2019年5月26日(日)

[E] 口頭発表 | セッション記号 U (ユニオン)：ユニオン

13:45 ~ 15:15 | 101 1F

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

コンビーナ:堀 和明(名古屋大学環境学研究科地理学講座)、Denis-Didier Rousseau(CNRS - ENS)、Jonathan L Bamber(member)、座長:村山 泰啓(情報通信研究機構)

13:45 ~ 15:15

[U01-01] Panel discussion about research assessment

*堀 和明[1] (1.名古屋大学環境学研究科地理学講座)

[E] 口頭発表 | セッション記号 U (ユニオン)：ユニオン

15:30 ~ 17:00 | 101 1F

[U-02] 地球惑星科学分野のダイバーシティ推進状況：国際的な視点から

コンビーナ:小口 千明(埼玉大学大学院理工学研究科)、堀 利栄(愛媛大学大学院理工学研究科 地球進化学)、高橋 幸弘(北海道大学・大学院理学院・宇宙理学専攻)、Claudia Jesus-Rydin(European Research Council)、座長:堀 利栄、小口 千明

15:30 ~ 15:45

[U02-01] Managing Diversity and Inclusiveness

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

15:45 ~ 16:00

[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)

16:00 ~ 16:15

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

*阿部 なつ江[1] (1.国立研究開発法人海洋研究開発機構海洋掘削科学研究開発センター)

16:15 ~ 16:30

[U02-04] 出産・育児における課題

*高橋 幸弘[1] (1.北海道大学・大学院理学院・宇宙理学専攻)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

9:00 ~ 10:30 | A02 東京ベイ幕張ホール

[P-PS04] 火星と火星圏の科学

コンビーナ:宮本 英昭(東京大学)、臼井 寛裕(東京工業大学地球生命研究所)、松岡 彩子(宇宙航空研究開発機構　宇宙科学研究所　太陽系科学研究系)、Sushil K Atreya(University of Michigan Ann Arbor)、座長:Sushil Atreya

9:00 ~ 9:15

[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 ~ 9:30

[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 ~ 9:45

[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 ~ 10:00

[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 ~ 10:15

[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 ~ 10:30

[PPS04-06] MRO/CRISM 火星リム観測による多重散乱を考慮したエアロゾル・ガス高度プロファイルのリトリーバル

*笠羽 康正[1]、豊岡 雅士[2]、青木 翔平[3]、Mahieux Arnaud[3,4]、中川 広務[2]、岩渕 弘信[2] (1.東北大学 惑星プラズマ・大気研究センター、2.東北大学 理学研究科 地球物理学専攻、3.Planetary Aeronomy, Belgian Institute for Space Aeronomy, Belgium 、4.University of Texas at Austin, USA)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

10:45 ~ 12:15 | A02 東京ベイ幕張ホール

[P-PS04] 火星と火星圏の科学

コンビーナ:宮本 英昭(東京大学)、臼井 寛裕(東京工業大学地球生命研究所)、松岡 彩子(宇宙航空研究開発機構　宇宙科学研究所　太陽系科学研究系)、Sushil K Atreya(University of Michigan Ann Arbor)、座長:宮本 英昭、臼井 寛裕

10:45 ~ 11:00

[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 ~ 11:15

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

*黒田 剛史[1,2]、鎌田 有紘[1]、鳥海 克成[1]、笠羽 康正[1]、寺田 直樹[1]、中川 広務[1] (1.東北大学　大学院理学研究科、2.情報通信研究機構)

11:15 ~ 11:30

[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 ~ 11:45

[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 ~ 12:00

[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 ~ 12:15

[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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

13:45 ~ 15:15 | 201B 2F

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

コンビーナ:Yang-Yi Sun(China University of Geosciences)、LIN CHIYEN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN)、MINYANG CHOU(National Cheng Kung University)、座長:Yang-Yi Sun

13:45 ~ 14:00

[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)

14:00 ~ 14:15

[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)

14:15 ~ 14:30

[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)

14:30 ~ 14:45

[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)

14:45 ~ 15:00

[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)

15:00 ~ 15:15

[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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

15:30 ~ 17:00 | 201B 2F

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

コンビーナ:Yang-Yi Sun(China University of Geosciences)、LIN CHIYEN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN)、MINYANG CHOU(National Cheng Kung University)、座長:CHI-YEN LIN

15:30 ~ 15:45

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

★Invited Papers

*斎藤 享[1]、吉原 貴之[1] (1.国立研究開発法人海上・港湾・航空技術研究所電子航法研究所)

15:45 ~ 16:00

[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)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

[PEM14-10] GBASにおける電離圏脅威となりうる電離圏勾配を含むプラズマバブルの継続時間について

*中村 真帆[1]、斎藤 享[1]、吉原 貴之[1] (1.国立研究開発法人 海上・港湾・航空技術研究所 電子航法研究所)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

9:00 ~ 10:30 | A01 東京ベイ幕張ホール

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

コンビーナ:尾崎 光紀(金沢大学理工研究域電子情報学系)、笠原 慧(東京大学)、亀田 真吾(立教大学理学部)、吉岡 和夫(東京大学大学院新領域創成科学研究科)、座長:吉岡 和夫(東京大学)、尾崎 光紀(金沢大学)

9:00 ~ 9:20

[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 ~ 9:35

[PCG21-02] 月・惑星探査用TOF質量分析器の開発

*福山 代智[1]、斎藤 義文[2]、浅村 和史[2]、横田 勝一郎[3] (1.東京大学大学院、2.宇宙航空研究開発機構・宇宙科学研究所、3.大阪大学)

9:35 ~ 9:50

[PCG21-03] In-situ太陽系探査を目指したOrbitrap質量分析器の開発

*川島 桜也[1]、笠原 慧[1]、斎藤 義文[4]、横田 勝一郎[2]、平原 聖文[3]、杉田 精司[1] (1.東京大学、2.大阪大学、3.名古屋大学、4.宇宙科学研究所)

9:50 ~ 10:05

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

*横田 勝一郎[1]、河井 洋輔[1]、青木 順[1]、斎藤 義文[2]、大竹 真紀子[2]、岡田 達明[2] (1.大阪大学・理学研究科、2.宇宙航空研究開発機構・宇宙科学研究所)

10:05 ~ 10:20

[PCG21-05] 深宇宙探査技術実証機DESTINY$^+$に搭載するダストアナライザDDAの開発と期待されるサイエンス

*平井 隆之[1]、小林 正規[1]、荒井 朋子[1]、木村 宏[1]、スラマ ラルフ[2]、クルーガー ハラルド[3] (1.千葉工業大学惑星探査研究センター、2.シュトゥットガルト大学、3.マックスプランク太陽系研究所)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

10:45 ~ 12:15 | A01 東京ベイ幕張ホール

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

コンビーナ:尾崎 光紀(金沢大学理工研究域電子情報学系)、笠原 慧(東京大学)、亀田 真吾(立教大学理学部)、吉岡 和夫(東京大学大学院新領域創成科学研究科)、座長:笠原 慧、尾崎 光紀(金沢大学)

10:45 ~ 11:05

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

★Invited Papers

*成影 典之[1]、岡 光夫[2]、深沢 泰司[3]、松崎 恵一[4]、渡辺 伸[4]、坂尾 太郎[4]、石川 真之介[5]、萩野 浩一[6]、三石 郁之[5]、水野 恒史[3]、篠原 育[4]、下条 圭美[1]、高棹 真介[5]、田辺 博士[7]、上野 宗孝[8]、高橋 忠幸[9]、高島 健[4]、太田 方之[4] (1.国立天文台、2.カリフォルニア大学バークレー校、3.広島大学、4.宇宙航空研究開発機構、5.名古屋大学、6.東京理科大学、7.東京大学、8.神戸大学、9.カブリ数物連携宇宙研究機構)

11:05 ~ 11:20

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

*阿部 琢美[1]、渡部 重十[2]、齊藤 昭則[3] (1.宇宙航空研究開発機構 宇宙科学研究所 太陽系科学研究系、2.北海道情報大学、3.京都大学大学院理学研究科)

11:20 ~ 11:35

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

*斎藤 義文[1]、小川 泰信[2]、小嶋 浩嗣[3] (1.宇宙航空研究開発機構・宇宙科学研究所・太陽系科学研究系、2.大学共同利用機関法人 情報・システム研究機構 国立極地研究所、3.京都大学・生存圏研究所)

11:35 ~ 11:50

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

*菊川 素如[2]、頭師 孝拓[2]、小嶋 浩嗣[2]、斎藤 義文[1] (1.宇宙航空研究開発機構、2.京都大学)

11:50 ~ 12:10

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

★招待講演

*Ezoe Yuichiro[1]、Miyoshi Yoshizumi[2]、Kasahara Satoshi[3]、Funase Ryu[3]、Nagata Harunori[4]、Nakajima Hiroshi[5]、Ishikawa Kumi[6]、Yamazaki Atsushi[6]、Hasegawa Hiroshi[6]、Hiraga Junko[7]、Fujimoto Masaki[6]、Mitsuda Kazuhisa[6]、Ueno Munetaka[8]、Koizumi Hiroyuki[3]、Kawakatsu Yasuhiro[6]、Iwata Takahiro[6]、Sahara Hironori[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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

13:45 ~ 15:15 | A01 東京ベイ幕張ホール

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

コンビーナ:尾崎 光紀(金沢大学理工研究域電子情報学系)、笠原 慧(東京大学)、亀田 真吾(立教大学理学部)、吉岡 和夫(東京大学大学院新領域創成科学研究科)、座長:亀田 真吾、尾崎 光紀(金沢大学)

13:45 ~ 14:05

[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)

14:05 ~ 14:25

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

★Invited Papers

*新中 善晴[1]、亀田 真吾[2]、笠原 慧[3]、河北 秀世[1]、小林 正規[4]、船瀬 龍[3]、吉川 一朗[3]、ジェライント ジョーンズ[5]、スノッドグラス コリン[6] (1.京都産業大学、2.立教大学、3.東京大学、4.千葉工業大学、5.UCL、6.The Open University)

14:25 ~ 14:45

[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)

14:45 ~ 15:00

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

*平原 聖文[1]、小嶋 浩嗣[2]、北村 成寿[3]、浅村 和史[4]、斎藤 義文[4] (1.名古屋大学宇宙地球環境研究所、2.京都大学生存圏研究所、3.東京大学大学院理学系研究科、4.宇宙航空研究開発機構宇宙科学研究所)

15:00 ~ 15:15

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

*吉村 義隆[1]、山岸 明彦[2]、佐藤 毅彦[3]、宮川 厚夫[2]、今井 栄一[4]、佐々木 聰[5]、小林 憲正[6]、癸生川 陽子[6]、岡田 朋華[6]、塩谷 圭吾[3]、薮田 ひかる[7]、長沼 毅[7]、三田 肇[8]、藤田 和央[3]、臼井 寛裕[3] (1.玉川大学、2.東京薬科大学、3.宇宙航空研究開発機構、4.長岡技術科学大学、5.東京工科大学、6.横浜国立大学、7.広島大学、8.福岡工業大学)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-OS 海洋科学・海洋環境

9:00 ~ 10:30 | 303 3F

[A-OS09] 海洋混合学：物質循環・気候・生態系の維持と長周期変動の解明

コンビーナ:安田 一郎(東京大学大気海洋研究所)、日比谷 紀之(東京大学大学院理学系研究科地球惑星科学専攻)、西岡 純(北海道大学低温科学研究所)、伊藤 進一(東京大学大気海洋研究所)、座長:安田 一郎(東京大学大気海洋研究所)

9:10 ~ 9:30

[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 ~ 9:45

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

*日比谷 紀之[1] (1. 東京大学 大学院理学系研究科 地球惑星科学専攻)

9:45 ~ 10:00

[AOS09-03] CTD取り付け型微細構造観測手法の開発と北太平洋海盆規模乱流分布

*安田 一郎[1]、後藤 恭敬[2]、長澤 真樹[1]、李 根淙[1]、中野 俊也[2]、纐纈 慎也[3] (1.東京大学大気海洋研究所、2.気象庁、3.海洋研究開発機構)

10:00 ~ 10:15

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

★Invited Papers

*川崎 高雄[1]、羽角 博康[1] (1.東京大学 大気海洋研究所)

10:15 ~ 10:30

[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] 口頭発表 | セッション記号 A (大気水圏科学)：A-OS 海洋科学・海洋環境

10:45 ~ 12:15 | 303 3F

[A-OS09] 海洋混合学：物質循環・気候・生態系の維持と長周期変動の解明

コンビーナ:安田 一郎(東京大学大気海洋研究所)、日比谷 紀之(東京大学大学院理学系研究科地球惑星科学専攻)、西岡 純(北海道大学低温科学研究所)、伊藤 進一(東京大学大気海洋研究所)、座長:西岡 純(北海道大学 低温科学研究所)

10:45 ~ 11:00

[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 ~ 11:15

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

*西岡 純[1]、小畑 元[2]、小川 浩史[2]、安田 一郎[2] (1.北海道大学低温科学研究所、2.東京大学大気海洋研究所)

11:15 ~ 11:30

[AOS09-08] 北太平洋中層に存在する溶存鉄の化学形に関する考察

*山下 洋平[1]、西岡 純[2]、小畑 元[3]、小川 浩史[3] (1.北海道大学 大学院地球環境科学研究院、2.北海道大学 低温科学研究所、3.東京大学 大気海洋研究所)

11:30 ~ 11:45

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

★Invited Papers

原田 尚美[1]、藤木 徹一[1]、*相田 真希[1]、本多 牧生[1]、喜多村 稔[1]、塩崎 拓平[1]、三野 義尚[3]、桑田 晃[2]、田所 和明[2]、関 宰[4]、近本 めぐみ[5] (1.国立研究開発法人 海洋研究開発機構 地球環境観測研究開発センター、2.国立研究開発法人 水産研究・教育機構　東北区水産研究所、3.名古屋大学 宇宙地球環境研究所 、4.北海道大学 低温科学研究所、5.ハワイ大学)

11:45 ~ 12:00

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

*三角 和弘[1]、西岡 純[2]、小畑 元[3]、津旨 大輔[1]、坪野 考樹[1]、Matthew Long[4]、Keith Lindsay[4]、J. Keith Moore[5] (1.電力中央研究所 環境科学研究所、2.北海道大学 低温科学研究所、3.東京大学 大気海洋研究所、4.米国大気研究センター、5.カリフォルニア大学アーバイン校)

12:00 ~ 12:15

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

*伊藤 進一[1]、王 子健[1]、西川 はつみ[3]、三寺 史夫[3]、石野 光弘[2] (1.東京大学大気海洋研究所、2.水産研究・教育機構、3.北海道大学)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-OS 海洋科学・海洋環境

13:45 ~ 15:15 | 303 3F

[A-OS09] 海洋混合学：物質循環・気候・生態系の維持と長周期変動の解明

コンビーナ:安田 一郎(東京大学大気海洋研究所)、日比谷 紀之(東京大学大学院理学系研究科地球惑星科学専攻)、西岡 純(北海道大学低温科学研究所)、伊藤 進一(東京大学大気海洋研究所)、座長:伊藤 進一(東京大学)

13:45 ~ 14:00

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

★Invited Papers

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

14:00 ~ 14:15

[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)

14:15 ~ 14:30

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

*長船 哲史[1]、増田 周平[1]、杉浦 望実[1]、土居 知将[1]、邉見 忠[1] (1.国立研究開発法人 海洋研究開発機構)

14:30 ~ 14:45

[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)

14:45 ~ 15:00

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

★Invited Papers

*郭 新宇[1]、松野 健[2]、千手 智晴[2]、市川 香[2]、遠藤 貴洋[2]、堤 英輔[2]、仁科 文子[3]、中村 啓彦[3]、張 勁[4]、長谷川 大介[5]、吉江 直樹[1]、小針 統[3] (1.愛媛大学沿岸環境科学研究センター、2.九州大学応用力学研究所、3.鹿児島大学水産学部、4.富山大学理工学研究部、5.東北区水産研究所)

15:00 ~ 15:15

[AOS09-17] 日向灘沖の陸棚斜面近傍を流れる黒潮において、水平30km、鉛直200m規模で観測された著しく強い乱流混合

*長井 健容[1]、Duran Silvana[2]、Otero Diego[2]、森 泰貴[1]、吉江 直樹[3]、大城 一輝[3]、長谷川 大介[4]、仁科 文子[5]、小針 統[5] (1.東京海洋大学 海洋環境科学部門、2.国立アグラリアラモリーナ大学水産学部、3.愛媛大学沿岸環境科学研究センター、4.東北区水産研究所・国立研究開発法人水産研究・教育機構、5.鹿児島大学　水産学部)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-GG 地理学

9:00 ~ 10:30 | 106 1F

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

コンビーナ:Yuei-An Liou(National Central University)、座長:Yuei-An Liou(Center for Space and Remote Sensing Research (CSRSR))、Kim-Anh Nguyen(National Central University)

9:00 ~ 9:15

[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 ~ 9:30

[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 ~ 9:45

[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 ~ 10:00

[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 ~ 10:15

[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 ~ 10:30

[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] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

10:45 ~ 12:15 | 106 1F

[H-TT20] Environmental Remote Sensing

コンビーナ:Wei Yang(Chiba University)、近藤 昭彦(千葉大学環境リモートセンシング研究センター)、座長:楊 偉(千葉大学)

10:45 ~ 11:00

[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 ~ 11:15

[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 ~ 11:30

[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 ~ 11:45

[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 ~ 12:00

[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 ~ 12:15

[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] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

10:45 ~ 12:15 | 301B 3F

[S-SS04] New methods for seismicity characterization

コンビーナ:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)、加藤 愛太郎(東京大学地震研究所)、青木 陽介(東京大学地震研究所)、Claudio Satriano(Institut de Physique du Globe de Paris)、座長:Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)

10:45 ~ 11:00

[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 ~ 11:15

[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 ~ 11:30

[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 ~ 11:45

[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 ~ 12:00

[SSS04-05] しきい値なし波形相関による前震検出

*平野 史朗[1]、川方 裕則[1]、土井 一生[2] (1.立命館大学理工学部物理科学科、2.京都大学防災研究所)

12:00 ~ 12:15

[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] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

13:45 ~ 15:15 | A04 東京ベイ幕張ホール

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

コンビーナ:Luca Urpi(Swiss Seismological Service - ETH Zurich)、Enescu Bogdan(京都大学 大学院 理学研究科 地球惑星科学専攻 地球物理学教室)、青木 陽介(東京大学地震研究所)、Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)、座長:Luca Urpi(ETH-Zurich; Swiss Seismological Service)、Bogdan Enescu(京都大学 大学院理学研究科)、Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)、青木 陽介

13:45 ~ 14:00

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

★Invited Papers

*椋平 祐輔[1]、Michael Fehler[2]、伊藤 高敏[1]、浅沼 宏[3]、Markus Häring[4] (1.東北大学　流体科学研究所、2.マサチューセッツ工科大学　地球資源研究所、3.産業技術総合研究所　福島再生可能エネルギー研究所、4.Häring GeoProject)

14:00 ~ 14:15

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

*佐藤 大祐[1]、吉田 圭佑[2] (1. 京都大学防災研究所、2.東北大学理学研究科附属地震噴火予知研究観測センター)

14:15 ~ 14:30

[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)

14:30 ~ 14:45

[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)

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

14:45 ~ 15:00

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

*Savage Martha[1]、Graham Kenny[1]、Aoki Yosuke[2]、Arnold Richard[1]、Okada Tomomi[3]、Iio Yoshihisa[4]、Matsumoto Satoshi[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)

15:00 ~ 15:15

[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] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

10:45 ~ 12:15 | A09 東京ベイ幕張ホール

[S-IT20] 地球型惑星内部での液体の特性とその役割

コンビーナ:坂巻 竜也(東北大学大学院理学研究科)、中島 陽一(熊本大学大学院先導機構)、座長:坂巻 竜也(東北大学)、中島 陽一(熊本大学)

10:45 ~ 11:15

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

★Invited Papers

*河野 義生[1]、Yu Shu[2]、Curtis Kenney-Benson[2]、Yanbin Wang[3]、Guoyin Shen[2] (1.愛媛大学地球深部ダイナミクス研究センター、2.Argonne National Laboratory、3.The University of Chicago)

11:15 ~ 11:30

[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 ~ 12:00

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

★Invited Papers

*大村 訓史[1]、土屋 卓久[2] (1.広島工業大学、2.愛媛大学)

12:00 ~ 12:15

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

*飯高 敏晃[1]、Nguyen Van Hong[2] (1.国立研究開発法人理化学研究所、2.Hanoi University of Science and Technology)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

13:45 ~ 15:15 | A09 東京ベイ幕張ホール

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

コンビーナ:中川 貴司(香港大学地球科学専攻)、芳野 極(岡山大学惑星物質研究所)、趙 大鵬(東北大学大学院理学研究科附属地震・噴火予知研究観測センター)、座長:芳野 極(岡山大学)

13:45 ~ 14:00

[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)

14:00 ~ 14:15

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

*宮腰 剛広[1]、亀山 真典[2]、小河 正基[3] (1.海洋研究開発機構、2.愛媛大学、3.東京大学)

14:15 ~ 14:30

[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)

14:30 ~ 14:45

[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)

14:45 ~ 15:00

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

*徐 雲遨[1]、吉澤 和範[1,2]、古村 孝志[3] (1.北海道大学　大学院理学院　自然史科学専攻、2.北海道大学　理学研究院、3.東京大学　地震研究所)

15:00 ~ 15:15

[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] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

15:30 ~ 17:00 | A09 東京ベイ幕張ホール

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

コンビーナ:中川 貴司(香港大学地球科学専攻)、芳野 極(岡山大学惑星物質研究所)、趙 大鵬(東北大学大学院理学研究科附属地震・噴火予知研究観測センター)、座長:趙 大鵬(東北大学)

15:30 ~ 15:45

[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)

15:45 ~ 16:00

[SIT23-08] 東北アジアのプレート内部火山の深部構造と起源

*趙 大鵬[1] (1.東北大学大学院理学研究科附属地震・噴火予知研究観測センター)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

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

*久家 慶子[1] (1.京都大学大学院理学研究科地球惑星科学専攻地球物理学教室)

16:30 ~ 16:45

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

*川添 貴章[1,2]、Florian Heidelbach[2]、宮島 延吉[2]、石井 貴之[2] (1.広島大学、2.バイロイト大学)

16:45 ~ 17:00

[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] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

9:00 ~ 10:30 | A09 東京ベイ幕張ホール

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

コンビーナ:小西 健介(台湾中央研究院地球科学研究所)、片山 郁夫(広島大学大学院理学研究科地球惑星システム学専攻)、芳野 極(岡山大学惑星物質研究所)、Alexandre Schubnel(CNRS)、座長:Kensuke Konishi(Institute of Earth Sciences)

9:00 ~ 9:15

[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 ~ 9:30

[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 ~ 9:45

[SIT24-03] 海洋アセノスフェア地震学的構造に対する新たな制約

★招待講演

*竹内 希[1]、川勝 均[1]、塩原 肇[1]、一瀬 建日[1]、杉岡 裕子[2]、伊藤 亜妃[3]、歌田 久司[1] (1.東京大学地震研究所、2.神戸大学、3.海洋研究開発機構)

9:45 ~ 10:00

[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 ~ 10:15

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

★Invited Papers

*武井 康子[1]、山内 初希[1]、角田 明博[1] (1.東京大学地震研究所)

10:15 ~ 10:30

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

*山内 初希[1]、武井 康子[1] (1.東京大学地震研究所)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-TT 計測技術・研究手法

9:00 ~ 10:30 | A04 東京ベイ幕張ホール

[S-TT42] Recent Advances in Exploration Geophysics 2019

コンビーナ:三ケ田 均(京都大学大学院工学研究科)、飯尾 能久(京都大学防災研究所)、島 伸和(神戸大学大学院理学研究科惑星学専攻)、武川 順一(京都大学大学院工学研究科)、座長:渡邊 勇介(京都大学大学院工学研究科)、武川 順一(京都大学大学院工学研究科)

9:00 ~ 9:15

[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 ~ 9:30

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

*大谷 颯[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学大学院工学研究科)

9:30 ~ 9:45

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

★Invited Papers

*武川 順一[1]、三ケ田 均[1] (1.京都大学大学院工学研究科)

9:45 ~ 10:00

[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 ~ 10:15

[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 ~ 10:30

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

★Invited Papers

*笠原 順三[1,5]、羽佐田 葉子[2,1]、久詰 陽康[1]、藤瀬 吉博[4,1]、三ケ田 均[3] (1.エンジニアリング協会、2.大和探査技術(株）、3.京都大学、4.WELMA(株）、5.静岡大学)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-TT 計測技術・研究手法

10:45 ~ 12:15 | A04 東京ベイ幕張ホール

[S-TT42] Recent Advances in Exploration Geophysics 2019

コンビーナ:三ケ田 均(京都大学大学院工学研究科)、飯尾 能久(京都大学防災研究所)、島 伸和(神戸大学大学院理学研究科惑星学専攻)、武川 順一(京都大学大学院工学研究科)、座長:武川 順一(京都大学大学院工学研究科)、渡邊 勇介(京都大学大学院工学研究科)

10:45 ~ 11:00

[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 ~ 11:15

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

*田村 怜[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

11:15 ~ 11:30

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

*木村 巧志[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

11:30 ~ 11:45

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

*益邑 遼[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

11:45 ~ 12:00

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

*岩田 優生[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学大学院工学研究科)

12:00 ~ 12:15

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

*渡邊 勇介[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-PT 古生物学・古生態学

9:00 ~ 10:30 | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

コンビーナ:豊福 高志(国立研究開発法人海洋研究開発機構)、北里 洋(国立大学法人東京海洋大学)、Bijma Jelle(アルフレッドウェゲナー極域海洋研究所)、廣瀬 孝太郎(早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻)、座長:廣瀬 孝太郎(早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻)、豊福 高志

9:00 ~ 9:15

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

★Invited Papers

*鈴木 拓馬[1]、林 広樹[1] (1.島根大学)

9:15 ~ 9:30

[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 ~ 9:45

[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

*吉村 寿紘[1]、為則 雄祐[2]、黒田 潤一郎[3]、黒柳 あずみ[4]、大河内 直彦[1] (1.海洋研究開発機構　生物地球化学研究分野、2.高輝度光科学研究センター、3.東京大学　大気海洋研究所、4.東北大学　総合学術博物館)

9:45 ~ 10:00

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

*氏家 由利香[1]、石谷 佳之[2]、石井 俊一[3]、長井 裕季子[3]、高木 善弘[3]、生田 哲朗[3]、豊福 高志[3] (1.高知大学・海洋コア総合研究センター、2.筑波大学・計算科学研究センター、3.海洋研究開発機構)

10:00 ~ 10:15

[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 ~ 10:30

[BPT04-06] 海底景観から底生有孔虫を特徴づける

*北里 洋[1] (1.国立大学法人東京海洋大学)

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-PT 古生物学・古生態学

10:45 ~ 12:15 | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

コンビーナ:豊福 高志(国立研究開発法人海洋研究開発機構)、北里 洋(国立大学法人東京海洋大学)、Bijma Jelle(アルフレッドウェゲナー極域海洋研究所)、廣瀬 孝太郎(早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻)、座長:Jelle Bijma(AWI)、北里 洋

10:45 ~ 11:00

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

*甕 聡子[1]、富岡 尚敬[1]、川野 潤[2]、波利井 佐紀[3]、永井 隆哉[2]、渡邊 剛[2]、兒玉 優[4]、伊藤 元雄[1] (1.海洋研究開発機構 高知コア研究所、2.北海道大学、3.琉球大学、4.マリン・ワーク・ジャパン)

11:00 ~ 11:15

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

*樋口 富彦[1]、湯山 育子[2] (1.東京大学大気海洋研究所、2.筑波大学)

11:15 ~ 11:30

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

*西尾 拓哉[1]、高柳 栄子[1]、浅海 竜司[1]、新城 竜一[2]、山本 鋼志[3]、井龍 康文[1] (1.東北大学大学院理学研究科地学専攻、2.琉球大学大学院理工学研究科物質地球科学科地学系、3.名古屋大学大学院環境学研究科地球環境科学専攻)

11:30 ~ 11:45

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

*高柳 栄子[1]、栃木 智子[1]、浅海 竜司[1]、新城 竜一[2]、板木 拓也[3]、井龍 康文[1] (1.東北大学、2.琉球大学、3.産業技術総合研究所)

11:45 ~ 12:05

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

★Invited Papers

*仲村 康秀[1]、堀 利栄[2]、辻 彰洋[1]、大藤 弘明[2]、鈴木 紀毅[3]、木元 克典[4] (1.国立科学博物館、2.愛媛大学、3.東北大学、4.海洋研究開発機構)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

13:45 ~ 15:15 | 304 3F

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

コンビーナ:Groisman Pavel(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)、座長:Shamil Maksyutov(National Institute for Environmental Studies, Japan)、Pavel Groisman(NC State University, USA)、Yoshihiro Iijima(Mie University, Japan)

13:45 ~ 14:00

[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)

14:00 ~ 14:15

[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,)

14:15 ~ 14:30

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

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

14:30 ~ 14:45

[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)

14:45 ~ 15:00

[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)

15:00 ~ 15:15

[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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

15:30 ~ 17:00 | 304 3F

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

コンビーナ:Groisman Pavel(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)、座長:Dmitry Streletskiy(George Washington University)、Pavel Groisman(NC State University, USA)、Tetsuya Hiyama(Nagoya University, Japan)

15:30 ~ 15:45

[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)

15:45 ~ 16:00

[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)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

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

*谷田貝 亜紀代[1]、千田 彩乃[1]、増田 南波[1]、Kumar Vinay[2] (1.弘前大学大学院理工学研究科、2.Texas A&M University)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

9:00 ~ 10:30 | 302 3F

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

コンビーナ:村山 泰啓(国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)、近藤 康久(総合地球環境学研究所)、Shelley Stall(American Geophysical Union)、Cecconi Baptiste(LESIA, Observatoire de Paris, CNRS, PSL Research University)、座長:村山 泰啓(情報通信研究機構)

9:00 ~ 9:15

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

*村山 泰啓[1] (1.国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)

9:15 ~ 9:30

[MGI31-02] Japan Data Repository Network (JDARN)：データリポジトリの信頼性向上を中心としたコミュニティ活動

*北本 朝展[1,2,4]、絹谷 弘子[3] (1.国立情報学研究所、2.ROIS-DS人文学オープンデータ共同利用センター、3.東京大学地球観測データ統融合連携研究機構、4.総合研究大学院大学)

9:30 ~ 9:45

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

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

9:45 ~ 10:00

[MGI31-04] Ethical issues in open science

*近藤 康久[1] (1.総合地球環境学研究所)

10:00 ~ 10:15

[MGI31-05] 統合イノベーション政策と学術情報流通の現状のギャップから見通すオープンサイエンスの展望

*林 和弘[1] (1.文部科学省科学技術・学術政策研究所)

10:15 ~ 10:30

[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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

10:45 ~ 12:15 | 302 3F

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

コンビーナ:村山 泰啓(国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)、近藤 康久(総合地球環境学研究所)、Shelley Stall(American Geophysical Union)、Cecconi Baptiste(LESIA, Observatoire de Paris, CNRS, PSL Research University)、座長:Shelley Stall(American Geophysics Union)

10:45 ~ 11:00

[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 ~ 11:15

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

*樋口 篤志[1,3]、豊嶋 紘一[1]、広瀬 民志[1]、竹中 栄晶[2,1] (1.千葉大学環境リモートセンシング研究センター、2.JAXA EORC、3.NICT)

11:15 ~ 11:30

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

*堀之内 武[1] (1.北海道大学地球環境科学研究院)

11:30 ~ 11:45

[MGI31-10] 測地観測データ提供の現状と問題

*大坪 俊通[1]、横田 裕輔[2]、石川 直史[3]、関戸 衛[4]、宮崎 隆幸[5]、栗原 忍[5] (1.一橋大学、2.東京大学生産技術研究所、3.海上保安庁海洋情報部、4.情報通信研究機構、5.国土地理院)

11:45 ~ 12:00

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

*能勢 正仁[1]、村山 泰啓[2] (1.名古屋大学 宇宙地球環境研究所、2.情報通信研究機構 戦略的プログラムオフィス)

12:00 ~ 12:15

[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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

15:30 ~ 17:00 | A04 東京ベイ幕張ホール

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

コンビーナ:村山 泰啓(国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)、近藤 康久(総合地球環境学研究所)、Shelley Stall(American Geophysical Union)、Cecconi Baptiste(LESIA, Observatoire de Paris, CNRS, PSL Research University)、座長:Baptiste Cecconi(LESIA - Observatoire de Paris)

15:30 ~ 15:45

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

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

15:45 ~ 16:00

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

*鈴木 亨[1] (1.海洋情報研究センター)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

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

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

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-SD 宇宙開発・地球観測

15:30 ~ 17:00 | A01 東京ベイ幕張ホール

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

コンビーナ:栗原 純一(北海道大学 大学院理学研究院)、Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines)、Huy Xuan Le(Vietnam National Space Center)、座長:栗原 純一(Hokkaido University)、石田 哲朗(北海道大学)

15:30 ~ 15:45

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

*高橋 幸弘[1] (1.北海道大学・大学院理学院・宇宙理学専攻)

15:45 ~ 16:00

[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)

16:00 ~ 16:15

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

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

16:15 ~ 16:30

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

*石田 哲朗[1]、Felix Mark[2]、Castro Ellison[2]、Namuco Shielo[2]、Felicio Francisco[2]、Merida Harry[2]、Vergel Kaye[2]、Perez Gay[2]、Marciano Joel[3,4]、高橋 幸弘[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)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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)

[E] 口頭発表 | セッション記号 U (ユニオン)：ユニオン

2019年5月26日(日) 13:45 ~ 15:15 | 101 1F

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

コンビーナ:堀 和明(名古屋大学環境学研究科地理学講座)、Denis-Didier Rousseau(CNRS - ENS)、Jonathan L Bamber(member)、座長:村山 泰啓(情報通信研究機構)

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.

13:45 ~ 15:15

[U01-01] Panel discussion about research assessment

*堀 和明[1] (1.名古屋大学環境学研究科地理学講座)

Panel discussion about research assessment

*堀 和明[1]
*Kazuaki Hori[1]

1. 名古屋大学環境学研究科地理学講座
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.

キーワード：研究評価、科学研究、オープンサイエンス
Keywords: research assessment, scientific research, open science

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 U (ユニオン)：ユニオン

2019年5月26日(日) 15:30 ~ 17:00 | 101 1F

[U-02] 地球惑星科学分野のダイバーシティ推進状況：国際的な視点から

コンビーナ:小口 千明(埼玉大学大学院理工学研究科)、堀 利栄(愛媛大学大学院理工学研究科 地球進化学)、高橋 幸弘(北海道大学・大学院理学院・宇宙理学専攻)、Claudia Jesus-Rydin(European Research Council)、座長:堀 利栄、小口 千明

日本の地球惑星科学分野におけるダイバーシティ推進の動向を考えるために、ロールモデル（国際、男女など、様々な方々）からの新鮮な気づき、研究機関および大学の優れた取り組みなどの有益な情報の共有を目的として、本セッションを提案します。日本人研究者・学生のみならず、日本で働いている外国人研究者や研究留学生、来日予定の外国人研究者からの発表を歓迎します。発表内容に基づき、本課題について国際的・学際的な観点から比較し、より良い方策を議論したいと思います。なお、本セッションは、EGU2019のユニオンシンポジウムUS4とも協力し、EGU/AGUコミュニティーとの現状情報の共有・交流も図ります。

15:30 ~ 15:45

[U02-01] Managing Diversity and Inclusiveness

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

15:45 ~ 16:00

[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)

16:00 ~ 16:15

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

*阿部 なつ江[1] (1.国立研究開発法人海洋研究開発機構海洋掘削科学研究開発センター)

16:15 ~ 16:30

[U02-04] 出産・育児における課題

*高橋 幸弘[1] (1.北海道大学・大学院理学院・宇宙理学専攻)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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

*阿部 なつ江[1]
*Natsue Abe[1]

1. 国立研究開発法人海洋研究開発機構海洋掘削科学研究開発センター
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

キーワード：ジェンダーバランス、多様性、IODP
Keywords: gender balance, diversity, IODP

©2019. Japan Geoscience Union. All Right Reserved.

出産・育児における課題
Problem in paternity leave

*高橋 幸弘[1]
*Yukihiro Takahashi[1]

1. 北海道大学・大学院理学院・宇宙理学専攻
1. Department of Cosmosciences, Graduate School of Science, Hokkaido University

私は1999年及び2004年に、育児休業を取得した。結婚当初より別居だったため、育児休業期間のそれぞれ半年及び3ヶ月の間、自分の当時の職場である宮城県を離れ、妻の住む山梨県で過ごした。男性の育児休業の取得率は、現在でも約5%、当時は1%未満、それもほとんどが短期であって、3ヶ月以上の取得率は2回目の育児休業当時（2004年）で何と75 ppmである。内閣府のHPには育児休業を取らなかった理由のアンケートが載っているが、そこに明示的に表現されない背景として、出産・育児を男女が共同で行うことが当たりあるという世界の流れから大きく取り残されていることが一つの要因であると思われる。男女共同参画まで広げると、ジェンダーギャップ指数が世界110位と恐ろしく低いが、そのこと自体、生活の中で実感している日本人、特に男性は少ないのではないか。先日ある大学で留学生が妊娠したが、休学は許されず奨学金も支払われない場合もあると伺った。日本社会やコミュニティが、何を当然と思うかが変わらないと、様々な問題の解決への道は遠く、国際社会からも遊離していくであろう。本講演では、国際的な視点と個人の経験から、JpGUの起こすべきアクションについて議論したい。

キーワード：育児休業、ジェンダーギャップ
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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

🏛2019年5月26日(日) 9:00 ~ 10:30 | 🏛A02 東京ベイ幕張ホール

[P-PS04] 火星と火星圏の科学

コンビーナ:宮本 英昭(東京大学)、臼井 寛裕(東京工業大学地球生命研究所)、松岡 彩子(宇宙航空研究開発機構　宇宙科学研究所　太陽系科学研究系)、Sushil K Atreya(University of Michigan Ann Arbor)、座長: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 ~ 9:15

[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 ~ 9:30

[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 ~ 9:45

[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 ~ 10:00

[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 ~ 10:15

[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 ~ 10:30

[PPS04-06] MRO/CRISM 火星リム観測による多重散乱を考慮したエアロゾル・ガス高度プロファイルのリトリーバル

*笠羽 康正[1]、豊岡 雅士[2]、青木 翔平[3]、Mahieux Arnaud[3,4]、中川 広務[2]、岩渕 弘信[2] (1.東北大学 惑星プラズマ・大気研究センター、2.東北大学 理学研究科 地球物理学専攻、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.

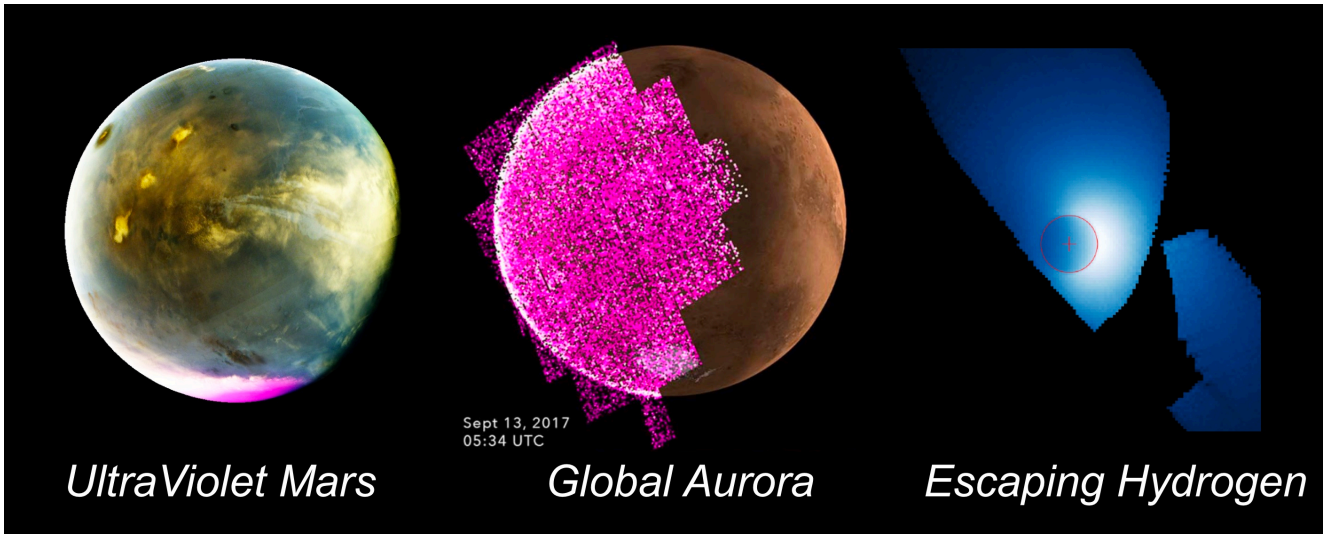
From Clouds to Aurora to Atmospheric Escape: Highlights from MAVEN’ s Imaging UltraViolet Spectrograph

*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

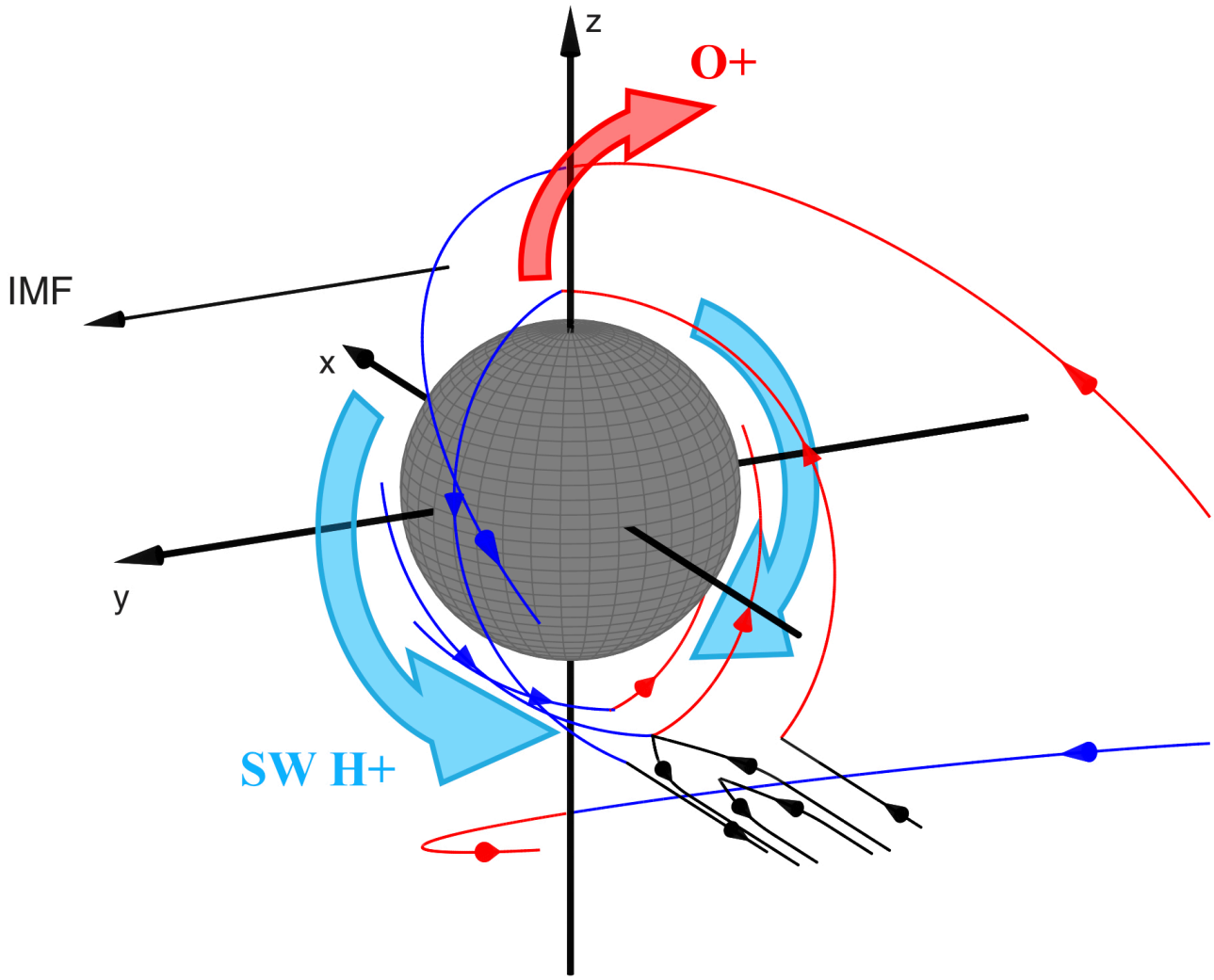
*Lihui Chai[1], Weixing Wan[1], Yong Wei[1], Tielong Zhang[2], Willi Exner[3], Markus Fraenz[4], Eduard Dubinin[4], Moritz Feyerabend[3], Uwe Motschmann[3], Yingjuan Ma[5], J. S. Halekas[6]

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.

MRO/CRISM 火星リム観測による多重散乱を考慮したエアロソ゛ル・カ゛ス高度フ゜ロファイルのリトリーハ゛ル

Retrieval of vertical aerosol and gas profiles considering multiple scattering from Martian limb observations by MRO/CRISM

*笠羽 康正[1]、豊岡 雅士[2]、青木 翔平[3]、Mahieux Arnaud[3,4]、中川 広務[2]、岩渕 弘信[2]
*Yasumasa Kasaba[1], Masashi Toyooka[2], Shohei Aoki[3], Arnaud Mahieux[3,4], Hiromu Nakagawa[2], Hironobu Iwabuchi[2]

1. 東北大学 惑星プラズマ・大気研究センター、2. 東北大学 理学研究科 地球物理学専攻、3. Planetary Aeronomy, Belgian Institute for Space Aeronomy, Belgium 、4. University of Texas at Austin, USA
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.

©2019. Japan Geoscience Union. All Right Reserved.

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.

キーワード：火星、リトリーバル、大気、垂直構造
Keywords: Mars, Retrieval , atmosphere, vertical profile

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月26日(日) 10:45 ~ 12:15 | A02 東京ベイ幕張ホール

[P-PS04] 火星と火星圏の科学

コンビーナ:宮本 英昭(東京大学)、臼井 寛裕(東京工業大学地球生命研究所)、松岡 彩子(宇宙航空研究開発機構　宇宙科学研究所　太陽系科学研究系)、Sushil K Atreya(University of Michigan Ann Arbor)、座長:宮本 英昭、臼井 寛裕

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 ~ 11:00

[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 ~ 11:15

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

*黒田 剛史[1,2]、鎌田 有紘[1]、鳥海 克成[1]、笠羽 康正[1]、寺田 直樹[1]、中川 広務[1] (1.東北大学　大学院理学研究科、2.情報通信研究機構)

11:15 ~ 11:30

[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 ~ 11:45

[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 ~ 12:00

[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 ~ 12:15

[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

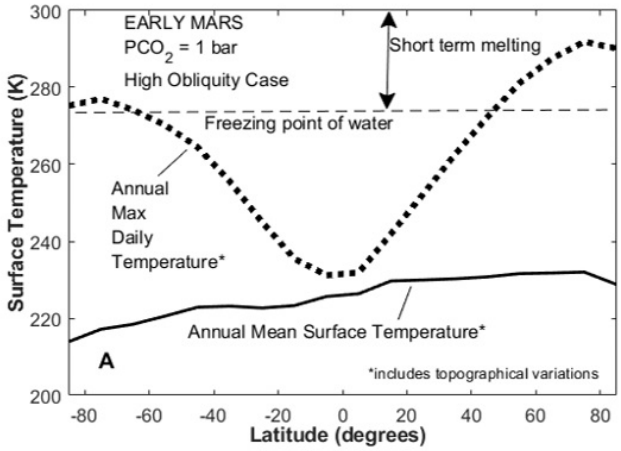


Figure 1: Computed surface temperatures per latitude band, which agrees well with the similar 1-bar case from the 3-D model of Wordsworth et al. 2015 Fig.1.

©2019. Japan Geoscience Union. All Right Reserved.

GCM simulations of the present and past water environment on Mars

*黒田 剛史[1,2]、鎌田 有紘[1]、鳥海 克成[1]、笠羽 康正[1]、寺田 直樹[1]、中川 広務[1]
*Takeshi Kuroda[1,2], Arihiro Kamada[1], Katsushige Toriumi[1], Yasumasa Kasaba[1], Naoki Terada[1], Hiromu Nakagawa[1]

1. 東北大学　大学院理学研究科、2. 情報通信研究機構
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.

キーワード：火星、水循環、水環境、古気候、全球気候モデル
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

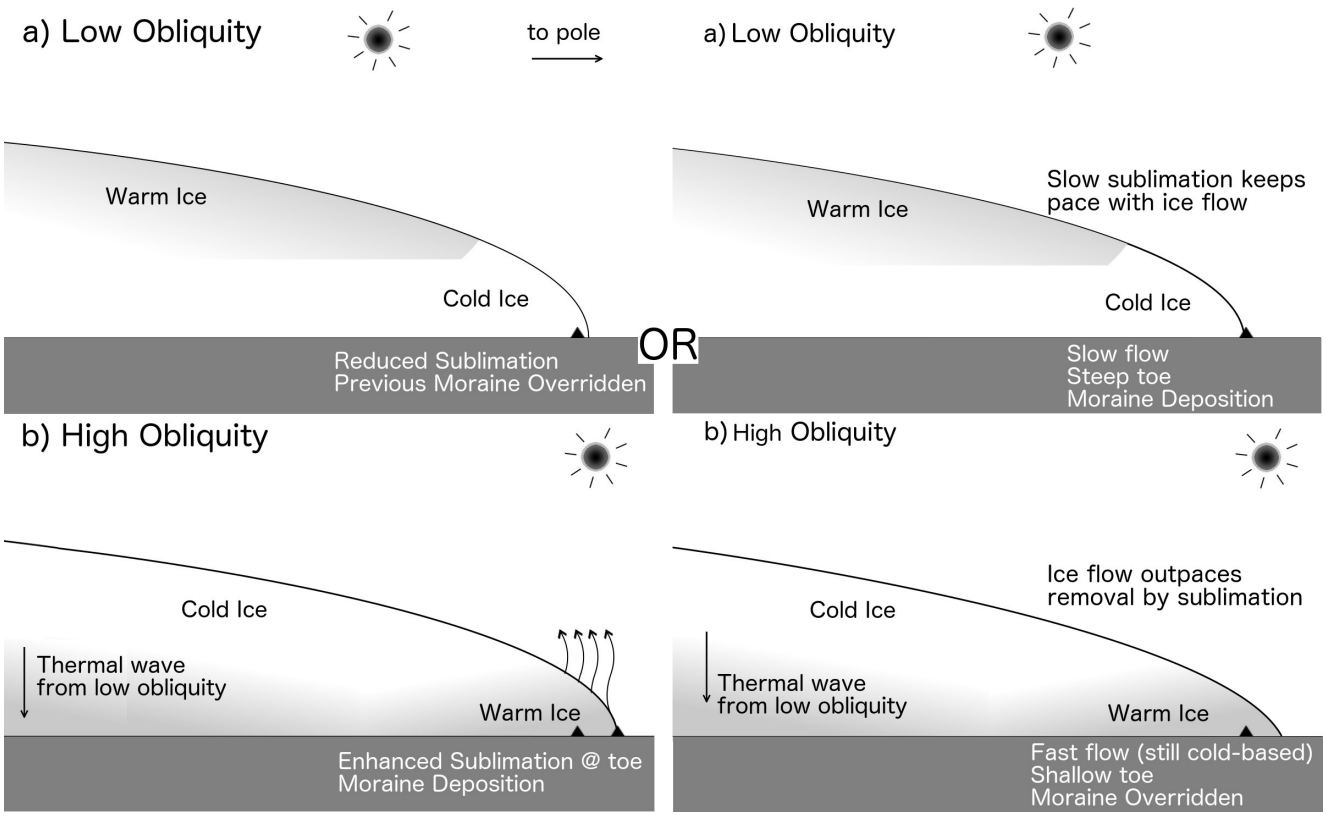
©2019. Japan Geoscience Union. All Right Reserved.

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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

2019年5月26日(日) 13:45 ~ 15:15 | 201B 2F

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

コンビーナ:Yang-Yi Sun(China University of Geosciences)、LIN CHIYEN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN)、MINYANG CHOU(National Cheng Kung University)、座長: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.

13:45 ~ 14:00

[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)

14:00 ~ 14:15

[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)

14:15 ~ 14:30

[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)

14:30 ~ 14:45

[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)

14:45 ~ 15:00

[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)

15:00 ~ 15:15

[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]

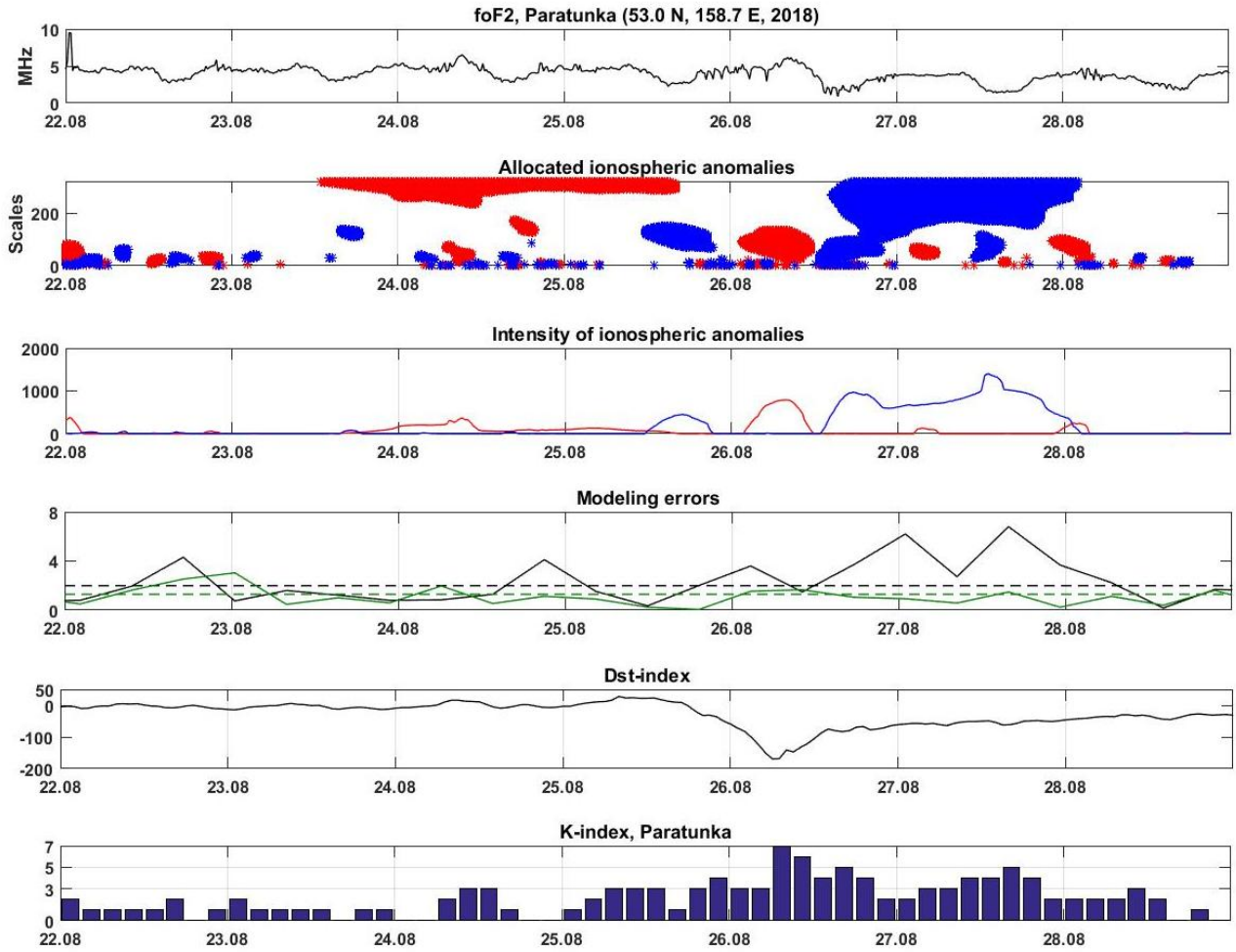
1. Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2. Kamchatka State Technical University

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.

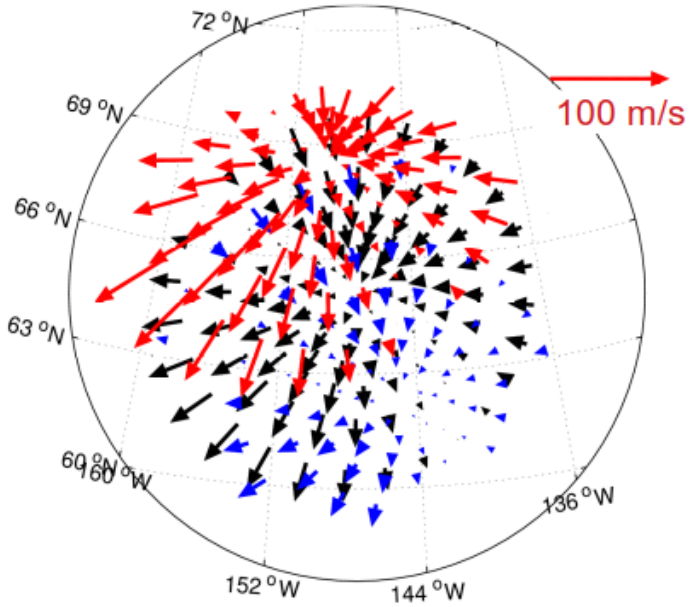
Our analysis technique is based on fitting the LOS data with special vector basis functions called Spherical Elementary Current Systems (SECS). In this approach the wind is naturally divided into curl-free and divergence-free components, and there is no need to provide any explicit boundary conditions 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.

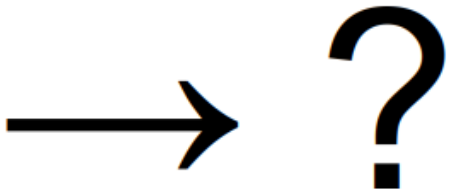
Keywords: Ionosphere, Thermosphere, Neutral wind

©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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

2019年5月26日(日) 15:30 ~ 17:00 | 201B 2F

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

コンビーナ:Yang-Yi Sun(China University of Geosciences)、LIN CHIYEN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN)、MINYANG CHOU(National Cheng Kung University)、座長: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.

15:30 ~ 15:45

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

★Invited Papers

*斎藤 享[1]、吉原 貴之[1] (1.国立研究開発法人海上・港湾・航空技術研究所電子航法研究所)

15:45 ~ 16:00

[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)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

[PEM14-10] GBASにおける電離圏脅威となりうる電離圏勾配を含むプラズマバブルの継続時間について

*中村 真帆[1]、斎藤 享[1]、吉原 貴之[1] (1.国立研究開発法人 海上・港湾・航空技術研究所 電子航法研究所)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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

*斎藤 享[1]、吉原 貴之[1]
*Susumu Saito[1], Takayuki Yoshihara[1]

1. 国立研究開発法人海上・港湾・航空技術研究所電子航法研究所
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.

キーワード：プラズマバブル、電離圏全電子数空間勾配、シンチレーション
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.

GBASにおける電離圏脅威となりうる電離圏勾配を含むプラズマバブルの継続時間について

Durations of ionospheric gradients and plasma bubbles as ionospheric threats to GBAS

*中村 真帆[1]、斎藤 享[1]、吉原 貴之[1]
*MAHO NAKAMURA[1], Susumu Saito[1], Takayuki Yoshihara[1]

1. 国立研究開発法人 海上・港湾・航空技術研究所 電子航法研究所
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

©2019. Japan Geoscience Union. All Right Reserved.

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).

キーワード：電離圏、電離圏脅威モデル、プラズマバブル、電離圏勾配、衛星測位、地上型衛星航法補強システム
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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

2019年5月26日(日) 9:00 ~ 10:30 | A01 東京ベイ幕張ホール

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

コンビーナ:尾崎 光紀(金沢大学理工研究域電子情報学系)、笠原 慧(東京大学)、亀田 真吾(立教大学理学部)、吉岡 和夫(東京大学大学院新領域創成科学研究科)、座長:吉岡 和夫(東京大学)、尾崎 光紀(金沢大学)

宇宙機による地球観測や宇宙空間探査がより容易になりつつある昨今、宇宙機関のみならず大学・民間での人工衛星・ロケットの製作や国際協同も活発になっている。理学的研究においては、宇宙への展開自体は本来の目的ではなく、より良い科学に向けた一手段である一方、技術革新と教育向上においては魅力的な動機である。宇宙計画の成功には、目的に応じた個々の搭載機器の研究開発が必須となり、将来に向けた基盤技術の開拓が計画全体の原動力ともなり得る。計画全体の推進には、搭載機器の提案・選定・製作の段階での綿密な検討も不可欠であり、必然的に、何らかの宇宙計画では、その大小を問わず、あらゆる過程・側面での多面的な調整と多角的な展開が求められる。このセッションでは、搭載機器の開発から計画全体の総括までに及ぶこれらの包括的な研究活動に焦点を絞り、科学的意義に加え、各々の戦略・手法における独自性・革新性、及び関連機器の先端的研究開発の状況と最新の成果に関する講演を集約し、実りある宇宙科学・探査計画・天文観測を実現できる未来により早く達するため、関連する研究者・開発者に活発な意見交換・情報共有・協同創出の機会を提供する。

9:00 ~ 9:20

[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 ~ 9:35

[PCG21-02] 月・惑星探査用TOF質量分析器の開発

*福山 代智[1]、斎藤 義文[2]、浅村 和史[2]、横田 勝一郎[3] (1.東京大学大学院、2.宇宙航空研究開発機構・宇宙科学研究所、3.大阪大学)

9:35 ~ 9:50

[PCG21-03] In-situ太陽系探査を目指したOrbitrap質量分析器の開発

*川島 桜也[1]、笠原 慧[1]、斎藤 義文[4]、横田 勝一郎[2]、平原 聖文[3]、杉田 精司[1] (1.東京大学、2.大阪大学、3.名古屋大学、4.宇宙科学研究所)

9:50 ~ 10:05

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

*横田 勝一郎[1]、河井 洋輔[1]、青木 順[1]、斎藤 義文[2]、大竹 真紀子[2]、岡田 達明[2] (1.大阪大学・理学研究科、2.宇宙航空研究開発機構・宇宙科学研究所)

10:05 ~ 10:20

[PCG21-05] 深宇宙探査技術実証機DESTINY$^+$に搭載するダストアナライザDDAの開発と期待されるサイエンス

*平井 隆之[1]、小林 正規[1]、荒井 朋子[1]、木村 宏[1]、スラマ ラルフ[2]、クルーガー ハラルド[3] (1.千葉工業大学惑星探査研究センター、2.シュトゥットガルト大学、3.マックスプランク太陽系研究所)

10:20 ~ 10:30

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.

月・惑星探査用TOF質量分析器の開発
Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*福山 代智[1]、斎藤 義文[2]、浅村 和史[2]、横田 勝一郎[3]
*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3]

1. 東京大学大学院、2. 宇宙航空研究開発機構・宇宙科学研究所、3. 大阪大学
1. The university of Tokyo, 2. ISAS/JAXA, 3. Osaka University

惑星探査の対象となるような重力天体からのサンプルリターンは困難であるため、太陽系探査において、その場観測は重要である。中でも天体表面物質のその場での質量分析は、惑星表面岩石中の揮発成分や同位体組成に関する情報を取得することができるため、惑星大気の変遷や月・惑星の進化を理解するうえで欠かせない観測である。NASAの火星探査ローバー「Curiosity」やESAの彗星探査機「Rosetta」には天体表面物質のその場元素分析を行うための質量分析器が搭載されている。また、近年の月探査機による観測により、月極域永久影におけるH_2Oの存在を示唆するリモートセンシングの観測結果が報告されているが、H_2O とOHの判別が困難などといった問題を抱えているため、存在を断定することはできていない。水の存在を着陸機によるその場観測で実証するための質量分析器の必要性が高まっている。

制約が多い惑星探査機に搭載する質量分析器には小型・軽量であることが求められるが、小型軽量と高質量分解能を両立した、惑星探査用質量分析器はいまだ開発されていない。そこで我々は、月・惑星探査を想定した、小型かつ高質量分解能の中性粒子計測用TOF-MS(Time-Of-Flight Mass Spectrometer:飛行時間計測型質量分析器)の開発を進めている。本機器は、ローバーに搭載し、前段に試料の採取を行う機構部分と、採取した試料を加熱・気化する部分、さらに取り込んだガスをイオン化するイオン化部があることを前提に設計した。

TOF-MSはイオンを電場で加速し、一定の距離を飛行させその飛行時間から質量を求めるが、高質量分解能を実現するためには、イオンの飛行経路を長くとる必要がある。機器を大型化させることなく飛行距離を稼ぐため、イオンを電場によって反射させるリフレクトロン型TOF-MSを採用した。一方で、イオンの軌道はイオンの飛行距離が長くなるにつれて分散するため、反射回数を増やすと検出効率が低下する。そこで、本機器は高質量分解能の複数回反射モードと、反射回数を抑え感度を重視した１回反射モードを搭載し、観測対象ごとにこれらの測定モードを切り替えられるようにした。シミュレーションにより、3回反射モードでは質量分解能360、1回反射モードでは180を達成した。現在は装置寸法と印加電圧の最適化を慎重に行った上で、装置の総合的な性能を最適化した試験モデルの製作を進めている。
本発表ではTOF-MSの最適化の過程と試作モデルの設計、シミュレーション結果について報告する

キーワード：太陽系探査、質量分析器
Keywords: Solar System Exploration, Mass Spectromete

©2019. Japan Geoscience Union. All Right Reserved.

In-situ太陽系探査を目指したOrbitrap質量分析器の開発
Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*川島 桜也[1]、笠原 慧[1]、斎藤 義文[4]、横田 勝一郎[2]、平原 聖文[3]、杉田 精司[1]
*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1]

1. 東京大学、2. 大阪大学、3. 名古屋大学、4. 宇宙科学研究所
1. The university of tokyo, 2. Osaka University, 3. Nagoya University, 4. ISAS / JAXA

今までの質量分析器を用いた探査により，太陽系天体の形成・成長の歴史や，その周囲を取り巻く環境で起こる物理現象についての理解が進んできた．今後はさらなる高分解能な装置を用いることによって，詳細かつ重要な情報を入手できるようになることが期待されている．そこで現在私たちは高分解能質量分析器の開発に着手しており，今回は特に設計したモデルについての紹介を行う予定である．モデルの質量分離部にはイオントラップフーリエ変換型質量分析器の一種であるOrbitrapを用いており，イオンを往復運動させるトラップ部の前には電子ビームによる空間電荷効果を用いたイオン蓄積部を用意している．数値計算によれば，このモデルをもとに作られた装置は質量分解能（m/dm）~10,000を十分達成可能であることが予想されている．このような高分解能質量分析器は応用範囲が広く，特に太陽系天体のin-situ探査において元素組成や同位体組成を決定する上で非常に有用となる．例えば火星の大気散逸を議論する上で重要である窒素N_2（28.0062 u）と一酸化炭素CO（27.9949 u）とを識別することが可能となる．

キーワード：質量分析器、高分解能、オービトラップ
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

*横田 勝一郎[1]、河井 洋輔[1]、青木 順[1]、斎藤 義文[2]、大竹 真紀子[2]、岡田 達明[2]
*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2]

1. 大阪大学・理学研究科、2. 宇宙航空研究開発機構・宇宙科学研究所
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.

キーワード：パルス高圧電源、質量分析、同位体
Keywords: High-voltage pulsed power supply, Mass spectrometry, Isotope

©2019. Japan Geoscience Union. All Right Reserved.

深宇宙探査技術実証機DESTINY$^+$に搭載するダストアナライザDDAの開発と期待されるサイエンス

Development of DESTINY$^+$ Dust Analyzer and its expected science return

*平井 隆之[1]、小林 正規[1]、荒井 朋子[1]、木村 宏[1]、スラマ ラルフ[2]、クルーガー ハラルド[3]
*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3]

1. 千葉工業大学惑星探査研究センター、2. シュトゥットガルト大学、3. マックスプランク太陽系研究所
1. Chiba Institute of Technology, Planetary Exploration Research Center, 2. University of Stuttgart, 3. Max Planck Institute for Solar System Research

2023年打ち上げ予定の宇宙航空研究開発機構/宇宙科学研究所(JAXA/ISAS)が主導する深宇宙探査技術実証機Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science (DESTINY$^+$)では、電気推進による宇宙航行技術の発展や、小天体探査を対象とした先進的フライバイ探査技術の獲得といった工学的ミッションに加え、活動小惑星3200 Phaehonの高速フライバイ撮像観測と惑星間空間およびPhaethonフライバイ時のダスト観測という2つの理学ミッションを掲げている。本講演では、ダスト観測に用いるダストアナライザーDESTINY$^+$ Dust Analyzer (DDA)の測定原理や探査機搭載機器としての特徴、DESTINY$^+$ミッションで目指すサイエンスを紹介する。

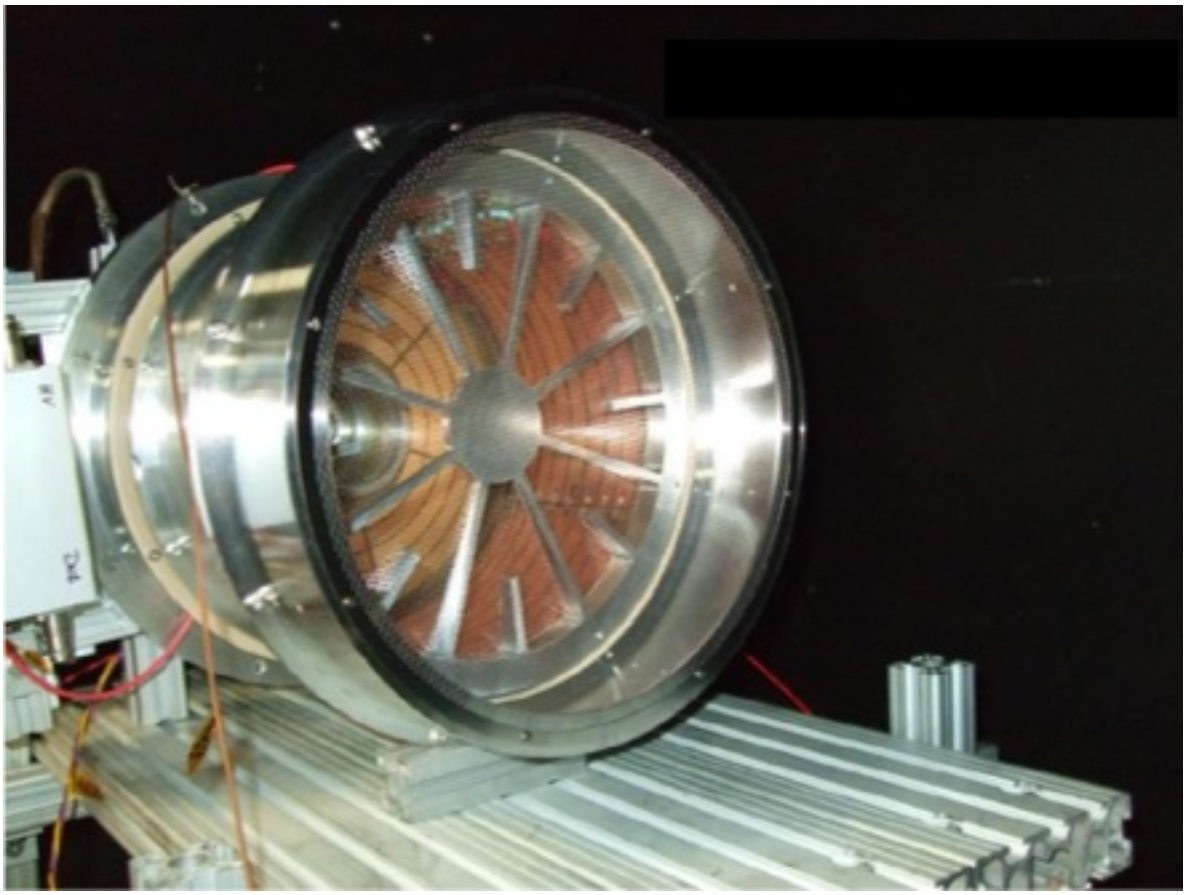
DDAは、米国航空宇宙局NASAの土星探査機Cassiniに搭載されたダストアナライザCosmic Dust Analyzer (CDA)を技術ヘリテージとして持つ、飛行時間型質量分析機能 (TOF-MS)を備えたダスト検出器である。DDAの開発主体はドイツ・シュトゥットガルト大学のグループであり、千葉工業大学惑星探査研究センターは、DDAの開発においては探査機とのインターフェース調整、探査計画の検討、ダストサイエンスのリードなどを担当している。

惑星間ダストや星間ダストが秒速1 km以上の超高速でDDAセンサ内部のターゲット面に衝突すると陰陽イオンと電子からなるプラズマが生成される。センサ内部に形成した電場によりこれらの荷電粒子を分離し、TOF-MSによって検出ダストの組成を推定する。従来、ダストアナライザーは陰陽どちらかのイオンのみを検出する方式だったが、DDAでは電場極性を逆にしたセンサを2台搭載し、軌道など同一観測条件下で陰陽イオンを同時に測定し、より幅広い元素分析の実現を目標としている。また、ダスト分布モデルから予想される最もフラックスが期待される方向にセンサを向けられるよう、二軸ジンバルを実装予定である。

DESTINY$^+$が金星軌道と地球軌道の間を約2年クルージング飛行する間、DDAは小惑星や彗星を起源とする惑星間ダストと星間ダストの観測を行う。そしてPhaethonとフライバイする際は、惑星間ダストが衝突することでPhaethonから放出される放出粒子の検出・組成分析も試みる。

キーワード：惑星間塵、星間塵、小惑星3200フェートン、衝突電離、飛行時間型質量分析計、ダスト分析器
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] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

2019年5月26日(日) 10:45 ~ 12:15 | A01 東京ベイ幕張ホール

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

コンビーナ:尾崎 光紀(金沢大学理工研究域電子情報学系)、笠原 慧(東京大学)、亀田 真吾(立教大学理学部)、吉岡 和夫(東京大学大学院新領域創成科学研究科)、座長:笠原 慧、尾崎 光紀(金沢大学)

宇宙機による地球観測や宇宙空間探査がより容易になりつつある昨今、宇宙機関のみならず大学・民間での人工衛星・ロケットの製作や国際協同も活発になっている。理学的研究においては、宇宙への展開自体は本来の目的ではなく、より良い科学に向けた一手段である一方、技術革新と教育向上においては魅力的な動機である。宇宙計画の成功には、目的に応じた個々の搭載機器の研究開発が必須となり、将来に向けた基盤技術の開拓が計画全体の原動力ともなり得る。計画全体の推進には、搭載機器の提案・選定・製作の段階での綿密な検討も不可欠であり、必然的に、何らかの宇宙計画では、その大小を問わず、あらゆる過程・側面での多面的な調整と多角的な展開が求められる。このセッションでは、搭載機器の開発から計画全体の総括までに及ぶこれらの包括的な研究活動に焦点を絞り、科学的意義に加え、各々の戦略・手法における独自性・革新性、及び関連機器の先端的研究開発の状況と最新の成果に関する講演を集約し、実りある宇宙科学・探査計画・天文観測を実現できる未来により早く達するため、関連する研究者・開発者に活発な意見交換・情報共有・協同創出の機会を提供する。

10:45 ~ 11:05

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

★Invited Papers

*成影 典之[1]、岡 光夫[2]、深沢 泰司[3]、松崎 恵一[4]、渡辺 伸[4]、坂尾 太郎[4]、石川 真之介[5]、萩野 浩一[6]、三石 郁之[5]、水野 恒史[3]、篠原 育[4]、下条 圭美[1]、高棹 真介[5]、田辺 博士[7]、上野 宗孝[8]、高橋 忠幸[9]、高島 健[4]、太田 方之[4] (1.国立天文台、2.カリフォルニア大学バークレー校、3.広島大学、4.宇宙航空研究開発機構、5.名古屋大学、6.東京理科大学、7.東京大学、8.神戸大学、9.カブリ数物連携宇宙研究機構)

11:05 ~ 11:20

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

*阿部 琢美[1]、渡部 重十[2]、齊藤 昭則[3] (1.宇宙航空研究開発機構 宇宙科学研究所 太陽系科学研究系、2.北海道情報大学、3.京都大学大学院理学研究科)

11:20 ~ 11:35

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

*斎藤 義文[1]、小川 泰信[2]、小嶋 浩嗣[3] (1.宇宙航空研究開発機構・宇宙科学研究所・太陽系科学研究系、2.大学共同利用機関法人 情報・システム研究機構 国立極地研究所、3.京都大学・生存圏研究所)

11:35 ~ 11:50

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

*菊川 素如[2]、頭師 孝拓[2]、小嶋 浩嗣[2]、斎藤 義文[1] (1.宇宙航空研究開発機構、2.京都大学)

11:50 ~ 12:10

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

★招待講演

*Ezoe Yuichiro[1]、Miyoshi Yoshizumi[2]、Kasahara Satoshi[3]、Funase Ryu[3]、Nagata Harunori[4]、Nakajima Hiroshi[5]、Ishikawa Kumi[6]、Yamazaki Atsushi[6]、Hasegawa Hiroshi[6]、Hiraga Junko[7]、Fujimoto Masaki[6]、Mitsuda Kazuhisa[6]、Ueno Munetaka[8]、Koizumi Hiroyuki[3]、Kawakatsu Yasuhiro[6]、Iwata Takahiro[6]、Sahara Hironori[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 ~ 12:15
Discussion

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

*成影 典之[1]、岡 光夫[2]、深沢 泰司[3]、松崎 恵一[4]、渡辺 伸[4]、坂尾 太郎[4]、石川 真之介[5]、萩野 浩一[6]、三石 郁之[5]、水野 恒史[3]、篠原 育[4]、下条 圭美[1]、高棹 真介[5]、田辺 博士[7]、上野 宗孝[8]、高橋 忠幸[9]、高島 健[4]、太田 方之[4]
*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. 国立天文台、2. カリフォルニア大学バークレー校、3. 広島大学、4. 宇宙航空研究開発機構、5. 名古屋大学、6. 東京理科大学、7. 東京大学、8. 神戸大学、9. カブリ数物連携宇宙研究機構
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.

キーワード：PhoENiX、粒子加速、磁気再結合、太陽フレア、X線、撮像分光観測
Keywords: PhoENiX, Particle Acceleration, Magnetic Reconnection, Solar Flare, X-rays, Imaging Spectroscopy

©2019. Japan Geoscience Union. All Right Reserved.

©2019. Japan Geoscience Union. All Right Reserved.

Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*阿部 琢美[1]、渡部 重十[2]、齊藤 昭則[3]
*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3]

1. 宇宙航空研究開発機構 宇宙科学研究所 太陽系科学研究系、2. 北海道情報大学、3. 京都大学大学院理学研究科
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

©2019. Japan Geoscience Union. All Right Reserved.

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.

キーワード：電離圏、イオンドリフト、イオン一中性粒子結合、観測ロケット
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

*斎藤 義文[1]、小川 泰信[2]、小嶋 浩嗣[3]
*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3]

1. 宇宙航空研究開発機構・宇宙科学研究所・太陽系科学研究系、2. 大学共同利用機関法人 情報・システム研究機構 国立極地研究所、3. 京都大学・生存圏研究所
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.

キーワード：観測ロケット、イオンアウトフロー、カスプ、オーロラ

©2019. Japan Geoscience Union. All Right Reserved.

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

*菊川 素如[2]、頭師 孝拓[2]、小嶋 浩嗣[2]、斎藤 義文[1]
*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1]

1. 宇宙航空研究開発機構、2. 京都大学
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.

キーワード：ASIC、WPIA
Keywords: ASIC, WPIA

©2019. Japan Geoscience Union. All Right Reserved.

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

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

*Ezoe Yuichiro[1]、Miyoshi Yoshizumi[2]、Kasahara Satoshi[3]、Funase Ryu[3]、Nagata Harunori[4]、Nakajima Hiroshi[5]、Ishikawa Kumi[6]、Yamazaki Atsushi[6]、Hasegawa Hiroshi[6]、Hiraga Junko[7]、Fujimoto Masaki[6]、Mitsuda Kazuhisa[6]、Ueno Munetaka[8]、Koizumi Hiroyuki[3]、Kawakatsu Yasuhiro[6]、Iwata Takahiro[6]、Sahara Hironori[1]
*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
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.

キーワード：X-ray、Earth's magnetosphere
Keywords: X-ray, Earth's magnetosphere

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

2019年5月26日(日) 13:45 ~ 15:15 | A01 東京ベイ幕張ホール

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

コンビーナ:尾崎 光紀(金沢大学理工研究域電子情報学系)、笠原 慧(東京大学)、亀田 真吾(立教大学理学部)、吉岡 和夫(東京大学大学院新領域創成科学研究科)、座長:亀田 真吾、尾崎 光紀(金沢大学)

宇宙機による地球観測や宇宙空間探査がより容易になりつつある昨今、宇宙機関のみならず大学・民間での人工衛星・ロケットの製作や国際協同も活発になっている。理学的研究においては、宇宙への展開自体は本来の目的ではなく、より良い科学に向けた一手段である一方、技術革新と教育向上においては魅力的な動機である。宇宙計画の成功には、目的に応じた個々の搭載機器の研究開発が必須となり、将来に向けた基盤技術の開拓が計画全体の原動力ともなり得る。計画全体の推進には、搭載機器の提案・選定・製作の段階での綿密な検討も不可欠であり、必然的に、何らかの宇宙計画では、その大小を問わず、あらゆる過程・側面での多面的な調整と多角的な展開が求められる。このセッションでは、搭載機器の開発から計画全体の総括までに及ぶこれらの包括的な研究活動に焦点を絞り、科学的意義に加え、各々の戦略・手法における独自性・革新性、及び関連機器の先端的研究開発の状況と最新の成果に関する講演を集約し、実りある宇宙科学・探査計画・天文観測を実現できる未来により早く達するため、関連する研究者・開発者に活発な意見交換・情報共有・協同創出の機会を提供する。

13:45 ~ 14:05

[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)

14:05 ~ 14:25

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

★Invited Papers

*新中 善晴[1]、亀田 真吾[2]、笠原 慧[3]、河北 秀世[1]、小林 正規[4]、船瀬 龍[3]、吉川 一朗[3]、ジェライント ジョーンズ[5]、スノッドグラス コリン[6] (1.京都産業大学、2.立教大学、3.東京大学、4.千葉工業大学、5.UCL、6.The Open University)

14:25 ~ 14:45

[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)

14:45 ~ 15:00

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

*平原 聖文[1]、小嶋 浩嗣[2]、北村 成寿[3]、浅村 和史[4]、斎藤 義文[4] (1.名古屋大学宇宙地球環境研究所、2.京都大学生存圏研究所、3.東京大学大学院理学系研究科、4.宇宙航空研究開発機構宇宙科学研究所)

15:00 ~ 15:15

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

*吉村 義隆[1]、山岸 明彦[2]、佐藤 毅彦[3]、宮川 厚夫[2]、今井 栄一[4]、佐々木 聰[5]、小林 憲正[6]、癸生川 陽子[6]、岡田 朋華[6]、塩谷 圭吾[3]、薮田 ひかる[7]、長沼 毅[7]、三田 肇[8]、藤田 和央[3]、臼井 寛裕[3] (1.玉川大学、2.東京薬科大学、3.宇宙航空研究開発機構、4.長岡技術科学大学、5.東京工科大学、6.横浜国立大学、7.広島大学、8.福岡工業大学)

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

*新中 善晴[1]、亀田 真吾[2]、笠原 慧[3]、河北 秀世[1]、小林 正規[4]、船瀬 龍[3]、吉川 一朗[3]、ジェライント ジョーンズ[5]、スノッドグラス コリン[6]
*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. 京都産業大学、2. 立教大学、3. 東京大学、4. 千葉工業大学、5. UCL、6. The Open University
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.

キーワード：Comet Interceptor Mission、力学的に新しい彗星
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

*平原 聖文[1]、小嶋 浩嗣[2]、北村 成寿[3]、浅村 和史[4]、斎藤 義文[4]
*Masafumi Hirahara[1], Hirotsugu Kojima[2], Naritoshi Kitamura[3], Kazushi Asamura[4], Yoshifumi Saito[4]

1. 名古屋大学宇宙地球環境研究所、2. 京都大学生存圏研究所、3. 東京大学大学院理学系研究科、4. 宇宙航空研究開発機構宇宙科学研究所
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

©2019. Japan Geoscience Union. All Right Reserved.

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 quantitatively address the ionospheric ions accelerations from the viewpoint of wave-particle interaction mechanisms occurring universally in space.

キーワード：波動粒子相互作用、超高層大気プラズマ、宇宙プラズマ波動、統合探査衛星観測、編隊飛行、先端的超小型衛星
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

*吉村 義隆[1]、山岸 明彦[2]、佐藤 毅彦[3]、宮川 厚夫[2]、今井 栄一[4]、佐々木 聰[5]、小林 憲正[6]、癸生川 陽子[6]、岡田 朋華[6]、塩谷 圭吾[3]、薮田 ひかる[7]、長沼 毅[7]、三田 肇[8]、藤田 和央[3]、臼井 寛裕[3]
*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. 玉川大学、2. 東京薬科大学、3. 宇宙航空研究開発機構、4. 長岡技術科学大学、5. 東京工科大学、6. 横浜国立大学、7. 広島大学、8. 福岡工業大学
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)

©2019. Japan Geoscience Union. All Right Reserved.

[4] Yamagishi, A. et al. *Biol. Sci. Space*, 24 (2010)

[5] Yamagishi, A. et al. *Trans. JSASS Aerospace Tech. Japan*, 16 (2018)

キーワード：火星、蛍光顕微鏡
Keywords: Mars, fluorescent microscope

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-OS 海洋科学・海洋環境

2019年5月26日(日) 9:00 ~ 10:30 | 303 3F

[A-OS09] 海洋混合学：物質循環・気候・生態系の維持と長周期変動の解明

コンビーナ:安田 一郎(東京大学大気海洋研究所)、日比谷 紀之(東京大学大学院理学系研究科地球惑星科学専攻)、西岡 純(北海道大学低温科学研究所)、伊藤 進一(東京大学大気海洋研究所)、座長:安田 一郎(東京大学大気海洋研究所)

海洋鉛直混合を含む統合的現場観測と混合を導入したモデルを開発することで、物質循環や気候、生態系への影響を明らかにすることを目的とした、新学術領域研究「海洋混合学の創設：物質循環・気候・生態系の維持と長周期変動（2015-2020年度）」における研究、及び内外の関連する研究を集約し、成果のまとめを図ると共に今後の課題を明らかにする。

9:00 ~ 9:10

Introduction

9:10 ~ 9:30

[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 ~ 9:45

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

*日比谷 紀之[1] (1. 東京大学 大学院理学系研究科 地球惑星科学専攻)

9:45 ~ 10:00

[AOS09-03] CTD取り付け型微細構造観測手法の開発と北太平洋海盆規模乱流分布

*安田 一郎[1]、後藤 恭敬[2]、長澤 真樹[1]、李 根淙[1]、中野 俊也[2]、纐纈 慎也[3] (1.東京大学大気海洋研究所、2.気象庁、3.海洋研究開発機構)

10:00 ~ 10:15

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

★Invited Papers

*川崎 高雄[1]、羽角 博康[1] (1.東京大学 大気海洋研究所)

10:15 ~ 10:30

[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

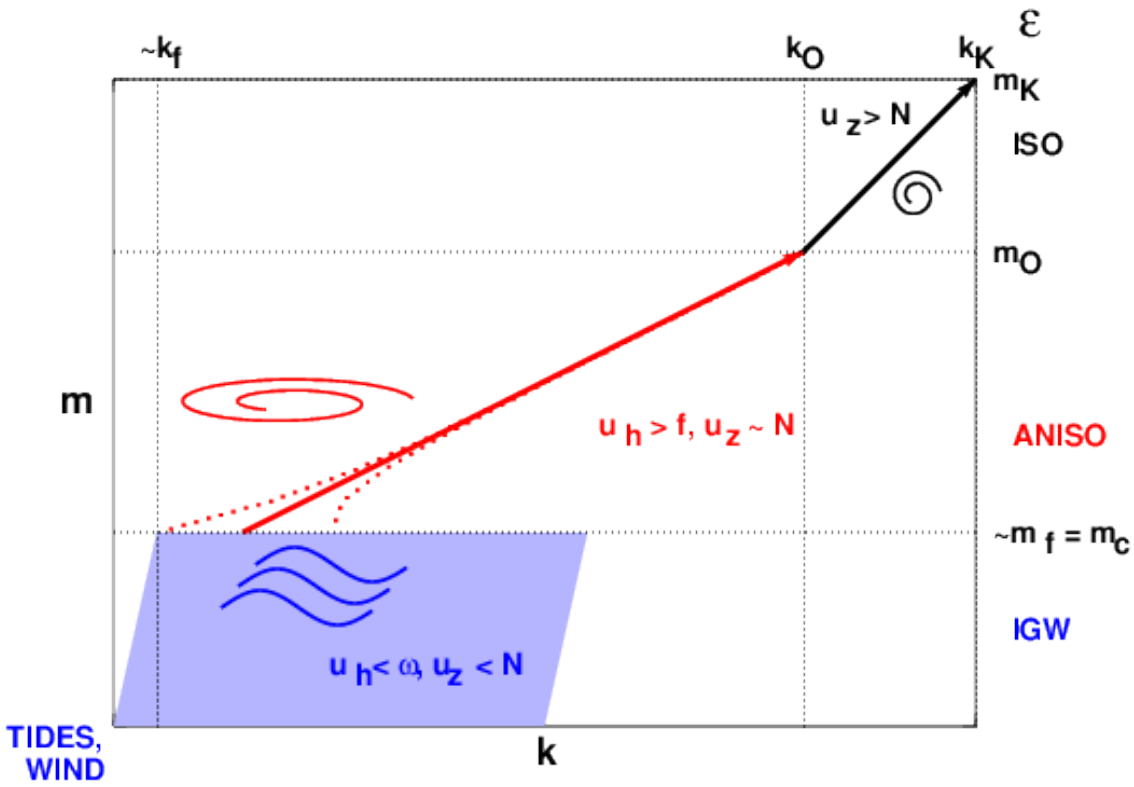
*Eric L Kunze[1]

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

*日比谷 紀之[1]
*Toshiyuki Hibiya[1]

1. 東京大学 大学院理学系研究科 地球惑星科学専攻
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).

キーワード：潮汐混合、深海底凹凸地形、パラメタリゼーション、内部潮汐波、内部風下波、三波共鳴干渉
Keywords: Tidal mixing, Abyssal rough bathymetry, Parameterization, Internal tidal waves, Internal lee waves, Resonant triad interactions

©2019. Japan Geoscience Union. All Right Reserved.

CTD取り付け型微細構造観測手法の開発と北太平洋海盆規模乱流分布
Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*安田 一郎[1]、後藤 恭敬[2]、長澤 真樹[1]、李 根淙[1]、中野 俊也[2]、纐纈 慎也[3]
*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3]

1. 東京大学大気海洋研究所、2. 気象庁、3. 海洋研究開発機構
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.

キーワード：乱流、微細構造観測手法、海洋子午面循環、潮汐混合、北太平洋
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

*川崎 高雄[1]、羽角 博康[1]
*Takao Kawasaki[1], Hiroyasu Hasumi[1]

1. 東京大学 大気海洋研究所
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.

キーワード：太平洋子午面循環、海洋大循環モデル、潮汐混合
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] 口頭発表 | セッション記号 A (大気水圏科学)：A-OS 海洋科学・海洋環境

2019年5月26日(日) 10:45 ~ 12:15 | 303 3F

[A-OS09] 海洋混合学：物質循環・気候・生態系の維持と長周期変動の解明

コンビーナ:安田 一郎(東京大学大気海洋研究所)、日比谷 紀之(東京大学大学院理学系研究科地球惑星科学専攻)、西岡 純(北海道大学低温科学研究所)、伊藤 進一(東京大学大気海洋研究所)、座長:西岡 純(北海道大学 低温科学研究所)

海洋鉛直混合を含む統合的現場観測と混合を導入したモデルを開発することで、物質循環や気候、生態系への影響を明らかにすることを目的とした、新学術領域研究「海洋混合学の創設：物質循環・気候・生態系の維持と長周期変動（2015-2020年度）」における研究、及び内外の関連する研究を集約し、成果のまとめを図ると共に今後の課題を明らかにする。

10:45 ~ 11:00

[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 ~ 11:15

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

*西岡 純[1]、小畑 元[2]、小川 浩史[2]、安田 一郎[2] (1.北海道大学低温科学研究所、2.東京大学大気海洋研究所)

11:15 ~ 11:30

[AOS09-08] 北太平洋中層に存在する溶存鉄の化学形に関する考察

*山下 洋平[1]、西岡 純[2]、小畑 元[3]、小川 浩史[3] (1.北海道大学 大学院地球環境科学研究院、2.北海道大学 低温科学研究所、3.東京大学 大気海洋研究所)

11:30 ~ 11:45

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

★Invited Papers

原田 尚美[1]、藤木 徹一[1]、*相田 真希[1]、本多 牧生[1]、喜多村 稔[1]、塩崎 拓平[1]、三野 義尚[3]、桑田 晃[2]、田所 和明[2]、関 宰[4]、近本 めぐみ[5] (1.国立研究開発法人 海洋研究開発機構 地球環境観測研究開発センター、2.国立研究開発法人 水産研究・教育機構　東北区水産研究所、3.名古屋大学 宇宙地球環境研究所 、4.北海道大学 低温科学研究所、5.ハワイ大学)

11:45 ~ 12:00

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

*三角 和弘[1]、西岡 純[2]、小畑 元[3]、津旨 大輔[1]、坪野 考樹[1]、Matthew Long[4]、Keith Lindsay[4]、J. Keith Moore[5] (1.電力中央研究所 環境科学研究所、2.北海道大学 低温科学研究所、3.東京大学 大気海洋研究所、4.米国大気研究センター、5.カリフォルニア大学アーバイン校)

12:00 ~ 12:15

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

*伊藤 進一[1]、王 子健[1]、西川 はつみ[3]、三寺 史夫[3]、石野 光弘[2] (1.東京大学大気海洋研究所、2.水産研究・教育機構、3.北海道大学)

Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves

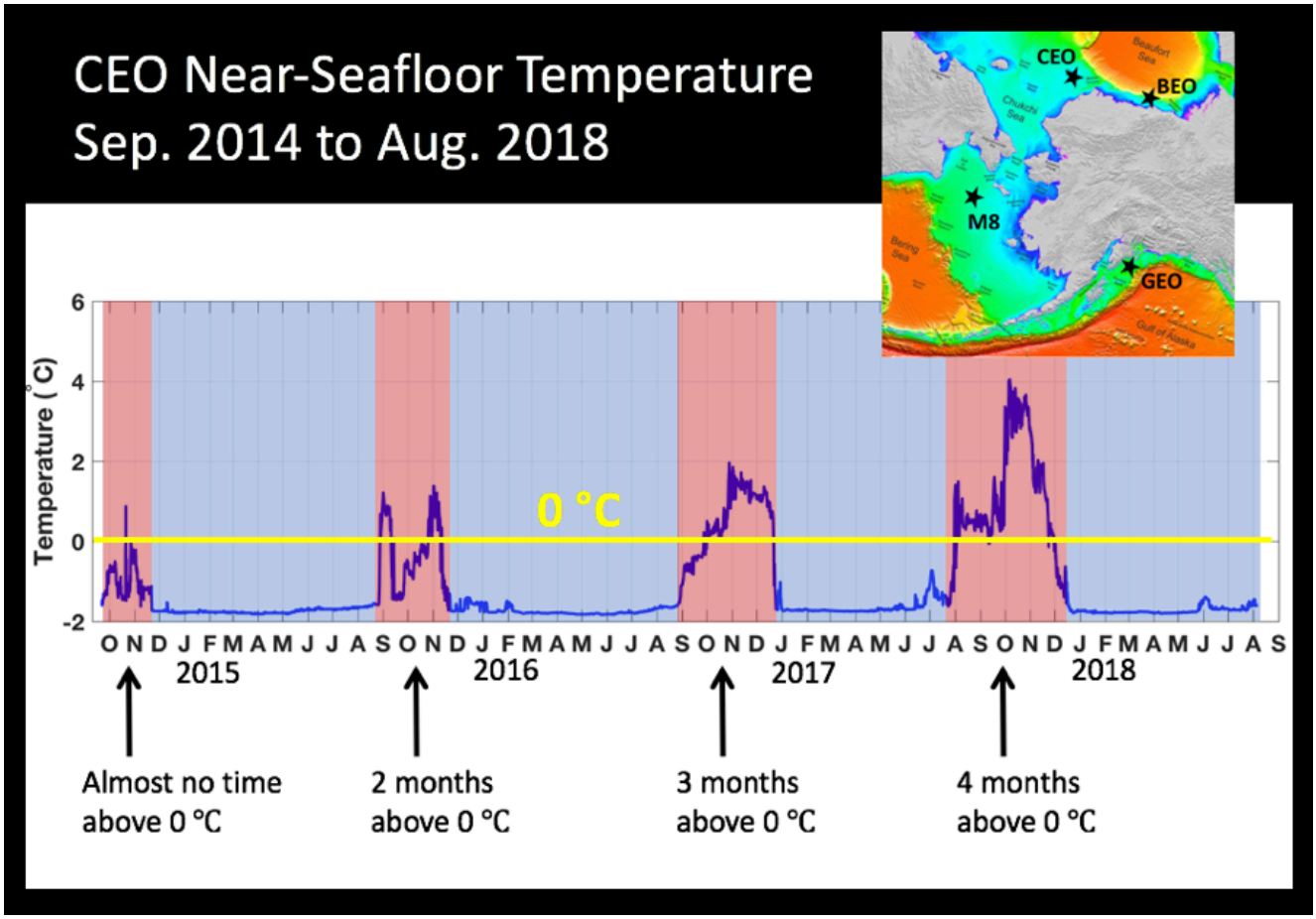
*Seth L Danielson[1]

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

*西岡 純[1]、小畑 元[2]、小川 浩史[2]、安田 一郎[2]
*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2]

1. 北海道大学低温科学研究所、2. 東京大学大気海洋研究所
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.

キーワード：微量および主要栄養物質、縁辺海、北太平洋中層水
Keywords: micro- and macro-nutrients circulation, marginal seas, North Pacific intermediate water

©2019. Japan Geoscience Union. All Right Reserved.

北太平洋中層に存在する溶存鉄の化学形に関する考察
An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*山下 洋平[1]、西岡 純[2]、小畑 元[3]、小川 浩史[3]
*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3]

1. 北海道大学 大学院地球環境科学研究院、2. 北海道大学 低温科学研究所、3. 東京大学 大気海洋研究所
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.

キーワード：北太平洋、鉄、腐植様蛍光性溶存有機物
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

原田 尚美[1]、藤木 徹一[1]、*相田 真希[1]、本多 牧生[1]、喜多村 稔[1]、塩崎 拓平[1]、三野 義尚[3]、桑田 晃[2]、田所 和明[2]、関 宰[4]、近本 めぐみ[5]
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. 国立研究開発法人 海洋研究開発機構 地球環境観測研究開発センター、2. 国立研究開発法人 水産研究・教育機構　東北区水産研究所、3. 名古屋大学 宇宙地球環境研究所 、4. 北海道大学 低温科学研究所、5. ハワイ大学
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.

©2019. Japan Geoscience Union. All Right Reserved.

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 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

*三角 和弘[1]、西岡 純[2]、小畑 元[3]、津旨 大輔[1]、坪野 考樹[1]、Matthew Long[4]、Keith Lindsay[4]、J. Keith Moore[5]
*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. 電力中央研究所 環境科学研究所、2. 北海道大学 低温科学研究所、3. 東京大学 大気海洋研究所、4. 米国大気研究センター、5. カリフォルニア大学アーバイン校
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.

キーワード：北太平洋、鉄、栄養塩
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

*伊藤 進一[1]、王 子健[1]、西川 はつみ[3]、三寺 史夫[3]、石野 光弘[2]
*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2]

1. 東京大学大気海洋研究所、2. 水産研究・教育機構、3. 北海道大学
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.

キーワード：海洋生態系モデル、魚類成長ー回遊モデル、スケトウダラ
Keywords: marine ecosystem model, fish growth-migration model, walleye pollock

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-OS 海洋科学・海洋環境

2019年5月26日(日) 13:45 ~ 15:15 | 303 3F

[A-OS09] 海洋混合学：物質循環・気候・生態系の維持と長周期変動の解明

コンビーナ:安田 一郎(東京大学大気海洋研究所)、日比谷 紀之(東京大学大学院理学系研究科地球惑星科学専攻)、西岡 純(北海道大学低温科学研究所)、伊藤 進一(東京大学大気海洋研究所)、座長:伊藤 進一(東京大学)

海洋鉛直混合を含む統合的現場観測と混合を導入したモデルを開発することで、物質循環や気候、生態系への影響を明らかにすることを目的とした、新学術領域研究「海洋混合学の創設：物質循環・気候・生態系の維持と長周期変動（2015-2020年度）」における研究、及び内外の関連する研究を集約し、成果のまとめを図ると共に今後の課題を明らかにする。

13:45 ~ 14:00

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

★Invited Papers

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

14:00 ~ 14:15

[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)

14:15 ~ 14:30

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

*長船 哲史[1]、増田 周平[1]、杉浦 望実[1]、土居 知将[1]、邉見 忠[1] (1.国立研究開発法人 海洋研究開発機構)

14:30 ~ 14:45

[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)

14:45 ~ 15:00

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

★Invited Papers

*郭 新宇[1]、松野 健[2]、千手 智晴[2]、市川 香[2]、遠藤 貴洋[2]、堤 英輔[2]、仁科 文子[3]、中村 啓彦[3]、張 勁[4]、長谷川 大介[5]、吉江 直樹[1]、小針 統[3] (1.愛媛大学沿岸環境科学研究センター、2.九州大学応用力学研究所、3.鹿児島大学水産学部、4.富山大学理工学研究部、5.東北区水産研究所)

15:00 ~ 15:15

[AOS09-17] 日向灘沖の陸棚斜面近傍を流れる黒潮において、水平30km、鉛直200m規模で観測された著しく強い乱流混合

*長井 健容[1]、Duran Silvana[2]、Otero Diego[2]、森 泰貴[1]、吉江 直樹[3]、大城 一輝[3]、長谷川 大介[4]、仁科 文子[5]、小針 統[5] (1.東京海洋大学 海洋環境科学部門、2.国立アグラリアラモリーナ大学水産学部、3.愛媛大学沿岸環境科学研究センター、4.東北区水産研究所・国立研究開発法人水産研究・教育機構、5.鹿児島大学　水産学部)

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

*長船 哲史[1]、増田 周平[1]、杉浦 望実[1]、土居 知将[1]、邉見 忠[1]
*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1]

1. 国立研究開発法人 海洋研究開発機構
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.

キーワード：鉛直混合、潮汐、データ同化
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

*郭 新宇[1]、松野 健[2]、千手 智晴[2]、市川 香[2]、遠藤 貴洋[2]、堤 英輔[2]、仁科 文子[3]、中村 啓彦[3]、張 勁[4]、長谷川 大介[5]、吉江 直樹[1]、小針 統[3]
*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. 愛媛大学沿岸環境科学研究センター、2. 九州大学応用力学研究所、3. 鹿児島大学水産学部、4. 富山大学理工学研究部、5. 東北区水産研究所
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.

キーワード：黒潮、鉛直混合、低次生態系
Keywords: Kuroshio, Vertical Mixing, low-trophic ecosystem

©2019. Japan Geoscience Union. All Right Reserved.

日向灘沖の陸棚斜面近傍を流れる黒潮において、水平30km、鉛直200m規模で観測された著しく強い乱流混合
Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*長井 健容[1]、Duran Silvana[2]、Otero Diego[2]、森 泰貴[1]、吉江 直樹[3]、大城 一輝[3]、長谷川 大介[4]、仁科 文子[5]、小針 統[5]
*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. 東京海洋大学 海洋環境科学部門、2. 国立アグラリアラモリーナ大学水産学部、3. 愛媛大学沿岸環境科学研究センター、4. 東北区水産研究所・国立研究開発法人水産研究・教育機構、5. 鹿児島大学　水産学部
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

表層で貧栄養な黒潮は、一方で、光の届かない亜表層では、栄養塩ストリームとして、日本南岸に沿って多量の栄養塩を輸送することが知られる。しかしながら、乱流等の密度面を横切る拡散や、湧昇などの輸送で有光層まで運ばれない限り、植物プランクトンは、この栄養塩ストリームの栄養塩を、光合成に利用することができない。果たして、日本南岸を亜表層で運ばれ続けている栄養塩は、光の届く陸棚上の表層へどの程度運ばれるのか、運ばれるのであれば、どの様に運ばれるのかについては、岸に接近して流れる黒潮と陸棚間における乱流微細構造を含めた詳細な物理場と栄養塩の高解像度同時観測が十分に行われていない為に不明である。本研究では、黒潮が陸棚斜面に乗り上げるように流れる日向灘において、自由落下曳航式乱流微細構造観測装置Underway-VMPを用いた乱流微細構造の鉛直断面観測と、これに並行した多項目プロファイラーRINKO Profilerを用いた自由落下曳航観測を交互に実施し、さらに、栄養塩の観測を実施した。観測の結果、黒潮が日向灘の大陸棚斜面近傍を流れるに際に、振幅の大きな鉛直高波数の内部波に伴う流速シアーと、それに伴った強い乱流混合が発生していることがわかった。乱流運動エネルギー散逸率は、黒潮を横断する断面において黒潮近傍の、表層200 mで30 kmに渡ってO(10^{-7} Wkg^{-1})程度と大きく、渦拡散係数は、同様な範囲で平均的にO(10^{-3} m^2s^{-1})程度と、周辺の海域に比べて100倍程度の散逸率と拡散が、水平20-30km、鉛直200mスケールに渡って発生していることが初めて明らかとなった。同時に観測した濁度は、陸棚縁で、海底から表層数10mまで高くなり、乱流に伴う懸濁粒子の巻き上げが発生していることを示唆した。この乱流に伴う硝酸塩の拡散フラックスを見積もったところ、同様な範囲の有光層下部で、1-10 mmol N m^2day^{-1}程度の硝酸塩の供給が発生していることが明らかとなった。

キーワード：黒潮、乱流、栄養塩
Keywords: Kuroshio, Turbulence, Nutrients

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-GG 地理学

2019年5月26日(日) 9:00 ~ 10:30 | 106 1F

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

コンビーナ:Yuei-An Liou(National Central University)、座長: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 ~ 9:15

[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 ~ 9:30

[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 ~ 9:45

[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 ~ 10:00

[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 ~ 10:15

[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 ~ 10:30

[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]

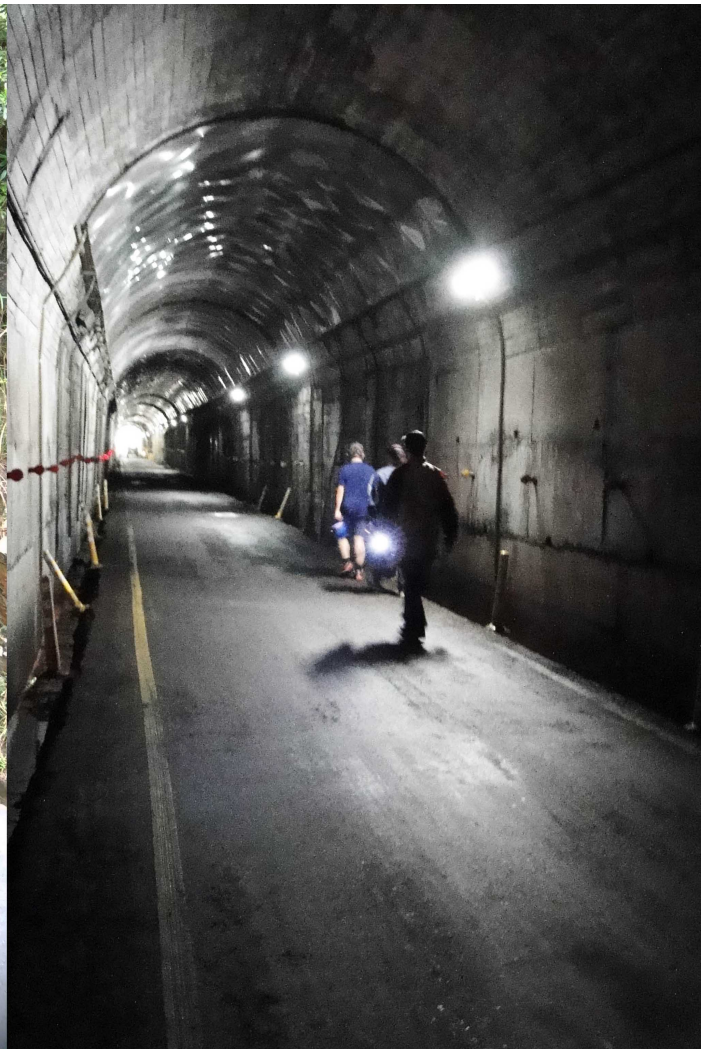
1. National Chung Hsing University

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] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

2019年5月26日(日) 10:45 ~ 12:15 | 106 1F

[H-TT20] Environmental Remote Sensing

コンビーナ:Wei Yang(Chiba University)、近藤 昭彦(千葉大学環境リモートセンシング研究センター)、座長:楊 偉(千葉大学)

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 ~ 11:00

[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 ~ 11:15

[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 ~ 11:30

[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 ~ 11:45

[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 ~ 12:00

[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 ~ 12:15

[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

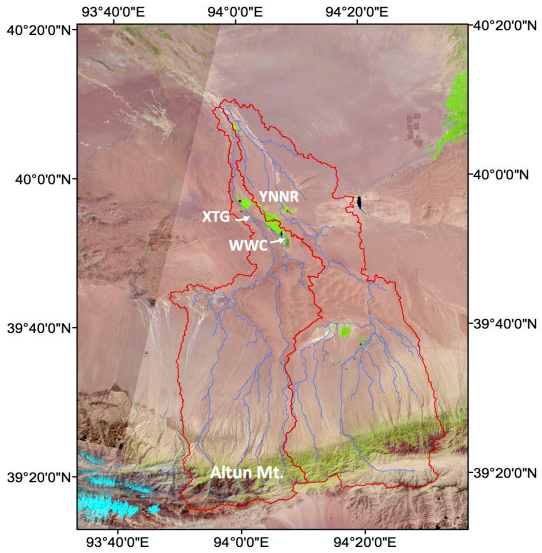
*Feifei Pan[1]

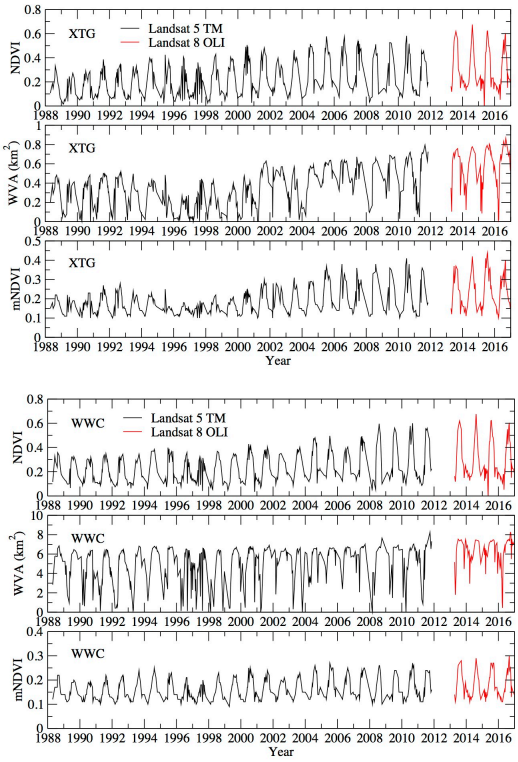
1. University of North Texas

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.

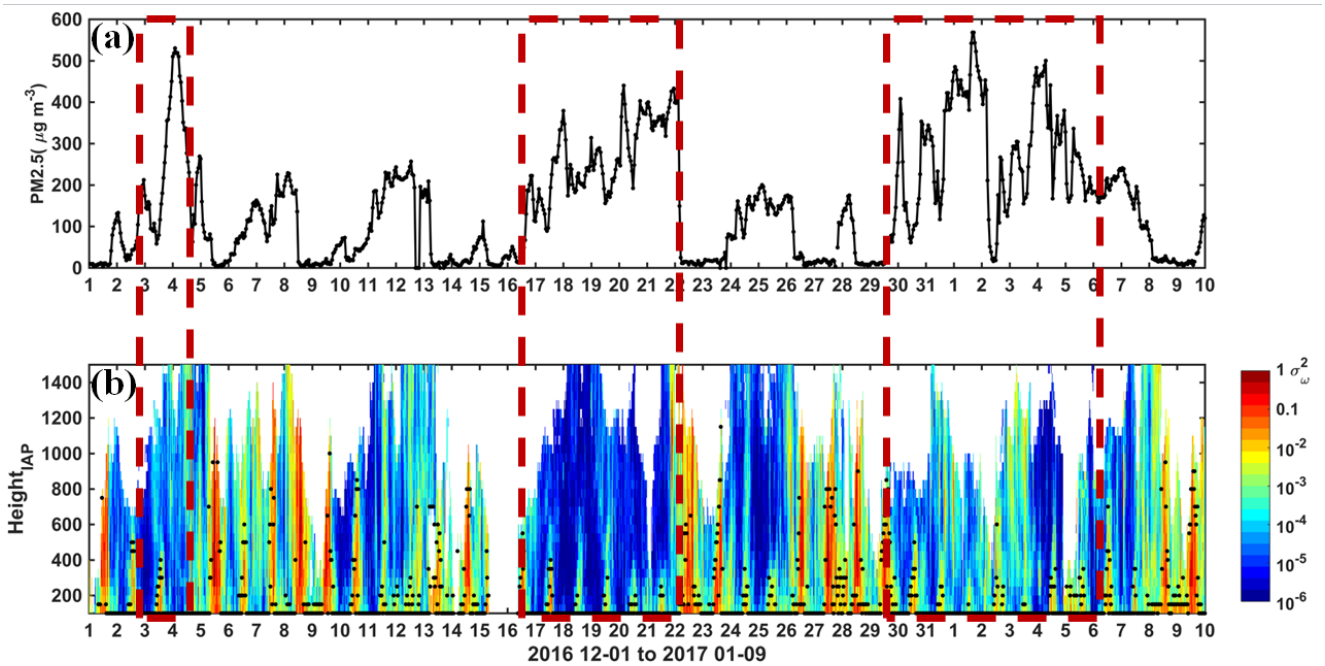
Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*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

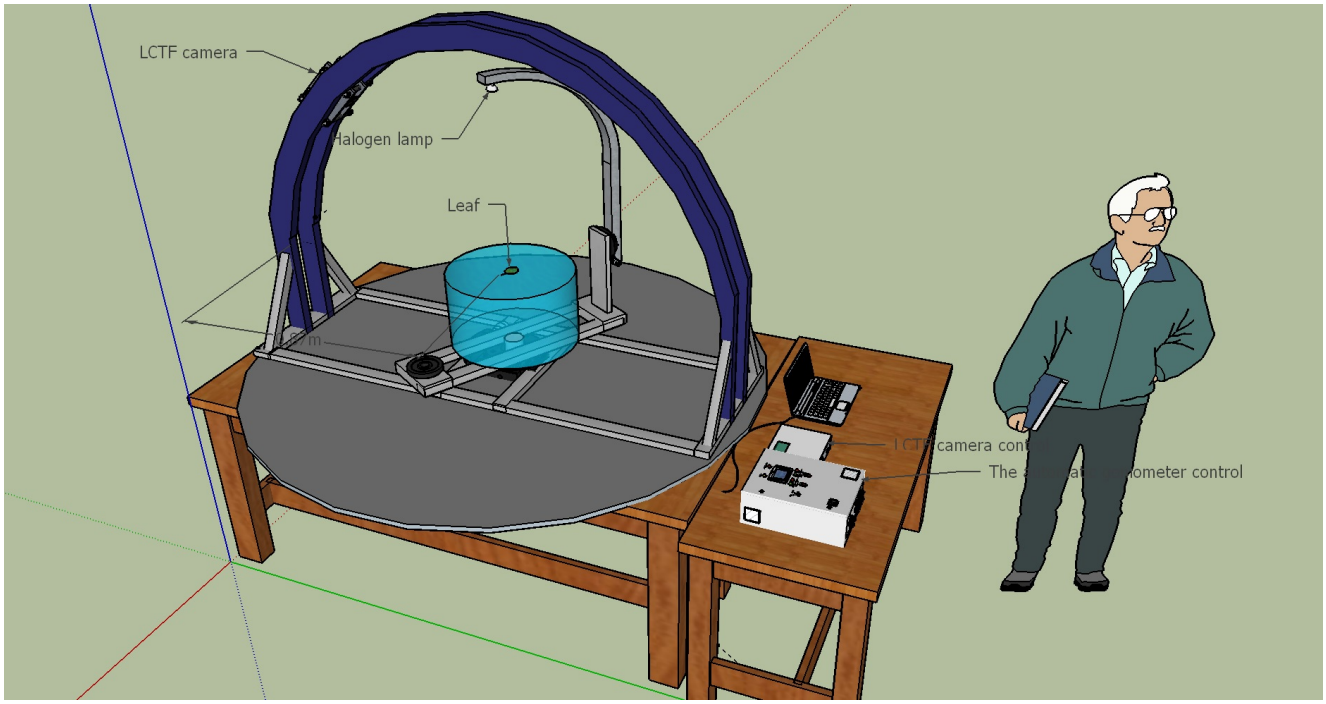
*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2]

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] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

2019年5月26日(日) 10:45 ~ 12:15 | 301B 3F

[S-SS04] New methods for seismicity characterization

コンビーナ:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)、加藤 愛太郎(東京大学地震研究所)、青木 陽介(東京大学地震研究所)、Claudio Satriano(Institut de Physique du Globe de Paris)、座長: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 ~ 11:00

[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 ~ 11:15

[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 ~ 11:30

[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 ~ 11:45

[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 ~ 12:00

[SSS04-05] しきい値なし波形相関による前震検出

*平野 史朗[1]、川方 裕則[1]、土井 一生[2] (1.立命館大学理工学部物理科学科、2.京都大学防災研究所)

12:00 ~ 12:15

[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

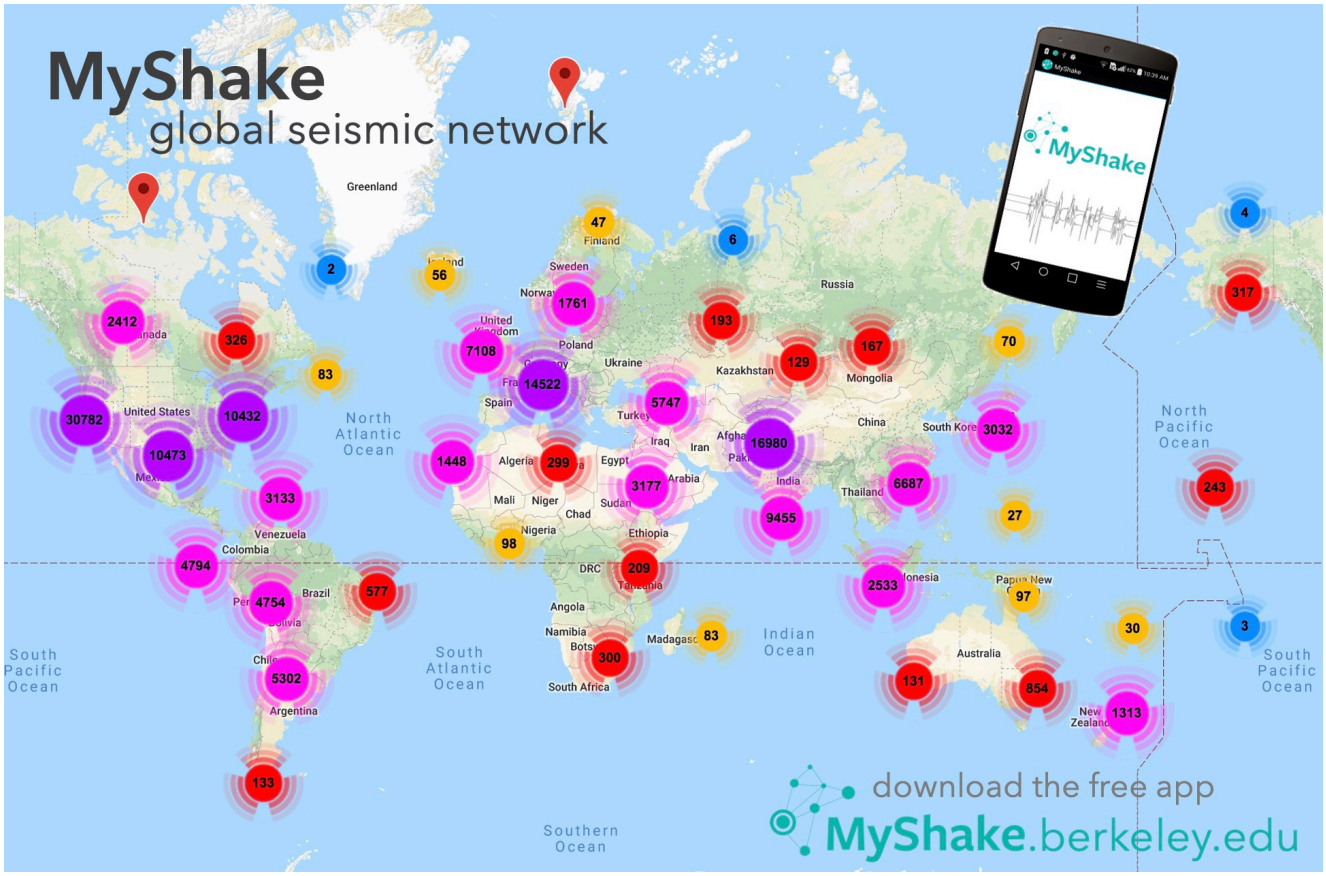
MyShake is a smartphone-based seismic network now collecting seismic data around the globe. Since its launch in 2016, over 300,000 people have downloaded the free public app. Once installed on a private phone, the phone goes into monitoring mode when it is stationary. Any subsequent motion is evaluated 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

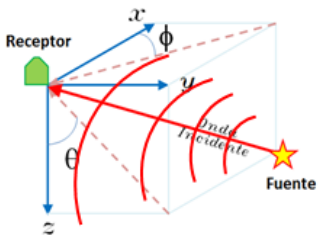
*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1]

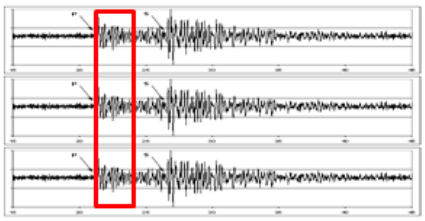
1. Universidad Nacional de Colombia

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.

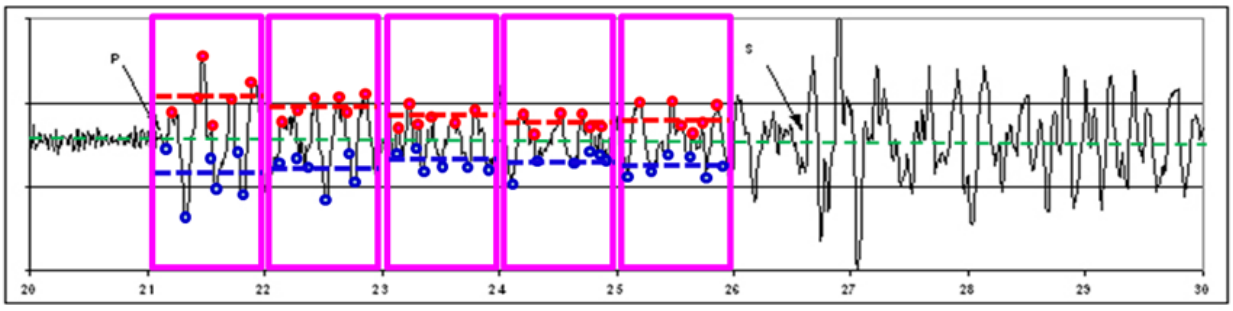
Keywords: Earthquake Early Warning, Support Vector Machine Regression, Polarity Attenuation Factor, Earthquake, Bogotá, Colombia, Location Parameters

©2019. Japan Geoscience Union. All Right Reserved.









©2019. Japan Geoscience Union. All Right Reserved.

しきい値なし波形相関による前震検出
Foreshock activity detection by a threshold-free matched-filter technique

*平野 史朗[1]、川方 裕則[1]、土井 一生[2]
*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2]

1. 立命館大学理工学部物理科学科、2. 京都大学防災研究所
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.

キーワード：波形相関法、前震活動、極値統計、赤池情報量規準
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] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

2019年5月26日(日) 13:45 ~ 15:15 | A04 東京ベイ幕張ホール

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

コンビーナ:Luca Urpi(Swiss Seismological Service - ETH Zurich)、Enescu Bogdan(京都大学 大学院 理学研究科 地球惑星科学専攻 地球物理学教室)、青木 陽介(東京大学地震研究所)、Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)、座長:Luca Urpi(ETH-Zurich; Swiss Seismological Service)、Bogdan Enescu(京都大学 大学院理学研究科)、Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)、青木 陽介

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.

13:45 ~ 14:00

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

★Invited Papers

*椋平 祐輔[1]、Michael Fehler[2]、伊藤 高敏[1]、浅沼 宏[3]、Markus Häring[4] (1.東北大学　流体科学研究所、2.マサチューセッツ工科大学　地球資源研究所、3.産業技術総合研究所　福島再生可能エネルギー研究所、4.Häring GeoProject)

14:00 ~ 14:15

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

*佐藤 大祐[1]、吉田 圭佑[2] (1. 京都大学防災研究所、2.東北大学理学研究科附属地震噴火予知研究観測センター)

14:15 ~ 14:30

[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)

14:30 ~ 14:45

[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)

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

14:45 ~ 15:00

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

*Savage Martha[1]、Graham Kenny[1]、Aoki Yosuke[2]、Arnold Richard[1]、Okada Tomomi[3]、Iio Yoshihisa[4]、Matsumoto Satoshi[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)

15:00 ~ 15:15

[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

*椋平 祐輔[1]、Michael Fehler[2]、伊藤 高敏[1]、浅沼 宏[3]、Markus Häring[4]
*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4]

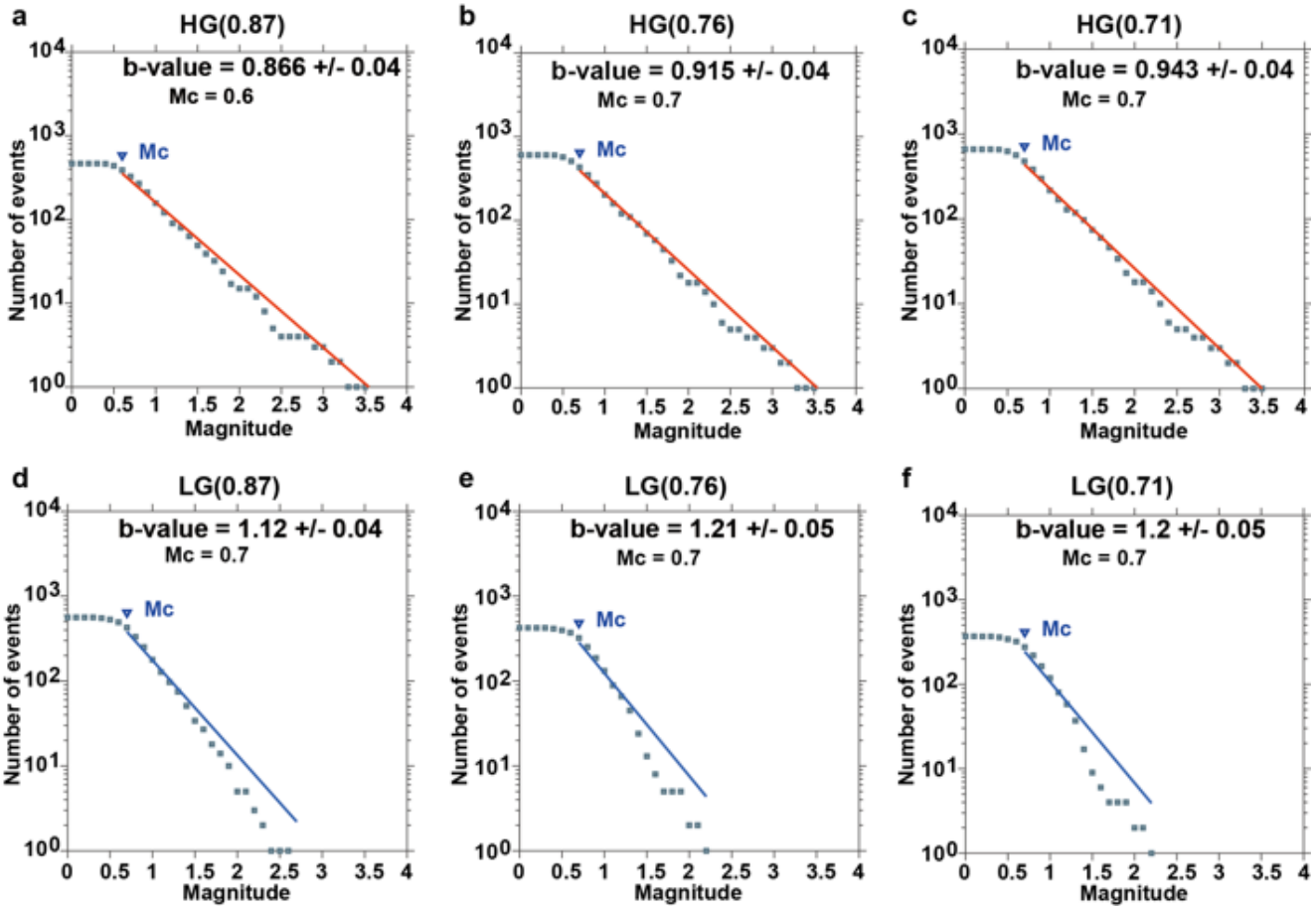
1. 東北大学　流体科学研究所、2. マサチューセッツ工科大学　地球資源研究所、3. 産業技術総合研究所　福島再生可能エネルギー研究所、4. Häring GeoProject
1. Institute of Fluid Science, Tohoku University, 2. ERL, Massachusetts Institute of Technology , 3. FREA, AIST, 4. Häring GeoProject

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.

キーワード：b値、せん断応力、誘発地震
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

*佐藤 大祐[1]、吉田 圭佑[2]
*Daisuke Sato[1], Keisuke Yoshida[2]

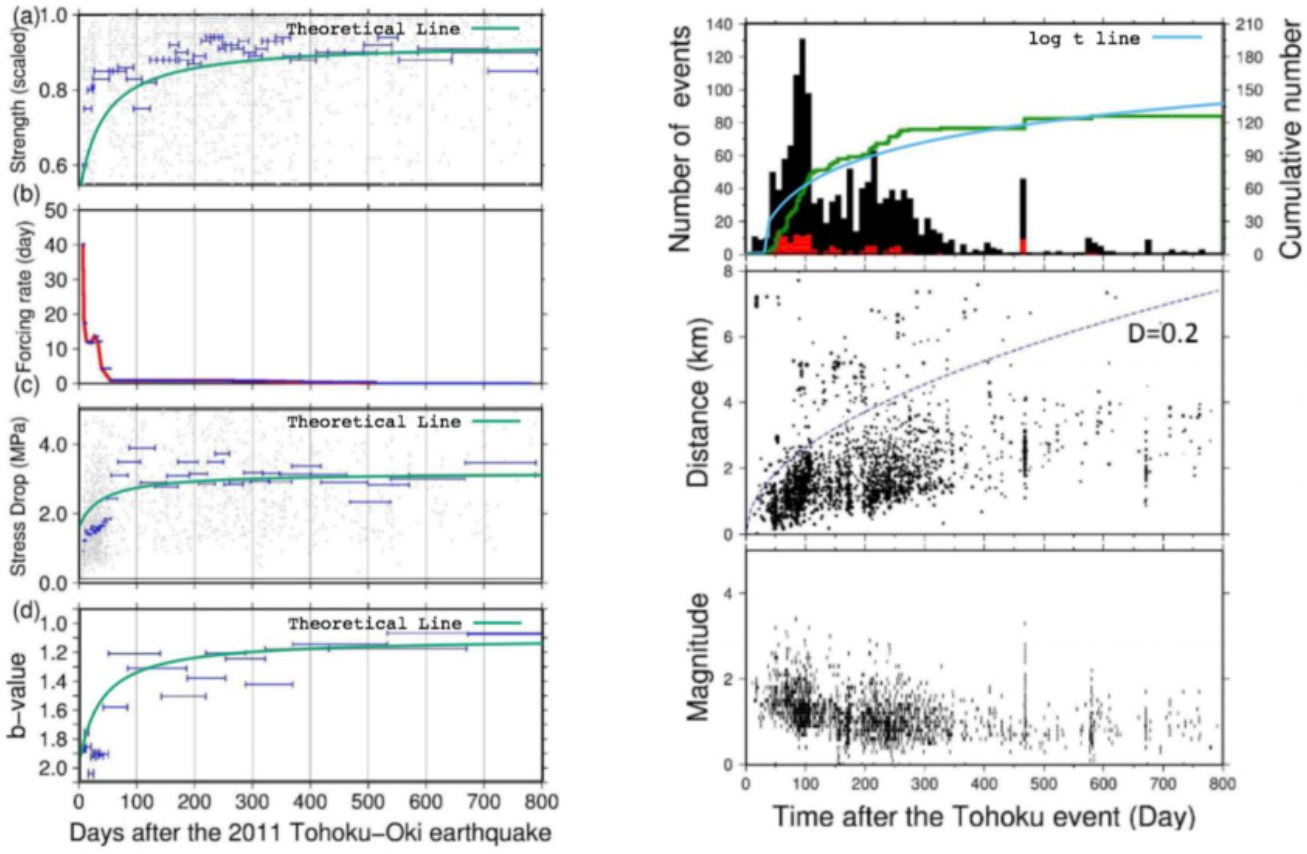
1. 京都大学防災研究所、2. 東北大学理学研究科附属地震噴火予知研究観測センター
1. Disaster Prevention Research Institute, Kyoto University, 2. Tohoku University

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.

キーワード：Induced-Seismicity and Earthquake Swarms、Micromechanical Model、Source Paraemters
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)

*嶋本 利彦[1]、Ellsworth William[2]、Ge Shermin[3]、Giardini Domenico[4]、Townend John[5]
*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
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.

キーワード：Pohang earthquake, Korea、induced earthquake、triggered earthquake
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

Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes

*Savage K Martha[1]、Graham Kenny[1]、Aoki Yosuke[2]、Arnold Richard[1]、Okada Tomomi[3]、Iio Yoshihisa[4]、Matsumoto Satoshi[5]
*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
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.

キーワード：Anisotropy、Vp/Vs、Kumamoto、Kaikoura、temporal variation、Shear wave splitting
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] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

2019年5月26日(日) 10:45 ~ 12:15 | A09 東京ベイ幕張ホール

[S-IT20] 地球型惑星内部での液体の特性とその役割

コンビーナ:坂巻 竜也(東北大学大学院理学研究科)、中島 陽一(熊本大学大学院先導機構)、座長:坂巻 竜也(東北大学)、中島 陽一(熊本大学)

ケイ酸塩メルトと液体金属は、地球型惑星の誕生時から現在に至るまでに辿ってきた物理的、化学的、熱的進化の過程で大きな役割を担ってきた。惑星形成時におけるマグマオーシャンからのコア分離過程は、液体間での元素分配、拡散や粘性といったそれぞれの液体の物理特性により特徴づけられる。地球表層の火山で直接観察されるマグマは地球内部に潜在する液体のごく一部であり、その殆どが深部に内包されており、今もその役割を果たしている。また、地球のみならず火星や水星の金属コアの一部は、今なお、液体状態である可能性が高い。しかしながら、惑星内部のような高圧高温極限下での液体を取り扱うことは実験的にも、理論的であっても容易ではなく、惑星内部のさまざまな液体の特性、その果たす惑星進化への役割を解明することは挑戦的なテーマである。本セッションでは実験・理論・観測・数値シミュレーションなど様々な手法での高圧高温下での液体に関する講演を歓迎し、惑星内部条件における液体の物理的・化学的性質や地球内部でのその振る舞いについて幅広い観点からの積極的な議論も歓迎する。

10:45 ~ 11:15

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

★Invited Papers

*河野 義生[1]、Yu Shu[2]、Curtis Kenney-Benson[2]、Yanbin Wang[3]、Guoyin Shen[2] (1.愛媛大学地球深部ダイナミクス研究センター、2.Argonne National Laboratory、3.The University of Chicago)

11:15 ~ 11:30

[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 ~ 12:00

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

★Invited Papers

*大村 訓史[1]、土屋 卓久[2] (1.広島工業大学、2.愛媛大学)

12:00 ~ 12:15

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

*飯高 敏晃[1]、Nguyen Van Hong[2] (1.国立研究開発法人理化学研究所、2.Hanoi University of Science and Technology)

Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

*河野 義生[1]、Yu Shu[2]、Curtis Kenney-Benson[2]、Yanbin Wang[3]、Guoyin Shen[2]
*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2]

1. 愛媛大学地球深部ダイナミクス研究センター、2. Argonne National Laboratory、3. The University of Chicago
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.

キーワード：high pressure、SiO2 glass、magma、core-mantle boundary
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

*大村 訓史[1]、土屋 卓久[2]
*Satoshi Ohmura[1], Taku Tsuchiya[2]

1. 広島工業大学、2. 愛媛大学
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)

キーワード：液体、シリケート　（ケイ酸塩）、原子拡散、第一原理分子動力学法
Keywords: liquid , silicate, atomic diffusion, ab initio molecular dynamics

©2019. Japan Geoscience Union. All Right Reserved.

Pressure-induced structural change in magnesium silicate melts

Pressure-induced structural change in magnesium silicate melts

*飯高 敏晃[1]、Nguyen Van Hong[2]
*Toshiaki Iitaka[1], Nguyen Van Hong[2]

1. 国立研究開発法人理化学研究所、2. Hanoi University of Science and Technology
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).

©2019. Japan Geoscience Union. All Right Reserved.

[7] T. Sekine, *et al.*: Science Advances, **2**, UNSP e1600157 (2016).

[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).

キーワード：magnesium silicate melts、liquid structure、phase diagram
Keywords: magnesium silicate melts, liquid structure, phase diagram

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

2019年5月26日(日) 13:45 ~ 15:15 | A09 東京ベイ幕張ホール

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

コンビーナ:中川 貴司(香港大学地球科学専攻)、芳野 極(岡山大学惑星物質研究所)、趙 大鵬(東北大学大学院理学研究科附属地震・噴火予知研究観測センター)、座長:芳野 極(岡山大学)

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.

13:45 ~ 14:00

[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)

14:00 ~ 14:15

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

*宮腰 剛広[1]、亀山 真典[2]、小河 正基[3] (1.海洋研究開発機構、2.愛媛大学、3.東京大学)

14:15 ~ 14:30

[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)

14:30 ~ 14:45

[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)

14:45 ~ 15:00

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

*徐 雲遨[1]、吉澤 和範[1,2]、古村 孝志[3] (1.北海道大学　大学院理学院　自然史科学専攻、2.北海道大学　理学研究院、3.東京大学　地震研究所)

15:00 ~ 15:15

[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.

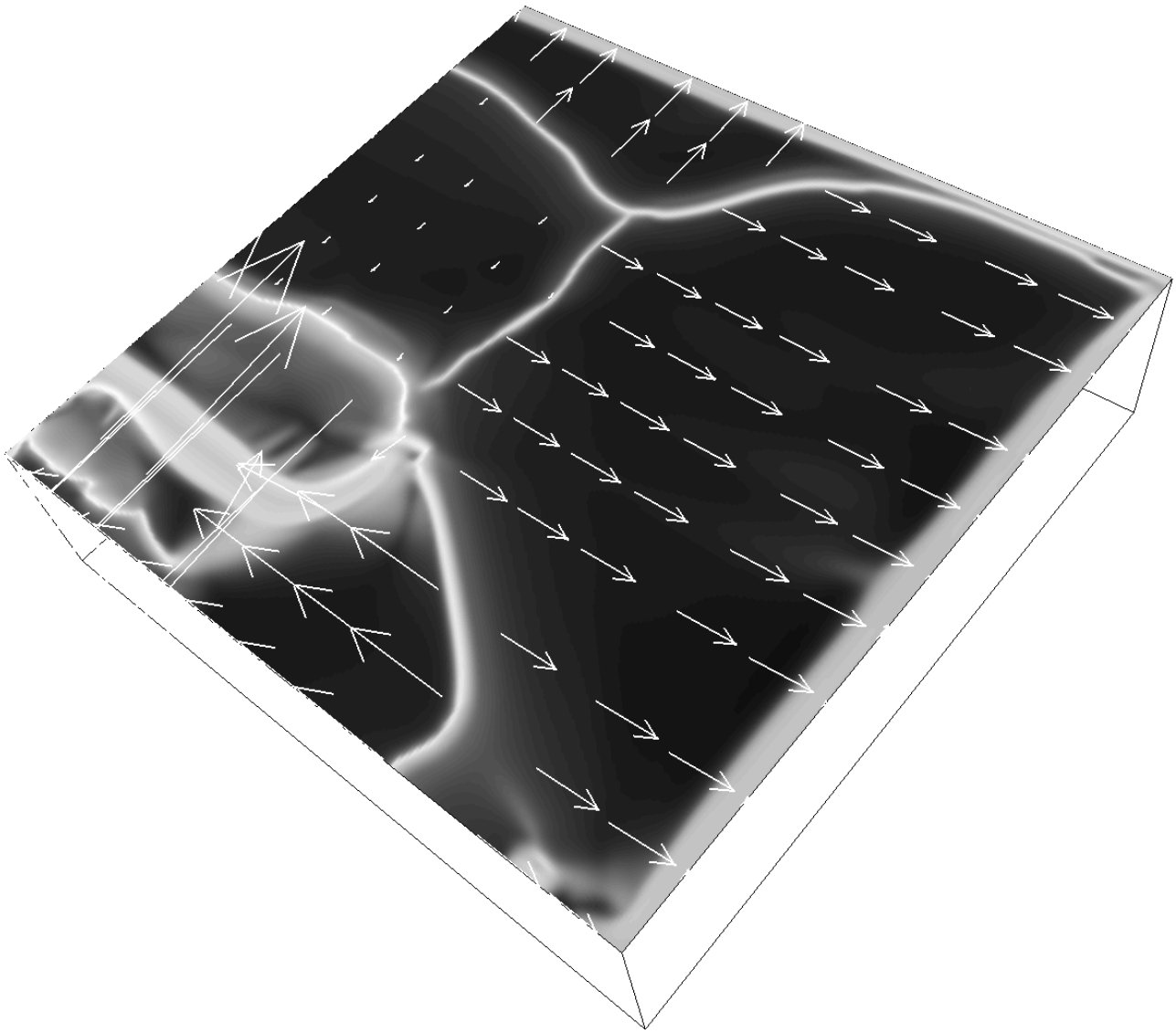
Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

*宮腰 剛広[1]、亀山 真典[2]、小河 正基[3]
*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3]

1. 海洋研究開発機構、2. 愛媛大学、3. 東京大学
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

*徐 雲遨[1]、吉澤 和範[1,2]、古村 孝志[3]
*Xu Yunao[1], Kazunori Yoshizawa[1,2], Takashi Furumura[3]

1. 北海道大学　大学院理学院　自然史科学専攻、2. 北海道大学　理学研究院、3. 東京大学　地震研究所
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

©2019. Japan Geoscience Union. All Right Reserved.

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 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.

キーワード：不均質性、地震波異方性、フォワードモデリング、表面波
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] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

2019年5月26日(日) 15:30 ~ 17:00 | A09 東京ベイ幕張ホール

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

コンビーナ:中川 貴司(香港大学地球科学専攻)、芳野 極(岡山大学惑星物質研究所)、趙 大鵬(東北大学大学院理学研究科附属地震・噴火予知研究観測センター)、座長:趙 大鵬(東北大学)

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.

15:30 ~ 15:45

[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)

15:45 ~ 16:00

[SIT23-08] 東北アジアのプレート内部火山の深部構造と起源

*趙 大鵬[1] (1.東北大学大学院理学研究科附属地震・噴火予知研究観測センター)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

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

*久家 慶子[1] (1.京都大学大学院理学研究科地球惑星科学専攻地球物理学教室)

16:30 ~ 16:45

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

*川添 貴章[1,2]、Florian Heidelbach[2]、宮島 延吉[2]、石井 貴之[2] (1.広島大学、2.バイロイト大学)

16:45 ~ 17:00

[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

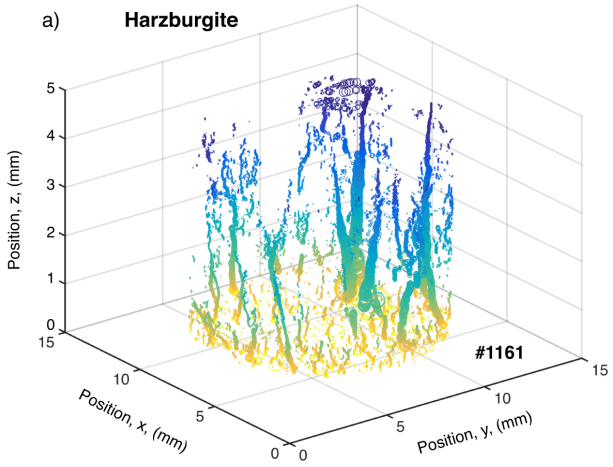
The formation of oceanic plates requires extraction of large volumes of melt from the mantle. Several lines of evidence suggest that melt extraction is rapid and, therefore, necessitates high-permeability pathways. Such pathways may form as a result of melt-rock reactions.

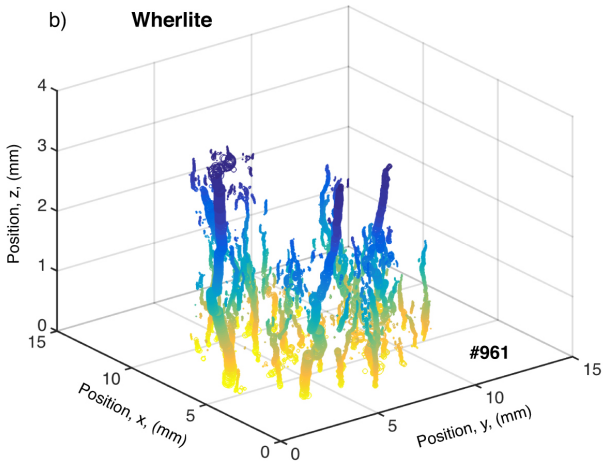
We report the results of a series of Darcy-type experiments designed to study the development of channels due to melt-solid reactions in mantle lithologies. We sandwiched a partially molten rock between a melt source and a porous sink and annealed it at high pressure (P = 300 MPa) and high temperatures (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.

東北アジアのプレート内部火山の深部構造と起源
Deep structure and origin of the intraplate volcanoes in Northeast Asia

*趙 大鵬[1]
*Dapeng Zhao[1]

1. 東北大学大学院理学研究科附属地震・噴火予知研究観測センター
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.

©2019. Japan Geoscience Union. All Right Reserved.

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. Asian Earth Sci.* 145, 349-367.

キーワード：プレート内部火山、マントル構造、地震波トモグラフィー
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

*久家 慶子[1]
*Keiko Kuge[1]

1. 京都大学大学院理学研究科地球惑星科学専攻地球物理学教室
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

*川添 貴章[1,2]、Florian Heidelbach[2]、宮島 延吉[2]、石井 貴之[2]
*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2]

1. 広島大学、2. バイロイト大学
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.

キーワード：マントル遷移層、地震波異方性、リングウッダイト、結晶選択配向、高圧、変形
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] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

2019年5月26日(日) 9:00 ~ 10:30 | A09 東京ベイ幕張ホール

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

コンビーナ:小西 健介(台湾中央研究院地球科学研究所)、片山 郁夫(広島大学大学院理学研究科地球惑星システム学専攻)、芳野 極(岡山大学惑星物質研究所)、Alexandre Schubnel(CNRS)、座長: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 ~ 9:15

[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 ~ 9:30

[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 ~ 9:45

[SIT24-03] 海洋アセノスフェア地震学的構造に対する新たな制約

★招待講演

*竹内 希[1]、川勝 均[1]、塩原 肇[1]、一瀬 建日[1]、杉岡 裕子[2]、伊藤 亜妃[3]、歌田 久司[1] (1.東京大学地震研究所、2.神戸大学、3.海洋研究開発機構)

9:45 ~ 10:00

[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 ~ 10:15

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

★Invited Papers

*武井 康子[1]、山内 初希[1]、角田 明博[1] (1.東京大学地震研究所)

10:15 ~ 10:30

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

*山内 初希[1]、武井 康子[1] (1.東京大学地震研究所)

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.

海洋アセノスフェア地震学的構造に対する新たな制約
New Constraints on Seismological Structures of the Oceanic Asthenosphere

*竹内 希[1]、川勝 均[1]、塩原 肇[1]、一瀬 建日[1]、杉岡 裕子[2]、伊藤 亜妃[3]、歌田 久司[1]
*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1]

1. 東京大学地震研究所、2. 神戸大学、3. 海洋研究開発機構
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.

キーワード：地球内部構造、プレートテクトニクス
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

*武井 康子[1]、山内 初希[1]、角田 明博[1]
*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1]

1. 東京大学地震研究所
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.

キーワード：非弾性、粒界プレメルティング、アセノスフェア
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

*山内 初希[1]、武井 康子[1]
*Hatsuki Yamauchi[1], Yasuko Takei[1]

1. 東京大学地震研究所
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.

キーワード：非弾性、地震波高減衰、部分溶融、メルト効果、メルトネットワーク

©2019. Japan Geoscience Union. All Right Reserved.

Keywords: anelasticity, seismic high attenuation, partial melting, the effect of melt, melt network

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-TT 計測技術・研究手法

2019年5月26日(日) 9:00 ~ 10:30 | A04 東京ベイ幕張ホール

[S-TT42] Recent Advances in Exploration Geophysics 2019

コンビーナ:三ケ田 均(京都大学大学院工学研究科)、飯尾 能久(京都大学防災研究所)、島 伸和(神戸大学大学院理学研究科惑星学専攻)、武川 順一(京都大学大学院工学研究科)、座長:渡邊 勇介(京都大学大学院工学研究科)、武川 順一(京都大学大学院工学研究科)

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 ~ 9:15

[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 ~ 9:30

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

*大谷 颯[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学大学院工学研究科)

9:30 ~ 9:45

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

★Invited Papers

*武川 順一[1]、三ケ田 均[1] (1.京都大学大学院工学研究科)

9:45 ~ 10:00

[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 ~ 10:15

[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 ~ 10:30

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

★Invited Papers

*笠原 順三[1,5]、羽佐田 葉子[2,1]、久詰 陽康[1]、藤瀬 吉博[4,1]、三ケ田 均[3] (1.エンジニアリング協会、2.大和探査技術(株）、3.京都大学、4.WELMA(株）、5.静岡大学)

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

*大谷 颯[1]、三ケ田 均[1]、武川 順一[1]
*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. 京都大学大学院工学研究科
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.

キーワード：水圧破砕シミュレーション、個別要素法、延性、固体ー液体ー熱連成モデル、高温高圧、地熱開発
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

*武川 順一[1]、三ケ田 均[1]
*Junichi Takekawa[1], Hitoshi Mikada[1]

1. 京都大学大学院工学研究科
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.

キーワード：亀裂支持材、数値シミュレーション、粒子法
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

*笠原 順三[1,5]、羽佐田 葉子[2,1]、久詰 陽康[1]、藤瀬 吉博[4,1]、三ケ田 均[3]
*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3]

1. エンジニアリング協会、2. 大和探査技術(株）、3. 京都大学、4. WELMA(株）、5. 静岡大学
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,

©2019. Japan Geoscience Union. All Right Reserved.

we could image the deep-seated supercritical geothermal reservoirs if they exist.

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.

キーワード：DAS、地熱フィールド、地熱貯留層、地震学的モニタリング、DTS、パッシブ地震波震源
Keywords: DAS, Geothermal field, Geothermal reservoir, Seismic monotoring, DTS, Passive seismic source

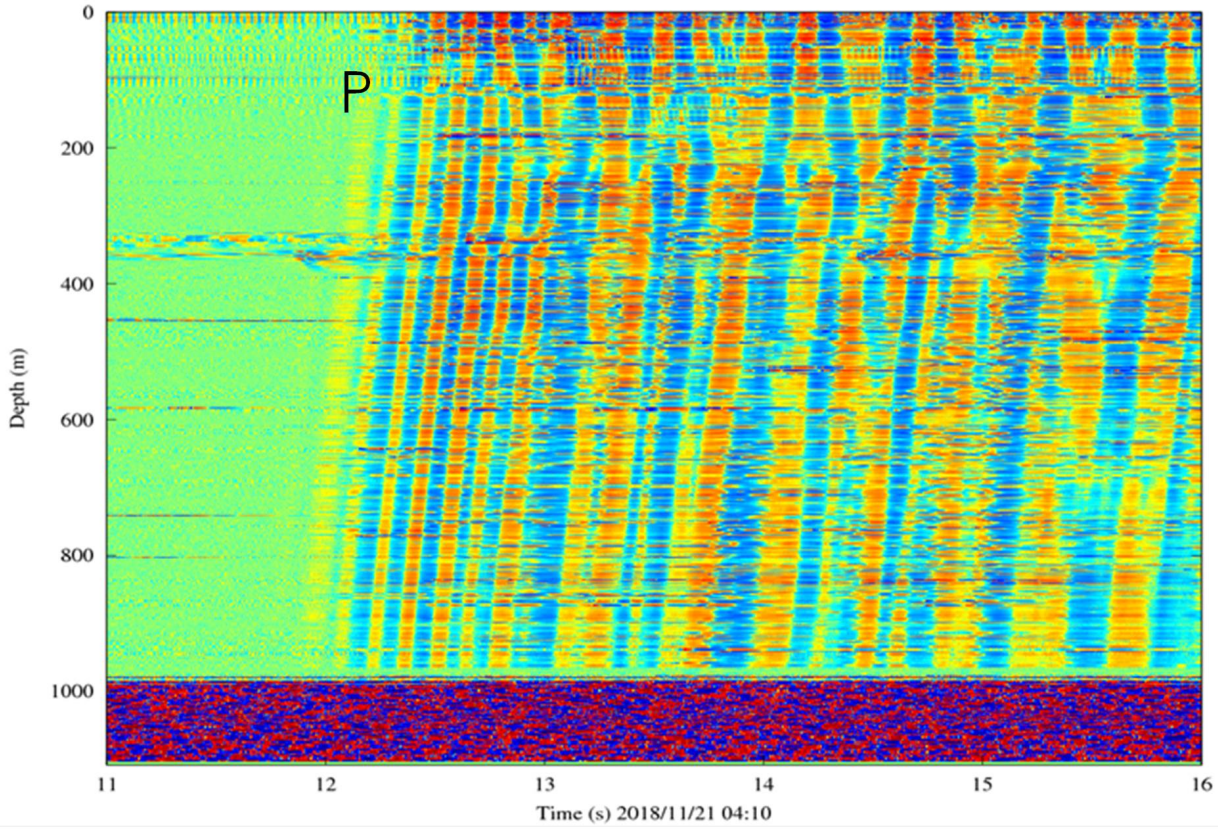


Figure : An M5.2 natural earthquake occurring 100 km focal distance and 123km focal depth recorded by the DAS. The vertical axis is depth from 0 m (top) to 977 m (bottom). The horizonal axis is the arrival time in seconds.

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-TT 計測技術・研究手法

2019年5月26日(日) 10:45 ~ 12:15 | A04 東京ベイ幕張ホール

[S-TT42] Recent Advances in Exploration Geophysics 2019

コンビーナ:三ケ田 均(京都大学大学院工学研究科)、飯尾 能久(京都大学防災研究所)、島 伸和(神戸大学大学院理学研究科惑星学専攻)、武川 順一(京都大学大学院工学研究科)、座長:武川 順一(京都大学大学院工学研究科)、渡邊 勇介(京都大学大学院工学研究科)

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 ~ 11:00

[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 ~ 11:15

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

*田村 怜[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

11:15 ~ 11:30

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

*木村 巧志[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

11:30 ~ 11:45

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

*益邑 遼[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

11:45 ~ 12:00

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

*岩田 優生[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学大学院工学研究科)

12:00 ~ 12:15

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

*渡邊 勇介[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

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

*田村 怜[1]、三ケ田 均[1]、武川 順一[1]
*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. 京都大学
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.

キーワード：フォームEOR、Reverse Time Migration、タイムラプス、数値実験
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

*木村 巧志[1]、三ケ田 均[1]、武川 順一[1]
*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. 京都大学
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.

キーワード：Coleプロット、仮想領域法、地中レーダー探査
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

*益邑 遼[1]、三ケ田 均[1]、武川 順一[1]
*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. 京都大学
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.

キーワード：浸透率、異方性、数値実験、粒子法
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

*岩田 優生[1]、三ケ田 均[1]、武川 順一[1]
*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. 京都大学大学院工学研究科
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.

キーワード：格子ボルツマン法、流体力学、スケール、腐食
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

*渡邊 勇介[1]、三ケ田 均[1]、武川 順一[1]
*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. 京都大学
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.

キーワード：地震波干渉法、クロスダイポール探査、S波探査、S波伝播速度異方性、全波形逆解析
Keywords: Seismic Interferometry, Cross-dipole survey, S-wave survey, S-wave anisotropy, Full waveform inversion

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-PT 古生物学・古生態学

2019年5月26日(日) 9:00 ~ 10:30 | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

コンビーナ:豊福 高志(国立研究開発法人海洋研究開発機構)、北里 洋(国立大学法人東京海洋大学)、Bijma Jelle(アルフレッドウェゲナー極域海洋研究所)、廣瀬 孝太郎(早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻)、座長:廣瀬 孝太郎(早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻)、豊福 高志

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 ~ 9:15

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

★Invited Papers

*鈴木 拓馬[1]、林 広樹[1] (1.島根大学)

9:15 ~ 9:30

[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 ~ 9:45

[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

*吉村 寿紘[1]、為則 雄祐[2]、黒田 潤一郎[3]、黒柳 あずみ[4]、大河内 直彦[1] (1.海洋研究開発機構　生物地球化学研究分野、2.高輝度光科学研究センター、3.東京大学　大気海洋研究所、4.東北大学　総合学術博物館)

9:45 ~ 10:00

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

*氏家 由利香[1]、石谷 佳之[2]、石井 俊一[3]、長井 裕季子[3]、高木 善弘[3]、生田 哲朗[3]、豊福 高志[3] (1.高知大学・海洋コア総合研究センター、2.筑波大学・計算科学研究センター、3.海洋研究開発機構)

10:00 ~ 10:15

[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 ~ 10:30

[BPT04-06] 海底景観から底生有孔虫を特徴づける

*北里 洋[1] (1.国立大学法人東京海洋大学)

Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

*鈴木 拓馬[1]、林 広樹[1]
*Takuma Suzuki[1], Hiroki Hayashi[1]

1. 島根大学
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).

キーワード：浮遊性有孔虫、サイズ、巨大化、中期中新世気候温暖期、東部南極氷床拡大
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

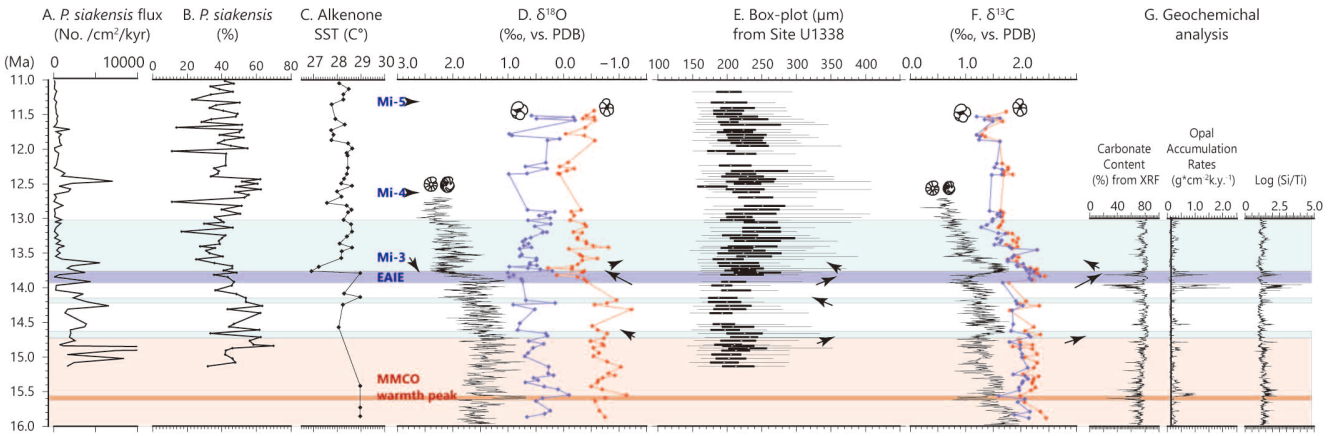


Fig.1 Temporal size changes are plotted with other previous data. A: Flux of *P. siakensis* at Site U1338 (Hayashi et al., 2013). B: Relative abundance of *P. siakensis* at Site U1338 (Hayashi et al., 2013). C: Alkenone SST data at Site U1338 (Rousselle et al., 2013). D: Stable oxygen isotope data. The 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

*吉村 寿紘[1]、為則 雄祐[2]、黒田 潤一郎[3]、黒柳 あずみ[4]、大河内 直彦[1]
*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1]

1. 海洋研究開発機構　生物地球化学研究分野、2. 高輝度光科学研究センター、3. 東京大学　大気海洋研究所、4. 東北大学　総合学術博物館
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.

キーワード：氷期間氷期サイクル、硫黄、有孔虫
Keywords: glacial-interglacial cycle, sulfur, foraminifera

©2019. Japan Geoscience Union. All Right Reserved.

Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*氏家 由利香[1]、石谷 佳之[2]、石井 俊一[3]、長井 裕季子[3]、高木 善弘[3]、生田 哲朗[3]、豊福 高志[3]
*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3]

1. 高知大学・海洋コア総合研究センター、2. 筑波大学・計算科学研究センター、3. 海洋研究開発機構
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.

キーワード：石灰化、単細胞真核生物、遺伝子発現
Keywords: calcification, single-cell eukaryote, gene expression

©2019. Japan Geoscience Union. All Right Reserved.

Characterization of cogwheel structures in foraminifera

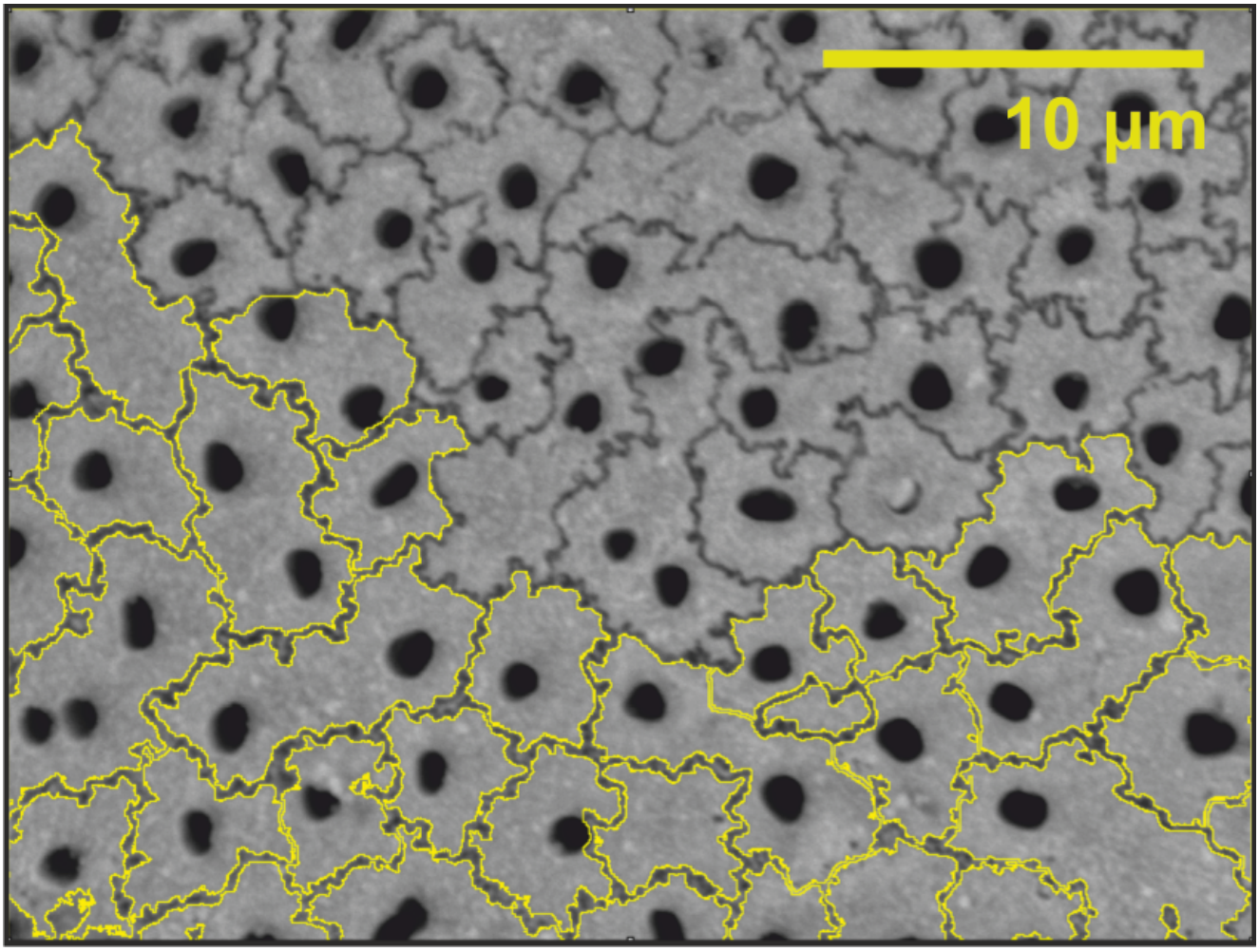
*Inge van Dijk[1], Markus Raitzsch[2], Gernot Nehrke[1], Jelle Bijma[1]

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.

海底景観から底生有孔虫を特徴づける
Benthic foraminiferal characterizations from the seascape point of view

*北里 洋[1]
*Hiroshi Kitazato[1]

1. 国立大学法人東京海洋大学
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.

キーワード：有孔虫、住み分け、海の景観
Keywords: foraminifers, habitat segregation, seascape in the sea

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-PT 古生物学・古生態学

2019年5月26日(日) 10:45 ~ 12:15 | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

コンビーナ:豊福 高志(国立研究開発法人海洋研究開発機構)、北里 洋(国立大学法人東京海洋大学)、Bijma Jelle(アルフレッドウェゲナー極域海洋研究所)、廣瀬 孝太郎(早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻)、座長: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 ~ 11:00

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

*甕 聡子[1]、富岡 尚敬[1]、川野 潤[2]、波利井 佐紀[3]、永井 隆哉[2]、渡邊 剛[2]、兒玉 優[4]、伊藤 元雄[1] (1.海洋研究開発機構　高知コア研究所、2.北海道大学、3.琉球大学、4.マリン・ワーク・ジャパン)

11:00 ~ 11:15

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

*樋口 富彦[1]、湯山 育子[2] (1.東京大学大気海洋研究所、2.筑波大学)

11:15 ~ 11:30

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

*西尾 拓哉[1]、高柳 栄子[1]、浅海 竜司[1]、新城 竜一[2]、山本 鋼志[3]、井龍 康文[1] (1.東北大学大学院理学研究科地学専攻、2.琉球大学大学院理工学研究科物質地球科学科地学系、3.名古屋大学大学院環境学研究科地球環境科学専攻)

11:30 ~ 11:45

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

*高柳 栄子[1]、栃木 智子[1]、浅海 竜司[1]、新城 竜一[2]、板木 拓也[3]、井龍 康文[1] (1.東北大学、2.琉球大学、3.産業技術総合研究所)

11:45 ~ 12:05

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

★Invited Papers

*仲村 康秀[1]、堀 利栄[2]、辻 彰洋[1]、大藤 弘明[2]、鈴木 紀毅[3]、木元 克典[4] (1.国立科学博物館、2.愛媛大学、3.東北大学、4.海洋研究開発機構)

12:05 ~ 12:15

Discussion

Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*甕 聡子[1]、富岡 尚敬[1]、川野 潤[2]、波利井 佐紀[3]、永井 隆哉[2]、渡邊 剛[2]、兒玉 優[4]、伊藤 元雄[1]
*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. 海洋研究開発機構　高知コア研究所、2. 北海道大学、3. 琉球大学、4. マリン・ワーク・ジャパン
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

©2019. Japan Geoscience Union. All Right Reserved.

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
Motai S., Kawano J., Harii S., Watanabe T., Nagai T., 2017, JpGU-AGU Joint Meeting

キーワード：造礁サンゴ、バイオミネラリゼーション、共生藻、アラゴナイト、カルサイト
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

*樋口 富彦[1]、湯山 育子[2]
*Tomihiko Higuchi[1], Ikuko Yuyama[2]

1. 東京大学大気海洋研究所、2. 筑波大学
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 $CaCO_3$.

キーワード：Aragonite-Calcite、scleractinian coral、Mg/Ca fluctuation
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

*西尾 拓哉[1]、高柳 栄子[1]、浅海 竜司[1]、新城 竜一[2]、山本 鋼志[3]、井龍 康文[1]
*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1]

1. 東北大学大学院理学研究科地学専攻、2. 琉球大学大学院理工学研究科物質地球科学科地学系、3. 名古屋大学大学院環境学研究科地球環境科学専攻
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.

キーワード：現生腕足動物、微量金属元素濃度、古環境指標、大槌湾
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

*高柳 栄子[1]、栃木 智子[1]、浅海 竜司[1]、新城 竜一[2]、板木 拓也[3]、井龍 康文[1]
*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1]

1. 東北大学、2. 琉球大学、3. 産業技術総合研究所
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.

キーワード：腕足動物、微量金属元素濃度、琉球諸島、古環境指標
Keywords: Brachiopoda, Trace element concentrations, Ryukyu Islands, Paleoenvironmental proxy

©2019. Japan Geoscience Union. All Right Reserved.

Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

*仲村 康秀[1]、堀 利栄[2]、辻 彰洋[1]、大藤 弘明[2]、鈴木 紀毅[3]、木元 克典[4]
*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4]

1. 国立科学博物館、2. 愛媛大学、3. 東北大学、4. 海洋研究開発機構
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.

キーワード：ケルコゾア、原生生物、バイオミネラリゼーション、シリカ、プランクトン
Keywords: Cercozoa, protist, biomineralization, silica, plankton

©2019. Japan Geoscience Union. All Right Reserved.

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

2019年5月26日(日) 13:45 ~ 15:15 | 304 3F

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

コンビーナ:Groisman Pavel(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)、座長: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)

13:45 ~ 14:00

[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)

14:00 ~ 14:15

[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,)

14:15 ~ 14:30

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

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

14:30 ~ 14:45

[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)

14:45 ~ 15:00

[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)

15:00 ~ 15:15

[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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

2019年5月26日(日) 15:30 ~ 17:00 | 304 3F

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

コンビーナ:Groisman Pavel(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)、座長: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)

15:30 ~ 15:45

[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)

15:45 ~ 16:00

[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)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

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

*谷田貝 亜紀代[1]、千田 彩乃[1]、増田 南波[1]、Kumar Vinay[2] (1.弘前大学大学院理工学研究科、2.Texas A&M University)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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

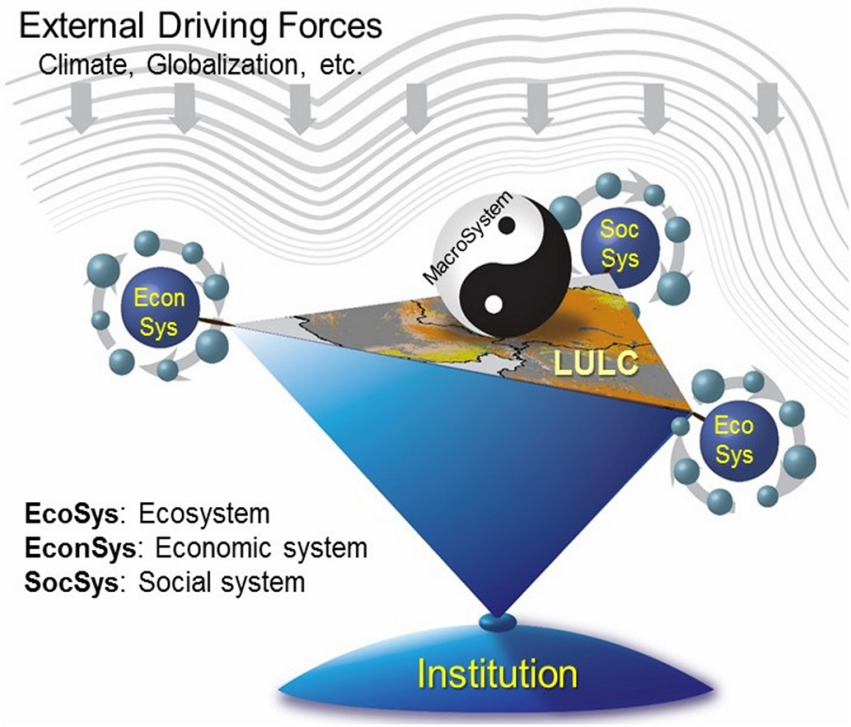
*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3]

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

*谷田貝 亜紀代[1]、千田 彩乃[1]、増田 南波[1]、Kumar Vinay[2]
*Akiyo Yatagai[1], Ayano Senda[1], Minami Masuda[1], Vinay Kumar[2]

1. 弘前大学大学院理工学研究科、2. Texas A&M University
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,

©2019. Japan Geoscience Union. All Right Reserved.

we could exclude them from the MMSE.

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.

キーワード：Multimodel Superensemble、CMIP、APHRODITE、Glaciological water resources
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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

2019年5月26日(日) 9:00 ~ 10:30 | 302 3F

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

コンビーナ:村山 泰啓(国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)、近藤 康久(総合地球環境学研究所)、Shelley Stall(American Geophysical Union)、Cecconi Baptiste(LESIA, Observatoire de Paris, CNRS, PSL Research University)、座長:村山 泰啓(情報通信研究機構)

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 ~ 9:15

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

*村山 泰啓[1] (1.国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)

9:15 ~ 9:30

[MGI31-02] Japan Data Repository Network (JDARN)：データリポジトリの信頼性向上を中心としたコミュニティ活動

*北本 朝展[1,2,4]、絹谷 弘子[3] (1.国立情報学研究所、2.ROIS-DS人文学オープンデータ共同利用センター、3.東京大学地球観測データ統融合連携研究機構、4.総合研究大学院大学)

9:30 ~ 9:45

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

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

9:45 ~ 10:00

[MGI31-04] Ethical issues in open science

*近藤 康久[1] (1.総合地球環境学研究所)

10:00 ~ 10:15

[MGI31-05] 統合イノベーション政策と学術情報流通の現状のギャップから見通すオープンサイエンスの展望

*林 和弘[1] (1.文部科学省科学技術・学術政策研究所)

10:15 ~ 10:30

[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

*村山 泰啓[1]
*Yasuhiro Murayama[1]

1. 国立研究開発法人情報通信研究機構 戦略的プログラムオフィス
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.

キーワード：open science、research data sharing 、WDS、international coordination
Keywords: open science, research data sharing , WDS, international coordination

©2019. Japan Geoscience Union. All Right Reserved.

Japan Data Repository Network (JDARN)：データリポジトリの信頼性向上を中心としたコミュニティ活動
Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*北本 朝展[1,2,4]、絹谷 弘子[3]
*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3]

1. 国立情報学研究所、2. ROIS-DS人文学オープンデータ共同利用センター、3. 東京大学地球観測データ統融合連携研究機構、4. 総合研究大学院大学
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の設立と経緯

Japan Data Repository Network (JDARN)とは、日本のデータリポジトリを対象として、世界の最新動向を共有しながら、信頼性を向上させるための取り組みを進める、コミュニティ活動である。その源流は、ジャパンリンクセンター（JaLC）が2014年10月から2015年9月にかけておこなった「研究データへのDOI登録実験プロジェクト」にある。このプロジェクトは、研究データに関する専門家が分野を越えて集まったという点では日本初とも言える画期的な場となった。この活動を引き継ぐものとして研究データ利活用協議会が2016年6月に設立され、その後いくつかの小委員会が提案されることとなった。その一つとして2017年10月に我々が立ち上げたのが「国内の分野リポジトリ関係者のネットワーク構築」小委員会である。2018年10月からは、より多くの分野と関係者を対象とするために「ジャパン･データリポジトリ･ネットワーク(Japan DAta Repository Network : JDARN)」と名称を変更した。

JDARNはデータリポジトリに関する動向を共有することが目的の一つであるが、中でも焦点となっているのがデータリポジトリの信頼性という問題である。研究データの生産者がデータを外部サービスに預ける際に、どこに預けるべきかを意思決定する基準として、データリポジトリの信頼性は重要な役割を果たす。そうした信頼性を示す基準の一つにCoreTrustSeal (CTS)がある。CTSはデータリポジトリに関する国際的な認証の一つであり、2019年2月現在で140あまりのデータリポジトリが認証を受けているが、日本ではまだ認証を受けているケースが少ない。CTSの認証が日本では少ない理由を探るため、2017年12月にセミナー「信頼できるデータリポジトリ～CoreTrustSeal認証に関する実践的情報共有の場～」を主催し、日本の有力なデータリポジトリがCTSの要求要件を用いて自己評価（self-assessment）してみる試みを行った。その結果、CTSの背景となる考え方がわからないとCTSによる自己評価も難しいことが判明した。そこでまずCTSを理解するための資料の作成を開始し、これが小委員会の主要な活動となった。そしてさらに議論を重ねた結果、CTSありきでなく利活用の側面も考慮したデータリポジトリのガイドラインを作成する課題に活動がシフトしていった。

2. データリポジトリのガイドライン

現在作成中のデータリポジトリガイドラインは、基本的にCTSの要求要件（16項目）を参考にしつつ、CTSを直訳するのではなくJDARNが独自に構成を提案するものである。このようにCTSを再考するきっかけとなったのが、バイオサイエンスデータベースセンター（NBDC）の八塚茂氏によるCTSのアイテム単位の整理である。CTSの審査過程では、様々なドキュメントを用意しそれを公開していることが透明性の一つの証拠となる。そこでCTSを実際に獲得したデータリポジトリの申請書を分析し、そこで言及されているドキュメントの種類を整理することで、CTSに必要なドキュメントを準備するという次のアクションがわかりやすくなると考えた。CTSの抽象的な項目を具体的なヒト・モノなどに落とし込むことで、より理解しやすいガイドラ

©2019. Japan Geoscience Union. All Right Reserved.

インを作れる可能性が生まれたのである。

しかしドキュメントの整理に比べると、データリポジトリに関わる人に関する項目の整理はより困難である。データリポジトリではどんな職務が必要なのか、それを担うのは誰なのか。しかも職務については、その職務を専門家として何と呼ぶかという名称の問題もある。データ専門家として近年提唱される職名には、データライブラリアン、データキュレーター、データサイエンティスト、データエンジニアなどがあり、その意味も人によって異なる。これらの職務の概念を整理し、それらの長期的なキャリアパスを示すこと、それができければデータリポジトリを基盤としたオープンサイエンスの展開はおぼつかない。こうした問題についてはまだ確固たるモデルがあるとは言えず、我々は現在も議論を続けている。

3. 今後の展開

JDARNは設立以来、毎月1回ほどの会合を開きながら活発な議論を交わしてきた。そうした議論に参加するデータリポジトリの数が増えれば、日本のデータリポジトリの品質を高め、世界の中での存在感も高め、オープンサイエンスのための基盤としての価値も向上するであろう。そのためにはデータリポジトリが研究に不可欠な存在となる必要がある。データリポジトリというデータのコンテナとしての信頼性・持続性の向上がCTSの焦点であるが、それに加えてデータの統合、分析、可視化、社会実装などコンテンツの利活用に向けた多様な専門家も必要になる。これを単独で担える組織は限られるため、データリポジトリ間のコラボレーションも重要な課題であり、そこにデータリポジトリのネットワークが活きてくると考えている。

キーワード：ジャパン･データリポジトリ･ネットワーク、データリポジトリ、信頼性、CoreTrustSeal、ガイドライン、データ専門家
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

*近藤 康久[1]
*Yasuhisa Kondo[1]

1. 総合地球環境学研究所
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.

キーワード：オープンサイエンス、倫理的衡平
Keywords: open science, ethical equity

©2019. Japan Geoscience Union. All Right Reserved.

統合イノベーション政策と学術情報流通の現状のギャップから見通すオープンサイエンスの展望

The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*林 和弘[1]
*Kazuhiro Hayashi[1]

1. 文部科学省科学技術・学術政策研究所
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.

キーワード：オープンサイエンス、統合イノベーション戦略、研究データプラットフォーム、学術出版
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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

2019年5月26日(日) 10:45 ~ 12:15 | 302 3F

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

コンビーナ:村山 泰啓(国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)、近藤 康久(総合地球環境学研究所)、Shelley Stall(American Geophysical Union)、Cecconi Baptiste(LESIA, Observatoire de Paris, CNRS, PSL Research University)、座長: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 ~ 11:00

[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 ~ 11:15

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

*樋口 篤志[1,3]、豊嶋 紘一[1]、広瀬 民志[1]、竹中 栄晶[2,1] (1.千葉大学環境リモートセンシング研究センター、2.JAXA EORC、3.NICT)

11:15 ~ 11:30

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

*堀之内 武[1] (1.北海道大学地球環境科学研究院)

11:30 ~ 11:45

[MGI31-10] 測地観測データ提供の現状と問題

*大坪 俊通[1]、横田 裕輔[2]、石川 直史[3]、関戸 衛[4]、宮崎 隆幸[5]、栗原 忍[5] (1.一橋大学、2.東京大学生産技術研究所、3.海上保安庁海洋情報部、4.情報通信研究機構、5.国土地理院)

11:45 ~ 12:00

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

*能勢 正仁[1]、村山 泰啓[2] (1.名古屋大学 宇宙地球環境研究所、2.情報通信研究機構 戦略的プログラムオフィス)

12:00 ~ 12:15

[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

*樋口 篤志[1,3]、豊嶋 紘一[1]、広瀬 民志[1]、竹中 栄晶[2,1]
*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1]

1. 千葉大学環境リモートセンシング研究センター、2. JAXA EORC、3. NICT
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.

キーワード：静止気象衛星、環境研究
Keywords: Geostationary meteorological satellites, Environmental studies

©2019. Japan Geoscience Union. All Right Reserved.

Scientific data chain for better data publication and preservation

*堀之内 武[1]
*Takeshi Horinouchi[1]

1. 北海道大学地球環境科学研究院
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.

キーワード：data publication、open data
Keywords: data publication, open data

©2019. Japan Geoscience Union. All Right Reserved.

測地観測データ提供の現状と問題
Current status and problems of geodetic observation data distribution

*大坪 俊通[1]、横田 裕輔[2]、石川 直史[3]、関戸 衛[4]、宮崎 隆幸[5]、栗原 忍[5]
*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5]

1. 一橋大学、2. 東京大学生産技術研究所、3. 海上保安庁海洋情報部、4. 情報通信研究機構、5. 国土地理院
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.

キーワード：測地学、宇宙測地学、測位、全球統合測地観測システム、データ DOI
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

*能勢 正仁[1]、村山 泰啓[2]
*Masahito Nose[1], Yasuhiro Murayama[2]

1. 名古屋大学 宇宙地球環境研究所、2. 情報通信研究機構 戦略的プログラムオフィス
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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

2019年5月26日(日) 15:30 ~ 17:00 | A04 東京ベイ幕張ホール

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

コンビーナ:村山 泰啓(国立研究開発法人情報通信研究機構 戦略的プログラムオフィス)、近藤 康久(総合地球環境学研究所)、Shelley Stall(American Geophysical Union)、Cecconi Baptiste(LESIA, Observatoire de Paris, CNRS, PSL Research University)、座長: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.

15:30 ~ 15:45

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

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

15:45 ~ 16:00

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

*鈴木 亨[1] (1.海洋情報研究センター)

16:00 ~ 16:15

[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)

16:15 ~ 16:30

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

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

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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

*鈴木 亨[1]
*Toru Suzuki[1]

1. 海洋情報研究センター
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.

キーワード：海洋データ、データ交換、品質管理
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] 口頭発表 | セッション記号 M (領域外・複数領域)：M-SD 宇宙開発・地球観測

2019年5月26日(日) 15:30 ~ 17:00 | A01 東京ベイ幕張ホール

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

コンビーナ:栗原 純一(北海道大学 大学院理学研究院)、Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines)、Huy Xuan Le(Vietnam National Space Center)、座長:栗原 純一(Hokkaido University)、石田 哲朗(北海道大学)

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.

15:30 ~ 15:45

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

*高橋 幸弘[1] (1.北海道大学・大学院理学院・宇宙理学専攻)

15:45 ~ 16:00

[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)

16:00 ~ 16:15

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

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

16:15 ~ 16:30

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

*石田 哲朗[1]、Felix Mark[2]、Castro Ellison[2]、Namuco Shielo[2]、Felicio Francisco[2]、Merida Harry[2]、Vergel Kaye[2]、Perez Gay[2]、Marciano Joel[3,4]、高橋 幸弘[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)

16:30 ~ 16:45

[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)

16:45 ~ 17:00

[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

*高橋 幸弘[1]
*Yukihiro Takahashi[1]

1. 北海道大学・大学院理学院・宇宙理学専攻
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.

キーワード：超小型衛星、アジア、コンソーシアム
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

*Le Xuan Huy[1]、Nguyen Thao[1]、Kurihara Junichi[2]
*Huy Xuan Le[1], Thao Thi Nguyen[1], Junichi Kurihara[2]

1. Vietnam National Space Center、2. Graduate School of Science, Hokkaido University
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
Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*石田 哲朗[1]、Felix Mark[2]、Castro Ellison[2]、Namuco Shielo[2]、Felicio Francisco[2]、Merida Harry[2]、Vergel Kaye[2]、Perez Gay[2]、Marciano Joel[3,4]、高橋 幸弘[1]
*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
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.

©2019. Japan Geoscience Union. All Right Reserved.

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.

キーワード：超小型衛星、地球観測、リモートセンシング
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]
*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2]

1. Universiti Putra Malaysia 、2. Hokkaido University
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.