation, measurement and monitoring techniques, experimental procedures, predictive models, damage assessment, etc. Papers from all research fields are invited dealing with the broad topic of geosites and cultural heritage.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS06-01] Geopark's response to conservation of geosites from natural hazards

*Kuniyasu Mokudai[1], Shuichi Hasegawa[2] (1.Japan Geoservice Incorporated, 2.Kagawa Univ.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS06-02] Physical and mechanical properties for damage assesment of Taya Cave rocks, central Japan

*Chiaki T. Oguchi[1], Yurina Akimoto[2], Yasuhiko TAMURA[3], Kaisei Sakane[1] (1.Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University, 2.Faculty of Engineering, Saitama University, 3.The Exective Committee for the Preservation of TAYA CAVERN)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS06-03] Interdisciplinary approaches on conservation of underground geoheritage for community development of Taya Cave and its adjacent area

★Invited Papers

*Yasuhiko TAMURA[1,2], Chiaki T. Oguchi[4], Yuichi S. Hayakawa[5,2], Takuro Ogura[2], OGATA KEISUKE[6], Masashi MORITA[3] (1.The Executive Committee for the Preservation of TAYA CAVERN , 2.The University of Tokyo, Center for Spatial Information Science, 3.Yokohama National University, Institute of Urban Innovation, 4.Saitama University, Graduate School of Science and Engineering, 5.Hokkaido University, Faculty of Environmental Earth Science, 6.Tsurumi University, The Department of Cultural Properties)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS06-04] **Italian underground cultural heritage: from monitoring to enhancement**

★Invited Papers

*Mario Parise[1], Tiziana Vitolo[2], Roberta Varriale[2] (1.Univ. Aldo Moro, Dept. Earth and Environmental Sciences, Bari, Italy, 2.CNR-ISSM, Italy)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS06-05] Possibility of insolation weathering of sandstone blocks composing Angkor temples, Cambodia

*Tetsuya Waragai[1] (1.Graduate School of Science and Engineering, Nihon University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS06-06] **Durability evaluation of pyroclastic rocks used in the historical built environment of Hungary**

*Luigi Germinario[1,2], Ákos Török[1] (1.Budapest University of Technology and Economics, Hungary, 2.Saitama University, Japan)

Geopark's response to conservation of geosites from natural hazards

*Kuniyasu Mokudai[1], Shuichi Hasegawa[2]

1. Japan Geoservice Incorporated, 2. Kagawa Univ.

Various natural hazards such as floods, slope failures, earthquake motions, etc. occur in the Japanese islands. Such natural hazards greatly affect the state of geosite. The Geopark performs activities in the event of a natural hazard, but its know-how has not accumulated. At Shikoku Seiyo Geopark, the Seiyo City needed to do disaster restoration work during the western Japan heavy rain in 2018. Therefore, it was difficult to transmit information and preserve the geosite as a geopark.

Keywords: geopark, geoconservation, natural hazard

©2019. Japan Geoscience Union. All Right Reserved.

Physical and mechanical properties for damage assesment of Taya Cave rocks, central Japan

*Chiaki T. Oguchi[1], Yurina Akimoto[2], Yasuhiko TAMURA[3], Kaisei Sakane[1]

1. Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University, 2. Faculty of Engineering, Saitama University, 3. The Exective Committee for the Preservation of TAYA CAVERN

Taya cave, an artificial cave in a hill in south Yokohama, was excavated from the Kamakura period through the late Edo period. There are many sculptures and bas-reliefs on the surface of the cave wall made of soft rock which deposited in Pleistocene. Those sculptures has been suffering from weathering and deterioration, especially exfoliation of the wall and ceiling. In this study, for the purpose of conservation and restoration of sculptural murals, rock physical properties were investigated to assess the current situation. As a result, the possibility of surface exfoliation is considered to be affected by moisture difference, whereas the possibility of collapse of ceilings or floors between stairs becomes higher if too much water infiltrate.

Keywords: Phisical property, Mechanical property, Taya Cave

©2019. Japan Geoscience Union. All Right Reserved.

Interdisciplinary approaches on conservation of underground geoheritage for community development of Taya Cave and its adjacent area

*Yasuhiko TAMURA[1,2], Chiaki T. Oguchi[4], Yuichi S. Hayakawa[5,2], Takuro Ogura[2], OGATA KEISUKE[6], Masashi MORITA[3]

1. The Executive Committee for the Preservation of TAYA CAVERN , 2. The University of Tokyo, Center for Spatial Information Science, 3. Yokohama National University, Institute of Urban Innovation, 4. Saitama University, Graduate School of Science and Engineering, 5. Hokkaido University, Faculty of Environmental Earth Science, 6. Tsurumi University, The Department of Cultural Properties

TAYA Cave is an underground geoheritage locating in a Buddhism temple of Shingon sect, Josen-ji, south Yokohama, Japan. The cave is supposed to have its origin in the Kamakura period about 800 years ago, and then been used for religious trainings for priests. After opened to public in Edo era, a certain number of general people visited there. It was registered as a cultural property of Yokohama City in 1990. The cave originates in Kamakura period over 800 years ago. It was made by digging with human hands to shape a tunnel-like three-layer structure. More than 300 beautiful bas-reliefs are existed on the walls. However, those artifacts have been damaged due to deterioration or weathering. We are facing to urgent problem to preserve it to inherit in the future.
The authors have been trying to preserve this cave for four years. *The Executive Committee for the Preservation of Taya Cave* was established to make 3D digital data of this underground cultural property. In order to outline the approaches, three practical trials were carried out. The first one is dissemination of basic conditions of the cave from the viewpoints of earth science such as geology, geography and geotechnics to local people. Throughout of this activity, environmental characteristics of Taya Cave will be understood quantitatively. The second one is to understand regional culture and environment by interpreting regional history appearing on fundamental survey of bas-relief. The third one is to consider the possibilities of city planning with considering various regulations existed in the real society and environmental regulations. By comprehensively advancing these activities, urban rural area will be able to develop and gain vitality. The present study reports the results of these multidisciplinary practical trials carried out so far.

Keywords: Preservation of cultural property, underground heritage, multi-field joint basic survey, regional cooperation, Elementary school - University collaboration, TAYA Cave

©2019. Japan Geoscience Union. All Right Reserved.



©2019. Japan Geoscience Union. All Right Reserved.

Italian underground cultural heritage: from monitoring to enhancement

*Mario Parise[1], Tiziana Vitolo[2], Roberta Varriale[2]

1. Univ. Aldo Moro, Dept. Earth and Environmental Sciences, Bari, Italy, 2. CNR-ISSM, Italy

Italy is among the European countries with the highest number of artificial cavities, many of which represent a precious testimony of past civilizations and cultures, and of the continuous link between town development and the underground as well. The Italian underground has historically managed several environmental conflicts and social interactions, in both urban and rural settings. Nowadays the artificial cavities represent a significant segment within the local cultural heritage and have become in the last decades the object of strategic planning addressed towards their regeneration, valorization and public fruition. All these actions, however, need to be based on sound studies and researches aimed at evaluating the opportunity to open to the public sites that could potentially be unsafe. At this regard, monitoring plans and activities, and careful assessment of the susceptibility to failure and collapses, must be performed. Only after the stability conditions have been positively ascertained, underground sites might be considered for valorization, public visits and other activities.
In such a framework, we present in this contribution some case studies (including the underground tanks Cisternone in Formia, Latium, and Palombaro in Matera, Basilicata), also to describe their use at the time of realization, and to illustrate the related "sense of place". Environmental, social, historical and economic reconstructions have been carried out to generate and manage the knowledge of the places selected in order to facilitate their use and contribute to their development, in direct link with the cities where they are hosted. The methodology adopted aims at highlighting the cultural vitality and the identity of these places for the benefit of the local populations, and of tourists as well.

Keywords: artificial cavity, underground, stability, monitoring, enhancement

©2019. Japan Geoscience Union. All Right Reserved.

Possibility of insolation weathering of sandstone blocks composing Angkor temples, Cambodia

*Tetsuya Waragai[1]

1. Graduate School of Science and Engineering, Nihon University

Angkor temples such as Angkor Wat and Bayon temples built from 9th to 13th century are mainly composed of sandstone blocks. However, as a result of tree cutting that has been proceeded to protect the temples from rootwedging processes, most of temples are exposed to direct insolation. Possibility of insolation weathering of the sandstone blocks are pointed out, since the sandstone blocks can keep high temperature condition during daytime. Therefore, this study carried out field experiments that expose a sandstone cylindrical specimen in a dry season as a trial experiment using an acoustic emission (AE) method that may detect microcracks in the specimen by temperature changes. The experiment was carried out at the test site of Angkor Wat temple by measuring surface temperatures and AE signals of the specimen in December 2018. As the results, the surface temperatures of the specimen were 51.5 ˚C in maximum and 20.8 ˚C in minimum, and diurnal difference was 30.3 ˚C. In addition, the maximum elevation rate of the temperature was 1.50 ˚C/min and the minimum descending rate of the temperature was -1.88 ˚C/min. Although the surface temperature measurement could not synchronize to the AE measurement, an AE signal that is 40% bigger than ordinal value, was detected at the time of 0.43 ˚C/min of the elevation rate of temperature. This is though that sandstone blocks maybe deteriorate due to temperature changes by insolation.

Keywords: Angkor temples, sandstone, insolation weathering, acoustic emission

©2019. Japan Geoscience Union. All Right Reserved.

Durability evaluation of pyroclastic rocks used in the historical built environment of Hungary

*Luigi Germinario[1,2], Ákos Török[1]

1. Budapest University of Technology and Economics, Hungary, 2. Saitama University, Japan

Pyroclastic rocks of diverse composition have experienced a broad historical usage in the built environment of Hungary, especially from the Middle Ages. In the northern regions, for instance, acid ignimbrites have been widely used as building stones in monumental construction, e.g., churches and castles, Ottoman architectures like mosques and spas, as well as common dwellings. Their characterization reveals a small-scale inconstancy of their physico-mechanical performance and petrographic features, which affects weathering susceptibility. That involves most significantly porosity, pore-size distribution, and tensile strength, considering the technical properties; on the other hand, texture must be accounted for in terms of changing quantity and size of pumice clasts, phenocrysts, and crystals, and amount of the weak and porous groundmass. The behavior of the ignimbrites when subjected to artificial weathering, by freeze-thaw and salt attack tests, alters accordingly. The variability of open porosity represents the most important factor marking a possible dramatically diverse durability. It turns out to be proportional to water absorption, controlling the amount of infiltrating water or salt solutions, at the base of potential rock failure due to ice or salt crystallization. The sole high moisture may also lead to an extreme and hazardous deterioration of the mechanical properties. Finally, high porosity is correlated with low welding degree and, in turn, low strength. Such outcomes suggest criteria for evaluating the vulnerability of these volcanic rocks in cultural heritage, and directing reasonable material selections for stonework restorations.

Keywords: Stone decay, Freeze-thaw, Salt weathering, Petrophysical properties, Mechanical properties, Rhyolite tuff

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 201A 2F

[M-IS07] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Hikaru Yabuta(Hiroshima University), Seiji Sugita(東京大学大学院 理学系研究科), Misato Fukagawa(名古屋大学大学院 理学研究科), Kosuke Fujishima(ELSI 地球生命研究所)

Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Individual themes related to Astrobiology, such as chemical evolution in the early Solar System, formation of planetary system, prebiotic chemistry in the early Earth, evolution of life in the Earth's history, extremophile, and habitable planetary environments, has been studied by the knowledge and methods from the multiple fields, which has enabled us to explain "Where we came from" in some ways. However, despite an overwhelming number of investigations and discussions through gathering of the scientists from different fields, there has remained the long-standing unsolved question: How did abiotic materials gain biological function in the Earth and elsewhere in universe? There is still a large gap between prebiotic organic chemistry and biochemistry toward Origins of Life and planetary habitability. Therefore, the JpGU Astrobiology session focuses on pathfinding of "integration of astronomy, geoscience, and biochemistry", which will face an increasing need for the future Astrobiology. In order to enhance our understanding of "What is life", we propose to discuss the biochemical events linked with planetary systems, which is beyond the knowledge in a test tube, by an integration of exoplanets and molecular biology, etc. Through this approach, we will lead the discussions and developments of life-detection strategies for the future exploration of life in universe.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[MIS07-06] How to find and characterize nearby habitable exoplanets

★Invited Papers

*Norio Narita[1] (1.Astrobiology Center)

9:20 AM - 9:40 AM JST | 12:20 AM - 12:40 AM UTC

[MIS07-07] **Organic Matter Preserved in Mudstones of a 3-Billion-Year-Old Lake Deposit in Gale Crater, Mars**

★Invited Papers

*Jennifer L Eigenbrode[1], Roger E Summons[2], Andrew Steele[3], Caroline Freissinet[4], Maëva Millan[5], Rafael Navarro-González[6], Paul Mahaffy[1] (1.NASA Goddard Space Flight Center, 2.Massachusetts Institute of Technology, 3.Carnegie Institution of Washington, 4.Institut Pierre Simon Laplace, CNRS, 5.Georgetown University, 6.Universidad Nacional Autónoma de México)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[MIS07-08] **The third year sample return of Tanpopo: Capture and Exposure Experiment of Micrometeorite and Microbes on Exposure Facility of International Space Station**

*Akihiko Yamagishi[1], Hirofumi Hashimoto[2], Hajime Yano[2], Shin-ichi Yokobori[3], Kensei Kobayashi[4], Hajime Mita[5], Hikaru Yabuta[6], Masumi Higashide[7], Makoto Tabata[8], Hideyuki Kawai[8], Eiichi Imai[9] (1.Tokyo University of Pharmacy and Life Science, Department of Molecular Biology, 2.ISAS/JAXA, Sagamihara, Japan, 3.Tokyo University of Pharmacy and Life Science, Tokyo, Japan, 4.Yokohama National University, Yokohama, Japan, 5.Fukuoka Institute of Technology, Fukuoka, Japan, 6.Hiroshima University, Hirosima, Japan, 7.Japan Aerospace Exploration Agency (JAXA), Tokyo, Japan, 8.Chiba University, Chiba, Japan, 9.Nagaoka University of Technology, Nagaoka, Japan)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[MIS07-09] Theoretical search for photosynthetic pigments applicable around low temperature stars: Modulation of physical-chemical properties by central metals

*Yu Komatsu[1,2], Kenji Takizawa[1,3] (1.Astrobiology Center, 2.National Astronomical Observatory of Japan, 3.National Institute for Basic Biology)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[MIS07-10] Effects of the formation of hydrocarbon aerosols on the climate stability of Earth-like planets and their habitability

*Yasuto Watanabe[1], Eiichi Tajika[1], Kazumi Ozaki[2], Peng Hong[3] (1.The University of Tokyo, 2.Toho University, 3.Chiba Institute of Technology)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

Discussion

How to find and characterize nearby habitable exoplanets

*Norio Narita[1]

1. Astrobiology Center

In this review, I will summarize previous and ongoing efforts to find habitable exoplanets in the vicinity of the Solar system and future prospects to characterize such planets with next generation telescopes and instruments. In addition, I will talk about the importance and some examples of interdisciplinary studies of astrobiology to consider future missions.

Keywords: Exoplanets, Astrobiology

©2019. Japan Geoscience Union. All Right Reserved.

Organic Matter Preserved in Mudstones of a 3-Billion-Year-Old Lake Deposit in Gale Crater, Mars

*Jennifer L Eigenbrode[1], Roger E Summons[2], Andrew Steele[3], Caroline Freissinet[4], Maëva Millan[5], Rafael Navarro-González[6], Paul Mahaffy[1]

1. NASA Goddard Space Flight Center, 2. Massachusetts Institute of Technology, 3. Carnegie Institution of Washington, 4. Institut Pierre Simon Laplace, CNRS, 5. Georgetown University, 6. Universidad Nacional Autónoma de México

In situ analyses of lake-deposited mudstones of the Murray formation at Pahrump Hills, Gale crater, Mars show the presence of aliphatic, aromatic, and sulfur-bearing organic gases upon heating to 500-860˚C, as detected by the Sample Analysis at Mars (SAM) instrument suite on the Mars Science Laboratory's (MSL's) Curiosity rover. Organic-sulfur compounds, including thiophenes, dimethylsulfide and thiols were identified by gas chromatography-mass spectrometry (GCMS) and observed in evolved gas analyses (EGA). Other aromatic and aliphatic hydrocarbon components were also indicated by EGA. The distributions of organic molecules observed were specific to samples and cannot be from SAM's instrument background. The temperatures these organic volatiles were released is consistent with the pyrolytic cleavage of organic fragments from large molecules (macromolecules) indigenous to the mudstones. Some portion may also be derived from the thermal release of organics entrained within minerals.

The release of organic-sulfur compounds occurs at high temperatures in the SAM oven; thus, these compounds are most likely derived from sulfurized organics in the sediments and are not an artifact of sulfurization reactions in the oven. On Earth, sulfurization is a key process that facilitates organic matter preservation over geological time-scales by transforming individual organic molecules into recalcitrant macromolecules. Organic matter at the base of the Murray formation probably underwent sulfurization prior to deposition or during early diagenesis. Multiple factors likely contribute to the organic preservation in the Gale crater mudstones, however, sulfurization may be largely responsible for the greater abundance and the molecular diversity observed in the lower Murray formation.

Keywords: Mars, organic matter, lacustrine, Curiosity rover, Mars Science Laboratory (MSL) mission, Sample Analysis at Mars (SAM)

©2019. Japan Geoscience Union. All Right Reserved.

The third year sample return of Tanpopo: Capture and Exposure Experiment of Micrometeorite and Microbes on Exposure Facility of International Space Station

*Akihiko Yamagishi[1], Hirofumi Hashimoto[2], Hajime Yano[2], Shin-ichi Yokobori[3], Kensei Kobayashi[4], Hajime Mita[5], Hikaru Yabuta[6], Masumi Higashide[7], Makoto Tabata[8], Hideyuki Kawai[8], Eiichi Imai[9]

1. Tokyo University of Pharmacy and Life Science, Department of Molecular Biology, 2. ISAS/JAXA, Sagamihara, Japan, 3. Tokyo University of Pharmacy and Life Science, Tokyo, Japan, 4. Yokohama National University, Yokohama, Japan, 5. Fukuoka Institute of Technology, Fukuoka, Japan, 6. Hiroshima University, Hirosima, Japan, 7. Japan Aerospace Exploration Agency (JAXA), Tokyo, Japan, 8. Chiba University, Chiba, Japan, 9. Nagaoka University of Technology, Nagaoka, Japan

Purpose of Tanpopo mission

Tanpopo, a dandelion in Japanese, is a plant species whose seeds with floss are spread by wind. We proposed this mission to examine possible interplanetary migration of microbes, and organic compounds at the Exposure Facility of Japan Experimental Module (JEM: KIBO) of the International Space Station (ISS).
We are testing the panspermia hypothesis, which proposes the interplanetary transfer of life. We are also testing if the organic compound may be transferred from space before the origin of life on the earth.
The Tanpopo mission consists of six subthemes: Capture of microbes in space (Subtheme 1), exposure of microbes in space (Subtheme 2), analysis of organic compounds in interplanetary dust (Subtheme 3), exposure of organic compounds in space (Subtheme 4), measurement of space debris at the ISS orbit (Subtheme 5), and evaluation of ultra low-density aerogel developed for the Tanpopo mission (Subtheme 6).

Apparatus developed for Tanpopo mission

We have developed two types of apparatus used for Tanpopo mission: Capture Panels for aerogel to capture micro-particles and Exposure Panels for exposure of microbes and organic materials.
Each Capture Panel contains a silica aerogel block in an aluminum mesh container. Silica aerogel, which is the lowest density solid material, is used to capture micro particles, which may include, micrometeorite, artificial space debris and earth-originated natural particles. We are going to analyze if the particles contain terrestrial microbial cells or not, and if the micrometeorite contains organic compounds or not.
Exposure Panels have been developed to expose microbes and organic compounds to the space environment. Several microbial species including, *Deinococcus radiodurans, Deinococcus aerius, Deinococcus aetherius, Nostoc sp., Schizosaccharomyces pombe,* have been exposed to the space environment. These species are expected to be resistant against space environment, vacuum, desiccation, temperature-cycle, UV and ionization radiation. We have tested the survival of these species after one-, two- and three-year exposure in space. Organic compound such as amino acids and the precursors have also been exposed.

Schedule of Tanpopo mission

Tanpopo apparatus was launched in April 2015. The Panels were placed on the Exposed Experiment Handrail Attachment Mechanism (ExHAM) in the ISS. The ExHAM with Panels were placed on the Exposure Facility of KIBO (JEM) with the Japanese robotic arms through the airlock of KIBO in May 2015.
The first set of Capture Panels and an Exposure Panel were retrieved in June 2016, contained in plastic

©2019. Japan Geoscience Union. All Right Reserved.

bags, and stored in the pressurized area of the International Space Station. They have returned to the ground in the space capsule, and returned to JAXA in September 2016. The second set of Capture Panels and an Exposure Panel were detached in July 2017 and returned to JAXA in October 2017. The third set were detached in June 2018, the Exposure Panel and the Capture Panels were returned to JAXA in September 2018 and in February 2019, respectively.
Exposure Panel was separated into Exposure Units, each harboring either microbe or organic compound was handed over to the scientist in charge of each microbe or organic compound. Some of the Units are dedicated to the UV or radiation dose measurement.
Each aerogel block of each Capture Panel was examined for the particles captured and the tracks made upon the impact, which were extracted from the aerogel block and handed over to the scientists. The analysis includes, fluorescence microscopic inspection to test if there are microbial cells or not. Particles and tracks will be used for the mineral analysis as well as the analysis of organic compounds.
The first report has been published and the following results will be reported.
References: 1) A. Yamagishi, et al. “TANPOPO: astrobiology exposure and micrometeoroid capture experiments.” International Symposium on Space Technology and Science (ISTS) Web Paper Archives. 2008-k-05 , 2008. 2) Y. Kawaguchi, et a. “Investigation of the interplanetary transfer of microbes in the Tanpopo mission at the Exposed Facility of the International Space Station,” *Astrobiolgy* Vol. 16, pp. 1-14, 2016 .
3) A. Yamagishi, et al. Environmental data and survival data of *Deinococcus aetherius* from the Exposure Facility of the Japan Experimental Module of the International Space Station obtained by the Tanpopo Mission. *Astrobiology* Vol. 18, pp. 1369-1374., 2018.

Keywords: Micrometeotite, Microbes, Organics, Debris, Aerogel

©2019. Japan Geoscience Union. All Right Reserved.

Theoretical search for photosynthetic pigments applicable around low temperature stars: Modulation of physical-chemical properties by central metals

*Yu Komatsu[1,2], Kenji Takizawa[1,3]

1. Astrobiology Center, 2. National Astronomical Observatory of Japan, 3. National Institute for Basic Biology

A lot of extrasolar planets have been discovered in the habitable zone, and the number of samples will be increasing in future. In order to discover planets which harbour lives, it will be a significant achievement to identify potential biosignatures, which are traces of life from planetary spectra. Gaseous molecules such as oxygen and ozone and spectral features in surface vegetation called as "vegetation red edge (VRE)" are considered as biosignatures. In current observations, planets around M dwarfs, lower temperature stars than the Sun, have been focused, and there are large uncertainties in how assumed photosynthetic organisms evolve in the planets and how they would exhibit spectral features. Recently, it has been shown that the Earth-type photosynthesis can be evolved even around M dwarfs, considered lighting conditions in shallow water and how phototrophs can adapt to it (Takizawa, K., et al.: 2017, *Scientific Reports*, **7**, 7561). Moreover, an interesting example has been discovered that a cyanobacteria, which are categorized into oxygenic photosynthetic bacteria, becomes to utilize longer wavelength radiation for photochemistry than previously known, after grown under near infrared light, 750 nm (Nürnberg, D. J. et al.: 2018, *Science*, **360**, 1210.). Accumulating such knowledges and benchmarks from various points of view would lead to implications for future observations.

We investigate thoroughly by quantum chemical calculations the properties of photosynthetic pigments like and artificial pigments which might form on early Earth or other planets to unravel the red limit of the pigment. Photosynthetic pigments play a central role to convert available light energies into chemical energies. Chlorophyll has a tetrapyrrole ring with a metal ion such as Mg in the center of the ring. The ring structure can encapsulate a variety of metals to have a modulation of physical-chemical properties. Starting with the tetrapyrrole, we search for the pigments which are applicable around M dwarfs by calculating their basic structures, functional groups, central metals and solvents to determine the absorption wavelength and other properties. At first, we focused on the role of the central metal. Metals *M={H2, Mg, Ca, Ni, Cu, Zn, Sr, Cd, Hg, Pb, ...}* are put in the center of rings and are evaluated. According to our calculations, the wavelength of the first excited state is slight long in *M=Ni* in chlorophylls *a* and *b* and bacteriochlorophylls *a* and *b*. Additionally, binding eneries for metals into the rings in solvent conditions, molecular orbitals and reactivities (ionization potential and electron affinity) are analyzed for each pigment.

Keywords: Extrasolar planet, Biosignatures, Photosynthesis, Quantum Chemistry

©2019. Japan Geoscience Union. All Right Reserved.

Effects of the formation of hydrocarbon aerosols on the climate stability of Earth-like planets and their habitability

*Yasuto Watanabe[1], Eiichi Tajika[1], Kazumi Ozaki[2], Peng Hong[3]

1. The University of Tokyo, 2. Toho University, 3. Chiba Institute of Technology

It is known that the haze particles composed of hydrocarbons can form in an anoxic atmosphere in which the CH_4/CO_2 ratio exceeds the critical level (~0.2), as observed in Titan's atmosphere. The haze particles have characteristic optical properties that could affect the planetary climate as discussed in the context of the anoxic early Earth before the rise of atmospheric oxygen owing to the activity of oxygen-producing photosynthetic bacteria. Under low pO_2 condition, CO_2 and CH_4 can be photochemically broken up to form CO, and the excess CO reacts with OH radical to form CO_2. If primitive anaerobic microbial ecosystem exists on the Earth-like planet as in the early Earth, it can also affect the balance between CO_2, CH_4, and CO. Primitive marine microbial ecosystem may produce CH_4 to the atmosphere-ocean system via methanogenesis. The primitive microbial ecosystem consumes CO_2 from the atmosphere-ocean system via anoxygenic photosynthesis, but it also provides CO_2 via decomposition of organic matters and methanogenesis, and/or other abiotic processes. This implies that the balance between CO_2, CH_4, and CO in the early Earth must have been significantly different from that at present. Photochemical reactions and biological processes in the ocean may affect the stability of the planetary climate through the formation of the haze particles.

Here we developed a coupled atmospheric photochemistry-marine microbial ecosystem-global carbon cycle model to explore how the atmospheric photochemistry and the primitive marine microbial ecosystem can affect the carbon cycle and CO_2 budget on the Earth-like planet. We found that when the primitive biosphere produces large CH_4 flux (~10^{11} cm^{-2} s^{-1}), OH radicals should be consumed in the lower atmosphere through the reaction with CH_4. As a result, the reaction between CO and OH, which produces CO_2, cannot compensate the photolysis of CO_2 in the upper atmosphere. This means that photochemical reactions may work as a net CO_2 consumption process in the atmosphere-ocean system. The excess CO in the atmosphere is considered to have been converted to CO_2 and CH_4 through the CO-using chemosynthesis and methanogenesis in the oceans on the early Earth. Therefore, marine microbial reactions can work as a net CO_2 production process in the atmosphere-ocean system. We also found that, when the CO_2 level is so low that the hydrocarbon haze can form, the photochemical net consumption of CO_2 exceeds the biospheric net production. In this case, CO_2 is removed from the atmosphere-ocean system as the haze particle. As a result, the climate with the hydrocarbon haze should be unstable, and the climate is expected to change to the snowball state with low pCO_2 or to the hot climate state (> ~310 K on the CO_2 degassing rate of the present Earth) with high pCO_2 and pCH_4 on the planets with anoxic environment and primitive microbial ecosystem in the ocean.

Our result would put a theoretical constraint on the existence of life on extrasolar Earth-like planets and their habitability.

Keywords: Habitability, Climate stability

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 201A 2F

[M-IS07] Astrobiology

convener:Hikaru Yabuta(Hiroshima University, Department of Earth and Planetary Systems Science), Seiji Sugita(Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo), Misato Fukagawa(National Astronomical Observatory of Japan), Fujishima Kosuke(Tokyo Institute of Technology, Earth-Life Science Institute), Chairperson:Kosuke Fujishima(ELSI 地球生命研究所), Misato Fukagawa(名古屋大学大学院 理学研究科), Seiji Sugita(東京大学大学院 理学系研究科), Hikaru Yabuta(Hiroshima University)

Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Individual themes related to Astrobiology, such as chemical evolution in the early Solar System, formation of planetary system, prebiotic chemistry in the early Earth, evolution of life in the Earth's history, extremophile, and habitable planetary environments, has been studied by the knowledge and methods from the multiple fields, which has enabled us to explain "Where we came from" in some ways. However, despite an overwhelming number of investigations and discussions through gathering of the scientists from different fields, there has remained the long-standing unsolved question: How did abiotic materials gain biological function in the Earth and elsewhere in universe? There is still a large gap between prebiotic organic chemistry and biochemistry toward Origins of Life and planetary habitability. Therefore, the JpGU Astrobiology session focuses on pathfinding of "integration of astronomy, geoscience, and biochemistry", which will face an increasing need for the future Astrobiology. In order to enhance our understanding of "What is life", we propose to discuss the biochemical events linked with planetary systems, which is beyond the knowledge in a test tube, by an integration of exoplanets and molecular biology, etc. Through this approach, we will lead the discussions and developments of life-detection strategies for the future exploration of life in universe.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[MIS07-11] the emergence of iron-sulfur protometabolism

★Invited Papers

*Sheref Mansy[1] (1.University of Trento)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[MIS07-12] Life-water-mineral interactions and their products

★Invited Papers

*Fumito Shiraishi[1] (1.Hiroshima University)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[MIS07-13] How much can we learn about ancient cells from sequence analysis? New metrics on an old problem.

*Shawn E McGlynn[1], Sarah J Berkemer[2,3] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Bioinformatics Group, Department of Computer Science, Interdisciplinary Center for Bioinformatics, University of Leipzig, 3.Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[MIS07-14] Scientific significance of searching living cells on Mars surface by Life Detection Microscope (LDM)

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[MIS07-15] Civilization-bearing planets in the Milky-Way Galaxy; 50 necessary conditions must be satisfied in order

*Shigenori Maruyama[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

Discussion

the emergence of iron-sulfur protometabolism

*Sheref Mansy[1]

1. University of Trento

Iron-sulfur clusters are considered to be one of life's most ancient cofactors. Traditionally, the reliance of extant biology on iron-sulfur proteins has been interpreted to mean that iron-sulfur clusters of some type actively participated in the prebiotic chemistry that led to life. Since globular proteins were likely not present on the prebiotic Earth, most investigations into the early roles of iron-sulfur clusters have centered upon the potential activity of minerals, such as greigite and pyrite. Although minerals undoubtedly heavily impacted prebiotic chemistry and likely participated in the synthesis of molecules necessary for the emergence of life, it is unclear how minerals could have been later superseded by protein enzymes. Here we discuss our efforts in understanding the plausibility of synthesizing iron-sulfur clusters coordinated to prebiotically plausible peptides. We find that the solution conditions impact the type of iron-sulfur cluster formed, that UV light facilitates the synthesis of iron-sulfur clusters, and that iron-sulfur peptides can mediate the types of electron transfer reactions needed to sustain an early form of metabolism.

Keywords: iron-sulfur cluster, protocell, prebiotic chemistry, origins of life

©2019. Japan Geoscience Union. All Right Reserved.

Life-water-mineral interactions and their products

*Fumito Shiraishi[1]

1. Hiroshima University

Studies of modern and ancient microbial deposits on the Earth have demonstrated that the traces of microbial life are preserved as various kinds of minerals via life-water-mineral interactions. They include carbonates, phosphates, iron oxides, and manganese oxides, and their recent knowledge is introduced in the presentation.

For carbonates, cyanobacterial photosynthesis can produce $CaCO_3$ minerals to form deposits like stromatolites. However, their depositional fabrics are strongly influenced by the acidity of EPS (extracellular polymeric substances) secreted by cyanobacteria. In some cases, $CaCO_3$ minerals formed by cyanobacteria exhibit specific traces.

For phosphates, phosphorites are generally produced via degradation of organic matter during diagenesis. In the case of high phosphorus concentration in the euphotic zone, however, microbial photosynthesis potentially produces phosphate minerals to form phosphate stromatolites. Such process may occur after the snowball Earth glaciations in the Neoproterozoic as well as in the Paleoproterozoic.

For iron oxides, microbial Fe(II) oxidation is effective only when O_2 concentration is below ca. 50 μM, and inorganic process prevails above this level. The trace of iron-oxidizing bacteria is potentially preserved in the structure of iron oxide minerals.

For manganese oxides, substantial Mn(II) oxidation does not occur inorganically even under O_2 concentration equilibrated with the modern atmospheric level, and microbial processes are essential for it. In addition, manganese oxides adsorb various metals that potentially sustain metal-dependent microbial ecosystems in organic matter-deficient settings.

The knowledge about microbial traces on the Earth would provide valuable information for exploring extraterrestrial life.

©2019. Japan Geoscience Union. All Right Reserved.

How much can we learn about ancient cells from sequence analysis? New metrics on an old problem.

*Shawn E McGlynn[1], Sarah J Berkemer[2,3]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Bioinformatics Group, Department of Computer Science, Interdisciplinary Center for Bioinformatics, University of Leipzig, 3. Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

A longstanding goal is to apply molecular phylogenetics to understanding ancient physiological and evolutionary states (*e.g.* [1]). With the current explosion of molecular sequencing data (e.g. [2]), it is a good time to consider how far back we can peer with the comparative molecular lens, and ask if we can understand life in its nascent years. A standard test for inferring ancient genes is to look for conservation in microbial genomes, and to analyze phylogenetic branch positions and determine if a gene separates the archaea and the bacteria. However, many phylogenetic trees are cluttered by phenomena such as horizontal gene transfer and non-orthologous displacement [3], making inferences difficult.

In this presentation, we will give an overview of recent work in this area [4, 5], and also present new analyses which help identify ancient proteins. Using the COG database, we built phylogenetic trees for all protein families and analyzed the number of interdomain gene transfer events for each family. We find that proteins assigned to COGs exhibit widely variable amounts of interdomain gene transfer. By using distance matrices which relate *intra*-domain sequence similarity to *inter*-domain similarity, we find that protein families exhibiting numerous inter domain gene transfer events are also most self-similar between domains. Integrating this observation with previous analyses, ancient proteins appear to have large branch lengths separating the domains, but recent proteins are more bushy in tree shape. These findings will be discussed in the context of inferring the characteristics of the most ancient cells. Although this work provides new dimensions to analyze protein families with, more work is needed to definitively identify the proteins in the last common ancestor of the bacteria and archaea.

REFERENCES CITED

1. Woese, C.R.: Bacterial evolution. Microbiol. Rev. 51, 221–271 (1987)
2. Castelle, C.J., Banfield, J.F.: Major New Microbial Groups Expand Diversity and Alter our Understanding of the Tree of Life. Cell. 172, 1181–1197 (2018). doi:10.1016/j.cell.2018.02.016
3. Koonin, E.V.: Comparative genomics, minimal gene-sets and the last universal common ancestor. Nat. Rev. Microbiol. 1, 127–136 (2003). doi:10.1038/nrmicro751
4. Forterre, P.: The universal tree of life: an update. Front. Microbiol. 6, (2015). doi:10.3389/fmicb.2015.00717
5. Weiss, M.C., Sousa, F.L., Mrnjavac, N., Neukirchen, S., Roettger, M., Nelson-Sathi, S., Martin, W.F.: The physiology and habitat of the last universal common ancestor. Nat. Microbiol. 1, 16116 (2016). doi:10.1038/nmicrobiol.2016.116

Keywords: LUCA, Early life, Phylogenetics , Bioinformatics

©2019. Japan Geoscience Union. All Right Reserved.

Scientific significance of searching living cells on Mars surface by Life Detection Microscope (LDM)

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3]

1. College of Agriculture, Tamagawa University, 2. Tokyo University of Pharmacy and Life Science, 3. Japan Aerospace Exploration Agency, 4. Nagaoka University of Technology, 5. Tokyo University of Technology, 6. Yokohama National University, 7. Hiroshima University, 8. Fukuoka Institute of Technology

Past trial of direct detection of life on Mars by 1970's Viking mission ended up with a negative conclusion [1]. Whereas, numbers of new finding provided by Mars exploration missions in the last decade indicate that there are good reasons to perform another life detection program. The sensitivity of the gas chromatograph mass spectrometer onboard the Viking mission was not very high, and was not able to detect the microbes 10^6 cells in 1 gram clay [2,3].

Recent findings on Mars tend to support the possible presence of living microbes near the surface of Mars. MSL Curiosity has found organic compounds [4], the temporal increase of methane concentration in Martian atmosphere [5] and reduced sulfur compounds such as pyrite in Martian soil [6]. Methane and reduced sulfur compounds can be energy sources to support the growth of chemoautotrophic microbes [7]. Possible presence of liquid water at Recurring Slope Lineae has been supported by the detection of hydrated salts [8]. These evidences tend to support the possible presence of living microbes near the surface of Mars and indicate that another life detection program is necessary.

The Life Detection Microscope (LDM) that we have proposed [7, 9] has the potential sensitivity much higher than the Viking instrument. Microscopes directly image life forms and identify their shapes, sizes, and other morphological structures and have the potential to detect a single cell in field of view. Therefore, the sensitivity can be as high as desired just by increasing the volume of sample to be scanned in a reasonable duration of experiment. LDM scans about 1 mm^3 and detects less than 10^4 cells in 1 gram soil at a spatial resolution of 1 μm [9]. LDM differentiates among organic compounds surrounded by membranes or with enzyme activity by staining the samples with fluorescent pigments. This technique is especially useful for the detection of living microorganisms.

The search for living microorganisms is important not only for scientific interest but for planetary protection. Before future human missions begin, surveys investigating the presence of living microorganisms should be conducted to mitigate the risk of human contact with Martian microorganisms, which may be harmful to human health. Scientific significance the development of LDM will be addressed in this report.

References

[1] Margulis, L. et al. *J. Mol. Evol.* 14 (1979)

[2] Glavin, et al, *Earth Planet. Sci. Let.*, 185 (2001)

©2019. Japan Geoscience Union. All Right Reserved.

[3] Navarro-González, et al., *Proc. Natl. Acad. Sci. USA.*, 103 (2006)

[4] Eigenbrode, J. L., et al., *Science*, 360 (2018).

[5] Webster, C. R., et al., *Science*, 360 (2018).

[6] Ming, D., et al., *Science*, 343 (2014)

[7] Yamagishi, A. et al. *Biol. Sci. Space*, 24 (2010)

[8] Ojha, L. et al. *Nature Geosci.*, 8 (2015)

[9] Yamagishi, A., et al., *Trans. JSASS, Aerospace Tech. Japan*, 16 (2018).

Keywords: fluorescent microscope, extraterrestrial life

©2019. Japan Geoscience Union. All Right Reserved.

Civilization-bearing planets in the Milky-Way Galaxy; 50 necessary conditions must be satisfied in order

*Shigenori Maruyama[1]

1. Earth-Life Science Institute, Tokyo Institute of Technology

<Purpose>

Is there any life in the Universe, or specifically civilization-bearing planets? Recent popular answer for this basic question is easy-going “Yes”, which was also trendy answer 100 years ago. They think there are so many stars in the Universe, e.g., 10^{11}, so it is reasonable to think the possibility of the presence of life in the Universe. However, is it right scientifically?

<Method>

If the number of necessary conditions to make civilization-bearing planet is 50, simple estimate of presence or absence is $(1/2)^{50}=1/(10^{11})$, indicating that it is only one in the Milky Way Galaxy. To discuss the presence of life in the Universe, the best example with the most detailed research information is the Earth and its history. Other examples are planets, asteroid and meteorites in the solar system. Applying those data to the Universe, we can lead to general aspects of necessary conditions to infer life in the Universe.

<Result>

Based on the data set inferred from the research of Earth and life, 48 requirements are listed up. Those necessary conditions are mainly categorized into the following four. First group has 11 planetary conditions to be a life-sustaining planet; for example, “Chemical composition of central star”, “Mass of central star”, and “Circular orbit”. Second Group has 14 conditions of rocky planets to prepare the cradle of life; such as “Formation of bimodal continental and oceanic lithospheres to initiate plate tectonics”, “Restricted amount of initial mass of ocean to supply of nutrients for life”. Third group has 9 conditions to emerge and evolve life; such as “continuous and strong outer energy by natural geyser”, and “well-balanced nutrients source of landmass”. Forth group has 10 conditions to evolve into civilization bearing planet; such as “Survival over 2 billion years until birth of Eukaryote”, “A way to Eukaryote from Prokaryotes”, “A way to metazoans and Plant”, “Acceleration of life evolution”. There are other important 4 conditions; such as “Galactic habitable Zone”

<Discussion>

If we simply calculate the probability of presence of life in the Universe, civilization-bearing planet is only one (Earth). It is also emphasized that the requirements mentioned above is treated as presence of absence for all requirements, but several requirements are definitely less than 50% probability, e.g., extremely strict constraint for the amount of ocean volume 3km±1km. Moreover, it is emphasized that the number 51 is combinations and not permutations. This strongly indicates that we are alone in the Universe, even including whole Universe beyond our Milky Way Galaxy.

Keywords: habitable planet, civilization bearing planet, condition

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 302 3F

[M-AG38] Satellite Land Physical Processes Monitoring at Medium/High/Very High Resolution

convener:Jean-Claude Roger(University of Maryland College Park), Shinichi Sobue(Japan Aerospace Exploration Agency), Eric Vermote(NASA Goddard Space Flight Center), Chairperson:Jean-Claude Roger, Eric Vermote

We solicit papers on the land physical processes monitoring. In particular, it will include the inversion and use of land products from medium, high, and very high spatial resolution. For the last years, medium, high, and very high resolutions became a useful and a powerful toll for Earth studies. Topics of interest mainly include (not limited to):
- New developments for data processing, including atmospheric correction and cloud screening;
- Analysis and correction of directional effects in land surface reflectances;
- Use of time series of surface reflectances for land monitoring, including land cover classification and crop yield prediction (including data integration and data harmonization);
- Development and use of new vegetation indices (i.e. red edge) and other products for agriculture applications;
- Theoretical studies for sensors capabilities enhancements to future sensors at high/medium resolutions;
- Use of products in agricultural monitoring applications (such as crop area, crop type, crop growing, yield estimation and prediction, damage assessment);
- Agriculture monitoring algorithm description;
- Evaluation or validation of potential products with ground measurements, official statistics;
- International initiative to enhance Earth-Observing-based agricultural information.

Depending on outcome, we think about a special issue.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[MAG38-01] 15-years of LSA-SAF/Eumetsat satellite-derived albedo products: method for retrieval validation, and recent advances using neural networks during spectral integration

*Florian Pinault[1], Dominique Carrer[1], Xavier Ceamanos[1], Gabriel Lellouch[1], Catherine Meurey[1], Suman Moparthy[1], Chloé Vincent[1], Sandra Coelho[2], Isabel Trigo[2] (1.Météo France, CNRM-GAME, UMR3589, Toulouse, France, 2.IPMA, Lisbon, Portugal)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[MAG38-02] **Toward a Consistent Land Long Term Climate Data Records from Large Field of View Polar Orbiting Earth Observation Satellites**

*Eric Vermote[1], Jean-Claude Roger[1,2], Belen Franch[1,2], Christopher Justice[2], Ivan Csiszar[3], Sadashiva Devadiga[1], Edward Masuoka[1] (1.NASA Goddard Space Flight Center, 2.University of Maryland, Dept. of Geographical Sciences, 3.NOAA/NESDIS/STAR)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[MAG38-03] **LaSRC Cloud Detection Algorithm for Landsat 8 and Sentinel-2 Data**

*Sergii Skakun[1], Eric Vermote[2], Jean-Claude Roger[1] (1.University of Maryland College Park, 2.NASA Goddard Space Flight Center)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[MAG38-04] **Aerosol models for the validation of Surface Reflectances for MODIS, VIIRS, Landsat-8, Sentinel-2 from LaSRC**

*Jean-Claude Roger[1,2], Eric Vermote[2], Sergii Skakun[1,2], Belen Franch[1,2], Georgia Doxani[4], William Rountree[1,2], Ferran Gascon[4], chris justice[1], oleg dubovik[3], Brent holben[2] (1.University of Maryland, College Park, USA, 2.NASA Goddard Space flight Center, Greenbelt, USA, 3.LOA, University of Lille, Villeneuve d'Ascq, France, 4.ESA, Frascati, Italy)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[MAG38-05] Quantity and spatial distribution of aboveground biomass carbon in Colombia's forest

*Pedro Rodriguez-Veiga[1,2], Adriana Paola Barbosa-Herrera[3], Edersson Cabrera[3], Gustavo Galindo[3], Valentin Louis[1], Pilar Lozano[3], Pacheco-Pascagaza Ana Maria[1], Indira Pachon-Cendales[3], Salinas Nelso Ricardo[3], Heiko Balzter[1,2] (1.Centre for Landscape and Climate Research, University of Leicester, Leicester, UK, 2.NERC National Centre for Earth Observation (NCEO), Leicester, UK, 3.Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), Bogota, Colombia)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

Discussion

15-years of LSA-SAF/Eumetsat satellite-derived albedo products: method for retrieval validation, and recent advances using neural networks during spectral integration

*Florian Pinault[1], Dominique Carrer[1], Xavier Ceamanos[1], Gabriel Lellouch[1], Catherine Meurey[1], Suman Moparthy[1], Chloé Vincent[1], Sandra Coelho[2], Isabel Trigo[2]

1. Météo France, CNRM-GAME, UMR3589, Toulouse, France, 2. IPMA, Lisbon, Portugal

Using two sets of Eumetsat satellite sensors (geostationary MSG with SEVIRI sensor, polar orbiting Metop/EPS with AVHRR sensors), the Land Surface Analysis (LSA-SAF) team provides to the community several remote sensing products related to the land surface properties (http://lsa-saf.eumetsat.int/). The long-term continuity and consistency of these products is ensured from 2004 to at least 2022 thanks to the Eumetsat funding. In this contribution, we are focus on the various albedo products, presenting their properties, algorithms (from the L1 Top-Of-Atmosphere reflectance data to the L3 albedo), and validation results.

The main albedo retrieval algorithm is based on three steps. First, atmospheric correction is performed using a Smac approximation of a 6S off-line model. Second, the surface interaction is modeled by a kernel-based BRDF (Ross-thick-Li-sparse kernels), with an additional Kalman filter. Third, angular and spectral integrations are performed to compute spectral albedos (white-sky and black-sky) and broadband albedos (visible and NIR and total-shortwave).Validation results show a good match when comparing albedos with other sensors (MODIS) or with in-situ measurements. And performances are here analyzed in details with regards to the user requirements.

Finally we discuss the potential added value of using machine learning techniques in the scope of the launch of the next generation of European satellites which will provide observations in more spectral bands (as for instance MTG/FCI which characteristics are close to HIMAWARI 8/9: 5 visible bands and 3 NIR bands). In the third step of the albedo algorithm (spectral integration), non-convolutional neural networks seem to offer a promising way forward.

Keywords: brdf, albedo, satellite, remote sensing, neural network, machine learning

©2019. Japan Geoscience Union. All Right Reserved.

Toward a Consistent Land Long Term Climate Data Records from Large Field of View Polar Orbiting Earth Observation Satellites

*Eric Vermote[1], Jean-Claude Roger[1,2], Belen Franch[1,2], Christopher Justice[2], Ivan Csiszar[3], Sadashiva Devadiga[1], Edward Masuoka[1]

1. NASA Goddard Space Flight Center, 2. University of Maryland, Dept. of Geographical Sciences, 3. NOAA/NESDIS/STAR

Surface reflectance is one of the key products used in developing several higher-order land products, such as Vegetation Indices, Albedo and LAI/FPAR, it is therefore seminal to detecting trends in the biosphere and land surface and has been classed by NOAA as a “Fundamental Climate Data Record (FDCR) for Land”. Building a long-term surface reflectance data record of climate quality implies combining different instruments, sensors and satellites, accounting for different spatial resolutions and spectral characteristics, assuring consistent calibration, and correcting for atmospheric and directional effects. As the spatial resolution issue is addressed by aggregating the original data to a resolution still suitable for climate studies (e.g. 0.05 degree latitude, longitude), the instrument calibration becomes the first major hurdle one has to go through before being able to proceed any further.

In this work, we are using robust reflectance data records and inter-comparison methods that we have developed over the past several years (consisting of atmospheric correction, directional effect correction and spectral normalization) to establish and verify the inter-consistency of the reflectance products from the AVHRR sensors on-board NOAA 7, 9, 11, 14, 16, 17 and 18, the MODIS sensors on-board Aqua and Terra and the VIIRS sensors on-board Suomi-NPP and JPSS1. The resulting dataset being the 35+ years surface reflectance product and vegetation indices from 1981 to present.

Several other calibration techniques are also be applied that have been developed in the past by our team, in particular combining the cloud spectral band inter-calibration with BELMANIP cross sensor calibration in the near-infrared, using Landsat 5, 7 and 8 calibration to bridge between AVHRR and MODIS.

Keywords: surface reflectance, land climate data record, earth observations satellites

©2019. Japan Geoscience Union. All Right Reserved.

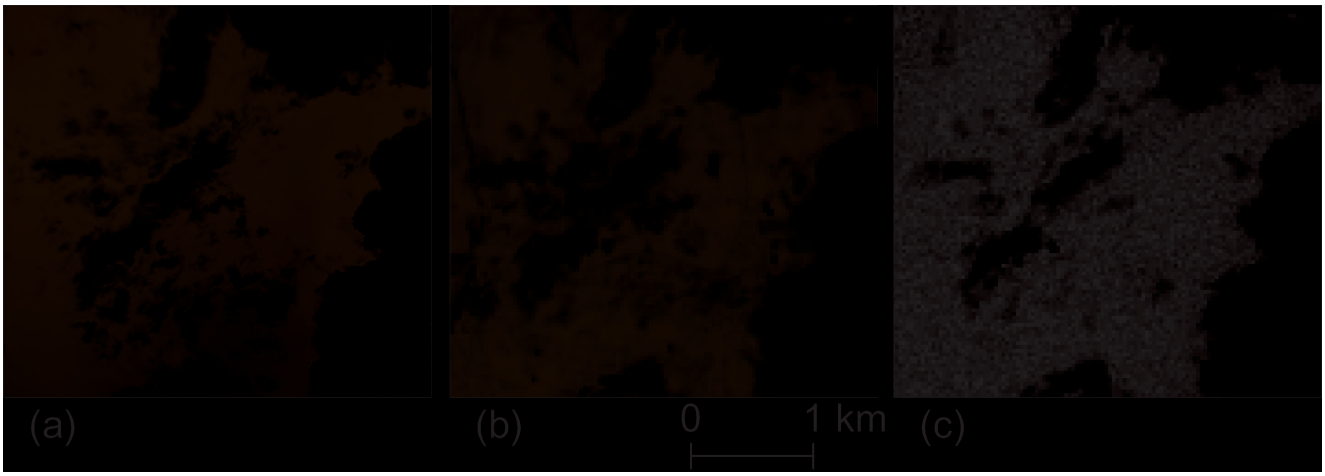
LaSRC Cloud Detection Algorithm for Landsat 8 and Sentinel-2 Data

*Sergii Skakun[1], Eric Vermote[2], Jean-Claude Roger[1]

1. University of Maryland College Park, 2. NASA Goddard Space Flight Center

This study aims at introducing and validating the cloud mask produced by the Land Surface Reflectance Code (LaSRC) for Landsat 8 and Sentinel-2 data. To detect clouds in optical satellite imagery, LaSRC uses quality assurance (QA) layers, which are produced during the atmospheric correction process. Validation is performed using two reference datasets. The former is the “L8 Biome” cloud validation dataset, which is produced by the US Geological Survey (USGS), and consists of 96 Landsat 8 scenes distributed globally over 12 different biomes. The latter is the dataset, which is produced over NASA GSFC assisted by ground photos of the sky and available for Landsat 8 and Sentinel-2A/B. We show that the LaSRC cloud detection algorithm reliably identifies thick clouds with commission and omission errors less than 4%. Large overdetection occurs for thin clouds. We conclude the study with recommendations on using the LaSRC QA layers, and provide an outlook on the need of acquiring objective reference cloud datasets.

Keywords: cloud, Landsat 8, Sentinel-2, LaSRC



©2019. Japan Geoscience Union. All Right Reserved.

Aerosol models for the validation of Surface Reflectances for MODIS, VIIRS, Landsat-8, Sentinel-2 from LaSRC

*Jean-Claude Roger[1,2], Eric Vermote[2], Sergii Skakun[1,2], Belen Franch[1,2], Georgia Doxani[4], William Rountree[1,2], Ferran Gascon[4], chris justice[1], oleg dubovik[3], Brent holben[2]

1. University of Maryland, College Park, USA, 2. NASA Goddard Space flight Center, Greenbelt, USA, 3. LOA, University of Lille, Villeneuve d'Ascq, France, 4. ESA, Frascati, Italy

The land surface reflectance is a fundamental climate data record at the basis of the derivation of other climate data records (Albedo, LAI/Fpar, Vegetation indices) and has been recognized as a key parameter in the understanding of the land-surface-climate processes.

This work relies on a generic approach developed to derive surface reflectance over land from a variety of sensors. The approach is based on the inversion of the radiative transfer equation in the Lambertian case, with no adjacency effects, that account for a simplified coupling of the absorption by atmospheric gases and scattering by molecules and aerosols as implemented in the 6SV radiative transfer code. The processing code relies on look-up tables generated by 6SV, for which the accuracy (~1%) has been well documented in several papers. The LaSRC code uses ancillary data such as pressure and gas concentrations but relies on a per pixel inversion of the aerosol properties to assure the best possible accuracy for the surface reflectance, as aerosols can be highly variable both in space and time. This new aerosol inversion builds on the extensive dataset acquired by the Terra platform, combining MODIS and MISR to derive an explicit and dynamic map of band ratio’ s between blue and red channels and is a refinement of the operational approach used for MODIS and LANDSAT over the past 15 years. The aerosol inversion is generic and applicable to a variety of sensors. We use this basic approach to derive Landsat 8 and Sentinel 2 surface reflectance products for medium, high and very high spatial resolution (MODIS, VIIRS, LANDSAT, SENTINEL-2, WORLD VIEW 3…). The validation scheme is based on using aerosol models developed for each AERONET sites. We will present here the methodology to get these models. We will also show comparison of surface reflectance products with field measurements done by an instrument developed by us.
Finally, we will presents performances of LaSRC inter-compared with other operational approaches in the framework of the CEOS-ACIX (Atmospheric Correction Intercomparison eXercise) Calibration Validation Task co-Lead by ESA and NASA.

Keywords: Aerosol model, Atmospheric correction, Validation, Medium and High spatial resolution

©2019. Japan Geoscience Union. All Right Reserved.

Quantity and spatial distribution of aboveground biomass carbon in Colombia’s forest

*Pedro Rodriguez-Veiga[1,2], Adriana Paola Barbosa-Herrera[3], Edersson Cabrera[3], Gustavo Galindo[3], Valentin Louis[1], Pilar Lozano[3], Pacheco-Pascagaza Ana Maria[1], Indira Pachon-Cendales[3], Salinas Nelso Ricardo[3], Heiko Balzter[1,2]

1. Centre for Landscape and Climate Research, University of Leicester, Leicester, UK, 2. NERC National Centre for Earth Observation (NCEO), Leicester, UK, 3. Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), Bogota, Colombia

In-situ national forest inventory data - NFI (IDEAM, 2018) as well as multispectral optical and synthetic aperture radar (SAR) satellite imagery were used to characterize the spatial distribution of forest aboveground biomass carbon (AGBC) stocks in Colombia. ALOS-2 PALSAR-2 gamma-0 backscatter annual mosaics (2015-2017) provided by JAXA were normalised and corrected using previous ALOS PALSAR annual mosaics (2007-2010) as reference. A multi-temporal Landsat 7 & 8 composite over the whole of Colombia was used for the year 2016 ±1. The national forest inventory in-situ plots used to train our model consisted of 5-subplots each and were collected during the period 2015-2017 in the main biomes of the country. A sample of permanent 1ha plots (PPMs) were also measured. Pan-tropical allometries (Chave et al, 2014) using diameter, height and specific wood gravity (type I) and a biomass-to-carbon ratio of 0.5 were used to estimate AGBC. A non-parametric random forests (RF) algorithm was used within a k-fold framework to retrieve AGBC at 30m spatial resolution for the whole of Colombia. The algorithm was trained using forest inventory plots and validated at plot (0.35 ha) and PPM level (1 ha). The accuracy assessment found coefficients of determination (R^2) of 0.70 and 0.68, and root mean square errors (RMSE) of 29.93 t C ha^{-1} and 24.79 t C ha^{-1} at plot and at PPM level, respectively. The results were also compared to the NFI estimates, and to current pantropical and global aboveground biomass carbon maps.

Keywords: biomass, carbon, SAR, machine-learning, multispectral, forest inventory

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 201B 2F

[M-AG38] Satellite Land Physical Processes Monitoring at Medium/High/Very High Resolution

convener:Jean-Claude Roger(University of Maryland College Park), Shinichi Sobue(Japan Aerospace Exploration Agency), Eric Vermote(NASA Goddard Space Flight Center), Chairperson:Sergii Skakun(University of Mrayland, USA), Eric Vermote

We solicit papers on the land physical processes monitoring. In particular, it will include the inversion and use of land products from medium, high, and very high spatial resolution. For the last years, medium, high, and very high resolutions became a useful and a powerful toll for Earth studies. Topics of interest mainly include (not limited to):
- New developments for data processing, including atmospheric correction and cloud screening;
- Analysis and correction of directional effects in land surface reflectances;
- Use of time series of surface reflectances for land monitoring, including land cover classification and crop yield prediction (including data integration and data harmonization);
- Development and use of new vegetation indices (i.e. red edge) and other products for agriculture applications;
- Theoretical studies for sensors capabilities enhancements to future sensors at high/medium resolutions;
- Use of products in agricultural monitoring applications (such as crop area, crop type, crop growing, yield estimation and prediction, damage assessment);
- Agriculture monitoring algorithm description;
- Evaluation or validation of potential products with ground measurements, official statistics;
- International initiative to enhance Earth-Observing-based agricultural information.
Depending on outcome, we think about a special issue.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

Introduction

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[MAG38-06] Introduction of GCOM-C/SGLI Leaf Area Index & Fraction of Absorbed Photosynthetically Active Radiation products

*Toshiyuki Kobayashi[1], Yoshiaki HONDA[2], Yuhsaku Ono[2], Hideki Kobayashi[3], Wei Yang[2], Shin Nagai[3], Tomoko Akitsu[4], Kenlo Nasahara[4], Risa Miyazaki[1], Masahiro Hori[1], Hiroshi Murakami[1] (1.Japan Aerospace Exploration Agency, 2.Center for Environmental Remote Sensing, Chiba University, 3.Japan Agency for Marine-Earth Science and Technology, 4.University of Tsukuba)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[MAG38-07] **35-years of Land Surface Albedo and 15-years of Down-Welling Short-Wave Radiation Retrievals from Satellites through the EUMETSAT/LSA-SAF and ECMWF/C3S projects**

*Dominique Carrer[1], Florian Pinault[1], Iskander Benhadj[2], Xavier Ceamanos[1], Sandra Coelho[3], Gabriel Lellouch[1], Catherine Meurey[1], Suman Moparthy[1], Else Swinnen[2], Chloé Vincent[1], Isabel Trigo[3] (1.Meteo France, CNRM, France, 2.VITO, Belgium, 3.IPMA, Portugal)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MAG38-08] **Integrating the satellite-based biophysical model and environmental zonation scheme to estimate rice yield gap in Northeast China**

*Jiahua Zhang[1,3], Jingwen Wang[1,2,3] (1.Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 2.University of Chinese Academy of Sciences, 3.Aerospace Information Research Institute, Chinese Academy of Sciences)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MAG38-09] Landsat-based Phenological Classification Mapping in Japan

*Narumasa Tsutsumida[1], Shin Nagai[2], Pedro Rodriguez-Veiga[3,4,1], Tomoaki Miura[5] (1.Graduate School of Global Environmental Studies, Kyoto Univeristy, 2.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 3.Centre for Landscape and Climate Research, University of Leicester, 4. National Centre for Earth Observation, University of Leicester, 5.Department of Natural Resources and Environmental Management University of Hawaii at Manoa)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MAG38-10] **Incorporating satellite-retrieved canopy nitrogen content into the biophysical process model for estimating crop yield and N fertilizer recommendation**

*Jingwen Wang[1,2,3], Jiahua Zhang[1,3] (1.Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 2.University of Chinese Academy of Sciences, 3.Aerospace Information Research Institute, Chinese Academy of Sciences)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

Discussion

Introduction of GCOM-C/SGLI Leaf Area Index & Fraction of Absorbed Photosynthetically Active Radiation products

*Toshiyuki Kobayashi[1], Yoshiaki HONDA[2], Yuhsaku Ono[2], Hideki Kobayashi[3], Wei Yang[2], Shin Nagai[3], Tomoko Akitsu[4], Kenlo Nasahara[4], Risa Miyazaki[1], Masahiro Hori[1], Hiroshi Murakami[1]

1. Japan Aerospace Exploration Agency, 2. Center for Environmental Remote Sensing, Chiba University, 3. Japan Agency for Marine-Earth Science and Technology, 4. University of Tsukuba

The Japan Aerospace Exploration Agency (JAXA) launched the Global Change Observation Mission - Climate (GCOM-C) satellite on December 23rd, 2017. The Leaf Area Index (LAI) and the fraction of Absorbed Photosynthetically Active Radiation (fAPAR) product (Algorithm ID: T2B) is one of the GCOM-C standard land products. The dataset is being produced from Second Generation Global Imager (SGLI) at 250-m resolution on a daily basis. At the present time, there are several limitations on the product. In this research, we summarize the early results and limitations of the T2B products.

The LAI is defined as one half of the total green leaf area per unit ground surface area. In the GCOM-C product, LAI is estimated for overstory leaves. The information for understory vegetation is added as understory NDVI. The fAPAR is defined as the proportion of the effectively absorbed solar radiation by plants in the photosynthetically active wavelengths (the spectral region from 400 to 700 nm). LAI and fAPAR were estimated based on the Look-Up Tables (LUTs) showing the relationships between the multi-angle atmospherically-corrected land surface reflectance data and the LAI or fAPAR. The LUTs were produced to fit with the field-observed reference data collected from literatures using a radiative transfer simulator, the Forest Light Environmental Simulator (FLiES) [1]. It simulates radiative transfers in the forests and grasslands based on the Monte Carlo method.

The accuracy of the retrieved LAI and fAPAR was assessed using the in-situ observation data which was collected at several sites. The product has the tendency of overestimating LAI especially at the needle-leaved forests. One of the reasons is that the current algorithm cannot distinguish the difference between the overstory LAI and the understory vegetation well at the forested areas with sparse trees. The accuracy of the T2B product should be improved by revising the algorithm and the LUTs for retrieving LAI. We are planning to revise the land cover datasets which are the basis of retrieving LAI. The LUTs will be revised by fitting the vegetation parameters for FLiES with the SGLI data.

[1] H. Kobayashi *et al.*, A coupled 1-D atmosphere and 3-D canopy radiative transfer model for canopy reflectance, light environment, and photosynthesis simulation in a heterogeneous landscape, *Remote Sensing of Environment*, **112** (2008), 173-185.

Keywords: LAI, fAPAR, GCOM-C

©2019. Japan Geoscience Union. All Right Reserved.

35-years of Land Surface Albedo and 15-years of Down-Welling Short-Wave Radiation Retrievals from Satellites through the EUMETSAT/LSA-SAF and ECMWF/C3S projects

*Dominique Carrer[1], Florian Pinault[1], Iskander Benhadj[2], Xavier Ceamanos[1], Sandra Coelho[3], Gabriel Lellouch[1], Catherine Meurey[1], Suman Moparthy[1], Else Swinnen[2], Chloé Vincent[1], Isabel Trigo[3]

1. Meteo France, CNRM, France, 2. VITO, Belgium, 3. IPMA, Portugal

The space program of EUMETSAT (project CDOP3, LSA-SAF) and the Copernicus Climate Change program (managed by ECMWF) provide (or will provide) added-value satellite products for the meteorological and environmental science communities, especially in the fields of climate modelling, environmental management, natural hazards management, and climate change detection.

The EUMETSAT/LSA-SAF project started in 1999 with research and development activities. The delivered operational products include land surface albedos, temperature, short-wave and long-wave downwelling radiation fluxes, and many others. After twenty years (1999-2019) of research, development, and progressive operational activities, Meteo-France built on a strong expertise on satellite retrieval of the surface albedo and down-welling short-wave radiation variables. Based on that experience, we started in 2016 within the framework of the COPERNICUS/C3S_312 project to develop consistent surface albedo products from the 80’ s until now using multiple sensors from the past to the current generation of instrument. This will complete the EUMETSAT/LSA-SAF albedo archive for the past period. This work will lead in 2019 to more than 35 years of products characterizing the albedo properties of the surface and 15 years of short-wave downwelling radiation fluxes from different satellite sensors. First C3S collection will be available in autumn 2019 whereas more than 10 different albedos and short-wave downwelling radiation fluxes are already operational in EUMETSAT/LSA-SAF (http://lsa-saf.eumetsat.int/). Product characteristics, and performances are presented here. The next scientific challenges related to the next generation of European satellites and the emergence of artificial intelligence are also discussed.

Finally, it is important to emphasize that these programs provide a great opportunity to monitor human-induced climate change since consistent production of data sets is ensured until at least 2022. In this perspective, our effort will be in the development of open source scientific code in order to share our expertise in the remote sensing of the Earth.

Keywords: satellite, surface albedo, short-wave radiation

©2019. Japan Geoscience Union. All Right Reserved.

Integrating the satellite-based biophysical model and environmental zonation scheme to estimate rice yield gap in Northeast China

*Jiahua Zhang[1,3], Jingwen Wang[1,2,3]

1. Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 2. University of Chinese Academy of Sciences, 3. Aerospace Information Research Institute, Chinese Academy of Sciences

Yield gap analysis is a powerful method to reveal the difference between the actual crop yield and yield potential, and to understand the possible yield increase for fulfilling the growing food demand. It used to be restricted to small geographic areas in previous studies, and thus the scope of untapped yield often remains unclear at macro scale. To this end, we proposed an improved remote sensing approach to better assess the regional rice yield gap in northeast China. A biophysical model based on satellite-retrieved LAI and crop classification map was used to derive the actual yield and its spatial patterns. In addition, a machine-learning zonation scheme was developed to further evaluate the attainable potential yield for farmers within domains having similar climatic, geomorphic, and edaphic context. Results indicated that the satellite-based biophysical model can provide reliable estimates of rice yields, with RMSE all below 20 percent at the county level from 2006 to 2017; and the zonation scheme enabled better portrayal of the spatial variation in potential yield. To identify areas with the greatest potential for narrowing the yield gap, northeast China was divided into four parts with different priorities for future yield improvement. In general, south of northeast China possessed substantial yield gaps with the primary priority to be explored; whereas in the north, the actual yield already approximating yield potential, further yield increase was limited and challenging. Quantile regression model provided a complete view of relationships between natural factors and potential yield, and revealed the significant limiting effects of growing degree days, cumulative solar radiation and elevation. This study demonstrates the potential of remote sensing for agricultural decisions, and will aid planners to recognize the macro-scale food production capacity and security situation, to prioritize regions and needs for research and exploitation, and to evaluate the impact of future scenarios such as climate change.

Keywords: remote sensing, crop yield, yield gap, biophysical process model, environmental zonation scheme, Northeast China

©2019. Japan Geoscience Union. All Right Reserved.

Landsat-based Phenological Classification Mapping in Japan

*Narumasa Tsutsumida[1], Shin Nagai[2], Pedro Rodriguez-Veiga[3,4,1], Tomoaki Miura[5]

1. Graduate School of Global Environmental Studies, Kyoto Univeristy, 2. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 3. Centre for Landscape and Climate Research, University of Leicester, 4. National Centre for Earth Observation, University of Leicester, 5. Department of Natural Resources and Environmental Management University of Hawaii at Manoa

Land surface phenology (LSP) is associated with climate and terrestrial conditions over space and time, and the monitoring of LSP helps understandings of the terrestrial environments. The LSP is often inferred by satellite observations, and long-term and regularly-composited satellite imagery is now freely available. Due to its complex interactions with geographical and environmental factors, it is often difficult to characterise phenological cycles by LSP. In order to understand the baseline of the phenological cycle which would be expected as the principal vegetation seasonal activity, we aim at classifying LSP temporal patterns over the entire territory of Japan. Normalised Vegetation Difference Index (NDVI) time series during the period of 2014 to 2017 with the spatial resolution of 30m calculated from Landsat 8 surface reflectance were decomposed into three harmonic terms by harmonic analysis with removing of the temporal trend. Then amplitudes and phases of these three harmonic terms were classified into 36 classes according to their orders. Considering tall vegetation (e.g., tree covers) and short vegetation (e.g., agricultural lands), while excluding other land covers, two types of phenological classification maps with 36 classes for each were produced. The phenological classification proposed in this study is a new terrestrial map which provides new important information for land cover studies regarding climate change, environmental degradation, and human impact assessment. This simple unsupervised classification approach can have diverse advantages such as i) only one specific variable (in this case NDVI) was used, yielding a consistent result compared to models with multivariate analysis, ii) complex temporal profiles can be considered, suggesting better descriptions of LSP than using phenological parameters such as start-of-season, peak-of-season, end-of-season, and length of greening period (In particular, our approach can classify temporal profiles with multiple peaks in the seasonal cycle), iii) the unsupervised classification approach do not need reference samples, which would require reliable observations of phenological events for a supervised classification scheme (such datasets are often limited), and iv) the non-thematic way of classification can avoid mislabelling problems. Interpretation of the classification map can be done by the users, making it easy to utilise towards further climate / environmental studies.

Keywords: Phenology, Earth Observation, Landsat

©2019. Japan Geoscience Union. All Right Reserved.

Incorporating satellite-retrieved canopy nitrogen content into the biophysical process model for estimating crop yield and N fertilizer recommendation

*Jingwen Wang[1,2,3], Jiahua Zhang[1,3]

1. Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 2. University of Chinese Academy of Sciences, 3. Aerospace Information Research Institute, Chinese Academy of Sciences

Remote sensing-based biophysical process models (RSBPM) are powerful and indispensable tools for estimating crop productivity over field and landscape scales. However, due to the lack of regional fertilization data, nitrogen stress is often poorly parameterized in these models, which may lead to considerable biases in crop yield simulation. To address this issue, current study improves the representation of nitrogen constraints on photosynthetic capacity in the RSBPM. Canopy nitrogen content retrieved from the newly available high-resolution Sentinel-2 spectral bands is integrated into the model to constrain nitrogen availability in the vital photosynthetic enzyme. And a two-leaf upscaling scheme is used to account for the vertically varying nitrogen content inside canopies and the associated physiological differences between leaves. Measurement data was collected for 32 field-years that spans major crops including wheat, maize, soybean and rice from 2016 to 2017 in China. The satellite-retrieved canopy nitrogen content partially reflects the field fertilization, and identifies seasonality of Rubiso-limited photosynthetic capacity. The new representation of nitrogen constraints significantly reduces the bias of estimated crop yields, and improves the temporal correlations between the simulated and the measured biomass, relative to the commonly employed cases of using specified constant nitrogen stress factor, default fertilization schemes, and the big-leaf nitrogen-constrained model. The improved RSBPM also enables the remote estimation of nitrogen nutrient index, which indicates the status of actual N absorbed versus critical N requirement in the crop. This model improvement on nitrogen constraints has significant implications for better assessment and prediction of crop yield and nitrogen use efficiency and for studying human-environment interactions.

Keywords: canopy nitrogen content, crop yield, biophysical process model, Sentinel-2, fertilization, nitrogen nutrient index

©2019. Japan Geoscience Union. All Right Reserved.

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 202 2F

[M-AG40] CTBT IMS Technologies for Detecting Nuclear Explosion and Their Applications to Earth Science

convener:Nurcan Meral Ozel(Comprehensive Nuclear-Test-Ban Treaty Organization), Hiroyuki Matsumoto(Japan Agency for Marine-Earth Science and Technology), Yosuke Naoi(Japan Atomic Energy Agency), Chairperson:Nurcan Meral Özel(Comprehensive Nuclear-Test-Ban Treaty Organization), Hiroyuki Matsumoto(JAMSTEC), Noriko Kamaya(ERI, University of Tokyo)

The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) was founded in 1996 in response to the adaption of the Treaty in 1996 by the United Nations General Assembly, which bans nuclear explosions on the Earth's surface, in the atmosphere, underwater and underground. The Treaty has a unique and comprehensive verification regime to make sure that no nuclear explosion goes undetected. The regime is supported by International Monitoring Systems (IMS) composed of the four state-of-art technologies; 1) Seismic, 2) Hydroacoustic, 3) Infrasound, and 4) Radionuclide, by the International Data Centre (IDC), and by the On-Site Inspections (OSI).
IMS will, when complete, consists of 337 facilities worldwide to monitor the planet for signs of nuclear explosion. Around 90 % of the facilities are in operation and sending the data to the IDC in Vienna, Austria.
The huge amount of data collected by the stations can be used for other purposes such as civil and scientific applications in addition to detecting nuclear explosions. They can provide Tsunami Warning centres with near real-time information about an underwater earthquake. During the Fukushima Daiichi Power Plant accident, in March 2011, the IMS network's radionuclide stations tracked the dispersion of radioactivity on a global scale. The data could also help better understand the oceans, volcanos, climate change, the movement of marine mammals, and many other issues.
This session will provide the overview of CTBTO and its IMS, the scientific discussion on each technology, and its outcomes. The session welcomes young scientists and engineers who are interested in four IMS technologies.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MAG40-01] Japanese Contributions and Collaborations for IMS Technologies and the Verification Regime

*Nurcan Meral Ozel[1], David Jepsen[1], Naoko Nakashima[1], Hideaki Komiyama[1], Hiroyuki Matsumoto[1,2] (1.Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MAG40-02] Review: Researches on detection of nuclear tests by seismic waves in Japan

★Invited Papers

*Noriko Kamaya[1] (1.Earthquake Research Institute, the University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MAG40-03] Waveform Analysis on Induced Earthquakes after the 2017 Nuclear Test and Detected Mining Events in DPRK

*Masashi Motohashi[1], Takanari Fujii[1], Takayuki Otsu[1] (1.Japan Weather Association)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MAG40-04] Submarine volcanoes and where to find them: Harnessing IMS hydroacoustic data

★Invited Papers

*Dirk Metz[1] (1.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MAG40-05] Importance of noble gas monitoring in CTBT verification technology and observation results in Takasaki radionuclide monitoring station

*Yoichi Yamamoto[1], Yuichi Kijima[1], Yutaka Tomita[1] (1.Japan Atomic Energy Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MAG40-06] ATM analysis results on radioxenons detected in Japan

*Yuichi Kijima[1], Yoichi Yamamoto[1], Yutaka Tomita[1] (1.Japan Atomic Energy Agency)

Japanese Contributions and Collaborations for IMS Technologies and the Verification Regime

*Nurcan Meral Ozel[1], David Jepsen[1], Naoko Nakashima[1], Hideaki Komiyama[1], Hiroyuki Matsumoto[1,2]

1. Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), 2. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

The CTBT verification regime is supported by the cooperation of member states who host monitoring stations and laboratories of the International Monitoring System (IMS) network. The proactive collaboration with state governments and research institutions hosting IMS facilities is crucial for improvement of the technologies for the verification regime.

Japan has contributed for many years in establishing and maintaining these facilities and in improving the verification technologies and regime, in a variety of aspects. Japan hosts stations for three of the technologies: seismic, infrasound and radionuclide. The technical contributions by Japan in projects for the improvement and enhancement of the radionuclide monitoring/detection capability are highlighted in this presentation.

In addition to the contributions through the operation of two IMS radionuclide monitoring stations in Japan, Okinawa, and Takasaki, two additional radionuclide measurement campaigns have been initiated at Horonobe and Mutsu, through financial support from the government of Japan (GoJ) in 2017. These campaigns started in early 2018, with the collaborations of Japan Atomic Energy Agency (JAEA). A new campaign in Fukuoka is being initiated, using another existing mobile system, aiming to configure a high dense measurement network for the evaluation and the calibration of the current noble gas system network of the IMS.

Another collaboration in the radionuclide sector is the air sampling for Ar-37 analysis and the new sampler testing at Takasaki station, in order to enhance the capability for On-site Inspection (OSI). Ar-37 is produced naturally by cosmic rays and exists in the atmosphere as background. Thus, it is also important to know its behavior in the environment. A 2-year sampling campaign was conducted at Takasaki in collaboration with JAEA in 2016-2018 utilizing their expertise.

The government of Japan (GoJ) has strongly supported to establish these collaborations, especially through voluntary contribution, in 2012, 2013 and 2017. They were used for enhancement of atmospheric transport modeling project, noble gas measurement campaign at Horonobe and Mutsu mentioned above, and sending Cost-free Experts (CFEs) of IMS HA Technology.

Keywords: Comprehensive Nuclear-Test-Ban Treaty (CTBT), International Monitoring System (IMS)

©2019. Japan Geoscience Union. All Right Reserved.

Review: Researches on detection of nuclear tests by seismic waves in Japan

*Noriko Kamaya[1]

1. Earthquake Research Institute, the University of Tokyo

1. Introduction

In Japan, if the Japan Meteorological Agency (JMA) observes a seismic wave that may not be a natural earthquake with epicenters around North Korea, the JMA immediately contacts the Prime Minister's Office and have press conferences and announces the parameters of that event. Then, with showing both waveforms of the North Korea's underground nuclear test and a natural earthquake, based on the characteristics of the waveform such as the S wave being ambiguous, JMA states there is a possibility that it is not a natural earthquake. The materials of these press conferences will be published on JMA’s website. However, because the detection of nuclear tests is not the original task of the JMA, no more analysis is not published. In addition, Japan Weather Association, which is responsible for monitoring nuclear tests based on the waveform data of the CTBTO (Comprehensive Nuclear Test Ban Treaty Organization), analyzes data, but only simple report is published on the website. It is important for Japan’s security to study detection technology of nuclear test by Japanese researchers. In this paper, we will review about Japanese researches on detection of nuclear tests by seismic waves which was published in Japanese papers.

2. Reports of observed events

The oldest paper would be written by Kubodera and Okano (1960). They reported long-period seismic waves with periods of 9 minutes to 1 minute were recorded at the same time that small atmospheric pressure change reached, when a hydrogen bomb test was conducted by the United States at Bikini Atoll in 1958. JMA (1972) published collection book of seismic waves recorded at underground nuclear test conducted by the US in the Amchitka Island on November 7, 1971.

3. Study on discrimination from natural earthquakes

Researches for discrimination nuclear tests from natural earthquakes were mainly conducted by using seismic waveforms at the Matsushiro Earthquake Observatory. Yamagishi et al. (1973) reported that the P wave of the nuclear tests were dominated by short-period waves. Also, they concluded that discrimination was possible by comparing Ms and mb. Seki et al. (1980) pointed out that S waves and surface waves were observed when large tests were conducted. Wakui and Kakishita (1986) pointed out that the discrimination method using the ratio of Mb and MS could only be applied to large-scale tests. Kamaya (1998) analyzed the waveforms of nuclear tests and natural earthquakes at Nevada and Xinjiang. She concluded the Complexity was the most effective method for discrimination. Okamoto and Kanjo (2007) analyzed waveforms of Matsushiro, Mudanjiang and Incheon of IRIS at the nuclear test by North Korea on October 9, 2006. They showed P wave radiation pattern had isotropic pattern. Koyama (2007) calculated the Complexity and the Spectral ratio of waveform in Matsushiro for the same test, and reported that the Spectral ratio was better than the Complexity for discrimination.

Kikuchi (1997) calculated the moment tensor for nuclear tests conducted by China and France from 1995

©2019. Japan Geoscience Union. All Right Reserved.

to 1996 by waveform of the IRIS. He showed that the combination of the three main values of the moment tensor were clearly different from those of the natural earthquake. In addition, he estimated that shape of epicenters of Chinese tests were acicular and French were disk-shaped.

4. Toward the Future
It is necessary for us to learn recent research in the world in cooperation with the CTBTO. In addition, our (Japanese researchers') continuous research on detection of nuclear tests by analyzing seismic waveforms around the world is important.

Keywords: Nuclear Test, Nuclear Explosion, Seismic waves, Complexity, Spectral Ratio, Moment Tensor

©2019. Japan Geoscience Union. All Right Reserved.

Waveform Analysis on Induced Earthquakes after the 2017 Nuclear Test and Detected Mining Events in DPRK

*Masashi Motohashi[1], Takanari Fujii[1], Takayuki Otsu[1]

1. Japan Weather Association

After the DPRK September 2017 nuclear test event, several earthquakes were occurred near the test site. The scale of these induced earthquake events was fairly very small, therefore there were a few CTBT IMS seismic stations (e.g. KSRS, USRK, KLR) which could detect earthquake signals. Japan NDC-1 (National Data Center-1) tried to locate and discriminate these events utilizing non-IMS data such as IRIS (Incorporated Research Institutions for Seismology).

Analyzing waveform data of these events, S-wave (Sn, Lg-Phase) amplitude of waveform at close stations is larger than that of P-wave (Pn, Pg-Phase) and the feature of these events is presumed to be natural earthquake rather than man-made explosion. Near the DPRK test site, there are two open-pit mines at Chung-gang city and Musan city which locates DPRK-China border. We also compared with past mining explosion event there and we discriminated events with the indexes such as regional P/S ratio, P/S Spectral Ratio.

It was quite difficult to make event discrimination using only IMS seismic waveform data. IMS seismic network is not designed for detecting small-scale nuclear test far less than 1kt. Therefore, local and non-IMS seismic network data could largely contribute to refine event location and event discrimination.

Keywords: Waveform Analysis, Event Discrimination, Nuclear Test, Induced Earthquake

©2019. Japan Geoscience Union. All Right Reserved.

Submarine volcanoes and where to find them: Harnessing IMS hydroacoustic data

*Dirk Metz[1]

1. Japan Agency for Marine-Earth Science and Technology

Low-frequency underwater sound waves are a key feature of the hydroacoustic waveform component of the International Monitoring System (IMS), a global sensor network maintained by the Comprehensive Nuclear-Test-Ban Treaty Organization in an effort to detect clandestine nuclear explosions in the ocean, in the atmosphere, and underground. However, the potential of IMS data extends beyond test-ban monitoring, for instance, when studying sound phases generated by remote natural sources that otherwise would be difficult to detect, such as submarine earthquakes or volcanic eruptions. Here, we focus on IMS hydrophone recordings of Monowai, a volcanic center in the Kermadec Arc, and Ahyi volcano, located in the Northern Mariana Islands. Tripatite array data are processed using standard cross-correlation and time-difference-of-arrival techniques. Density-based clustering of arrivals at station H03, Juan Fernández Islands, reveals 82 discrete episodes of unrest at Monowai over the course of 3.5-years, making it one of the most active arc volcanoes currently known. IMS data suggests further volcanic activity at both known and unknown sites in the Tonga-Kermadec Arc region. Hydroacoustic recordings of the 2014 eruption at Ahyi show how data analysis can be advanced and streamlined, for example, to determine spectral parameters and acoustic energy release, which has implications for studying volcanic source processes and their respective impact on the ocean soundscape. IMS hydrophone arrays register volcanic seismicity as low as ~2.5 m_b even at megameter distances, thus exceeding the resolution of most regional, land-based networks by more than one order of magnitude. Detectability strongly depends on frequency, source depth, and ray path geometry, which is illustrated by 2D transmission loss modeling for a range of synthetic scenarios. The findings presented here highlight the capabilities of the IMS hydrophone network for remotely detecting and studying volcanic activity in the global ocean.

Keywords: CTBTO, IMS, Submarine volcanoes, Hydroacoustics

©2019. Japan Geoscience Union. All Right Reserved.

Importance of noble gas monitoring in CTBT verification technology and observation results in Takasaki radionuclide monitoring station

*Yoichi Yamamoto[1], Yuichi Kijima[1], Yutaka Tomita[1]

1. Japan Atomic Energy Agency

Radionuclide monitoring for CTBT verification is the only way to judge whether the target explosion event was a nuclear test. Among the radionuclides produced by the nuclear explosion, the noble gases are particularly important because they are inert and more likely to leak to the ground rather than other substances in an underground nuclear test. Only 4 radioxenon isotopes as the noble gases are monitored for the CTBT verification. After the first nuclear test of North Korea in October 2006, a radioxenon monitoring system installed at the Takasaki radionuclide monitoring station in Japan and the radioxenon monitoring has been carried out since January 2007. We report on the past observation results of the radioxenon at the Takasaki radionuclide monitoring station and the characteristics of radioxenon background.

Keywords: CTBT, international monitoring system, noble gas, xenon, Takasaki radionuclide monitoring station

©2019. Japan Geoscience Union. All Right Reserved.

ATM analysis results on radioxenons detected in Japan

*Yuichi Kijima[1], Yoichi Yamamoto[1], Yutaka Tomita[1]

1. Japan Atomic Energy Agency

The Japan Atomic Energy Agency installed transportable xenon laboratories (TXLs) in collaboration with the CTBT Organization at Horonobe, Hokkaido and Mutsu, Aomori, respectively and has been measuring radioxenon since 2018. Therefore, the measurements of radioxenon for CTBT verification in Japan are currently conducted at total 3 measuring points adding the CTBT Takasaki radionuclide monitoring station. The analyses of estimation of emission source location by atmospheric transport modelling (ATM) were carried out to investigate the emission source of the radioxenons detected at these measuring points. We report the measurement results of radioxenons at 3 measuring points and the ATM analysis results.

©2019. Japan Geoscience Union. All Right Reserved.