2019年5月27日(月)

[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

15:30 ~ 17:00 | A03 東京ベイ幕張ホール

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

コンビーナ:木村 淳(大阪大学)、笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Kunio M. Sayanagi(Hampton University)、座長:笠羽 康正、吉岡 和夫(東京大学)

15:30 ~ 15:45

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

*疋田 伶奈[1]、吉岡 和夫[2]、土屋 史紀[3]、鍵谷 将人[3]、村上 豪[4]、木村 智樹[5]、山崎 敦[4]、吉川 一朗[2] (1.東京大学大学院 理学系研究科 地球惑星科学専攻、2.東京大学大学院　新領域創成科学研究科　複雑理工学専攻、3.東北大学大学院　理学研究科　惑星プラズマ・大気研究センター、4.宇宙航空研究開発機構 宇宙科学研究所、5.東北大学　学際科学フロンティア研究所)

15:45 ~ 16:00

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

*古賀 亮一[1]、土屋 史紀[1]、鍵谷 将人[1]、坂野井 健[1]、木村 智樹[1]、吉川 一朗[2]、吉岡 和夫[2]、村上 豪[3]、山崎 敦[3]、Howard Smith[4]、Fran Bagenal[5] (1.東北大学、2.東京大学、3.宇宙科学研究所、4.Johns Hopkins University、5.University of Colorado)

16:00 ~ 16:18

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

★Invited Papers

*土屋 史紀[1]、吉岡 和夫[2]、木村 智樹[1]、垰 千尋[3]、吉川 一朗[2]、村上 豪[4]、北 元[4]、古賀 亮一[1]、疋田 伶奈[2]、鈴木 文晴[2]、韓 秀萬[2]、鍵谷 将人[1]、坂野井 健[1]、三澤 浩昭[1]、笠羽 康正[1]、山崎 敦[4] (1.東北大学、2.東京大学、3.情報通信研究機構、4.JAXA宇宙科学研究所)

16:18 ~ 16:33

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

*中村 勇貴[1]、寺田 綱一郎、垰 千尋[2]、寺田 直樹[1]、笠羽 康正[3]、北 元[4]、中溝 葵[2]、吉川 顕正[5]、大谷 晋一[6]、土屋 史紀[3]、鍵谷 将人[3]、坂野井 健[3]、村上 豪[4]、吉岡 和夫[7]、木村 智樹[1]、山崎 敦[4]、吉川 一朗[8] (1.東北大学大学院理学研究科地球物理学専攻、2.情報通信研究機構、3.東北大学惑星プラズマ・大気研究センター、4.宇宙航空研究開発機構　宇宙科学研究所、5.九州大学大学院理学研究院地球惑星科学部門、6.ジョンズホプキンス大学応用物理研究所、7.東京大学大学院新領域創成科学研究科、8.東京大学)

16:33 ~ 16:51

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

★Invited Papers

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

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9:00 ~ 10:30 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Takeshi Horinouchi

9:00 ~ 9:15

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

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

9:15 ~ 9:30

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

*河瀬 慎一郎[1]、田口 真[1]、福原 哲哉[1]、Yeon Joo Lee[2]、山崎 敦[3,4] (1.立教大学、2.マックスプランク太陽系研究所、3.宇宙科学研究所、4.宇宙航空研究開発機構)

9:30 ~ 9:45

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

*鈴木 杏那[1]、高木 征弘[1]、前島 康光[2]、安藤 紘基[1]、杉本 憲彦[3]、松田 佳久[4] (1.京都産業大学、2.理化学研究所 計算科学研究機構、3.慶應大学、4.東京学芸大学)

9:45 ~ 10:00

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

*山本 勝[1]、池田 恒平[2]、高橋 正明[2] (1.九州大学応用力学研究所、2.国立環境研究所)

10:00 ~ 10:15

[PPS05-05] あかつき/LIR観測により同定された金星雲層高度における熱潮汐波が作る温度擾乱構造

★招待講演

*神山 徹[1]、田口 真[2]、福原 哲哉[2]、今村 剛[3]、二口 将彦[4]、山田 武尊[2]、秋場 聖浩[2]、Yeon Joo Lee、佐藤 隆雄[7]、村上 真也[5]、はしもと じょーじ[6]、佐藤 毅彦[5]、中村 正人[5] (1.産業技術総合研究所、2.立教大学、3.東京大学、4.東邦大学、5.宇宙航空研究開発機構、6.岡山大学、7.北海道情報大学)

10:15 ~ 10:30

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

★Invited Papers

*今村 剛[1]、小郷原 一智[2]、中川 広務[3]、青木 翔平[3] (1.東京大学大学院　新領域創成科学研究科、2.滋賀県立大学　工学部、3.東北大学大学院　理学研究科)

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10:45 ~ 12:15 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Takehiko Satoh

10:45 ~ 11:05

[PPS05-07] 金星マントルの二段階進化モデルと地球への応用

★招待講演

*小河 正基[1] (1.東京大学大学院総合文化研究科広域科学専攻)

11:05 ~ 11:20

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

*奈良 佑亮[1]、今村 剛[1]、吉川 一朗[1]、吉岡 和夫[1]、益永 圭[2]、山崎 敦[3]、渡部 重十[4]、山田 学[5]、Lee Yoen Joo[1]、寺田 直樹[6]、関 華奈子[1] (1.東京大学大学院、2.Swedish Institute of Space Physics、3.宇宙航空研究開発機構　宇宙科学研究所、4.北海道情報大学、5.千葉工業大学、6.東北大学)

11:20 ~ 11:35

[PPS05-09] Mesoscale Dyanmics in the Venus Atmosphere

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

11:35 ~ 11:50

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

梶原 直也[1]、*今村 剛[1]、田口 真[2]、福原 哲哉[2]、神山 徹[3] (1.東京大学大学院　新領域創成科学研究科、2.立教大学　理学部、3.産業技術総合研究所)

11:50 ~ 12:10

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

★Invited Papers

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

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

13:45 ~ 15:15 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Kevin McGouldrick

13:45 ~ 14:00

[PPS05-12] 金星探査機「あかつき」IR2の昼面観測から明らかとなった金星雲頂構造

★招待講演

*佐藤 隆雄[1]、佐藤 毅彦[2]、佐川 英夫[3]、眞子 直弘[2]、Lee Yeon Joo、村上 真也[2]、小郷原 一智[4]、はしもと じょーじ[5]、笠羽 康正[6]、山崎 敦[2]、山田 学[7]、渡部 重十[1]、今村 剛[8]、中村 正人[2] (1.北海道情報大学、2.宇宙航空研究開発機構宇宙科学研究所、3.京都産業大学、4.滋賀県立大学、5.岡山大学、6.東北大学、7.千葉工業大学、8.東京大学)

14:00 ~ 14:15

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

*堀之内 武[1] (1.北海道大学地球環境科学研究院)

14:15 ~ 14:30

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

*成田 穂[1]、今村 剛[1]、奈良 佑亮[1]、Yeon Joo Lee、渡部 重十[2]、山崎 敦[3]、佐藤 毅彦[3]、田口 真[4]、福原 哲哉[4]、山田 学[5] (1.東京大学、2.北海道情報大学、3.宇宙航空研究開発機構、4.立教大学、5.千葉工業大学惑星探査研究センター)

14:30 ~ 14:45

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

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

14:45 ~ 15:00

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

★Invited Papers

*今井 正尭[1]、神山 徹[1]、高橋 幸弘[2]、堀之内 武[3]、今村 剛[4]、山崎 敦[5]、渡部 重十[6]、山田 学[7]、中村 正人[5]、佐藤 毅彦[5] (1.国立研究開発法人 産業技術総合研究所、2.北海道大学 大学院理学院 宇宙理学専攻、3.北海道大学 地球緩急化学研究所、4.東京大学大学院 新領域創成科学研究科、5.宇宙科学研究所、6.北海道情報大学 宇宙情報センター、7.千葉工業大学 惑星探査研究センター)

15:00 ~ 15:15

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

★Invited Papers

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

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15:30 ~ 17:00 | A05 東京ベイ幕張ホール

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

コンビーナ:Yue Deng(University of Texas at Arlington)、Toshi Nishimura(Boston University)、Liu Huixin(九州大学理学研究院地球惑星科学専攻 九州大学宇宙空環境研究センター)、Yanshi Huang(Harbin Institute of Technology, Shenzhen)、座長:Yue Deng(University of Texas at Arlington)、Huixin Liu(Kyushu University, Japan)、Yanshi Huang(Harbin Institute of Technology, Shenzhen, China)、Yukitoshi Nishimura(Boston University)

15:30 ~ 15:45

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

★Invited Papers

*塩川 和夫[1]、西 勝輝[1] (1.名古屋大学宇宙地球環境研究所)

15:45 ~ 16:00

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

★Invited Papers

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

16:00 ~ 16:15

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

★Invited Papers

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

16:15 ~ 16:30

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

*西谷 望[1]、堀 智昭[1] (1.名古屋大学宇宙地球環境研究所)

16:30 ~ 16:45

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

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

16:45 ~ 17:00

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

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

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9:00 ~ 10:30 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:Antti Pulkkinen(NASA/GSFC)

9:00 ~ 9:15

[PEM12-01] NASA Heliophysics Division Space Weather Update

★Invited Papers

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

9:15 ~ 9:30

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

★Invited Papers

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

9:30 ~ 9:45

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

★Invited Papers

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

9:45 ~ 10:00

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

*三好 由純[1]、栗田 怜[1]、片岡 龍峰[2]、齊藤 慎司[1]、Jordanova Vania[3]、篠原 育[4]、三谷 烈史[4]、高島 健[4]、東尾 奈々[4]、笠原 慧[5]、横田 勝一郎[6]、堀 智昭[1]、桂華 邦裕[5]、笠原 禎也[7]、松田 昇也[4]、熊本 篤志[8]、土屋 史紀[8]、小路 真史[1]、松岡 彩子[1]、寺本 万里子[1]、Spence Harlan[9]、Reeves Geoff[3]、Baker Daniel[10] (1.名古屋大学宇宙地球環境研究所、2.国立極地研究所、3.ロスアラモス国立研究所、4.宇宙航空研究開発機構、5.東京大学、6.大阪大学、7.金沢大学、8.東北大学、9.ニューハンプシャー大学、10.コロラド大学)

10:00 ~ 10:15

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

*草野 完也[1]、伊集 朝哉[2]、伴場 由美[1] (1.名古屋大学宇宙地球環境研究所、2.国立天文台)

10:15 ~ 10:30

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

*石井 守[1] (1.国立研究開発法人情報通信研究機構)

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10:45 ~ 12:15 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:片岡 龍峰(国立極地研究所)

10:45 ~ 11:00

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

★Invited Papers

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

11:00 ~ 11:15

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

★Invited Papers

*岩井 一正[1]、塩田 大幸[2]、徳丸 宗利[1]、藤木 謙一[1]、田 光江[2]、久保 勇樹[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)

11:15 ~ 11:30

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

*塩田 大幸[1,2]、八代 誠司[3]、岩井 一正[2] (1.国立研究開発法人 情報通信研究機構、2.名古屋大学 宇宙地球環境研究所、3.米国カトリック大学)

11:30 ~ 11:45

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

*伴場 由美[1,2]、井上 諭[1]、林 啓志[1,3,4] (1.名古屋大学宇宙地球環境研究所、2.宇宙航空研究開発機構 宇宙科学研究所、3.Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences、4.State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences)

11:45 ~ 12:00

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

*林 沛萱[1]、草野 完也[1]、塩田 大幸[2]、井上 諭[1]、KD レカ[1,3]、水野 雄太[1] (1.名古屋大学宇宙地球環境研究所、2.国立研究開発法人　情報通信研究機構、3.ノースウエスト　リサーチ　アソシエーツ)

12:00 ~ 12:15

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

★Invited Papers

*金子 岳史[1]、草野 完也[1] (1.名古屋大学 宇宙地球環境研究所)

[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 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:Antti Pulkkinen(NASA/GSFC)

13:45 ~ 14:00

[PEM12-13] オーロラ・ジェット電流の大きさは予測できるか？

★招待講演

*海老原 祐輔[1]、田中 高史[2]、上吉川 直輝[3] (1.京都大学生存圏研究所、2.九州大学、3.三菱電機)

14:00 ~ 14:15

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

★Invited Papers

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

14:15 ~ 14:30

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

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

14:30 ~ 14:45

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

*中村 紗都子[1]、海老原 祐輔[1]、藤田 茂[2]、後藤 忠徳[3]、亘 慎一[4] (1.京都大学生存圏研究所、2.気象庁気象大学校、3.京都大学大学院工学研究科 、4.情報通信研究機構)

14:45 ~ 15:00

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

*菊池 崇[1,2]、海老原 祐輔[2]、橋本 久美子[3]、亘 慎一[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.吉備国際大学、4.情報通信研究機構)

15:00 ~ 15:15

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

*片岡 龍峰[1]、内野 志織[1]、藤原 康徳[1]、藤田 茂[1]、山本 和明[2] (1.国立極地研究所、2.国文学研究資料館)

[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 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:草野 完也(名古屋大学)

15:30 ~ 15:45

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

★Invited Papers

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

15:45 ~ 16:00

[PEM12-20] NICT宇宙天気予報センターにおける宇宙天気予報担当の業務

★招待講演

*酒井 光資[1]、鵜川 健太郎[1]、川原 健太郎[1]、石井 守[2]、久保 勇樹[2] (1.株式会社セック、2.国立研究開発法人情報通信研究機構)

16:00 ~ 16:15

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

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

16:15 ~ 16:30

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

*関 大吉[1,2,3] (1.京都大学大学院総合生存学館、2.ケンブリッジ大学極端リスク研究センター、3.京都大学大学院理学研究科附属天文台)

16:30 ~ 16:45

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

*西塚 直人[1]、久保 勇樹[1]、杉浦 孔明[1]、田 光江[1]、石井 守[1] (1.国立研究開発法人　情報通信研究機構)

16:45 ~ 17:00

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

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

[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

15:30 ~ 17:00 | 301B 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: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)

15:30 ~ 15:45

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

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

15:45 ~ 16:00

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

*渡辺 路生[1]、建部 洋晶[1]、鈴木 立郎[1]、立入 郁[1] (1.海洋研究開発機構)

16:00 ~ 16:15

[AOS09-20] A Wave Resolving Simulation for Upper Ocean Turbulence Driven by Wave-Current Interaction

*吉川 裕[1]、藤原 泰[1]、松村 義正[2] (1.京都大学大学院理学研究科、2.東京大学大気海洋研究所)

16:15 ~ 16:30

[AOS09-21] **Revisiting the Characteristics of Mixing Efficiency in the Brazil Basin**

*伊地知 敬[1]、Louis St. Laurent[1]、Kurt Polzin[1] (1.ウッズホール海洋研究所)

16:30 ~ 16:45

[AOS09-22] Instabilities of finite-amplitude internal wave beams

*大貫 陽平[1]、田中 祐希[2] (1.九州大学応用力学研究所、2.東京大学大学院理学系研究科地球惑星科学専攻)

16:45 ~ 17:00

[AOS09-23] Evaluation of nutrient flux enhanced by double diffusion in the Kuroshio using glider measurements

*李 根淙[1]、山本 龍[1]、安田 一郎[1]、田中 雄大[2] (1.東京大学　大気海洋研究所、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)

[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 | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

コンビーナ:伊藤 進一(東京大学大気海洋研究所)、平田 貴文(北海道大学地球環境科学研究院)、Enrique N Curchitser(Rutgers University New Brunswick)、Eileen E Hofmann(Old Dominion University)、座長:伊藤 進一(東京大学)

9:10 ~ 9:30

[AOS12-01] Projected coastal hypoxia in a coupled bio-physical model of the California Current System.

★Invited Papers

*Enrique N Curchitser[1]、Raphael Dussin[1,2]、Charles Stock[3]、Nicoals van Oostende[4] (1.Rutgers University New Brunswick、2.Lamont-Doherty Earth Observatory of Columbia University、3.NOAA Geophysical Fluid Dynamics Laboratory、4.Princeton University)

9:30 ~ 9:45

[AOS12-02] **Decadal salinity variation in the western North Pacific correlated with the strength of the Oyashio and the Kuroshio Extension**

*金子 仁[1]、奥西 武[2]、纐纈 慎也[3]、伊藤 幸彦[1]、瀬藤 聡[4]、黒田 寛[5]、清水 勇吾[4] (1.東京大学 大気海洋研究所、2.水産教育・研究機構 東北区水産研究所、3.海洋研究開発機構、4.水産教育・研究機構 中央水産研究所、5.水産教育・研究機構 北海道区水産研究所)

9:45 ~ 10:00

[AOS12-03] **Multiscale routes to supply nutrients through the Kuroshio nutrient stream**

*長井 健容[1]、Clayton Sophie[2]、内山 雄介[3] (1.東京海洋大学 海洋環境科学部門、2.Ocean, Earth & Atmospheric Sciences, Old Dominion University、3.神戸大学)

10:00 ~ 10:15

[AOS12-04] **Seasonal variability of upper-ocean primary production around the Kuroshio analyzed using a ROMS-NPZD model**

*Xu Zhang[1]、Yusuke Uchiyama[1,2]、Yota Suzue[3]、Hidekatsu Yamazaki[4] (1.Kobe University、2.Port and Airport Research Institute、3.Construction Technique Institute Engineering Co., Ltd.、4.Tokyo University of Marine Science and Technology)

10:15 ~ 10:30

[AOS12-05] Nutrient and light conditions at subsurface chlorophyll maximum: physical-biogeochemical observations along a mid-Pacific meridional transect

*伊藤 幸彦[1]、金子 仁[1]、纐纈 慎也[2]、奥西 武[3]、小川 浩史[1]、佐藤 光秀[4]、齊藤 宏明[1] (1.東京大学大気海洋研究所、2.海洋研究開発機構、3.水産研究・教育機構 東北区水産研究所、4.香港科技大學)

[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 | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

コンビーナ:伊藤 進一(東京大学大気海洋研究所)、平田 貴文(北海道大学地球環境科学研究院)、Enrique N Curchitser(Rutgers University New Brunswick)、Eileen E Hofmann(Old Dominion University)、座長:松村 義正(東京大学大気海洋研究所)

10:45 ~ 11:05

[AOS12-06] A Lagrangian view of spring phytoplankton blooms

★Invited Papers

*木田 新一郎[1]、伊藤 貴充[2] (1.九州大学・応用力学研究所、2.ジョージア工科大学)

11:05 ~ 11:20

[AOS12-07] Significance of acclimation process in simulating chlorophyll distribution in the Arctic Ocean

*増田 良帆[1]、山中 康裕[1]、平田 貴文[1]、中野 英之[2] (1.北海道大学地球環境科学研究院、2.気象研究所)

11:20 ~ 11:35

[AOS12-08] 瀬戸内海中央部における栄養塩変動に対する低次生態系の応答

*吉江 直樹[1]、水口 隼人[1]、郭 新宇[1]、米田 道夫[2]、阿保 勝之[2]、河野 悌昌[2]、藤田 辰徳[3] (1.愛媛大学沿岸環境科学研究センター、2.水産研究・教育機構、3.香川県水産試験場)

11:35 ~ 11:50

[AOS12-09] Effects of the temperature and fish size on metabolism and swimming performance of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

*郭 晨穎[1]、伊藤 進一[1]、米田 道夫[2]、北野 載[2] (1.東京大学大気海洋研究所、2.（国）水産研究・教育機構)

11:50 ~ 12:05

[AOS12-10] Sensitivity analyses of growth and migration of Japanese anchovy (*Engraulis japonicus*) in the East China Sea using a fish growth-migration model.

*伊藤 進一[1]、瀬藤 聡[2]、米田 道夫[2]、高橋 素光[2]、松山 倫也[3]、郭 晨穎[1]、北川 貴士[1] (1.東京大学大気海洋研究所、2.水産研究・教育機構、3.九州大学)

[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 | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

コンビーナ:伊藤 進一(東京大学大気海洋研究所)、平田 貴文(北海道大学地球環境科学研究院)、Enrique N Curchitser(Rutgers University New Brunswick)、Eileen E Hofmann(Old Dominion University)、座長:Enrique Curchitser(Rutgers University)

13:45 ~ 14:05

[AOS12-11] Micro-scale patchiness enhances trophic transfer efficiency and potential plankton biodiversity

★Invited Papers

*山崎 秀勝[1]、Priyadarshi Anupam[2]、Smith Lan[3]、Mandal Sandip[4]、田中 衛[1] (1.東京海洋大学、2.Banaras Hindu University、3.海洋研究開発機構、4.Public Health Foundation of India)

14:05 ~ 14:20

[AOS12-12] 海底オブザバトリーを使用した微小凝集体の長期観測

*竹内 茉莉香[1,2]、Doubell Mark[3]、Mitchell Jim[2]、山崎 秀勝[1] (1.東京海洋大学、2.Flinders University、3.South Australia Research and Development Institute)

14:20 ~ 14:35

[AOS12-13] An insight into the area characteristic of seasonal change in nitrogen isotope ratio based on a marine nitrogen isotope model

*吉川 知里[1]、重光 雅仁[1]、山本 彬友[1]、岡 顕[2]、大河内 直彦[1] (1.海洋研究開発機構、2.東大大気海洋研)

14:35 ~ 14:50

[AOS12-14] Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain

*S. Lan Smith[1]、Yoshikazu Sasai[1]、Chisato Yoshikawa[2] (1.Marine Ecosystem Dynamics Research Group, RCGC, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan、2.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan)

14:50 ~ 15:05

[AOS12-15] Discussions

伊藤 進一[2]、*平田 貴文[1] (1.北海道大学　大学院地球環境科学研究院、2.東京大学　大気海洋研究所)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

13:45 ~ 15:15 | 104 1F

[A-CG33] 中緯度海洋と大気

コンビーナ:西井 和晃(三重大学大学院生物資源学研究科)、佐々木 克徳(Hokkaido University)、西川 はつみ(北海道大学　低温科学研究所)、大石 俊(名古屋大学　宇宙地球環境研究所　陸域海洋圏生態研究部)、座長:西井 和晃(三重大学)

13:45 ~ 14:05

[ACG33-01] Gulf Stream and Kuroshio are synchronized

★Invited Papers

*神山 翼[1]、三浦 裕亮[1]、木戸 晶一郎[1] (1.東京大学大学院理学系研究科地球惑星科学専攻)

14:05 ~ 14:20

[ACG33-02] A study on mixed layer depth variability in the Kuroshio Extension region based on a frontal Ekman model

*東塚 知己[1] (1.東京大学大学院理学系研究科地球惑星科学専攻)

14:20 ~ 14:35

[ACG33-03] Mechanisms of Reemergence in the North Pacific revealed by Mixed Layer Heat Budget Analysis

*村田 壱学[1]、木戸 晶一郎[1]、東塚 知己[1] (1.東京大学理学系研究科地球惑星科学専攻大気海洋講座)

14:35 ~ 14:50

[ACG33-04] Formation mechanism for the North Pacific Transition domain SST and SSS fronts

*西川 はつみ[1]、三寺 史夫[1]、奥西 武[2]、伊藤 進一[3]、和川 拓[4]、長谷川 大介[2]、美山 透[5]、金子 仁[2] (1.北海道大学　低温科学研究所、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.東京大学　大気海洋研究所、4.国立研究開発法人　水産研究・教育機構　日本海区水産研究所、5.国立研究開発法人　海洋研究開発機構)

14:50 ~ 15:10

[ACG33-05] Impact of the Kuroshio front on frontal structure of an extratropical cyclone associated with heavy precipitation

★Invited Papers

*平田 英隆[1]、川村 隆一[2]、吉岡 真由美[1]、野中 正見[3]、坪木 和久[1] (1.名古屋大学　宇宙地球環境研究所、2.九州大学　大学院理学研究院、3.海洋研究開発機構　アプリケーションラボ)

15:10 ~ 15:15

[ACG33-06] Discussion on future studies on the role of midlatitude oceans

*西井 和晃[1] (1.三重大学大学院生物資源学研究科)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

15:30 ~ 17:00 | 104 1F

[A-CG33] 中緯度海洋と大気

コンビーナ:西井 和晃(三重大学大学院生物資源学研究科)、佐々木 克徳(Hokkaido University)、西川 はつみ(北海道大学　低温科学研究所)、大石 俊(名古屋大学　宇宙地球環境研究所　陸域海洋圏生態研究部)、座長:大石 俊

15:30 ~ 15:45

[ACG33-07] Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

★Invited Papers

*高橋 直也[1]、早坂 忠裕[1] (1.東北大学理学研究科地球物理学専攻大気海洋変動観測研究センター)

15:45 ~ 16:00

[ACG33-08] **Sea surface temperature trend in the East China Sea during the 20th century simulated by a regional ocean model**

*佐々木 克徳[1]、梅田 千智[1] (1.北海道大学)

16:00 ~ 16:15

[ACG33-09] Kuroshio Extension and Gulf Stream's influences on the variability of near-surface baroclinicity and the associated atmospheric fields

★Invited Papers

*田口 文明[1]、西井 和晃[2]、中村 尚[1,3] (1.東京大学　先端科学技術研究センター、2.三重大学　生物資源学部、3.海洋研究開発機構　アプリケーションラボ)

16:15 ~ 16:30

[ACG33-10] Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

*中山 盛雄[1]、水越 正敏[1]、中村 尚[1]、小坂 優[1]、田口 文明[1]、森 正人[1]、小川 史明[2] (1.東京大学先端科学技術研究センター、2.ベルゲン大学)

16:30 ~ 16:45

[ACG33-11] **Hydro-climatic variation in northwestern China and its multi-decadal to multi-centennial teleconnection with the Pacific Ocean**

*Harry F Lee[1] (1.The Chinese University of Hong Kong)

16:45 ~ 17:00

[ACG33-12] Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

*西井 和晃[1]、田口 文明[2]、中村 尚[2] (1.三重大学大学院生物資源学研究科、2.東京大学先端科学技術研究センター)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

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

[H-DS11] Subaqueous Landslides and Their Anthropogenic Impact for Coastal Regions

コンビーナ:北村 有迅(鹿児島大学大学院理工学研究科地球環境科学専攻)、山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、座長:北村 有迅(鹿児島大学大学院理工学研究科地球環境科学専攻)、宇都宮 正志(産業技術総合研究所地質調査総合センター地質情報研究部門層序構造研究グループ)、山田 泰広(JAMSTEC)

15:30 ~ 15:45

[HDS11-01] 北海道南部沖日高舟状海盆を埋積する海底地すべり堆積物の分布と堆積学的特徴ーとくに第四系最上部の地すべり堆積体についてー

*荒戸 裕之[1] (1.秋田大学大学院国際資源学研究科)

15:45 ~ 16:00

[HDS11-02] Origin and distribution of mass-transport deposits in the Pleistocene forearc basin, central Japan, deduced from tephro- and biostratigraphy

*宇都宮 正志[1]、山本 由弦[2]、水野 清秀[1] (1.産業技術総合研究所　地質調査総合センター、2.海洋研究開発機構)

16:00 ~ 16:15

[HDS11-03] Physico-chemical properties of sediment cores from Yatsushiro Sea, western Kyushu

*北村 有迅[1]、後藤 滝弥[2]、堀 航喜[2]、池端 雄太[2]、影山 遼[2]、川端 訓代[1]、小山 大輝[1]、山﨑 楓[2]、白鳳丸KH-18-3 乗船研究者 (1.鹿児島大学大学院理工学研究科地球環境科学専攻、2.鹿児島大学理学部地球環境科学科)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

13:45 ~ 15:15 | 301B 3F

[H-CG26] デルタとエスチュアリー：複雑な河口システムへの学際的取り組み

コンビーナ:齋藤 文紀(島根大学エスチュアリー研究センター)、Guan-Hong Lee(Inha University)、David L Dettman(University of Arizona)、堀 和明(名古屋大学環境学研究科地理学講座)、座長:Yoshiki Saito(Shimane Univ/GSJ, AIST)、David Dettman(University of Arizona)

13:45 ~ 14:15

[HCG26-01] Recent Changes of the Asian Major Deltas

★Invited Papers

*Paul Liu[1] (1.North Carolina State University Raleigh)

14:15 ~ 14:30

[HCG26-02] **Matching trends in channel width, sinuosity, and depth along the fluvial to marine transition zone of tide-dominated river deltas: the need for a revision of depositional and hydraulic models**

★Invited Papers

*Marcello Gugliotta[1]、Yoshiki Saito[1] (1.Shimane University)

14:30 ~ 14:45

[HCG26-03] **Effects of an Estuarine Dam on Sediment Flux Mechanisms in a Macrotidal Estuary**

Steven Miguel Figueroa[1]、*Guan-Hong Lee[1] (1.Inha University)

14:45 ~ 15:00

[HCG26-04] **Late Pleistocene sedimentary evolution of the north Jiangsu coastal plain revealed by OSL dating based chronostratigraphy**

*Lei Gao[1]、Hao Long[1]、Ping Zhang[2]、Toru Tamura[3,4]、Ji Shen[1] (1.Nanjing Institute of Geography and Limnology, CAS,China、2.Geological Survey of Jiangsu Province (GSJP), Key Lab of EFGD, Ministry of LR, China、3.Geological Survey of Japan (GSJ), AIST、4.Graduate School of Frontier Sciences, The University of Tokyo)

15:00 ~ 15:15

[HCG26-05] The sedimentary environments and provenance of the late Quaternary sediments, in South Yellow Sea shelf, eastern China

*Yong Yin[1] (1.School of Geography and Ocean Science, Nanjing University)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

9:00 ~ 10:30 | 301B 3F

[H-CG27] 混濁流:発生源から堆積物・地形形成まで

コンビーナ:横川 美和(大阪工業大学情報科学部)、成瀬 元(京都大学大学院理学研究科)、泉 典洋(北海道大学大学院工学研究院)、池原 研(産業技術総合研究所地質情報研究部門)、座長:横川 美和(大阪工業大学)、泉 典洋(北海道大学)

9:00 ~ 9:15

[HCG27-01] Inverse analysis of turbidity currents using two dimensional shallow water model

*成瀬 元[1] (1.京都大学大学院理学研究科)

9:15 ~ 9:30

[HCG27-02] 深度学習によるタービダイト逆解析手法の実験的検証

*Cai Zhirong[1]、成瀬 元[1]、姚 奇峰[1] (1.京都大学)

9:30 ~ 9:45

[HCG27-03] Conditions for development of depositional submarine channels: examination by flume experiments

*Justine Poppeschi[1]、Kazushi Nakata[1]、Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

9:45 ~ 10:00

[HCG27-04] Cyclic steps formed by long-runout turbidity currents

*Zhuyuan Wu[1]、Norihiro Izumi [1] (1.Hokkaido University)

10:00 ~ 10:15

[HCG27-05] 表層堆積物の再懸濁は地震起源混濁流発生のより普遍的なメカニズムか？南海トラフ西端と日本海溝の海底コアの放射性炭素年代測定から

*池原 研[1]、金松 敏也[3]、Tobias Schwestermann[2]、喜岡 新[2]、Michael Strasser[2] (1.産業技術総合研究所地質情報研究部門、2.インスブルック大学、3.海洋研究開発機構)

10:15 ~ 10:30

[HCG27-06] 日本海溝海溝軸の表層浅部イベント層序

*Kioka A.[1]、Schwestermann T.[1]、Moernaut J.[1]、Ikehara K.[2]、Kanamatsu T.[3]、Strasser M.[1,4] (1.インスブルック大学、2.産業技術総合研究所、3.海洋研究開発機構、4.ブレーメン大学)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

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

[H-CG27] 混濁流:発生源から堆積物・地形形成まで

コンビーナ:横川 美和(大阪工業大学情報科学部)、成瀬 元(京都大学大学院理学研究科)、泉 典洋(北海道大学大学院工学研究院)、池原 研(産業技術総合研究所地質情報研究部門)、座長:成瀬 元(Kyoto University)、池原 研(産総研)

10:45 ~ 11:07

[HCG27-07] Canyon changes caused by an earthquake-triggered turbidity current in the 2016 M7.8 Kaikōura Earthquake, New Zealand

★Invited Papers

*Joshu J Mountjoy[1]、Jamie D Howarth[2]、Alan R Orpin[1]、Philip M Barnes[1]、David A Bowden[1]、Ashley A Rowden[1]、Alexander C. G. Schimel[1]、Caroline Holden[3]、Huw J Horgan[2]、Scott D Nodder[1]、Jayson R Patton[4]、Geoffroy Lamarche[1,5]、Matt Gerstenberger[3]、Aaron Micallef[6]、Arne Pallentin[1]、Tim Kane[1] (1.NIWA, Wellington. New Zealand、2.VUW, Wellington. New Zealand、3.GNS Science, Lower Hutt. New Zealand、4.HSU, Arcata CA. USA、5.UoA, Auckland. New Zealand、6.UoM, Msida. Malta)

11:07 ~ 11:29

[HCG27-08] Far More Prolonged Deep-sea Turbidity Currents triggered by typhoon and earthquake in the Gaoping Submarine Canyon

★Invited Papers

*Yanwei Zhang[1]、Zhifei Liu[1]、Yulong Zhao[1]、Xiaodong Zhang[1] (1.Tongji University)

11:29 ~ 11:51

[HCG27-09] **Filling the gap between turbidity current processes and products in British Columbia fjords**

★Invited Papers

*Sophie Hage[1,2,3] (1.School of Ocean and Earth Sciences, University of Southampton, United Kingdom、2.National Oceanography Centre Southampton, United Kingdom、3.Department of Geography, Durham University, United Kingdom)

11:51 ~ 12:13

[HCG27-10] **Sediment transfer from shelf to abyss through giant ganyons and valleys system in deep-sea carbonate slopes (Bahamas)**

★Invited Papers

*Thierry Mulder[1]、Hervé Gillet[1]、Vincent Hanquiez[1]、Audrey Recouvreur[1]、Kelly Fauquembergue[1]、Johan Le Goff[2]、John J.G. Reijmer[2]、Emmanuelle Ducassou[1]、Margot Joumes、Thibault Cavailhes[1]、Elsa Tournadour[5]、Jean Borgomano[3]、Emmanuelle Poli[4] (1.University of Bordeaux, UMR CNRS 5805 EPOC, Allée Geoffroy Saint Hilaire, Pessac, France、2.King Fahd Univ. of Petroleum. and Minerals, Dhahran, Saudi Arabia.、3.Aix Marseille University, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France.、4.Total, CSTJF, avenue Larribau, Pau, France、5.Ifremer, Centre de Brest, Plouzané)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

15:30 ~ 17:00 | A10 東京ベイ幕張ホール

[S-SS07] Rigorous Seismicity Modelling and Hypothesis Testing

コンビーナ:庄 建倉(統計数理研究所)、Schorlemmer Danijel(GFZ German Research Centre for Geosciences)、Matt Gerstenberger(GNS Science)、鶴岡 弘(東京大学地震研究所)、座長:Matthew Gerstenberger(GNS Science, New Zealand)、Danijel Schorlemmer(GFZ-Potsdam, Germany)

15:30 ~ 15:45

[SSS07-01] Improving medium-term earthquake forecasts by compensating the EEPAS model for the time-lag

★Invited Papers

David Rhoades[1]、Christophersen Annemarie[1]、*Matt Gerstenberger[1] (1.GNS Science)

15:45 ~ 16:00

[SSS07-02] Earthquake probability forecast incorporating non-seismic data

*Peng Han[1]、Jiancang Zhuang[2]、Yosihiko Ogata[2]、Katsumi Hattori[3] (1.Southern University of Science and Technology, Shenzhen, China、2.The Institute of Statistical Mathematics, Tokyo, Japan 、3.Chiba University, Chiba, Japan)

16:00 ~ 16:15

[SSS07-03] **Extended versions of the space-time ETAS model and application to the 2016 Kumamoto earthquake sequence**

★Invited Papers

*YICUN GUO[1]、Jiancang Zhuang[1]、Yosihiko Ogata[1] (1.The Institute of Statistical Mathematics, Tokyo, Japan)

16:15 ~ 16:30

[SSS07-04] CSEP Japan の結果と今後に向けて

*平田 直[1]、鶴岡 弘[1]、Schorlemmer Danijel[3]、庄 建倉[2] (1.東京大学地震研究所、2.統計数理研究所、3.GFZ)

16:30 ~ 16:45

[SSS07-05] From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

★招待講演

*Ma Kuo-Fong[1,2,3]、Yen Mingshen [1]、Liao Yiwun[1]、Su Henyi[2] (1.Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC、2.Department of Earth Sciences, National Central University, Taiwan, ROC、3.Institute of Earth Sciences, Academia Sinica, Taiwan, ROC)

16:45 ~ 17:00

[SSS07-06] **首都圏直下の３次元高解像度地震活動予測**

★招待講演

*尾形 良彦[1,2]、桂 康一、鶴岡 弘[2]、平田 直[2] (1.大学共同利用機関法人　情報・システム研究機構　統計数理研究所、2.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-IT 地球内部科学・地球惑星テクトニクス

9:00 ~ 10:30 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:Anselme Borgeaud、土屋 卓久

9:00 ~ 9:15

[SIT21-01] The role of stishovite as a deep nitrogen carrier indicated from high-pressure and high-temperature experiments

*福山 鴻[1]、鍵 裕之[1]、井上 徹[2,3]、新名 亨[3]、柿澤 翔[3]、菱田 俊一[4]、佐野 有司[5]、高畑 直人[5] (1.東京大学大学院理学系研究科附属地殻化学実験施設、2.広島大学大学院理学研究科地球惑星システム学専攻、3.愛媛大学地球深部ダイナミクス研究センター、4.国立研究開発法人物質・材料研究機構、5.東京大学大気海洋研究所)

9:15 ~ 9:30

[SIT21-02] 3-D P- and S-velocity structure of the D″ layer beneath Central America and the Caribbean using waveform inversion

★Invited Papers

*Anselme F. E. Borgeaud[1,2]、Kenji Kawai[1]、Robert J. Geller[1] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo、2.Institute of Earth Sciences, Academia Sinica)

9:30 ~ 9:45

[SIT21-03] D111型高圧発生装置を用いたブリッジマナイトの一軸変形実験

★招待講演

*辻野 典秀[1]、山崎 大輔[1]、西原 遊[2] (1.岡山大学・惑星物質研究所、2.愛媛大学・地球深部ダイナミクス研究センター)

9:45 ~ 10:00

[SIT21-04] **Waveform inversion for 3D anisotropic structure in D″ beneath the Northern Pacific: Constraints on mineralogy and flow in the lowermost mantle**

*鈴木 裕輝[1]、河合 研志[1]、ゲラー ロバート[1] (1.東京大学大学院理学系研究科地球惑星科学専攻)

10:00 ~ 10:15

[SIT21-05] Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

*柿澤 翔[1]、井上 徹[1,2,3]、阿部 綾太郎[1]、黒田 みなみ[4]、坂本 直哉[5]、圦本 尚義[4,5,6] (1.愛媛大学地球深部ダイナミクス研究センター、2.広島大学大学院理学研究科、3.広島大学プレート収束域の物質科学研究拠点、4.北海道大学大学院理学院、5.北海道大学創成研究機構、6.宇宙航空研究開発機構宇宙科学研究所)

10:15 ~ 10:30

[SIT21-06] Origin and role of lost continents

*丸山 茂徳[1]、河合 研志[2]、Gréaux Steeve[3]、土屋 卓久[3]、趙 大鵬[4] (1.東京工業大学地球生命研究所、2.東京大学大学院理学系研究科地球惑星科学専攻、3.愛媛大学、4.東北大学大学院理学研究科)

[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 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:太田 健二、飯塚 理子

10:45 ~ 11:00

[SIT21-07] Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

★Invited Papers

*Zhongqing Wu[1] (1.University of Science and Technology of China)

11:00 ~ 11:15

[SIT21-08] Discussion

*太田 健二[1] (1.東京工業大学大学院理工学研究科地球惑星科学専攻)

11:15 ~ 11:30

[SIT21-09] ***Ab initio*** **anharmonic lattice dynamics for Fe-bearing lower mantle minerals**

*出倉 春彦[1]、土屋 卓久[1] (1.愛媛大学地球深部ダイナミクス研究センター)

11:30 ~ 11:45

[SIT21-10] **Measurements of high pressure-temperature thermal conductivity of the Earth's lower mantle minerals in a laser-heated diamond anvil cell**

*太田 健二[1]、長谷川 暉[1,2]、八木 貴志[2]、奥田 善之[1]、恩賀 皓太郎[1]、廣瀬 敬[3,4]、大石 泰生[5] (1.東京工業大学理学院地球惑星科学系、2.産業技術総合研究所、3.東京工業大学　地球生命研究所、4.東京大学 大学院理学系研究科　地球惑星科学専攻、5.高輝度光科学研究センター)

11:45 ~ 12:00

[SIT21-11] Is there evidence for a paleo-LLSVP beneath Eurasia?: Implications for the origin of the Siberian Traps

*上 翼[1]、鈴木 裕輝[1]、河合 研志[1] (1.東京大学大学院理学系研究科地球惑星科学専攻固体地球講座)

12:00 ~ 12:15

[SIT21-12] Alに富んだ無水ブリッジマナイトの存在可能組成領域

*井上 徹[1,2]、野田 昌道[2]、柿澤 翔[2] (1.広島大学大学院理学研究科地球惑星システム学専攻、2.愛媛大学地球深部ダイナミクス研究センター)

[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 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:五味 斎、飯塚 毅

13:45 ~ 14:00

[SIT21-13] Evolution of the Earth mantle and its possible interaction with core: view from olivine and its inclusions study

★Invited Papers

*Alexander V Sobolev[1]、Valentina G. Batanova[2] (1.ISTerre Institute of Earth Sciences、2.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygina str. 19, Moscow 119991, Russia.)

14:00 ~ 14:15

[SIT21-14] Discussion

*飯塚 毅[1] (1.東京大学)

14:15 ~ 14:30

[SIT21-15] Ultralow-velocity zones possibly explained by light element-enriched iron compounds

*Liang Yuan[1]、Eiji Ohtani[1]、Xiang Wu[2]、Shengxuan Huang[3]、Daijo Ikuta[1]、Tatsuya Sakamaki[1]、Seiji Kamada[1]、Hiroshi Fukui[4,5]、Satoshi Tsutsui[6]、Hiroshi Uchiyama[6]、Daisuke Ishikawa[5,6]、Naohisa Hirao[6]、Alfred Q. R. Baron[5] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan、2.State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China、3.Key Laboratory of Orogenic Belts and Crustal Evolution, MOE, Peking University and School of Earth and Space Sciences, Peking University, Beijing 100871, China、4.Center for Novel Material Science under Multi-Extreme Conditions, Graduate School of Material Science, University of Hyogo, Hyogo 678-1297, Japan、5.Materials Dynamics Laboratory, RIKEN SPring-8 Center, Hyogo 679-5148, Japan、6.Japan Synchrotron Radiation Research Institute (JASRI), SPring-8, Hyogo, 679-5198, Japan)

14:30 ~ 14:45

[SIT21-16] High-precision $^{142}W/^{144}W$ ratios of oceanic island basalts and Large Igneous Province basalts.

賞雅 朝子[1]、*鈴木 勝彦[1]、深海 雄介[2]、飯塚 毅[3] (1.海洋研究開発機構・海底資源研究開発センター、2.海洋研究開発機構・深海・地殻内生物圏研究分野、3.東京大学・大学院理学系研究科)

14:45 ~ 15:00

[SIT21-17] Some technological developments in high temperature generation using KMA and precise melting/phase relations of minerals and rocks under deep mantle conditions

*入舩 徹男[1,2]、周 佑黙[1]、有本 岳史[1]、桑原 秀治[1]、野村 龍一[3]、西 真之[1]、山口 桃子[1]、丹下 慶範[4]、栗林 貴弘[5]、劉 兆東[6] (1.愛媛大学地球深部ダイナミクス研究センター、2.東京工業大学地球生命研究所、3.京都大学白眉センター/大学院人間・環境学研究科、4.高輝度光科学研究センター利用研究促進部門、5.東北大学理学研究科、6.吉林大超硬材料研究所)

15:00 ~ 15:15

[SIT21-18] Zr isotope constraints on early Earth differentiation

*飯塚 毅[1]、板野 敬太[1]、山本 伸次[2] (1.東京大学、2.横浜国立大学)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-CG 固体地球科学複合領域・一般

15:30 ~ 17:00 | A07 東京ベイ幕張ホール

[S-CG49] ハードロック掘削科学〜陸上掘削から深海底掘削、そしてオマーン〜

コンビーナ:道林 克禎(名古屋大学大学院環境学研究科地球環境科学専攻地質・地球生物学講座岩石鉱物学研究室)、高澤 栄一(新潟大学理学部地質科学科)、秋澤 紀克(東京大学　大気海洋研究所　海洋底科学部門)、座長:道林 克禎

15:30 ~ 15:45

[SCG49-01] **Geochemical and Geochronological Constraints on the Origin and Emplacement of the East Taiwan Ophiolite: Implication for Subduction Initiation of the South China Sea.**

*林 秋婷[1]、ロン ハリス[2]、孫 衛東[1]、張 国良[1] (1.中国科学院海洋研究所深海研究中心、2.ブリガムヤング大学地質科学科)

15:45 ~ 16:05

[SCG49-02] Towards a complete profile of hydrothermal alteration in the lower oceanic crust and uppermost mantle; Insights from the Oman Drilling Project and ChikyuOman2017 and 2018

★Invited Papers

*Damon A H Teagle[1]、Michelle Harris[2]、Gretchen Früh-Green[3]、Eiichi TAKAZAWA[4]、 Katsuyoshi Michibayashi[5]、Peter B Kelemen[6]、Oman Drilling Project Science Team[1] (1.Ocean & Earth Science, National Oceanography Centre Southampton, University of Southampton, SO14-3ZH, Southampton, UK、2.School of Geography, Earth and Environmental Sciences, Plymouth University, UK、3.Earth Sciences, ETH Zürich, Switzerland、4.Geology, Niigata University, Japan、5.Earth and Planetary Sciences, Nagoya University, Japan、6.LDEO, Columbia University, New York, USA)

16:05 ~ 16:25

[SCG49-03] Peridotite alteration in OmanDP cores

★Invited Papers

*Peter B Kelemen[1]、Juan Carlos de Obeso[1]、Craig Manning[2]、Marguerite Godard[3]、Wolfgang Bach[4]、Merry Yue Cai[1]、Saebyul Choe[5]、Judith Coggon[6]、Eric Ellison[7]、Alireza Eslami[8]、Katy Evans[9]、Michelle Harris[10]、Wolf-Achim Kahl[4]、Jürg Matter[6]、Katsu Michibayashi[11]、Keichi Okazaki[12]、Philippe Pézard[3]、Damon A.H. Teagle[6]、Alexis Templeton[7]、OmanDP Oman Drilling Project Science Team (1.LDEO、2.UCLA、3.U. Montpellier、4.U. Bremen、5.AMNH、6.U. Southampton、7.U. Colorado、8.U. Tehran、9.Curtin U.、10.U. Plymouth、11.Nagoya U.、12.JAMSTEC)

16:25 ~ 16:40

[SCG49-04] Oman Drilling Project Phase 1 のリストヴェナイト中のドロマイト脈に薄い塩水からなる流体包有物があるぜよ

*川本 竜彦[1]、佐藤 宏樹[2]、髙橋 藤馬[3]、Juan Miguel Guotana[4]、森下 知晃[4]、Peter Kelemen[5]、Jude Coggon[6]、Michelle Harris[7]、Juerg Matter[6]、道林 克禎[8]、高澤 栄一[9]、Damon Teagle[6]、The Oman Drilling Project Phase 1 Science Party (1.Department of Geoscience, Faculty of Science, Shizuoka University、2.Faculty of Science, Kyoto University、3.Faculty of Geosciences and Civil Engineering, Kanazawa University、4.Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa University、5.Lamont-Doherty Earth Observatory, Columbia University、6.School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton、7.School of Geography, Earth and Environmental Sciences, Plymouth University、8.Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya University、9.Institute of Science and Technology, Niigata University)

16:40 ~ 17:00

[SCG49-05] Hydration and development of fracture network within oceanic lower crust: an evidence from CM1A of Oman Drilling

★Invited Papers

*岡本 敦[1]、吉田 一貴[1]、大柳 良介[2]、Oman Drilling Project Phase 2 Science Party[3] (1.東北大学大学院環境科学研究科、2.海洋研究開発機構、3.Oman Drillng Project Phase 2 Science Party)

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-BG 地球生命科学・地圏生物圏相互作用

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

[B-BG01] Elemental cycling in terrestrial and coastal ecosystems- Carbon and Nitrogen perspectives

コンビーナ:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata)、座長:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata)

15:35 ~ 16:00

[BBG01-01] **Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem**

★Invited Papers

*Santanu Ray[1] (1.Systems ecology and ecological modelling laboratory, Dept. of Zoology, Visva-Bharati University, Santiniketan 731235, India)

16:00 ~ 16:15

[BBG01-02] ^{17}O-rich nitrate as a tracer for constraining nitrogen transformations in coastal sediments

*Chawalit Charoenpong[1,2]、Scott D Wankel[2]、Carolyn Buchwald[3,2]、Wiebke Ziebis[4] (1.Chulalongkorn University、2.Woods Hole Oceanographic Institution、3.Dalhousie University、4.University of Southern California)

16:15 ~ 16:30

[BBG01-03] **Exploring changes in bacterioplankton community structure in response to tannic acid, a major component of litterfall, in a mangrove ecosystem: a laboratory mesocosm approach**

*Anwesha Ghosh[1] (1.Integrative Tax Microb Ecol Res Group, Dept. of Biol Sci, IISERK)

16:30 ~ 16:45

[BBG01-04] **Diel variations of dissolved inorganic carbon in the Pearl River plume and the northern South China Sea shelf upwelling during summer**

*Wei-Jen Huang[1]、Kai-Jung Kao[1]、Yu-Shih Lin[1]、James T. Liu[1]、Chen-Tung Arthur Chen[1] (1.National Sun Yat-sen University)

16:45 ~ 17:00

[BBG01-05] **Spatial and vertical variations of carbon and nitrogen isotopes of larch forest and NDVI in Eastern Siberia**

*Aleksandr Nogovitcyn[1]、Atsuko Sugimoto[2]、Ruslan Shakhmatov[1]、Tomoki Morozumi[1]、Shunsuke Tei[2]、Yumiko Miyamoto[2]、Trofim Maximov[3,4] (1.Graduate School of Environmental Science, Hokkaido University, Sapporo, Hokkaido, Japan、2.Arctic Research Center, Hokkaido University, Sapporo, Hokkaido, Japan、3.Institute for Biological Problems of Cryolithozone, Siberian Blanch of Russian Academy of Sciences, Yakutsk, Yakutia, Russia、4.International Center for Biogeoscience Educational and Scientific Trainings (BEST), North-Eastern Federal University, Yakutsk, Yakutia, Russia)

[E] 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

9:00 ~ 10:30 | A07 東京ベイ幕張ホール

[M-IS02] 地球掘削科学

コンビーナ:山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、針金 由美子(産業技術総合研究所)、黒柳 あずみ(東北大学学術資源研究公開センター東北大学総合学術博物館)、山口 耕生(東邦大学, NASA Astrobiology Institute.)、座長:黒柳 あずみ(東北大学)、Kan Hsiung(海洋研究開発機構)

9:00 ~ 9:15

[MIS02-01] 南シナ海IODP Exp.367 U1499における浮遊性有孔虫生層序

*古澤 明輝[1]、林 広樹[1] (1.島根大学　総合理工学研究科)

9:15 ~ 9:30

[MIS02-02] High heat with slow cooling of rift margin in the South China Sea, IODP Exp.368

*坂口 有人[1,2]、大園 宣明[1]、中野 敬太[1] (1.山口大学、2.海洋研究開発機構)

9:30 ~ 9:45

[MIS02-03] 酸化的な遠洋性堆積物中に存在する大量の微小マンガン粒について（IODP Exp. 329）

*浦本 豪一郎[1,2]、諸野 祐樹[2]、富岡 尚敬[2]、若木 重行[2]、中田 亮一[2]、和穎 朗太[3]、上杉 健太朗[4]、竹内 晃久[4]、星野 真人[4]、鈴木 芳生[4,5]、光延 聖[6]、白石 史人[7]、菅 大暉[5]、武市 泰男[8]、高橋 嘉夫[5]、稲垣 史生[2] (1.高知大学、2.海洋研究開発機構、3.農業・食品産業技術総合研究機構、4.高輝度光科学研究センター、5.東京大学、6.愛媛大学、7.広島大学、8.高エネルギー加速器研究機構)

9:45 ~ 10:00

[MIS02-04] **Regional stratigraphic framework, Gas Hydrate occurrence and distribution of National Gas Hydrate Program Expedition 02 (NGHP-02) Area-B, offshore eastern India**

*熊 衍昕[1]、斎藤 実篤[1]、金松 敏也[1]、真田 佳典[1]、山田 泰広[1]、MOE KYAW[1]、濱田 洋平[1]、中村 恭之[1]、呉 泓昱[1] (1.国立研究開発法人海洋研究開発機構)

10:00 ~ 10:15

[MIS02-05] Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

*井尻 暁[1]、若木 重行[1]、西尾 嘉朗[2]、濱田 洋平[1]、石川 剛志[1]、稲垣 史生[1] (1.国立研究開発法人海洋研究開発機構、2.高知大学)

10:15 ~ 10:30

[MIS02-06] Recent progress and perspective on paleomagnetism by means of deep-sea drilling

*山崎 俊嗣[1]、山本 裕二[2]、金松 敏也[3]、熊谷 祐穂[4]、中村 教博[4] (1.東京大学大気海洋研究所、2.高知大学海洋コア総合研究センター、3.海洋研究開発機構、4.東北大学)

[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

10:45 ~ 12:15 | A07 東京ベイ幕張ホール

[M-IS02] 地球掘削科学

コンビーナ:山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、針金 由美子(産業技術総合研究所)、黒柳 あずみ(東北大学学術資源研究公開センター東北大学総合学術博物館)、山口 耕生(東邦大学, NASA Astrobiology Institute.)、座長:山口 耕生(東邦大学)、山田 泰広(JAMSTEC)

10:45 ~ 11:00

[MIS02-07] Patterns in natural fractures during transitions between stress regimes

*Nikita Dubinya[1] (1.The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences)

11:00 ~ 11:15

[MIS02-08] ICDP DSeis 1: Introduction into JpGU 2019 papers on Drilling into Seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

*小笠原 宏[1]、Liebenberg Bennie[2]、Ziegler Martin[3]、矢部 康男[4]、Durrheim Ray[5]、Manzi Musa[5]、Onstott Tullis C[6]、Thomas Weirsberg[7] (1.立命館大学理工学部、2.Moab Khotsong mine, South Africa、3.ETH, Zurich Dep. Earth Sciences、4.Graduate School of Science, Tohoku Univ.、5.Univ. Witwatersrand, School of Geoscience, South Africa、6.Princeton Univ., Dept. Geoscience, USA、7.GFZ, Potzdam, Germany)

11:15 ~ 11:30

[MIS02-09] ICDP DSeis 2: Preliminary results of physical property measurement and XRD analysis of the M5.5 fault material recovered from DSeis Project

*廣野 哲朗[1]、横山 友暉[1]、金木 俊也[2]、小笠原 宏[3]、矢部 康男[4]、松崎 琢也[5]、山本 裕二[5]、徳山 英一[5]、Tullis C. Onstott[6]、Martin Ziegler[7]、Durrheim Ray[8]、Esterhuizen van Heerden[9]、Bennie Liebenberg[9]、The ICDP DSeis team (1.大阪大学 大学院 理学研究科 宇宙地球科学専攻、2.京都大学 防災研究所、3.立命館大学、4.東北大学、5.高知大学 海洋コア総合研究センター、6.Princeton University、7.ETH Zurich、8.Witwatersrand University、9.Moab Khotsong mine)

11:30 ~ 11:45

[MIS02-10] ICDP DSeis 3: Spatial variation in stress state in the source region of Orkeny earthqauke (M5.5) based on analyses of the ICDP-DSeis borehole cores

*矢部 康男[1]、石田 亮壮[2]、杉村 幸祐[2]、兼松 慎[2]、東 充也[2]、吉田 峻輔[2]、Liebenberg Bennie[7]、伊藤 高敏[3]、船戸 明雄[5]、Watson Bryan[6]、Durrheim Raymond[4]、小笠原 宏[2] (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、2.立命館大学理工学部、3.東北大学流体科学研究所、4.School of Geoscience, University of the Witwatersrand、5.深田地質研究所、6.School of Mining Engeneering, University of the Witwatersrand、7.Moab Khotsong mine)

11:45 ~ 12:00

[MIS02-11] コア変形法を適用した原位置地殻応力測定ー防災科研地震観測井コアへの適用例ー

*小村 健太朗[1]、林 為人[2]、伊藤 高敏[3]、船戸 明雄[4] (1.防災科学技術研究所、2.京都大学大学院工学研究科、3.東北大学流体科学研究所、4.深田地質研究所)

12:00 ~ 12:15

[MIS02-12] 阿蘇火山地帯にある深度700メートルの鉛直掘削孔内の温度分布

*林 為人[1]、澁谷 奨[1,2]、佐渡 耕一郎[2]、神谷 奈々[1]、杉本 達洋[1]、佐野　暉[1]、石塚 師也[1]、楊 小秋[4]、林 愛明[3] (1.京都大学大学院工学研究科、2.地圏総合コンサルタント、3.京都大学大学院理学研究科、4.中国科学院南海海洋研究所)

[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 | A07 東京ベイ幕張ホール

[M-IS02] 地球掘削科学

コンビーナ:山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、針金 由美子(産業技術総合研究所)、黒柳 あずみ(東北大学学術資源研究公開センター東北大学総合学術博物館)、山口 耕生(東邦大学, NASA Astrobiology Institute.)、座長:針金 由美子(産総研)、阿部 なつ江(海洋研究開発機構 海洋掘削科学研究開発センター)

13:45 ~ 14:00

[MIS02-13] Estimation of Shear Stress and Lithology Prediction Using Machine Learning and Surface Drilling Data

井上 朝哉[1]、*田中 隆太[1]、石渡 隼也[1] (1.国立研究開発法人海洋研究開発機構)

14:00 ~ 14:15

[MIS02-14] Overview of drilling of crust-mantle boundary of Oman ophiolite: the ICDP Oman Drilling Project

*高澤 栄一[1,4]、Damon Teagle[2]、道林 克禎[3]、田村 芳彦[4]、Jude Coggon[2]、Juerg Matter[2]、Peter Kelemen[5]、Oman Drilling Project Phase 2 Science Party (1.新潟大学理学部地質科学科、2.サウサンプトン大学、3.名古屋大学、4.海洋研究開発機構、5.コロンビア大学)

14:15 ~ 14:30

[MIS02-15] Geophysical Logging of Crust-Mantle boundary at Oman Ophiolite

*山田 泰広[1]、Kyaw Moe[1]、Philippe Pezard[2]、Juerg Matter[3]、OmanDP Science Party (1.海洋研究開発機構、2.モンペリエ大学、3.サウザンプトン大学)

14:30 ~ 14:45

[MIS02-16] Overview of the physical property measurements, ChikyuOman 2017 and 2018: Crust and Mantle sections from ICDP Oman Drilling Project Phase I and II

*阿部 なつ江[1]、岡崎 啓史[1,11]、片山 郁夫[2]、畠山 航平[2]、赤松 祐哉[2]、Ildefonse Benoit[3]、Ulven Ole[4]、Hong Gilbert[5]、Zhu Wenlu[6]、Cordonnier Benoit[4]、道林 克禎[7]、高澤 栄一[8]、Harris Michell[12]、Teagle Damon[10]、ケレメン ピーター[9]、Godard Marguerite[3]、Matter Jurg[10]、Coggon Jude[10]、Science Party The Oman Drilling Project (1.国立研究開発法人海洋研究開発機構、2.広島大学、3.モンペリエ大学、4.オスロ大学、5.ソウル大学、6.メリーランド大学、7.名古屋大学、8.新潟大学、9.コロンビア大学、10.サウザンプトン大学、11.金沢大学、12.プリマス大学)

14:45 ~ 15:00

[MIS02-17] Exploring the deep subseafloor biosphere and biogeochemical carbon cycling beneath the Arctic ocean

*稲垣 史生[1]、Steffen Leth Jørgensen[2]、Rolf Birger Pedersen[2] (1.国立研究開発法人海洋研究開発機構、2.ノルウェー・ベルゲン大学)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-TT 計測技術・研究手法

9:00 ~ 10:30 | 104 1F

[M-TT46] 統合地球観測システムとしてのGPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Yusaku Ohta

9:00 ~ 9:30

[MTT46-01] 準天頂衛星システムの現状と将来構想

★招待講演

*小暮 聡[1] (1.内閣府宇宙開発戦略推進事務局準天頂衛星システム戦略室)

9:30 ~ 9:45

[MTT46-02] Application of the GNSS-A for other academic fields and fundamental marine information network

*横田 裕輔[1]、石川 直史[2]、渡邉 俊一[2] (1.東京大学生産技術研究所、2.海上保安庁海洋情報部)

9:45 ~ 10:00

[MTT46-03] Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

*田中 優介[1]、太田 雄策[1]、宮崎 真一[2] (1.東北大学、2.京都大学)

10:00 ~ 10:15

[MTT46-04] Assimilation experiments of GNSS-derived ZTD and Sentinel-derived products into WRF to improve forecasts of severe rain events in Italy

*Eugenio Realini[1]、Martina Lagasio[2]、Luca Pulvirenti[2]、Antonio Parodi[2]、Andrea Gatti[1]、Giulio Tagliaferro[1]、Giovanna Venuti[3]、Stefano Barindelli[3]、Emanuele Passera[4]、Alessio Rucci[4]、Nazzareno Pierdicca[5]、Bjorn Rommen[6] (1.Geomatics Research & Development srl、2.CIMA Research Foundation、3.Dept. of Civil and Environmental Engineering, Politecnico di Milano、4.TRE Altamira srl、5.Dept. of Information Engineering, Electronics and Telecommunications, Sapienza Univ. of Rome、6.European Space Agency (ESA-ESTEC))

10:15 ~ 10:30

[MTT46-05] **An analysis of tropospheric delays using goGPS software on all GEONET stations during the passage of Typhoon Jebi in September 2018**

*Andrea Gatti[1]、Eugenio Realini[1]、Giulio Tagliaferro[1] (1.Geomatics Research & Development srl)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-TT 計測技術・研究手法

10:45 ~ 12:15 | 104 1F

[M-TT46] 統合地球観測システムとしてのGPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Takuya Tsugawa

10:45 ~ 11:05

[MTT46-06] 全球GNSS-TEC観測データを用いた磁気嵐時の電離圏ダイナミクスに関する新知見

★招待講演

*新堀 淳樹[1]、大塚 雄一[1]、惣宇利 卓弥[1]、津川 卓也[2]、西岡 未知[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)

11:05 ~ 11:20

[MTT46-07] Ionospheric space weather studies for GNSS users

*津川 卓也[1]、穂積 コンニャナット[1]、Jamjareegulgarn Punyawi[2]、Pornchai Supnithi[2]、斎藤 享[3]、大塚 雄一[3,4]、浜 真一[1]、直井 隆浩[1]、石井 守[1] (1.情報通信研究機構、2.KMITL、3.電子航法研究所、4.名古屋大学)

11:20 ~ 11:35

[MTT46-08] QZSS-TECでみる電離圏

*日置 幸介[1] (1.北海道大学大学院理学研究院地球惑星科学部門)

11:35 ~ 11:50

[MTT46-09] Precise estimation of total electron content by double-shell model using local receiver network

*丸山 隆[1,2]、穂積 コンニャナット[1]、G Ma[2]、Q Wan[2] (1.国立研究開発法人情報通信研究機構、2.中国科学院国家天文台)

11:50 ~ 12:05

[MTT46-10] Investigation of sea surface height detection by Global Navigation Satellite System Reflectometry (GNSS-R)

*磯口 治[1]、市川 香[2]、北澤 幸人[3] (1.（一財）リモート・センシング技術センター、2.九州大学、3.JAXA 宇宙科学研究所)

12:05 ~ 12:15

[MTT46-11] Discussion

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-TT 計測技術・研究手法

15:30 ~ 17:00 | 106 1F

[M-TT46] 統合地球観測システムとしてのGPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Yoshinori Shoji(Meteorological Research Institute)

15:30 ~ 15:45

[MTT46-12] Study on tropospheric delay variations extracted from a short baseline analysis and their application to meteorological observation

*吉原 貴之[1]、斎藤 享[1]、毛塚 敦[1]、齊藤 真二[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

[MTT46-13] Water vapor estimation using digital terrestrial broadcasting waves
- Field test in Tokyo metropolitan area and trial production of small devices -

*川村 誠治[1]、花土 弘[1]、太田 弘毅[1]、松村 喜修[2]、森 良輔[2]、野田 一善[2]、長谷川 照晃[2] (1.国立研究開発法人 情報通信研究機構、2.株式会社ソシオネクスト)

16:00 ~ 16:15

[MTT46-14] 920MHz通信無線の伝搬遅延計測による水蒸気推定

*志賀 信泰[1]、安田 哲[1]、川村 誠治[1]、花土 弘[1]、市川 隆一[1]、岩井 宏徳[1]、佐藤 晋介[1] (1.国立研究開発法人　情報通信研究機構)

16:15 ~ 16:30

[MTT46-15] Comparison of a water vapor observation with GPS and high sensitivity microwave radiometer, KUMODeS

*長崎 岳人[1]、田島 治[2]、市川 隆一[3]、瀧口 博士[4]、荒木 健太郎[5]、石元 裕史[5] (1.大学共同利用機関法人　高エネルギー加速器研究機構　素粒子原子核研究所、2.京都大学、3.国立研究開発法人　情報通信研究機構、4.国立研究開発法人　宇宙航空研究開発機構、5.気象庁気象研究所)

16:30 ~ 16:45

[MTT46-16] 局地的豪雨予測のための水蒸気ラマンライダーの開発と観測

*永井 智広[1]、酒井 哲[1]、吉田 智[1]、泉 敏治[2]、横田 祥[1]、瀬古 弘[1]、小司 禎教[1]、白石 浩一[3] (1.気象庁　気象研究所、2.気象庁、3.福岡大学)

16:45 ~ 17:00

[MTT46-17] Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

*小司 禎教[1]、加藤 照之[2]、寺田 幸博[3]、津田 敏隆[4]、矢吹 正教[4] (1.気象研究所気象衛星・観測システム研究部第２研究室、2.神奈川県温泉地学研究所、3.高知工業高等専門学校、4.京都大学生存圏研究所)

[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27日(月) 15:30 ~ 17:00 | A03 東京ベイ幕張ホール

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

コンビーナ:木村 淳(大阪大学)、笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Kunio M. Sayanagi(Hampton University)、座長:笠羽 康正、吉岡 和夫(東京大学)

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Cassini, Juno, New Horizons, JUICE, and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its trojan asteroids.

15:30 ~ 15:45

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

*疋田 伶奈[1]、吉岡 和夫[2]、土屋 史紀[3]、鍵谷 将人[3]、村上 豪[4]、木村 智樹[5]、山崎 敦[4]、吉川 一朗[2] (1.東京大学大学院 理学系研究科 地球惑星科学専攻、2.東京大学大学院　新領域創成科学研究科　複雑理工学専攻、3.東北大学大学院　理学研究科　惑星プラズマ・大気研究センター、4.宇宙航空研究開発機構 宇宙科学研究所、5.東北大学　学際科学フロンティア研究所)

15:45 ~ 16:00

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

*古賀 亮一[1]、土屋 史紀[1]、鍵谷 将人[1]、坂野井 健[1]、木村 智樹[1]、吉川 一朗[2]、吉岡 和夫[2]、村上 豪[3]、山崎 敦[3]、Howard Smith[4]、Fran Bagenal[5] (1.東北大学、2.東京大学、3.宇宙科学研究所、4.Johns Hopkins University、5.University of Colorado)

16:00 ~ 16:18

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

★Invited Papers

*土屋 史紀[1]、吉岡 和夫[2]、木村 智樹[1]、垰 千尋[3]、吉川 一朗[2]、村上 豪[4]、北 元[4]、古賀 亮一[1]、疋田 伶奈[2]、鈴木 文晴[2]、韓 秀萬[2]、鍵谷 将人[1]、坂野井 健[1]、三澤 浩昭[1]、笠羽 康正[1]、山崎 敦[4] (1.東北大学、2.東京大学、3.情報通信研究機構、4.JAXA宇宙科学研究所)

16:18 ~ 16:33

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

*中村 勇貴[1]、寺田 綱一郎、垰 千尋[2]、寺田 直樹[1]、笠羽 康正[3]、北 元[4]、中溝 葵[2]、吉川 顕正[5]、大谷 晋一[6]、土屋 史紀[3]、鍵谷 将人[3]、坂野井 健[3]、村上 豪[4]、吉岡 和夫[7]、木村 智樹[1]、山崎 敦[4]、吉川 一朗[8] (1.東北大学大学院理学研究科地球物理学専攻、2.情報通信研究機構、3.東北大学惑星プラズマ・大気研究センター、4.宇宙航空研究開発機構　宇宙科学研究所、5.九州大学大学院理学研究院地球惑星科学部門、6.ジョンズホプキンス大学応用物理研究所、7.東京大学大学院新領域創成科学研究科、8.東京大学)

16:33 ~ 16:51

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

★Invited Papers

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

16:51 ~ 17:00

Discussion

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

*疋田 伶奈[1]、吉岡 和夫[2]、土屋 史紀[3]、鍵谷 将人[3]、村上 豪[4]、木村 智樹[5]、山崎 敦[4]、吉川 一朗[2]
*Reina Hikida[1], Kazuo Yoshioka[2], Fuminori Tsuchiya[3], Masato Kagitani[3], Go Murakami[4], Tomoki Kimura[5], Atsushi Yamazaki[4], Ichiro Yoshikawa[2]

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1. Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 2. Department of Complexity Science and Engineering, Graduate School of Frontier Science, the University of Tokyo, 3. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 4. Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA) , 5. Frontier Research Institute for Interdisciplinary Sciences, Tohoku University

The satellite Io, which has many volcanoes and is located at 5.9 R_J from the center of Jupiter, is a powerful plasma source in the magnetosphere. The resulting specificity of the Jupiter's magnetosphere is the magnitude of energy that circulates internally. Previous researches, using data obtained by Voyager and Cassini spacecraft and chemical models complementarily, showed that the pickup energy of heavy ions originating from volcanoes on Io and the energy of hot electrons are converted into radiation reaching ~3 TW. However, the origins of hot electrons, that is, heating and/or transport mechanisms are still unrevealed. Therefore, in this research, we focus on the response to the change in the amount of plasma supplied to the magnetosphere and explore the above problem. In this study, the radial distributions of plasma density and temperature were derived from the intensities of emission lines in the extreme ultraviolet range obtained by Hisaki satellite. In this presentation, we will show the results using data obtained from December 2014 to May 2015. The activation of volcanoes on Io in early January 2015 was confirmed by ground-based infrared observations.

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Volcanic change of the distribution of Io’s neutral oxygen cloud observed by Hisaki

*古賀 亮一[1]、土屋 史紀[1]、鍵谷 将人[1]、坂野井 健[1]、木村 智樹[1]、吉川 一朗[2]、吉岡 和夫[2]、村上 豪[3]、山崎 敦[3]、Howard Smith[4]、Fran Bagenal[5]
*Ryoichi Koga[1], Fuminori Tsuchiya[1], Masato Kagitani[1], Takeshi Sakanoi[1], Tomoki Kimura[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Go Murakami[3], Atsushi Yamazaki[3], Howard Todd Smith[4], Fran Bagenal[5]

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Io has a thin atmosphere created by volcanism and sublimation from the surface frost. Io’s atmospheric oxygen atoms are heated by atmospheric sputtering, and escape from Io’s gravity, forming a neutral oxygen cloud around Io’s orbit. The neutral cloud is important as a source of the Io plasma torus. Previous studies derived the distribution and density of the equilibrium neutral oxygen cloud, and showed changes in Io’s volcanism can lead to increase densities of both neutral clouds and Io plasma torus. Koga et al (2018) showed the distribution of Io’s neutral oxygen cloud from Hisaki observation data during a volcanically quiet period (November and December in 2014). The equilibrium neutral oxygen cloud consists of a dense region distributed around Io (the “banana cloud”) and a longitudinally uniform, diffuse region distributed along Io’s orbit. However, the evolution of the distribution of neutral clouds was not understood. In this study, we analyzed the Hisaki satellite observations of the spatial distribution of OI 130.4 nm emissions around Io’s orbit during a volcanic event in 2015.
The radial distribution shows the oxygen cloud spread outward during the volcanically active period. The outer edge of the OI emission was 7 R_J (Jupiter radii) before the volcanic activity, but it spread to around 8-8.6 R_J during the volcanically active period. We also estimated the oxygen number density outward Io's orbit represented as $n(r)=n_0(r/r_0)^{\gamma}$, where r is radial distnace from Jupiter, r_0 is 5.9 R_J (orbit of Io), n_0 is a number density at 5.9 R_J, γ is a power law slope of the profile. The number density at Io’s orbit (where north-south thickness is 1.2 R_J) increased to 88±9 cm^{-3} during the active period that is more than twice as large as the number density during the quiet period (40 cm^{-3}). The power law slope outward Io’s orbit during the active period (γ=-5.5±1.3) is similar to that during the quiet period (γ=-5.3). The azimuthal distribution shows the neutral oxygen cloud during the active period also consists of the banana cloud and diffuse region distributed along Io’s orbit, but both of the regions enlarge. The observation results show the main escape process of neutrals from Io’s graivity remains atmospheric sputtering, but the escape rate of them significantly increased during a volcanically active period. One of the possible mechanisms to increase the escape rate is that the sublimation frost area increases and the density of sublimation driven atmosphere also increases. Another mechanism is that plumes increase the height of the exobase, and the area of atmospheric sputtering increases.

キーワード：木星衛星イオ、中性酸素、紫外線観測
Keywords: Jupiter moon Io, Neutral oxygen, Ultraviolet observation

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New pictures of Jovian magnetosphere obtained from the Hisaki satellite observation

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In 2013, we got an opportunity to have an extreme ultra-violet (EUV) space telescope orbiting around the Earth, the Hisaki satellite. The strong EUV emissions come from both magnetospheric plasma and aurora through electron impact excitation of ions and molecular hydrogen, respectively. From the spectral observation, we can obtain not only total amount of energy deposited in each region but characteristic energy of electrons. Hisaki is dedicated for observing solar system planets. The monitoring capability of HISAKI provided us discoveries of dynamical behavior of the giant magnetosphere. Here, we show new pictures of Jovian magnetosphere obtained from the Hisaki satellite observation. This paper includes following topics: (1) Origin of hot electron in the inner magnetosphere, (2) Transient brightening of Jovian aurora and subsequent global expansion of the disturbance in the whole magnetosphere, (3) Global response of the magnetosphere to volcanic activity of the satellite Io, (4) Solar wind effects on the inner and middle magnetospheres, (5) Driver of radial diffusion in the Jovian radiation belt, (6) Electromagnetic magnetosphere-satellite interaction, and (7) Identification of new emission lines and new energy states of ion.

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Axisymmetric conductivities of Jupiter's middle- and low-latitude ionosphere

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Ionospheric Hall and Pedersen conductivities are important parameters in determining the electric potential distribution and plasma convection in a magnetosphere-ionosphere system. At Jupiter, meteoric ions deposited by meteoroid ablation are expected to play a major role in the ionospheric conductivities [e.g., Cloutier et al., 1978]. Hall and Pedersen conductivities are expected to be axisymmetric at Jupiter due to the long lifetime of meteoric ions. This study evaluates the modification of the potential distribution and plasma convection in the inner magnetosphere caused by the axisymmetric ionospheric conductivities at Jupiter.

We have developed a photochemical model and an ionospheric potential solver to evaluate the contributions of meteoric ions to the Jovian ionospheric conductivities and dawn-to-dusk electric field in the inner magnetosphere. Our photochemical model includes chemical reactions taken from Kim et al. [1994, 2001], mass deposition of meteoric atoms and ions by meteoroid ablation, ionizations by precipitating electrons, and ambipolar diffusion of ions. The input parameters of field-aligned currents are taken from the Region 2-like current in Khurana [2001] and axisymmetric Hill current. Our ionospheric potential solver has been developed using the methods in Nakamizo et al. [2012]. We calculate the global distribution of ionospheric conductivities using ion and electron density profiles acquired from the photochemical model. The ionospheric potential distribution and the resulting dawn-to-dusk electric field in the inner magnetosphere are obtained by the ionospheric potential solver.

Our simulation results reveal that the largest contributions to the Hall and Pedersen conductivities occur in the meteoric ion layer, and the resulting height-integrated conductivities are axisymmetric in the middle- and low- latitudes. Meteoric ions dominate the ion densities in the altitude region of 350 - 450 km with a peak electron number density of ~10^{11} [m^{-3}]. The obtained electron density profile is almost constant at any local time in the middle- and low-latitudes because the lifetimes of H^+ in the high altitude and meteoric ions in the lower altitude ionosphere are sufficiently longer than the half Jovian day (~ 5h). The ionospheric conductivities reach their maxima at the meteoric ion layer, and the height-integrated Hall and Pedersen conductivities become axisymmetric in the middle- and low- latitudes. At high

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latitudes, the conductance are enhanced at dawn side associated with the Region 2-like upward field-aligned current. The dawn-to-dusk electric field generated in the inner magnetosphere is 4 - 27 [mV/m] around Io’s orbit. For comparison, we model another case of ionosphere without H^+ and meteoric ions. In this case, the ionospheric conductance are entirely smaller than the former case, and diminished at night side. The resulting dawn-to-dusk electric field is 45 - 270 [mV/m] around Io’s orbit in this case.

In order to evaluate the validity of our results, we compare our results to observations. Observations by the Hisaki satellite revealed that the variation of dawn-to-dusk brightness intensity ratio of Io plasma torus coincided with a rapid increase in the solar wind dynamic pressure. The correlation between them can be explained by the existence of a dawn-to-dusk electric field of ~4 - 9 [mV/m] around Io’s orbit [Murakami et al., 2016]. Our model results are almost consistent with the Hisaki observations in the case of the existence of meteoric ions in the lower ionosphere. It is concluded that the existence of meteoric ions in the lower ionosphere causes the axisymmetric enhanced ionospheric conductance at Jupiter. The large axisymmetric conductance results in the small dawn-to-dusk electric field in the inner magnetosphere, and our model results can be supported by the Hisaki observations.

キーワード：木星、流星起源のイオン、電離圏磁気圏結合
Keywords: Jupiter, Meteoric ion, M-I coupling

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The magnetospheres of Saturn and Jupiter as viewed by Cassini and Juno

*G Provan[1], Stanley W. H. Cowley[1], Emma Jane Bunce[1]

1. University of Leicester

The magnetospheres of the gas giants Saturn and Jupiter are believed to be driven to varying degrees by external drivers, planetary rotation and internal plasma sources. Both planets are rapid rotators with active volcanic moons and complicated ring systems. Their auroras are key indicators to the magnetosphere-ionosphere coupling at the giant planets. At Saturn Planetary Period Oscillations (PPOs) are observed throughout the magnetosphere, including during Cassini’ s Grand Finale on field lines mapping to Saturn’ s rings. In this paper we will report on the latest results from the Cassini and Juno missions, including both the latest observations and theoretical modelling. We will elucidate on a series of studies determining properties of Saturn’ s PPOs throughout the Cassini mission, and compare our results with those derived from analysis of Saturn kilometric radiation emissions from the Voyager, Ulysses, and Cassini mission. We will further model the magnetosphere-ionosphere coupling current at Jupiter and compare these results with observations from the Juno spacecraft and HST observations. We will finish by detailing some of the outstanding questions in the field.

Keywords: Saturn, Jupiter, Juno

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[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27日(月) 9:00 ~ 10:30 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Takeshi Horinouchi

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

9:00 ~ 9:15

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

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

9:15 ~ 9:30

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

*河瀬 慎一郎[1]、田口 真[1]、福原 哲哉[1]、Yeon Joo Lee[2]、山崎 敦[3,4] (1.立教大学、2.マックスプランク太陽系研究所、3.宇宙科学研究所、4.宇宙航空研究開発機構)

9:30 ~ 9:45

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

*鈴木 杏那[1]、高木 征弘[1]、前島 康光[2]、安藤 紘基[1]、杉本 憲彦[3]、松田 佳久[4] (1.京都産業大学、2.理化学研究所 計算科学研究機構、3.慶應大学、4.東京学芸大学)

9:45 ~ 10:00

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

*山本 勝[1]、池田 恒平[2]、高橋 正明[2] (1.九州大学応用力学研究所、2.国立環境研究所)

10:00 ~ 10:15

[PPS05-05] あかつき/LIR観測により同定された金星雲層高度における熱潮汐波が作る温度擾乱構造

★招待講演

*神山 徹[1]、田口 真[2]、福原 哲哉[2]、今村 剛[3]、二口 将彦[4]、山田 武尊[2]、秋場 聖浩[2]、Yeon Joo Lee、佐藤 隆雄[7]、村上 真也[5]、はしもと じょーじ[6]、佐藤 毅彦[5]、中村 正人[5] (1.産業技術総合研究所、2.立教大学、3.東京大学、4.東邦大学、5.宇宙航空研究開発機構、6.岡山大学、7.北海道情報大学)

10:15 ~ 10:30

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

★Invited Papers

*今村 剛[1]、小郷原 一智[2]、中川 広務[3]、青木 翔平[3] (1.東京大学大学院　新領域創成科学研究科、2.滋賀県立大学 工学部、3.東北大学大学院　理学研究科)

Super-rotation of Venusian atmosphere in the equatorial region may be caused by the density driven separation

*Adhithiyan Neduncheran[1], Ugur Guven[1,2], Ananyo Bhattacharya[3]

1. University of Petroleum and Energy Studies, India, 2. United Nations Centre for Space Science and Technology Education in Asia and the Pacific, 3. Sardar Vallabhbhai National Institute of Technology,India

On Venus, the clouds move nearly 60 times faster than the rotation of the planet. Super-rotation of the Venusian atmosphere is an intriguing phenomena and the reasons are still unclear. The super-rotation is possibly due to Venus being tidally locked to Sun as a consequence of which the planet experiences maximum heating in the equatorial zones causing meridional flows in the lower latitudes. The latent heat trapped by the Carbon dioxide gradually rises above due to its increased kinetic energy, which increases the motion of the cloud layers over time. Previous works done shows that the clouds are highly unstable in the altitude ranging from 49-55Km and below 30Km as per *Zasova et al* 2006 (doi:10.1016/j.pss.2007.01.011). This work shall put forth a possibility of density driven separation of cloud layers and its viscosity which helps in the super-rotation of the clouds. Similar hypothesis were presented by *Lebonnois et al* 2017 (DOI: 10.1038/NGEO2971). Using the known densities of atmospheric constituents, and applying the principles of viscosity and fluid dynamics, a simulation in COMSOL Multiphysics is done and analyzed for the flow behavior in the atmospheric layers ranging between 20Km and 80Km with respect to it’ s horizontal distance. The possible reasons regarding the flow will be discussed considering the solar convection in the equatorial region.

Keywords: Venus, atmosphere, super-rotation, clouds, flow simulation

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Comparison of horizontal distributions of temperature and UV absorbers at the Venus cloud-tops

*河瀬 慎一郎[1]、田口 真[1]、福原 哲哉[1]、Yeon Joo Lee[2]、山崎 敦[3,4]
*Shinichiro Kawase[1], Makoto Taguchi[1], Tetsuya Fukuhara[1], Yeon Joo Lee[2], Atsushi Yamazaki[3,4]

1. 立教大学、2. マックスプランク太陽系研究所、3. 宇宙科学研究所、4. 宇宙航空研究開発機構
1. Rikkyo University, 2. Max Planck Institute for Solar System Research, 3. Institute of Space and Astronautical Science, 4. Japan Aerospace Exploration Agency

Venus is the nearest neighbor planet, which has a size similar to that of the earth. However, unlike the earth, Venus is covered with thick - clouds floating at 45-70 km altitudes (Nakamura et al. 2011). It is considered that the clouds are photochemically generated by oxidation of and . In the visible region, light reflected by the clouds are poorly absorbed and few structures are noticeable. On the other hand, in the ultraviolet (UV) region, inhomogeneity of albedo has been identified to be inhomogeneous distribution of UV absorbers above the layer of UV scattering. It has been identified that in the Venusian atmosphere absorbs light in the wavelength region between 200 nm and 320 nm, but chemical species responsible for the absorption in the wavelength region longer than 320 nm is still unidentified. and are candidates (Perez et al. 2018). The UV absorbers play an important role in the atmospheric dynamics, controlling vertical thermal stability by heating at the top of convection layer. The dynamics may feedback the distribution of the UV absorbers by transport of them from the lower atmosphere. Details of the chemical and dynamical coupling are still unknown.

We analyzed images obtained by the Longwave Infrared Camera (LIR) and Ultraviolet Imager (UVI) onboard the Venus orbiter Akatsuki. LIR takes images of thermal radiation in the wavelength range of 8-12 μm emitted from the cloud-tops (Fukuhara et al., 2011). Temperature distributions are derived from the images. Disturbances seen in the temperature distributions are thought to be caused by atmospheric waves and tides, changes in the cloud-top altitude and adiabatic heating and cooling due to convection, direct heating by the UV absorbers, and so on. UVI takes images of the solar radiation reflected by the clouds with narrow bandpass filters centered at the 283 and 365 nm wavelengths, which correspond to the absorption bands of and unknown absorbers (Yamazaki et al., 2018).

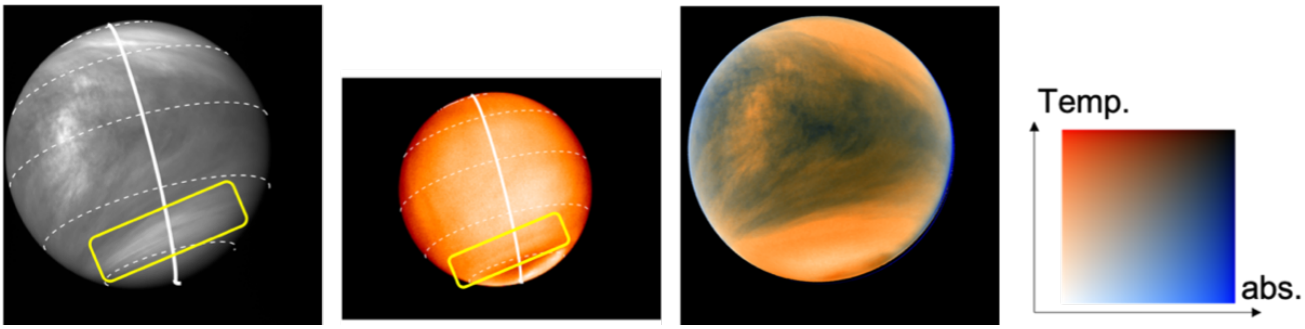
Observations at 365 nm often find clouds with a little radiation in the middle latitudes. Such clouds with low radiation (bright) are covering on the clouds with high radiation (dark). The bright clouds are hard to receive the supply of UV absorbers from the lower layer (Titov et al., 2008). We found such bright distributions in the middle latitudes of images taken by LIR and UVI. Examples (on January 26, 2017) are shown in figures. The fact that we can see the similar distributions at different wavelengths means that two cameras observe clouds almost the same altitude. Therefore, we are studying of the dynamics of cloud top distributions at middle latitudes to use data taken by LIR and UVI.

We converted the UV radiation obtained into the absorption rate. Furthermore, we compared by combining the absorption rate and the temperature. The combined image is displayed more reddish when the temperature is higher and it is displayed more blueish when UV absorption rate is higher. Example are shown in figures. The figure is displayed blackish in the equatorial region and whitish in the polar region. In the middle latitudes where we pay attention, the temperature is high and the amount of absorption is small, so it is displayed reddish. In this presentation, we will introduce some examples like this, and will present relationships between temperature and , temperature and unknown absorbers.

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As a next step, we will further study the relationship between temperature and UV absorbers for each latitude and local time, and will clarify what atmospheric dynamics is occurring at the cloud top.

キーワード：金星、あかつき、未知紫外吸収物質
Keywords: Venus, Akatsuki, unknown UV absorber



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Orographic Gravity Waves in the Venus Atmospheric

*鈴木 杏那[1]、高木 征弘[1]、前島 康光[2]、安藤 紘基[1]、杉本 憲彦[3]、松田 佳久[4]
*Anna Suzuki[1], Masahiro Takagi[1], Yasumitsu Maejima[2], Hiroki Ando[1], Norihiko Sugimoto[3], Yoshihisa Matsuda[4]

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1. Kyoto Sangyo University, 2. RIKEN Advanced Institute for Computational Science, 3. Keio University, 4. Tokyo Gakugei University

Fast zonal winds called “super-rotation” are predominant globally in the Venus atmosphere, whose wind speed reaches ~100 m/s at ~70 km level (Schubert et al., 1980). Based on the zonal winds inferred from UV cloud images taken by the Venus Monitoring Camera onboard the Venus Express orbiter, Bertaux et al. (2016) pointed out that the zonal wind at ~70 km might be decreased by about 20 m/s over the Aphrodite terra, and suggested that the gravity waves generated by the Venus topography propagate upward, breaking at the cloud levels, giving their momentum to the atmosphere and decreasing of zonal wind. Young et al. (1987, 1994) numerically investigated the excitation and propagation processes of the gravity waves. Their results show that the gravity waves with horizontal wavelengths of 50 –800 km can propagate to the cloud levels if the zonal wind near the surface is of 2.2–3.0 m/s. However, the momentum transfer by the gravity waves is not examined. In the present study, we investigate the gravity waves in the Venus atmosphere with a focus on their momentum transfer using a cloud resolving numerical model named Cloud Resolving Storm Simulator (CReSS). Our preliminary results suggest that the orographic gravity waves can propagate upward and reach the cloud levels, as shown by Young et al. (1987, 1994). We will examine the momentum transfer by the gravity waves and discuss its effect on the super-rotation.

キーワード：金星大気、地形性重力波
Keywords: Venus atmosphere, orographic gravity wave

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Atmospheric structures simulated by T21 and T63 Venus GCMs with radiative transfer

*山本 勝[1]、池田 恒平[2]、高橋 正明[2]
*Masaru Yamamoto[1], Kohei Ikeda[2], Masaaki Takahashi[2]

1. 九州大学応用力学研究所、2. 国立環境研究所
1. Research Institute for Applied Mechanics, Kyushu University, 2. National Institute for Environmental Studies

Radiative forcing and topography are important in the formations of the thermal and wind structures on Venus. The surface topography forces stationary waves, which induce large-scale stationary bow-shaped wave pattern (Fukuhara et al. 2017) and conspicuous variation of cloud-top zonal flow (Bertaux et al. 2016) over the Aphrodite Terra. The topographical and radiative effects on Venus' atmosphere general circulation have been investigated using a T21L52 Venus AGCM at Atmosphere and Ocean Research Institute, Univ. Tokyo (Ikeda 2011). Our Venus GCM with the topographical data and radiative code simulated solar-locked and geographical atmospheric structures on Venus (Yamamoto et al. 2019). The model reproduced the wind structure near the subsolar point and the slowness of zonal wind over the Aphrodite Terra. Furthermore it showed that (1) the sub-rotation is formed near the surface in and around high land and mountains, (2) weakly stable layer is formed at 10-20 km at low latitudes, and (3) the zonal wind is weakened at the cloud top over the Aphrodite Terra. The third result implies that the negative wind deviation of the topographically forced stationary wave produces the slowness of the cloud-top zonal wind around the Aphrodite Terra. The GCM with the radiative code estimated the heat budget in the lower and middle atmospheres and reproduced the static stability similar to the observation. For the simulated zonal-mean structure, an equatorial fast flow of ~90 m/s and mid-latitude jets of ~120 m/s are formed around the cloud top. A poleward flow of >8 m/s is formed above the cloud layer, where the imbalance between solar and infrared radiative heating is large. Around the cloud top where the solar radiative heating balances the infrared one, a poleward flow is small (~1 m/s) and confined within the equatorward flank of the jet core. In and around the jet core, indirect circulations are formed by the eddy heat fluxes owing to the thermal tide and baroclinic waves. In solar-fixed coordinates, differences are significant between the zonal and dayside averages of the meridional wind and its related fluxes within the cloud layer. This suggests that we must carefully estimate the zonal-mean Hadley circulation, eddy momentum flux, and eddy heat flux from the one-side hemisphere. Most of the abovementioned features obtained from the T21 GCM are also seen in the T63 GCM. In this presentation, under the realistic thermal and topographical condition, the effects of the high resolution are also discussed. If we have room or time in this presentation, we briefly show the momentum budget, together with the heat budget shown in Yamamoto et al. (2019).

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あかつき/LIR観測により同定された金星雲層高度における熱潮汐波が作る温度擾乱構造

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

*神山 徹[1]、田口 真[2]、福原 哲哉[2]、今村 剛[3]、二口 将彦[4]、山田 武尊[2]、秋場 聖浩[2]、Yeon Joo Lee、佐藤 隆雄[7]、村上 真也[5]、はしもと じょーじ[6]、佐藤 毅彦[5]、中村 正人[5]
*Toru Kouyama[1], Makoto Taguchi[2], Tetsuya Fukuhara[2], Takeshi Imamura[3], Masahiko Futaguchi[4], Takeru Yamada[2], Masahiro Akiba[2], Yeon Joo lee, Takao M. Sato[7], Shin-ya Murakami[5], George HASHIMOTO[6], Takehiko Satoh[5], Masato Nakamura[5]

1. 産業技術総合研究所、2. 立教大学、3. 東京大学、4. 東邦大学、5. 宇宙航空研究開発機構、6. 岡山大学、7. 北海道情報大学
1. AIST, 2. Rikkyo Univ., 3. Tokyo Univ., 4. Toho Univ., 5. JAXA, 6. Okayama Univ., 7. Hokkaido Information Univ.

Atmospheric acceleration due to thermal-tides excited in the cloud layer has been considered as one of main contributors for maintaining the atmospheric super-rotation in Venus, where zonal wind speed of the atmosphere at the cloud top (~70 km) rotates more than 60 times faster than the rotation speed of the solid body of Venus. The structures of the thermal-tides have been confirmed firstly in a temperature field and in zonal and meridional wind fields at the cloud top level by tracking cloud motions in several Venus exploration missions. In numerical studies, it has been confirmed that the thermal-tides structure is composed of diurnal, semi-diurnal, and higher frequent components which enhance at different altitudes and latitudes. Since they may contribute atmospheric acceleration according to their enhancement, observational monitoring should be important to understand what components of thermal-tides are dominant in different latitudes. On the other hand, there have been less observational studies about the latitudinal structures of thermal-tides in temperature fields due to time limitation for ground-based observations and limitation of spatial coverage for previous satellite observations.

In this study, we investigated latitudinal profiles of diurnal, semi-diurnal, and higher frequent components of thermal-tides in the temperature field obtained from long-term observation data by Longwave Infrared Camera (LIR) onboard Akatsuski that catches thermal emission from Venusian cloud layer (60-70km). We used the LIR data from October 2016 to December 2018 in which LIR had been remained to be turned on to prevent unexpected temperature increasing in LIR images, and we selected a specified emission angle (60˚) in the analysis to minimize emission angle dependence of a limb darkening effect.

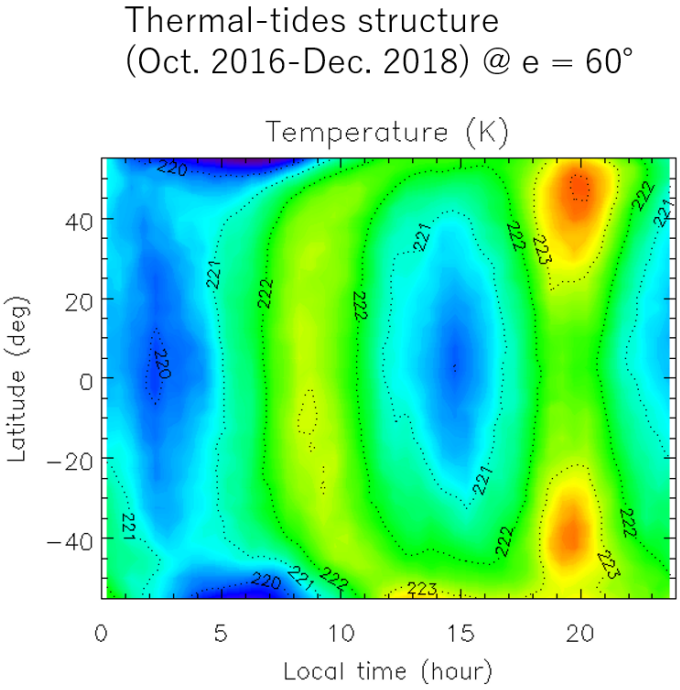
Thanks to the global coverage of LIR observation in both dayside and night side, a global thermal-tides structure (local time-latitude coordinate) was firstly obtained by averaging the long-term LIR observation. By applying Fourier analysis to the thermal-tides structure, we found that the semi-diurnal component was clearly dominant in lower latitudes (< 30˚) whereas the diurnal component became significant in higher latitudes (> 45˚), and both diurnal and semi-diurnal tides showed almost equatorial symmetric profiles. These characteristics were consistent with a numerical expectation in a global circulation model by Takagi et al. (2018). In addition, the diurnal component showed clear phase tilting in mid-latitudes, which may

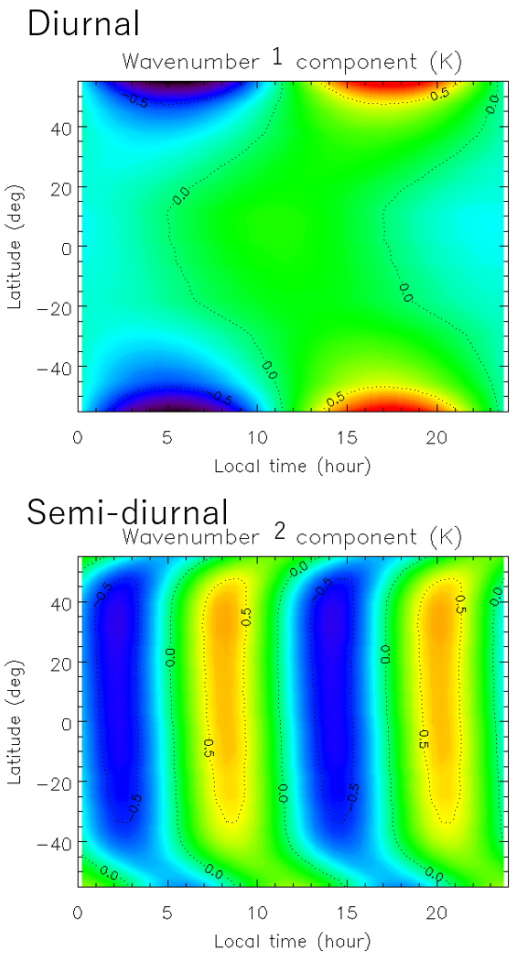
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indicate latitudinal energy transportation due to the diurnal component, while the semi-diurnal and other components with higher wavenumbers did not show such clear phase tilting in low-mid latitudes.

In this presentation, we will provide the structures of each thermal tide components, and latitudinal profiles of their amplitudes and phases, and we will also discuss thermal-tides structures at different periods for more detail discussion about variability of the tides.

キーワード：金星、熱潮汐波、LIR
Keywords: Venus, Thermal tides, LIR





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From Venus to Mars: viewpoint of comparative meteorology

*今村 剛[1]、小郷原 一智[2]、中川 広務[3]、青木 翔平[3]
*Takeshi Imamura[1], Kazunori Ogohara[2], Hiromu Nakagawa[3], Shohei Aoki[3]

1. 東京大学大学院　新領域創成科学研究科、2. 滋賀県立大学　工学部、3. 東北大学大学院　理学研究科
1. The University of Tokyo, 2. University of Shiga Prefecture, 3. Tohoku University

The next Japanese planetary mission focusing on atmospheric science will be the Mars observation in the MMX (Martian Moons eXploration) mission. The spacecraft will enter a near-equatorial, high-altitude, circular orbit around Mars in 2025 and stay in orbit for 3 years. During this Mars-orbiting phase, the spacecraft will collect samples from Phobos and remotely observe Phobos, Deimos and Mars. Continuous, high-resolution, multi-wavelength, global observations of the Mars atmosphere enable monitoring of meteorological processes driving dust/water cycle in the atmosphere-surface system. The instruments used will be a near-infrared imaging spectrometer and multi-band cameras.

The Mars observation in MMX is considered a natural extension of the Venus orbiter Akatsuki. The observation sequence of MMX is similar to that of Akatsuki in that global images are acquired at short time intervals from an equatorial orbit similarly to Earth's meteorological satellites. From the viewpoint of comparative meteorology, Martian meteorology is contrasted with Venusian meteorology in many aspects. Examples include: superrotation on Venus vs. strong high-latitude jets on Mars; weak thermal forcing on Venus vs. strong thermal forcing on Mars; internal oscillation on Venus vs. seasonal cycle on Mars; wave-driven circulation on Venus vs. heat-driven circulation on Mars; slow convection on Venus vs. fast convection on Mars; uniform aerosols on Venus vs. variable aerosols on Mars; weak vertical coupling on Venus vs. strong vertical coupling on Mars. In order to maximize scientific achievements, feedbacks from Akatsuki to MMX are required.

キーワード：金星、火星、気象学
Keywords: Venus, Mars, meteorology

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[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27日(月) 10:45 ~ 12:15 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Takehiko Satoh

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

10:45 ~ 11:05

[PPS05-07] 金星マントルの二段階進化モデルと地球への応用

★招待講演

*小河 正基[1] (1.東京大学大学院総合文化研究科広域科学専攻)

11:05 ~ 11:20

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

*奈良 佑亮[1]、今村 剛[1]、吉川 一朗[1]、吉岡 和夫[1]、益永 圭[2]、山崎 敦[3]、渡部 重十[4]、山田 学[5]、Lee Yoen Joo[1]、寺田 直樹[6]、関 華奈子[1] (1.東京大学大学院、2.Swedish Institute of Space Physics、3.宇宙航空研究開発機構 宇宙科学研究所、4.北海道情報大学、5.千葉工業大学、6.東北大学)

11:20 ~ 11:35

[PPS05-09] Mesoscale Dyanmics in the Venus Atmosphere

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

11:35 ~ 11:50

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

梶原 直也[1]、*今村 剛[1]、田口 真[2]、福原 哲哉[2]、神山 徹[3] (1.東京大学大学院　新領域創成科学研究科、2.立教大学　理学部、3.産業技術総合研究所)

11:50 ~ 12:10

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

★Invited Papers

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

12:10 ~ 12:15

Discussion

金星マントルの二段階進化モデルと地球への応用
A two-stage evolution model of Venus’s mantle and its implication for the Earth

*小河 正基[1]
*Masaki Ogawa[1]

1. 東京大学大学院総合文化研究科広域科学専攻
1. Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo

There are two elementary processes that exert control over the evolution of the mantle in Venus and the Earth. The first is the magmatism-mantle upwelling (MMU) feedback: Suppose an upwelling flow in the solid mantle generates magma by decompression melting. The buoyancy of the magma boosts the upwelling flow itself. This positive feedback makes the magmatism and the upwelling flow vigorous. The second is mantle burst. The solid-solid phase transitions at the top of the lower mantle makes the convective flow across the phase boundaries pulsating, provided that the mantle is hot enough to cause an active magmatism. When coupled with the MMU feedback, this pulse of mantle upwelling flow causes an extensive magmatism in the upper mantle. Because of these two elementary processes, the mantle of Venus evolves in two stages. On the earlier stage when the mantle is strongly heated by radioactive elements, mantle bursts repeatedly occurs to episodically resurface Venus. As the radioactive elements decay, however, the mantle evolves into the later stage. Mantle bursts subside, and only a mild magmatism occurs at the top of the mantle to continuously resurface the planet. When a model of tectonic plates is added to this model of Venus, I obtained a two-stage evolution model of the Earth. On the earlier stage, mantle bursts repeatedly occur to make plate motion chaotic and the mantle compositionally rather homogeneous. On the later stage, in contrast, mantle bursts subside, and plate motion becomes more steady; ridge magmatism differentiates the mantle, and basaltic materials accumulate on the core-mantle boundary to form thermo-chemical piles similar to the Large Low Shear wave Velocity Provinces.

キーワード：金星、内部進化、数値シミュレーション
Keywords: Venus, Evolution of the interior, numerical simulation

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

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In the thermosphere of Venus, the flow directing from sub-solar to anti-solar (SS-AS) is dominant driven by large temperature gradient associated with a long Venusian solar day which is ~117 Earth days. According to a numerical study by Mayr et al. (1985), the SS-AS flow without drag would exceed 300 m s^{-1} at the maximum.
It is believed that the drag force generated by gravity waves breaking effectively decelerates the thermospheric wind speed. Zalcucha et al. (2013) developed a Venus Thermosphere General Circulation Model in the presence of the gravity wave-drag, which accelerates the atmosphere when the gravity waves are broken. The model showed the SS-AS flow speed of 100-200 m s^{-1}.
The periodical variation that indicates the atmospheric waves in the thermosphere was observed by Masunaga et al. (2017). They analyzed OI dayglow variation using data obtained by the Extreme Ultraviolet Spectroscope for Exospheric Dynamics (EXCEED) on-board the Hisaki spacecraft and detected the periodicity of ~4 days only on the dawn side. They pointed out planetary-scale waves in the middle atmosphere which are expected to be exist in Venus might responsible for the variations in the thermosphere, while the existence of the planetary-scale waves at that time was not confirmed.
In this study, we investigated the vertical coupling between cloud-level atmosphere and the thermosphere of Venus, focusing on the role of atmospheric waves. To find the evidence for the wave propagation, we used data that are obtained simultaneously by Hisaki and Akatsuki spacecraft on the dawn side of Venus in June 2017.
Analyzing the time series of the atomic O dayglow emissions measured by the EXCEED and the UV images which reflect the spatial distribution of unidentified absorbers at the cloud top (~70 km) obtained by the Ultraviolet Imager (UVI), we identified characteristic periodicities of 3.5 days in both data. The wind velocity deduced with cloud tracking from UV images suggests that the 3.5-day periodicity can be associated with Kelvin waves at the cloud top; however, Kelvin waves should decay with height through radiative damping and will not reach the thermosphere. We propose an indirect process in which the Kelvin waves change the wind field periodically and examine how the vertically propagating small-scale gravity waves influence the thermospheric dayglow with a simplified numerical model.

キーワード：金星、熱圏、雲層、上下結合、重力波
Keywords: Venus, Thermosphere, Cloud level, Vertical coupling, Gravity waves

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Mesoscale Dyanmics in the Venus Atmosphere

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The Akatsuki Spacecraft is capable of observing the full disk of Venus at a number of filter-specified wavelengths, with time cadence on the order of an hour, and for up to nine days at a time (until the orbit brings the spacecraft so close that Venus exceeds the instrumental fields of view). Because of this, it is capable of supporting the elucidiation of both global atmospheric dynamics (i.e., the super-rotation) and mesoscale atmospheric dynamics. Here, we describe the analysis of the driving dynamics associated with mesoscale features observed in the Akatsuki IR2 camera data. This work focuses on just a single orbit of Akatsuki, but the features and behaviors we describe appear to be common in the Venus atmosphere. We make comparisons with similar terrestrial phenomena; and assess the implications for energy and momentum transport that may affect the overall global atmospheric dynamics. Three of the four filters in Akatsuki's IR2 camera image the night side of the planet in emitted radiation. These filters have central wavelegnths of 1.74 micron, 2.26 micron, and 2.32 micron, which are most sensitive to the conditions between about 50 km and 60 km altitude, in the midst of the lower and middle, condensational, cloud deck of Venus.

Keywords: Venus, Akatsuki, Meteorology, Clouds, Atmospheric Dynamics, Infrared Observations

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Periodicity analysis of Venus' cloud-top temperature measured by Akatsuki LIR

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Planetary-scale waves are thought to play crucial roles in the maintenance of the general circulation of the Venusian atmosphere. However, observational clues are limited, and the nature of such waves is poorly constrained. Here we analyze for the first time the cloud-top temperature field to deduce the periods (frequency) and the spatial structures of planetary-scale waves using LIR image data acquired continuously. Since the systematic (absolute) error in LIR data of around 3 K is larger than the expected amplitudes of the temperature oscillations of around 1 K, the waves are hard to detect by deducing temperature variations with time. In this study, we analyze oscillations of the zonal gradient of the temperature in each image associated with planetary-scale waves. The small random (relative) error in LIR data of 0.3 K enables detection of such small-amplitude waves with this method. Through spectral analyses of the time series of the temperature gradient spanning 142 Earth days from 18 May 2017, distinct oscillations with periods of 3.5 days, 4.9 days and 5.2 days were discovered. All of these modes show almost constant phases along the latitude, indicating that they are planetary-scale waves. Based on the wave period and the latitude dependence of the amplitude, the 3.5-day wave is identified as a Kelvin wave and the 4.9-day and 5.2-day waves seem to be hemispherically-symmetric Rossby waves. The amplitudes of these waves changed with time during the observation period.

キーワード：金星、あかつき、大気
Keywords: Venus, Akatsuki, atmosphere

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

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Using a modern three-dimensional general circulation coupled atmosphere/ocean model [1] we recently demonstrated [2] that climatic conditions may have permitted liquid water on Venus' surface for ~2 billion years in its early history. Similar such conditions on Earth are believed amenable to the rise of life. Several assumptions were made based on what little data we have for early Venus such as; the type of solar spectrum extant at that time, orbital parameters, estimates of a shallow ocean from Pioneer Venus D/H ratios, and topography from the Magellan Mission. We also assumed that it would have had an atmosphere similar to modern day Earth: 1 bar N2, 400ppmv CO2, 1ppmv CH4. I will discuss the motivations behind these assumptions and additional parameter space studies with direct relevance to hypothetical exoplanetary Venus-like worlds found at the inner edge of the liquid water habitable zone. Finally, I will show how our studies demonstrate that the reason for Venus' present climatic state is unlikely to be related to the gradual warming of our sun over the past 4Gyr as is commonly believed

[1] Way, M.J. et al. (2017) Astroph Journ Suppl, 231, 1
[2] Way, M. J., et al. (2016) Geophy Res Lett, 43, 8376-838

Keywords: Venus, Habitabilty, Exoplanets

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[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27日(月) 13:45 ~ 15:15 | A03 東京ベイ幕張ホール

[P-PS05] Recent advances of Venus science

コンビーナ:佐藤 毅彦(宇宙航空研究開発機構・宇宙科学研究本部)、堀之内 武(北海道大学地球環境科学研究院)、山本 勝(九州大学応用力学研究所)、Kevin McGouldrick(University of Colorado Boulder)、座長:Kevin McGouldrick

Akatsuki, being in Venus orbit since December 2015, has acquired a volume of high-quality data, unveiled many new phenomena and is allowing researchers to investigate the underlying mechanisms. As the data accumulate, numerical models and theories are being advanced as well. We are no doubt living in the new golden era of Venus studies. This session invites papers of the new scientific results with Akatsuki data and the latest results of theoretical and numerical works. We expect participants of this session share the latest research results through presentations and discussion.

13:45 ~ 14:00

[PPS05-12] 金星探査機「あかつき」IR2の昼面観測から明らかとなった金星雲頂構造

★招待講演

*佐藤 隆雄[1]、佐藤 毅彦[2]、佐川 英夫[3]、眞子 直弘[2]、Lee Yeon Joo、村上 真也[2]、小郷原 一智[4]、はしもと じょーじ[5]、笠羽 康正[6]、山崎 敦[2]、山田 学[7]、渡部 重十[1]、今村 剛[8]、中村 正人[2] (1.北海道情報大学、2.宇宙航空研究開発機構宇宙科学研究所、3.京都産業大学、4.滋賀県立大学、5.岡山大学、6.東北大学、7.千葉工業大学、8.東京大学)

14:00 ~ 14:15

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

*堀之内 武[1] (1.北海道大学地球環境科学研究院)

14:15 ~ 14:30

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

*成田 穂[1]、今村 剛[1]、奈良 佑亮[1]、Yeon Joo Lee、渡部 重十[2]、山崎 敦[3]、佐藤 毅彦[3]、田口 真[4]、福原 哲哉[4]、山田 学[5] (1.東京大学、2.北海道情報大学、3.宇宙航空研究開発機構、4.立教大学、5.千葉工業大学惑星探査研究センター)

14:30 ~ 14:45

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

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

14:45 ~ 15:00

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

★Invited Papers

*今井 正尭[1]、神山 徹[1]、高橋 幸弘[2]、堀之内 武[3]、今村 剛[4]、山崎 敦[5]、渡部 重十[6]、山田 学[7]、中村 正人[5]、佐藤 毅彦[5] (1.国立研究開発法人 産業技術総合研究所、2.北海道大学 大学院理学院 宇宙理学専攻、3.北海道大学 地球緩急化学研究所、4.東京大学大学院 新領域創成科学研究科、5.宇宙科学研究所、6.北海道情報大学 宇宙情報センター、7.千葉工業大学 惑星探査研究センター)

15:00 ~ 15:15

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

★Invited Papers

*Javier Peralta[1]、Naomoto Iwagami[2]、Sánchez-Lavega Agustín[3]、Yeon Joo Lee[4]、Ricardo Hueso[3]、Minori Narita[4]、Takeshi Imamura[4]、Phil Miles[5]、Anthony Wesley[6]、Emmanuel Kardasis[7]、Seiko Takagi[8]

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金星探査機「あかつき」IR2の昼面観測から明らかとなった金星雲頂構造
Cloud top structure of Venus retrieved from the Akatsuki IR2 dayside observations

*佐藤 隆雄[1]、佐藤 毅彦[2]、佐川 英夫[3]、眞子 直弘[2]、Lee Yeon Joo、村上 真也[2]、小郷原 一智[4]、はしもと じょーじ[5]、笠羽 康正[6]、山崎 敦[2]、山田 学[7]、渡部 重十[1]、今村 剛[8]、中村 正人[2]
*Takao M. Sato[1], Takehiko Satoh[2], Hideo Sagawa[3], Naohiro Manago[2], Yeon Joo Lee, Shin-ya Murakami[2], Kazunori Ogohara[4], George HASHIMOTO[5], Yasumasa Kasaba[6], Atsushi Yamazaki[2], Manabu Yamada[7], Shigeto Watanabe[1], Takeshi Imamura[8], Masato Nakamura[2]

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1. Hokkaido Information University, 2. ISAS/JAXA, 3. Kyoto Sangyo University, 4. University of Shiga Prefecture, 5. Okayama University, 6. Tohoku University, 7. Chiba Institute of Technology, 8. The University of Tokyo

We present the cloud top structure of Venus retrieved from a total of 93 dayside images acquired at a wide variety of solar phase angles (0-120 deg) by the 2.02-μm channel of the 2-μm Camera (IR2) onboard Japanese Venus orbiter, Akatsuki, during the period from April 4 to May 25, 2016. Since the 2.02-μm channel locates in a CO_2 absorption band, the sunlight reflected from Venus allows us to determine the cloud top altitude corresponding to unit aerosol optical depth at 2.02 μm with radiative transfer calculation. Firstly, the observed solar phase angle dependence and zonal variation of the reflected sunlight in the equatorial region were used to construct a baseline model characterized by cloud top altitude , Mode 2 radius , and cloud scale height which are 70.287 km, 1.26 μm and 5.1 km, respectively. Secondly, individual cloud top altitudes were retrieved with the assumption that the last two values are valid for the entire planet. The latitudinal structure of cloud top altitude is symmetrical with respect to the equator: the averaged cloud top locates at a constant altitude of 68-70 km equatorward of ±45 deg but rapidly drops in latitudes of 50-60 deg and reaches 61 km poleward of ±70 deg. The averaged cloud top in the equatorial region indicates the tendency to increase from early morning (~7 h) and reach a maximum near early afternoon (~14 h) and decrease toward late afternoon (~17 h). The magnitude of the change is in the order of 1 km. After high-pass filtering of the cloud top altitude maps, small-amplitude features including stationary structures occur within several hundred meters and typically show less contrast than those at two channels (283 and 365 nm) of the Ultraviolet Imager (UVI). Although the long, zonal or tilted streaky features poleward of ~45 deg are clearly identifiable, the features in low and middle latitudes are usually faint and do not necessarily appear as the local variation in cloud top altitude where mottled and patchy patterns are seen in the UV channels, suggesting the existence of convection and turbulence at the cloud top level.

キーワード：金星、大気、雲、あかつき、近赤外、放射伝達
Keywords: Venus, atmosphere, clouds, Akatsuki, near-infrared, radiative transfer

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Formation of superrotation studied by a TEM model

Formation of superrotation studied by a TEM model

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Recently, a number of studies have reported the formation of atmospheric superrotation in three-dimensional Venus GCMs. However, its mechanism has not been fully understood, which is partly due to the difficulty of model data analysis and possible numerical problems (Lebonnois et al 2012). Earlier studies with two-dimensional models by Matsuda (1980, 1982) and Yamamoto and Yoden (2013) provided useful insights, but to assess their applicability is not straightforward, since these studies are based on the Boussinesq approximation and use fixed uniform eddy diffusivity and Newtonian cooling rate. Here, I present the results of numerical simulations with a two-dimensional axi-symmetric model to overcome these difficulties. The model is based on the transformed Eulerian mean (TEM) equations supporting deep atmosphere over multiple scale heights, and it conserves total zonal angular momentum very well when surface friction is tuned off. The model does not use prescribed eddy diffusivity. Instead, effects of dynamical instabilities (convective, symmetric, barotropic-baroclinic instabilities) are parameterized. The model was initialized with the uniform solid-body rotation at the rate of the planetary rotation and run under radiative forcing similar to that in the recent Venus AFES simulations. A realistic superrotation emerged, and it reached a statistical steady state. It is revealed that the dynamical disturbances associated with dynamical instabilities can work like eddy diffusivity in the Gierasch mechanism to create a local maximum of the angular momentum within the atmosphere. The steady-state meridional circulation is multi-layered. The surface friction works to keep the angular momentum at low levels. Effects of thermal tides will be investigated elsewhere.

キーワード：Venus、superrotation
Keywords: Venus, superrotation

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Morphological Feature Extraction from Venus' Cloud Images Using Principal Component Analysis

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*Minori Narita[1], Takeshi Imamura[1], Yusuke Nara[1], Yeon Joo Lee, Shigeto Watanabe[2], Atsushi Yamazaki[3], Takehiko Satoh[3], Makoto Taguchi[4], Tetsuya Fukuhara[4], Manabu Yamada[5]

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We applied principal component analysis (PCA) to Venus' multi-wavelength image data obtained by Venus orbiter Akatsuki, to extract latent morphological patterns for each wavelength and compare them to reveal similarities and dissimilarities between the wavelengths. Statistical approaches that extract latent features using massive amounts of data have hardly been done in Venus researches. The new analysis showed that tilted streaky features are dominant at all wavelengths, especially in mid-latitudes; this feature can be explained by the combination of the latitudinal gradient of the mean zonal velocity and the meridional circulation. Moreover, the result shows a strong morphological similarity between cloud height and ultraviolet absorbers.

We preprocessed images as follows. We used data in which images have been projected onto the latitude-longitude coordinate (Level-3 data). We used the following four wavelengths; near-infrared 2.02 μm (cloud height), thermal infrared 10 μm (cloud top temperature), ultraviolet 283 nm (SO_2 distribution at the cloud top), and ultraviolet 365 nm (an unknown UV absorber). First, we performed photometric correction using Minnaert Law (except for 10 μm images). Then these images are high-pass filtered by subtracting a Gaussian-smoothed image from each original image to extract scales smaller than 6 degrees both in latitude and longitude. Lastly, we extracted image patches from these images to increase the number of samples and extract specific spatial scale. The size of the image patches is 12 degrees in latitude/longitude. The total number of image patches is around 60,000 for each wavelength. Also, we analyzed images in low-latitudes and mid-latitudes separately.

We performed PCA for the image patches. PCA converts a set of observational data into a set of linearly uncorrelated variables called principal components and enables to extract spatial features that appear in data frequently. We focus on 20 most major principal components for each wavelength, and we also calculated the contribution ratios. As a result, it turned out that tilted streaky features are dominant both in low and middle latitudes. Considering that zonal winds have a latitudinal gradient and that a slow, poleward meridional circulation exists, cloud parcels are stretched obliquely while drifting from low latitudes to middle latitudes. Moreover, we found that SO_2 (283 nm) and the unknown UV absorber (365 nm) have spatial patterns similar to that of the cloud height (2.02 μm). It indicates that mechanisms that make the distribution of clouds and these chemical compounds in low latitudes are common. As unique patterns for a specific wavelength, it is worth noting that streaks in the north-south direction prevail in patterns of the cloud top temperature (10 μm). Considering that meridional bow-shaped structures are observed at this wavelength, it seems that these structures are appearing as the main principal component. Besides, the statistical approach could successfully extract streaky features from 10 μm as well, while we cannot recognize such features at this wavelength by our eyes because of apparent dominance of random, patchy features. In conclusion, we successfully extracted statistical spatial patterns

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in Venus' clouds and enabled further discussions about physical properties corresponding to each wavelength more in detail.

キーワード：金星、主成分分析、画像
Keywords: Venus, Principal Component Analysis, Image

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Principal Components of UV Albedo Variability in Venus' Atmosphere as seen at 283 nm

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We explore the dominant modes of variability in the observed albedo at the cloud tops of Venus using the Akatsuki UVI 283 nm observations over the period Dec 2016 to May 2018. The observations consist of images of the dayside of Venus, most often observed at intervals of 2 hours, but interspersed with longer gaps. The orbit of the spacecraft does not allow for continuous observation of the full dayside, and the unobserved regions cause significant gaps in the dataset. The missing data are interpolated and the dataset is then subjected to a principal component analysis (PCA) to find six oscillating patterns in the albedo. Some of the spatial patterns and the time scales of these modes correspond to well known physical processes in the atmosphere of Venus such as short period atmospheric waves and the overturning circulation, while others defy a simple explanation. We also a find a hemispheric mode that has not been identified before and discuss its implications.

Keywords: Venus atmosphere, Clouds, UV Observations

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Active and inactive behaviors of the planetary-scale waves on Venus cloud top

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Planetary-scale waves on Venus cloud top cause periodical fluctuations in winds and also UV brightness. The candidates of these waves are 4-day Kelvin wave and 5-day Rossby wave of zonal wavenumber 1, however, their temporal evolutions are poorly understood. In this work, we conducted time-resolved periodical analysis in 365 nm brightness and cloud tracking wind fluctuations obtained by UVI onboard AKATUSKI Japanese Venus Climate Orbiter from January to September 2017, and we have revealed the dramatical evolution of planetary-scale waves and the dynamical connection between wave and planetary-scale UV features.

During the observation season, we could find prominent ~5-day periodicity in both wind and brightness fluctuations, whose phase velocity was slower than dayside mean zonal winds (or the super-rotation) by > 35 ms^{-1}. We succeeded to reconstruct the horizontal wind field related to the observed 5-day mode, and since planetary-scale vortices, whose the center existed ~35° latitudes, having large equatorial symmetric structures in the latitudinal direction were found, it can be a strong manifestation of the retrograde propagating Rossby wave. The observed Rossby wave subjected to temporal changes of enhancing and attenuating in the amplitude of wind fluctuations with ~100-day time scale. According to the temporal evolution of the Rossby wave, white cloud belts in 45° --60° latitudinal regions began rippling synchronously in both hemispheres. Moreover, the Rossby wave deformed the planetary-scale dark UV feature in the equatorial region, and that should be the reason for significant 5.1-day periodicity in brightness variation. Before the Rossby wave enhancement, weak 3.8-day periodical signals can be observed in zonal wind and brightness variations in the equatorial region. This is a suggestive prograde propagating Kelvin wave, and this might be the reason for the origin of dark clusters in the equatorial region.

While wave activities during the observation season from January to September 2017 were clear, significant periodical wind or brightness fluctuations were not always confirmed in the other observation seasons. In orther to investigate the reason for active and inactive behaviors in planetary-scale waves, we will compare seasons when significant planetary-scale waves were observed and they were not focusing on the connection with mean zonal wind speed, global UV albedo, and cloud top temperature.

キーワード：金星、あかつき、ロスビー波、ケルビン波
Keywords: Venus, AKATSUKI, Rossby wave, Kelvin wave

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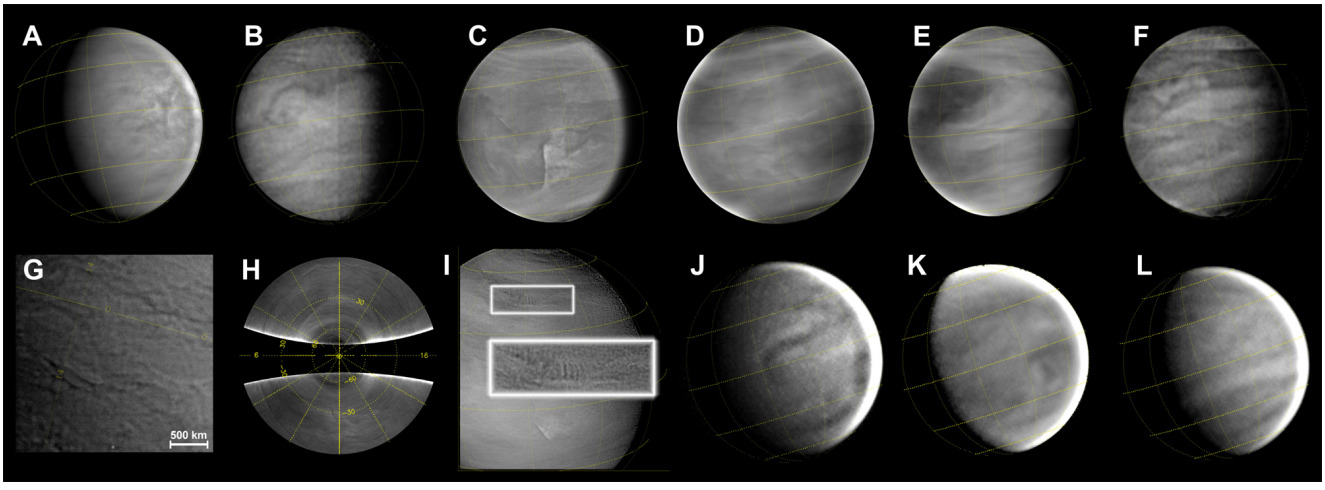
Long-term behaviour of the morphology and dynamics of Venus's middle clouds with Akatsuki/IR1.

*Javier Peralta[1], Naomoto Iwagami[2], Sánchez-Lavega Agustín[3], Yeon Joo Lee[4], Ricardo Hueso[3], Minori Narita[4], Takeshi Imamura[4], Phil Miles[5], Anthony Wesley[6], Emmanuel Kardasis[7], Seiko Takagi[8]

1. Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), Sagamihara, Japan, 2. Tokyo 156-0044, Japan, 3. Escuela de Ingeniería de Bilbao, University of the Basque Country (UPV/EHU), Bilbao, Spain, 4. Graduate School of Frontier Sciences, The University of Tokyo, Japan, 5. Rubyvale QLD, Australia, 6. Astronomical Society of Australia, Australia, 7. Hellenic Amateur Astronomy Association, Greece, 8. Research and Information Center, Tokai University, Japan

The Venusian atmosphere is covered by clouds with super-rotating winds whose accelerating mechanism is still not well understood. Fastest wind speeds occur at the top of the clouds (about 70 km height), and they have been studied for decades thanks to their visual contrast in dayside ultraviolet images caused by the presence of a yet unknown absorber. The middle clouds (at about 50-55 km) can be observed using near-infrared wavelengths (800-950 nm) and they exhibit much weaker contrasts. Here we present the first long-term study of the dayside middle clouds of Venus at middle to low latitudes thanks to the combination of the full dataset of Akatsuki/IR1 images acquired at 900 nm during the year 2016 (A-I), complemented with observations of Venus with small telescopes and band-pass filters 1.0-1.1 μm and 884-900 nm (J-L). Thanks to the analysis of more than 1,000 images, we report the discovery of new cloud morphologies, like fast sharp discontinuities (C), elongated "hook-like" stripes (B,J) and a single case of mesoscale wave packet (I). Surprisingly, the albedo of Venus at 900 nm exhibit periodical hemispherical asymmetry (E-F), and clouds' contrasts varying from 3% to 21%. These contrasts are larger than reported in previous missions, and they are suggestive of important changes in the optical thickness of the clouds or they might imply the presence of a new atmospheric absorber at near-infrared wavelengths. Finally, we also present more than 500 wind measurements from IR1 images and —for the first time— with ground-based observations. The mean zonal winds are observed to peak at the equator, while the combination with data from Venus Express reveals long-term variations in the zonal winds of ˜20 m/s along 10 years.

Keywords: Venus, Atmosphere, Clouds, Atmospheric dynamics, Remote sensing



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2019年5月27日(月) 15:30 ~ 17:00 | A05 東京ベイ幕張ホール

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

コンビーナ:Yue Deng(University of Texas at Arlington)、Toshi Nishimura(Boston University)、Liu Huixin(九州大学理学研究院地球惑星科学専攻 九州大学宙空環境研究センター)、Yanshi Huang(Harbin Institute of Technology, Shenzhen)、座長:Yue Deng(University of Texas at Arlington)、Huixin Liu(Kyushu University, Japan)、Yanshi Huang(Harbin Institute of Technology, Shenzhen, China)、Yukitoshi Nishimura(Boston University)

Determining the effects of energy deposition and transport, and momentum exchange across different spatial and temporal scales is an important objective in the M-I-T system, due to the clear evidence of multi-scale forcing. Coupling over multiple scales is also a critical challenge since observational and modeling methodologies for bridging different scales do not presently exist. This session solicits presentations on a wide range of coupling processes in the high-latitude M-I-T system from global to small-scale processes and related solar wind forcing. Relevant topics include (but are not limited to) (1) density structures and temperature gradients (polar cap, cusp, plume, trough, irregularities); (2) convection (flow channels, SAPS) and FAC; (3) energy transfer and deposition by precipitation and ULF waves, conductivity, aurora, and heating; and (4) coupling and feedback into the magnetosphere. Discussions of relevant multi-scale observations by means of multiple instruments, including space and ground-based, modeling and data science are encouraged.

15:30 ~ 15:45

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

★Invited Papers

*塩川 和夫[1]、西 勝輝[1] (1.名古屋大学宇宙地球環境研究所)

15:45 ~ 16:00

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

★Invited Papers

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

16:00 ~ 16:15

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

★Invited Papers

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

16:15 ~ 16:30

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

*西谷 望[1]、堀 智昭[1] (1.名古屋大学宇宙地球環境研究所)

16:30 ~ 16:45

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

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

16:45 ~ 17:00

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

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

Auroral fragmentation into patches and pressure balance condition in the source magnetosphere

*塩川 和夫[1]、西 勝輝[1]
*Kazuo Shiokawa[1], Katsuki Nishi[1]

1. 名古屋大学宇宙地球環境研究所
1. Institute for Space-Earth Environmental Research, Nagoya University

The auroral fragmentation into patches has been reported by Shiokawa et al. (JGR, 2010; 2014) as finger-like structures developed in the diffuse aurora with horizontal scale sizes of 5-25 km (small scale) and 40-100 km (large scale). The development of these finger-like structures divides the diffuse aurora into patches. Thus we call it as the auroral fragmentation which is a cause of the patchy auroral structures in the diffuse aurora. Hashimoto et al. (JGR, 2015) made a statistical analysis of these auroral finger-like structures and found their occurrence rates of 13% and 4 % for large- and small-scale events, respectively. They also indicated that the finger-like structures tend to occur at the beginning of the substorm recovery phase in the post-midnight and dawn sectors. The auroral finger-like structure suggests the development of pressure-driven instability in the magnetosphere. Recently Nishi et al. (JGR, 2017) made the first conjugate measurement of the auroral finger-like structures with the THEMIS-E satellite at ~8 Re in the magnetosphere. They found clear anti-phase oscillations between the magnetic and plasma pressures in the post-midnight plasma sheet. This anti-phase variation is consistent with the idea of the pressure-driven instability. On the other hand, Nishi et al. (JGR, 2018a) reported that a conjugate event with the RBSP-A satellite at ~5.5 Re does not show systematic phase relationship between the magnetic and plasma pressures. Then Nishi et al. (JGR, 2018b) investigate statistical features of the phase relationship between magnetic and plasma pressures using two-year THEMIS-E observations in the nightside plasma sheet and obtained a high occurrence of the anti-phase oscillations between the magnetic and plasma pressures. In the presentation, we will review these recent results on the auroral fragmentation and pressure balance condition in the source magnetosphere, and discuss possible physical mechanism that contributes these phenomena.

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キーワード：オーロラの破砕、磁気圏圧力バランス、ディフューズオーロラ
Keywords: auroral fragmentation into patches, pressure balance in the magnetosphere, diffuse aurora

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Formation and Evolution of Polar Cap Ionospheric Patches and Their Associated Upflows and Scintillations: A Review

*Qing-He Zhang[1], Zan-Yang Xing[1], Yong Wang[1], Yu-Zhang Ma[1]

1. Institute of Space Sciences, Shandong University, Weihai, China

Polar cap patches are common phenomena, especially during southward interplanetary magnetic field (IMF) conditions, in the polar ionosphere. We summarized the recent new progress about the formation and evolution of patches as well as their impact on the magnetosphere-ionosphere-thermosphere (M-I-T) coupling processes and space weather. The dayside reconnection and bursty sunward return flows produced by the modulation of nightside reconnection, are confirmed as the dominated mechanisms to separate the entering ionization into islands (patches). The patches evolve along streamlines of the Dungey convection cycle from the dayside to the nightside and exit the polar cap modulated by pulsed nightside reconnection. However, they slowly move and rapidly fade away behind a lobe “reverse” convection cell when the IMF suddenly changed to northward. Rapidly moving patches are associated with clear ion upflows due to frictional heating and offer more upwelling ion fluxes. Patches often produce significant scintillations due to strong density gradients at their edges, especially during their merging into the auroral oval, which will result in variable disturbances to High Frequency (HF) radio communications, over-the-horizon radar location errors, disruption and errors to satellite navigation and communication.

Keywords: Polar cap patches, Magnetosphere-ionosphere coupling, Ion upflows, Ionospheric scintillations

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Global ionospheric disturbances during the 6-10 September 2017 solar storms

*Shunrong Zhang[1]

1. MIT Haystack Observatory

Solar activity during the period of 6-10 September 2017 is characterized with a series of very strong flares and powerful coronal mass ejections (CMEs). Observations indicate more than two dozens of M-class and 4 X-class flares being emmitted from the solar Active Region 12673. In particular, one of these flares led to a halo-type CME which traveled earth-bound at ~1570 km/s apparent speed. With the arrival of this CME, IMF Bz turned to southward and reached a minimum of -30 nT at 23:25 UT on 7 September, triggering a Kp 8 geomagnetic storm with a sudden commencerment at ~2300 UT and a minimum Dst ~ -150 nT near 0100 UT on 8 September. These conditions caused very significant geospace disturbances, in particular, ionospheric disturbances with various spatial and temporal scales. In this presentation, we report flare induced ionospheric perturbations and post-flare traveling ionospheric disturbances (TIDs), storm-enhanced density (SED) plumes at subauroral and high latitudes of the dayside ionosphere, subauroral polarization streams (SAPs), and large scale TIDs over the globe. Our discussion will focus on some unique post-flare ionospheric oscillation and TID features, TIDs at high latitudes, and gigantic cross-hemispheric ionospheric electron density depletion channels. This study is based primarily on ground-based GNSS and Millstone Hill incoherent scatter radar observations.

Keywords: geospace storm, solar flare, traveling ionospheric disturbance

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Multiscape Coupling of Sub-auroral Polarization Streams

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*Nozomu Nishitani[1], Tomoaki Hori[1]

1. 名古屋大学宇宙地球環境研究所
1. Institute for Space-Earth Environmental Research, Nagoya University

Sub-Auroral Polarization Streams (SAPS) are fast westward flows slightly equatorward of the auroral precipitation boundary, and manifestations of magnetosphere-coupling processes. Recenty it was shown that SAPS sometimes contain perturbation in westward speed, typically with temporal scale of a few minutes (e.g., Hori et al., GRL, 2018). However, it has not yet been clear how small the temporal scales of these perturbations can be and how perturbations with different temporal scales are related to each other. In this paper, multiscape coupling of the sub-auroral polarization streams will be studied, using multiple events observed mainly by the SuperDARN Hokkaido East / West radars.

キーワード：スケール間結合、SuperDARN北海道-陸別第一・第二レーダー、サブオーロラ帯高速プラズマ流(SAPS)
Keywords: multiscale coupling, SuperDARN Hokkaido East / West radars, sub-auroral polarization stream (SAPS)

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Scale sizes of mass density enhancements inferred from accelerometer measurements

*Yanshi Huang[1], Cheryl Huang[2]

1. Harbin Institute of Technology, Shenzhen, China, 2. Space Physics Directoriate, Air Force Research Laboratory, Kirtland AFB, USA

The spatial scale sizes of neutral mass density enhancements inferred from the accelerometer measurements on CHAMP and GRACE satellites are analyzed. Density enhancements are found as the peaks with more than 30% above the average density baseline fitted over a 90 degree magnetic latitude window. The widths of mass density peaks are defined in two different methods, one using the maximum above the average density baseline, the other method using the two minima surrounding each one density peak above a threshold value. We study various cases including one-peak and multi-peak cases using high-resolution density data from year 2002 to 2010. The results give a statistical understanding of the scale sizes of the density enhancements observed at high and polar latitudes. The scale sizes using the baseline are rather independent of solar activity, and the average is over 2500 km, whereas the scale sizes using adjacent density minima vary with solar activity, and the mean value is more than 1000 km. No significant different results are found between northern and southern hemisphere. We also investigate the impact of these mass density peaks on the orbit-averaged densities.

Keywords: neutral mass density , accelerometer measurements , CHAMP and GRACE satellites , spatial scale sizes

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Meso-scale forcing in the upper atmosphere: sources and impacts

*Yue Deng[1], Qingyu Zhu[1], Cissi Lin[1]

1. University of Texas at Arlington

We present a systematical study crossing both data analysis and model simulation to improve the specification of the energy and momentum inputs into the ionosphere-thermosphere (IT) system, especially at the meso-scale, and the system response. Our results are organized in two parts. First, two-years of Swarm satellite field-aligned current (FAC) data have been analyzed in order to study the distributions of mean pattern and variability of FACs on different scales (small scale: <150 km; mesoscale: 100~500 km; large scale: >500 km). The FAC distributions are then implemented in the Global Ionosphere-Thermosphere Model (GITM) to assess relative contributions of FACs at different scales to Joule heating. To enhance our capability to directly simulate the meso- and small-scale structures, GITM has been improved with a local patch grid refinement capability. Utilizing GITM with the new grid structure, the meso- and small-scale gravity wave perturbations have been included at the lower boundary of GITM to simulate the influence of meso- and small-scale gravity waves on the upper atmosphere.

Keywords: Meso-scale forcing , upper atmosphere, Joule heating, Gravity waves

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2019年5月27日(月) 9:00 ~ 10:30 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:Antti Pulkkinen(NASA/GSFC)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

9:00 ~ 9:15

[PEM12-01] NASA Heliophysics Division Space Weather Update

★Invited Papers

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

9:15 ~ 9:30

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

★Invited Papers

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

9:30 ~ 9:45

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

★Invited Papers

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

9:45 ~ 10:00

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

*三好 由純[1]、栗田 怜[1]、片岡 龍峰[2]、齊藤 慎司[1]、Jordanova Vania[3]、篠原 育[4]、三谷 烈史[4]、高島 健[4]、東尾 奈々[4]、笠原 慧[5]、横田 勝一郎[6]、堀 智昭[1]、桂華 邦裕[5]、笠原 禎也[7]、松田 昇也[4]、熊本 篤志[8]、土屋 史紀[8]、小路 真史[1]、松岡 彩子[1]、寺本 万里子[1]、Spence Harlan[9]、Reeves Geoff[3]、Baker Daniel[10] (1.名古屋大学宇宙地球環境研究所、2.国立極地研究所、3.ロスアラモス国立研究所、4.宇宙航空研究開発機構、5.東京大学、6.大阪大学、7.金沢大学、8.東北大学、9.ニューハンプシャー大学、10.コロラド大学)

10:00 ~ 10:15

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

*草野 完也[1]、伊集 朝哉[2]、伴場 由美[1] (1.名古屋大学宇宙地球環境研究所、2.国立天文台)

10:15 ~ 10:30

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

*石井 守[1] (1.国立研究開発法人情報通信研究機構)

NASA Heliophysics Division Space Weather Update

*Nicola Justine Fox[1]

1. NASA Headquarters

NASA is a mission driven agency whose science mission is focused on discovering the secrets of the universe, looking for life elsewhere, and safeguarding and improving life on Earth. Heliophysics plays a key role in every aspect of the NASA science mission, including understanding the drivers of and enabling the prediction of space weather. Heliophysics has an established research program that motivates and funds solar and space physics, which is the essence and foundation of space weather research. Recently, the Heliophysics Division established a Space Weather Science Applications Program, SnAP. The objective of this competed program is to enable the transition of the knowledge and understanding of space weather to operation environments, by partnering with sister agencies, the commercial sector, and academia. SnAP leverages relevant NASA capabilities to reach this objective. This talk provides an overview of space weather research and SnAP in the NASA Heliophysics Division

Keywords: Heliophysics, Space Weather, Sun Earth Connections, Sun, Solar Wind, Magnetosphere

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NOAA's Current and Future Space Weather Architecture

*Elsayed R Talaat[1]

1. NOAA National Environmental Satellite, Data, and Information Service

NOAA observational responsibilities in support of space weather forecasting are in the context of significant, numerous, complementary international and domestic efforts. Each measurement plays a unique role at different phases of the forecasting or event characterization process. This paper overviews the current suite of observation that NOAA maintains and utilizes on various platforms, NOAA's forecasting capability, contributions to research efforts, and the status of the NOAA/NESDIS plan forward efforts for the Space Weather Follow-On (SWFO) program to provide needed continuity. This paper will also brief the NOAA space weather goals within the NOAA Satellite Observing System Architecture.

Keywords: space weather, coronagraph, energetic particles

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

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

1. NASA Goddard Space Flight Center, 2. NASA Johnson Space Center

The Community Coordinated Modeling Center (CCMC, http://ccmc.gsfc.nasa.gov) was established at the end of past millennium as a multi-agency strategic investment in the US space weather program. The CCMC has two main goals: 1) to support space weather research and model development aiming to advance understanding of space weather phenomena and to improve forecasting; 2) to facilitate development of space weather applications and deployment of operational capabilities. The CCMC hosts a rapidly growing collection of space weather models and applications, provides simulations services to the international research community through a one-of-a-kind runs-on-request system, and maintains real-time simulations and perpetual archives of space weather information streams. In support of NASA missions, the CCMC provides support for mission planning, develops applications for space weather monitoring and forecasting, and provides space environment analysis services. In partnership with NASA Space Radiation Analysis Group (SRAG) and international modeling community the CCMC is building a flexible system for Solar Proton Event (SPE) risk assessment and forecasting in support of human exploration. Unbiased testing, evaluating and prototyping of new models and forecasting techniques for potential transition to operational organizations (R2O) is one of the primary CCMC functions. To establish internationally recognized metrics and benchmarks the CCMC initiated an international community-wide Forum for Space Weather Capabilities Assessment. Guided by the unfolding activities of Forum working teams as well as by the needs of operational agencies and end users to quantify and track improvements over time, the CCMC has begun to develop an extensive information technology infrastructure to support validation activities through a centralized database and an interactive web-based framework. The presentation will highlight the recent progress and discuss opportunities for international research initiatives aiming to improve space weather forecasting capabilities.

Keywords: space weather, models, assessment, Solar Proton Event

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

*三好 由純[1]、栗田 怜[1]、片岡 龍峰[2]、齊藤 慎司[1]、Jordanova Vania[3]、篠原 育[4]、三谷 烈史[4]、高島 健[4]、東尾 奈々[4]、笠原 慧[5]、横田 勝一郎[6]、堀 智昭[1]、桂華 邦裕[5]、笠原 禎也[7]、松田 昇也[4]、熊本 篤志[8]、土屋 史紀[8]、小路 真史[1]、松岡 彩子[1]、寺本 万里子[1]、Spence Harlan[9]、Reeves Geoff[3]、Baker Daniel[10]
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1. Institute for Space-Earth Environmental Research, Nagoya University, 2. NIPR, 3. Los Alamos National Laboratory, 4. JAXA, 5. University of Tokyo, 6. Osaka University, 7. Kanazawa University, 8. Tohoku University, 9. University of New Hampshire, 10. University of Colorado

Relativistic and ultra-relativistic electrons increase largely during the high-speed coronal hole streams, and the enhanced flux levels are controlled by the solar wind speed and the prolonged southward IMF. Such flux enhancements associated with high-speed streams have been observed by Arase/HEP and XEP instruments as well as Van Allen Probes/MagEIS and REPT. Some coronal hole streams produce large flux enhancement of both relativistic and ultra-relativistic electrons, while other coronal holes produce large flux enhancement of relativistic electrons (~2 MeV) but do not produce enhancement of ultra-relativistic electrons. In this presentation, we will show evolutions of the energy spectrum of relativistic electrons during the coronal hole streams and discuss how evolutions of the energy spectrum are related to chorus wave activities that are derived from Arase/PWE measurements and the proxy data from the low-altitude satellite data.

キーワード：放射線帯、あらせ、太陽風-磁気圏相互作用
Keywords: radiation belts, Arase, Sun-Earth Connection

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Study on the predictability of imminent giant solar flares based on the theory of double-arc instability

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1. Institute for Space-Earth Environmental Research, Nagoya University, 2. NAOJ

Solar flares are catastrophic explosions in the solar corona and sometimes may cause a severe space weather disaster in geo-space and the infrastructure. Although many efforts have been taken for understanding and predicting the onset of solar flares, it is still difficult to accurately predict when, where and how large giant solar flares will occur. Here, we propose a new type of solar flare prediction scheme called the κ-scheme. The κ-scheme is the totally physics-based prediction, and it is capable of providing the information of the location as well as the energy of imminent giant solar flares. The prediction is performed by evaluating how small reconnection can trigger the onset of the double-arc instability, which was recently proposed as the initial driver of solar flares by Ishiguro and Kusano (2017), using the nonlinear force-free field extrapolation. We carried out the analysis of more than 200 active regions in the solar cycle 24 by applying the κ-scheme to the SDO/HMI data. The result shows that most of the imminent giant solar flares larger than the GOES X2 class are predictable with the κ-scheme.

キーワード：太陽フレア、予測、宇宙天気
Keywords: solar flares, prediction, space weather

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Update of space weather research and operation activities in NICT

*石井 守[1]
*Mamoru Ishii[1]

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1. National Institute of Information and Communications Technology

Since September 6 2017, when X9.3 solar flare occured most of Japanese people were scared of it, the situation of Japanese spacw weather operation has been changed so much. The ionosphere observing network has been set more robustly with dual systems. A back up center of space weather information service has been installed at NICT Kobe branch. In addition, we will begin 24/7 operation of space weather forecast services in FY2019.We have been collaborating with academic researchers under the framework of PSTEP which will finish the end of FY2019. Through the activities, we have provided some applications for better service than before. A radio propagatoin simulator, HF-START, and the estimation system of human radiation on flight, WASAVIES will be up on our web soon. In addition, we continue to discuss hazardous map against severe space weather disasters, which will be published within a year.I would like to share our information and have close cooperation with Asia Oceania space weather researchers and operators.

キーワード：宇宙天気予報、AOSWA、社会影響
Keywords: Space Weather forecast, AOSWA, social impact

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[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27日(月) 10:45 ~ 12:15 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:片岡 龍峰(国立極地研究所)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

10:45 ~ 11:00

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

★Invited Papers

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

11:00 ~ 11:15

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

★Invited Papers

*岩井 一正[1]、塩田 大幸[2]、徳丸 宗利[1]、藤木 謙一[1]、田 光江[2]、久保 勇樹[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)

11:15 ~ 11:30

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

*塩田 大幸[1,2]、八代 誠司[3]、岩井 一正[2] (1.国立研究開発法人 情報通信研究機構、2.名古屋大学 宇宙地球環境研究所、3.米国カトリック大学)

11:30 ~ 11:45

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

*伴場 由美[1,2]、井上 諭[1]、林 啓志[1,3,4] (1.名古屋大学宇宙地球環境研究所、2.宇宙航空研究開発機構 宇宙科学研究所、3.Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences、4.State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences)

11:45 ~ 12:00

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

*林 沛萱[1]、草野 完也[1]、塩田 大幸[2]、井上 諭[1]、KD レカ[1,3]、水野 雄太[1] (1.名古屋大学宇宙地球環境研究所、2.国立研究開発法人　情報通信研究機構、3.ノースウエスト　リサーチ　アソシエーツ)

12:00 ~ 12:15

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

★Invited Papers

*金子 岳史[1]、草野 完也[1] (1.名古屋大学 宇宙地球環境研究所)

Commercial Space Weather Activities From a USA small Business Perspertive

*Chigomezyo Mudala Ngwira[1], Geoff Crowley[1], Chad Fish[1]

1. Atmospheric and Space Technology Research Associates, LLC

This talk offers a brief overview of ASTRA (Atmospheric and Space Technology Research Associates), a small business company based in Louisville, Colorado USA. ASTRA was born out of the vision for applying fundamental space physics knowledge to real-world problems. Its motto is Science + Technology + Applications –Bringing it all together. Founded in 2005, ASTRA has become a system design and technology development company. ASTRA is a leader in the “New Space” small satellite revolution specializing in miniaturized sensors, and data modeling and analytics for the government and commercial customers. ASTRA leverages its scientific and engineering expertise to develop unique solutions in HF radar and radio, GPS systems, satellite remote sensing, CubeSats/Smallsats, and LiDAR. ASTRA's technical background spans fundamental space physics disciplines of the upper atmosphere, data analysis and modeling of the complex coupling of the meso-iono- thermosphere, as well as LEO constellation design, spacecraft design, instrument sensor design and manufacture, and space to earth communications.

Keywords: Space Weather, Commercial activities

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Development of coronal mass ejection arrival time forecasting system using interplanetary scintillation observations

*岩井 一正[1]、塩田 大幸[2]、徳丸 宗利[1]、藤木 謙一[1]、田 光江[2]、久保 勇樹[2]
*Kazumasa Iwai[1], Daikou Shiota[2], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Mitsue Den[2], Yûki Kubo[2]

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1. Institute for Space–Earth Environmental Research (ISEE), Nagoya University, 2. National Institute of Information and Communications

Coronal mass ejections (CMEs) sometimes cause disturbances in the environment of the Earth. However, prediction of the arrival of CMEs still remains a challenge. We have developed a data assimilation forecasting system of the CME arrival time by combining radio interplanetary scintillation (IPS) observations and a global magnetohydrodynamic (MHD) simulation of the inner heliosphere. In this system, the initial speed of a CME is roughly derived from the white light coronagraph observations. Then, the propagation of the CME is calculated by global MHD simulation (Shiota et al. submitted in this session). The IPS is estimated by the three-dimensional density distribution of the inner heliosphere derived from the MHD simulation. The estimated IPS is compared with the actual IPS observation made by the Institute for Space-Earth Environmental Research, Nagoya University. The estimated IPS shows good agreement with the observed IPS. We demonstrated the working of the simulation system using a typical halo CME event generated by a X9.3 flare observed on September 5, 2017. We found that the CME simulation that estimates IPS most similar to the observation can most accurately predict the time of arrival of the CME to the Earth. These results suggest that the accuracy of the CME arrival time will be improved if the current MHD simulations include IPS data.

キーワード：コロナ質量放出（CME）、宇宙天気予報、惑星間空間シンチレーション（IPS）、データ同化
Keywords: coronal mass ejection (CME), space weather forecasting, interplanetary scintillation (IPS), data assimilation

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

*塩田 大幸[1,2]、八代 誠司[3]、岩井 一正[2]
*Daikou Shiota[1,2], Seiji Yashiro[3], Kazumasa Iwai[2]

1. 国立研究開発法人 情報通信研究機構、2. 名古屋大学 宇宙地球環境研究所、3. 米国カトリック大学
1. National Institute of Information and Communications Technology (NICT), 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Catholic University

The predictions of CME arrival to the Earth and the southward magnetic field brought by the CMEs are one of crucial tasks for space weather forecast.
We have developed an MHD simulation capable of reproducing the interplanetary propagation of multiple CMEs with internal magnetic flux rope (Shiota & Kataoka 2016) called as SUSANOO-CME. The simulation solves propagation of solar wind and CMEs in the inner heliosphere from 25 solar radii where all the balk flow exceeds fast mode speed. The information of solar wind and CME is specified at the inner boundary with empirical and analytical models using real-time observations of the Sun and the corona.
Recently, we have been constructing a new prediction system of CME impacts (CME arrival and magnetic field) utilizing SUSANOO-CME with the real-time solar observations for the purpose of use in space weather forecast in NICT. The system is capable of preforming ensemble simulation with different sets of multiple CME input parameters, which is controlled from web-browser based interfaces. The results of ensemble simulation can be evaluated with real-time IPS observation in Nagoya University (the detail is reported by Iwai et al. submitted in this session). We will report the current status of the development and discuss the future directions.

キーワード：宇宙天気予報、コロナ質量放出、太陽風
Keywords: Space weather forecast, CME, solar wind

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

*伴場 由美[1,2]、井上 諭[1]、林 啓志[1,3,4]
*Yumi Bamba[1,2], Satoshi Inoue[1], Keiji Hayashi[1,3,4]

1. 名古屋大学宇宙地球環境研究所、2. 宇宙航空研究開発機構 宇宙科学研究所、3. Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences、4. State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences
1. Institute for Space-Earth Environmental Research/Nagoya University, 2. Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency, 3. Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, 4. State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences

The largest magnetic storm in solar cycle 24 was caused by a fast coronal mass ejection (CME) that was related to a small C9.1 flare that occurred on 15 March 2015 in solar active region (AR) NOAA 12297. The purpose of this study is to understand the onset mechanism of the geo-effective huge solar eruption. We focused on the C2.4 flare that occurred prior to the C9.1 flare of the filament eruption. The magnetic field structure in the AR was complicated: there were several filaments including the one that erupted and caused the CME. We hence carefully investigated the photospheric magnetic field, brightenings observed in the solar atmosphere, and the three-dimensional coronal magnetic field extrapolated from nonlinear force-free field modeling, using data from *Hinode* and *Solar Dynamics Observatory*. We found three intriguing points : (1) There was a compact but noticeably highly twisted magnetic field structure that is represented by a small filament in the C2.4 flaring region, where a tiny precursor brightening was observed before the C2.4 flare. (2) The C2.4 flaring region is located in the vicinity of a foot point of the closed field that prohibits the filament from erupting. (3) The filament shows a sudden eruption after the C2.4 flare and accompanying small filament eruption. From our analysis, we suggest that a small magnetic disturbance that was represented by the tiny precursor brightening at the time of the C2.4 flare is related to the trigger of the huge filament eruption.

キーワード：St Patrick's Day Storm、Solar Flares、Filament Eruption、Hinode、Solar Dynamics Observatory
Keywords: St Patrick's Day Storm, Solar Flares, Filament Eruption, Hinode, Solar Dynamics Observatory

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Critical Parameters of Photospheric Magnetic Field to Produce Eruptive Solar Flares and CMEs in Active Regions

*林 沛萱[1]、草野 完也[1]、塩田 大幸[2]、井上 諭[1]、KD レカ[1,3]、水野 雄太[1]
*Pei Hsuan Lin[1], Kanya Kusano[1], Daikou Shiota[2], Satoshi Inoue[1], KD Leka[1,3], Yuta Mizuno[1]

1. 名古屋大学宇宙地球環境研究所、2. 国立研究開発法人　情報通信研究機構、3. ノースウエストリサーチアソシエーツ
1. Institute for Space-Earth Environmental Research, Nagoya University, 2. National Institute of Information and Communications Technology, 3. NorthWest Research Associates

Solar flares and coronal mass ejections (CMEs) are eruptive phenomena caused by magnetic field in the solar corona. In particular, large eruptive events originate in active regions (AR) on the solar surface. However, it is still unclear what determines the capability of an AR to produce eruptive flares and CMEs, and it hinders our ability to predict CMEs. In this study, we propose a new parameter r_m to measure the possibility that a flare on an AR can be eruptive and produce a CME. The parameter r_m is defined by the ratio of the magnetic flux of twist higher than a threshold T_c to the overlying magnetic flux. The value of rm for each AR can be estimated using the nonlinear force-free field (NLFFF) extrapolation. Based on the data obtained by the Solar Dynamics Observatory (SDO)/Helioseismic and Magnetic Imager (HMI), we calculated the values of r_m for 29 ARs at 51 times before to flares larger than M5.0 class. We find that the foot-point of field lines with twist larger than 0.2 can well represent the flare ribbons, and we thus evaluated r_m for T_c=0.2 as a critical parameter for producing eruptive flares and CMEs using discriminant analysis. The result shows that r_m is moderately able to discriminate ARs which have capability to produce CME-accompanied flares.

キーワード：太陽物理、コロナ磁場、コロナ質量放出、太陽フレア
Keywords: solar physics, coronal magnetic field, coronal mass ejection, solar flare

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Simulation study on internal velocity field variation of eruptive prominence

*金子 岳史[1]、草野 完也[1]
*Takafumi Kaneko[1], Kanya Kusano[1]

1. 名古屋大学 宇宙地球環境研究所
1. Institute for Space-Earth Environmental Research, Nagoya University

Solar prominences, cool dense plasma clouds in the hot tenuous corona, sometimes erupt and evolve into coronal mass ejections. Prominence eruptions have attracted interest in the researches of space weather as well as solar physics. It is known that the interior of prominences is turbulent. Recent observational statistical studies reported that standard deviation of the Doppler velocity in the eruptive prominences started to increase several hours before eruptions even when the mean velocity was nearly zero. This finding is useful to predict prominence eruptions; however, the physical relationship between the magnetically-driven eruptive mechanisms (i.e., magnetohydrodynamic instabilities) and the internal velocity field variation of prominence has not been revealed.
In this study, we performed three-dimensional magnetohydrodynamic simulation including gravity, radiative cooling, and thermal conduction to reproduce eruption of turbulent prominence. In our simulation, a bipolar magnetic field is randomly introduced along the polarity inversion line of the sheared coronal arcade field. A magnetic flux rope is created by reconnection between the bipole and the coronal arcade field. Cool dense prominence is formed in the flux rope by radiative condensation. The prominence erupts after the flux rope exceeds the critical height of torus instability. Before the eruption, the height of flux rope axis monotonically increases; however, the velocity field inside the prominence has complicated distribution containing both upflows and downflows. We confirmed that the increase in standard deviation of the vertical velocity is quantitatively consistent with the observational results. To investigate the relationship with the magnetic field, we compared the histogram of the velocity components perpendicular and parallel to the magnetic field. As a result, we found that the upflows and downflows stem from perpendicular and parallel velocity, respectively. This result indicates that upflows and downflows are driven by Lorentz force and gravity along magnetic field, respectively. We also found that the increase in standard deviation of perpendicular velocity is larger than that of parallel velocity, suggesting that the increase in standard deviation of vertical velocity is caused mainly by increase in Lorentz force.

キーワード：太陽プロミネンス, フィラメント、プロミネンス噴出
Keywords: solar prominences, filaments, prominence eruption

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[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27日(月) 13:45 ~ 15:15 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:Antti Pulkkinen(NASA/GSFC)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

13:45 ~ 14:00

[PEM12-13] オーロラ・ジェット電流の大きさは予測できるか？

★招待講演

*海老原 祐輔[1]、田中 高史[2]、上吉川 直輝[3] (1.京都大学生存圏研究所、2.九州大学、3.三菱電機)

14:00 ~ 14:15

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

★Invited Papers

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

14:15 ~ 14:30

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

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

14:30 ~ 14:45

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

*中村 紗都子[1]、海老原 祐輔[1]、藤田 茂[2]、後藤 忠徳[3]、亘 慎一[4] (1.京都大学生存圏研究所、2.気象庁気象大学校、3.京都大学大学院工学研究科 、4.情報通信研究機構)

14:45 ~ 15:00

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

*菊池 崇[1,2]、海老原 祐輔[2]、橋本 久美子[3]、亘 慎一[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.吉備国際大学、4.情報通信研究機構)

15:00 ~ 15:15

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

*片岡 龍峰[1]、内野 志織[1]、藤原 康徳[1]、藤田 茂[1]、山本 和明[2] (1.国立極地研究所、2.国文学研究資料館)

オーロラ・ジェット電流の大きさは予測できるか？
Is intensity of auroral electrojet predictable?

*海老原 祐輔[1]、田中 高史[2]、上吉川 直輝[3]
*Yusuke Ebihara[1], Takashi Tanaka[2], Naoki Kamiyoshikawa[3]

1. 京都大学生存圏研究所、2. 九州大学、3. 三菱電機
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A large amount of energy (of the order of 10^{11} W) is consumed in the auroral ionosphere as Joule dissipation during the substorm expansion phase. The origin of the energy consumed in the auroral ionosphere is in the solar wind, but the energy flow and conversion in between are problematic. Previously, the energy consumed in the ionosphere is thought to consist of the directly driven (DD) component and the loading and unloading (UL) component. The DD component is thought to respond to the magnetic energy entering the magnetosphere, and hence, the DD component is probably predictable. The UL component, on the other hand, is thought to be unpredictable because it might depend on the amount of released energy in the lobe. On the basis of the global magnetohydrodynamics (MHD) simulation, we show that the maximum intensity of the auroral electrojet (and the Joule dissipation rate) during the substorm expansion is well correlated with the magnetic energy entering the magnetosphere. The correlation coefficient between them is 0.90 (and 0.97). There are a few key reasons. First, the amount of the released energy from the lobe increases with the southward component of interplanetary magnetic field (SBZ) and the solar wind velocity, meaning that the amount of the released energy is regulated by the solar wind parameters. Secondly, the magnetic energy released from the lobe goes into the near-Earth reconnection region, and seems not to contribute significantly to the generation of the field-aligned current associated with the substorm expansion. Thirdly, the release of the energy lasts for ~10 minutes, whereas the auroral electrojet keeps developing for 15 minutes and more. Fourthly, 40-90% of the magnetic energy entering the magnetosphere comes from the solar wind kinetic energy for the southward IMF. About 2% of the entering energy goes into the ionosphere during the expansion phase. The ratio is almost independent of the solar wind condition. These simulation results may suggest that the maximum intensity of the auroral electrojet (and the Joule dissipation rate) is predictable when the magnetic energy entering the magnetosphere is adequately predicted.

キーワード：サブストーム、オーロラジェット電流、電磁流体シミュレーション
Keywords: Substorm, Auroral electrojet, MHD simulation

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Geoelectromagnetics with the Geophysical Instrument Combination of Hydro-Québec, AUTUMNX, and USArray Magnetotellurics

*Martin G Connors[1], Sébastien Guillon[2], Adam Schultz[3], Naoto Imamura[3]

1. Athabasca University, 2. Hydro-Québec TransÉnergie, 3. Oregon State University

Geoelectromagnetics is a term used by Bolduc et al. (2000) regarding a pioneering study in which electric fields near a part of the Hydro-Québec transmission network were measured during an intense auroral event. To fully characterize space weather effects on an electric power transmission network, we must proceed from the source currents and their variations, through the changing magnetic fields near Earth’s surface, to the electric fields induced in the Earth and to some extent in the conducting structures directly, to electric currents flowing in the grid, and finally to the effects of such currents, ranging from voltage distortion to possible equipment damage. The more data can be measured at each link in this complex chain, the better will be our ability to monitor current events in a precautionary manner and assess the robustness of the grid to varying levels of stress.

The Hydro-Québec network has had enhanced monitoring capabilities (as well as improved ability to deal with geomagnetic stresses) since 1989 (Guillon et al., 2016). The last link of the chain, effects, is able to be well quantified, especially through measures of voltage distortion. Direct measurements of transformer grounding currents, essentially the geomagnetically induced currents (GIC) themselves, are available at a few points. The AUTUMNX magnetic network (Connors et al., 2015) complemented grid instrumentation in Québec starting in 2014, and has produced a new view of the association of magnetic variations with signals in the grid. Magnetotellurics (MT) tends to operate in campaign mode, but also measures the electric field, including at relevant low frequencies, giving a more complete indication of the geoelectromagnetic environment while also providing measurements of the frequency dependent electromagnetic impedance of the ground, which can be used to reconstruct the electrical conductivity structure of the Earth’s crust and mantle.

We illustrate these comprehensive geoelectromagnetic measurements with the case of the magnetic storm of September 7-9 2017, during which the NSF EarthScope MT array installed by Oregon State University was operating in the northeastern US, near the Hydro-Québec grid, at a time when the electrojet had expanded southward. We find a close correlation of times of large magnetic field variation, measured electric fields, and harmonic distortion in the grid.

While we note the complications stressed by Love et al. (2018), we feel that the enhanced MT monitoring advocated by Love et al. (2016), would give more knowledge of geological structure and geoelectric response in northeastern North America. In this way, our understanding of GIC would be greatly improved, in the areas of understanding basic processes and hazard assessment.

Bolduc et al., A Study of Geoelectromagnetic Disturbances in Québec, 2. Detailed Analysis of a Large Event, IEEE Trans. Power Delivery, 15, 272-278 (2000)
Connors et al., The AUTUMNX Magnetometer Meridian Chain in Québec, Canada, Earth, Planets and Space, 68:2(21pp.) , doi:10.1186/s40623-015-0354-4 (2015)
Guillon et al., A Colorful Blackout: The Havoc Caused by Auroral Electrojet Generated Magnetic Field Variations in 1989, IEEE Power and Energy, doi: 10.1109/MPE.2016.2591760 (2016)
Love et al. Geoelectric hazard maps for the continental United States, Geophys. Res. Lett., 43, 9415–9424

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(2016)
Love et al. Geoelectric hazard maps for the Pacific Northwest. Sp. Weather, 16, 1114–1127 (2018)

Keywords: space weather, geomagnetically induced currents, magnetometry, magnetotellurics, geomagnetic storms, instrument networks

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Quantifying the Latitudinal Extent of the Aurorae During Large Geomagnetic Storms

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As geomagnetic storms grow larger, the extent of the auroral ovals can be seen to travel further towards the equator. During the famous Carrington event for example, the aurora was reportedly seen as far South as Cuba. Accompanying the auroras are large electric currents in the ionosphere. The magnetic signature of these ionospheric currents can be detected on the ground in magnetic observatories around the world in the form of increased magnetic variations. These variations can lead to large local geoelectric fields, posing a risk to the operation of power networks around the world.

It is therefore necessary to estimate the extent of the aurora and accompanying geoelectric fields during infrequent and large-scale (1-in-100 year) events. Using three decades of historical geomagnetic data from around the world, we have developed a method to detect and quantify the extent of the auroral oval (or latitude threshold) using ground-based data. We use this to statistically estimate the southernmost extent for storms with Dst values < -600 nT, as well as the geoelectric field strengths at these latitude thresholds.

In addition, building on the work by Ngwira et al. (2014) by using magnetospheric and ionospheric magnetohydrodynamic simulations, we simulate 'worst-case' scenario superstorms of different magnitudes. Applying our threshold detecion to the magnetic field outputs of these simulations enable us to estimate the latitude thresholds for storms of magnitudes not seen in the modern era.

Keywords: Aurora, Geomagnetism, Geostorms

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

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We evaluate geomagnetically induced currents (GICs) flowing in the Japanese power grid during severe space weather by using several methods. First, the three-dimensional distribution of the geomagnetically induced electric field (GIE) was calculated by using the 3D finite-difference time-domain (FDTD) method with a three-dimensional electrical conductivity model constructed from a global relief model and a global map of sediment thickness. To simulate a time evolution of magnetic storms, the sheet current with its intensity inferred from the ground magnetic disturbance for famous magnetic storms is imposed. We compared the calculated GICs with the observed ones at substations around Tokyo, and found a certain agreement when the uneven distribution of GIE is incorporated with the simulation. The simulation result shows that GIE exhibits localized, uneven distribution that can be attributed to charge accumulation due to the inhomogeneous conductivity below the Earth's surface. The charge accumulation becomes large when the conductivity gradient vector is parallel, or anti-parallel to the incident electric field. For given GIE, we calculated the GICs flowing in a simplified 500 kV power grid network in Japan. The influence of the inhomogeneous ground conductivity on GIC appears to depend on a combination of the location of substations and the direction of the source current. Second, we assume conductivity anomaly simulating a plate boundary to test the effect of large-scale underground structure on GICs. We find that these structures may strongly enhance GIC just above them. Finally, we derive transfer functions between the GIC observation at 4 substations in Japan and geomagnetic field recorded at the Kakioka station. The transfer functions are not always applicable for Japanese GIC. We will discuss the validity of the assumption of uniform ground and influence of the time variation of earthing resistance of substations.

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Reproducibility of the geomagnetically induced currents in Hokkaido with a two-layer conductivity model

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*Takashi Kikuchi[1,2], Yusuke Ebihara[2], Kumiko K. Hashimoto[3], Shinichi Watari[4]

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1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Institute for Sustainable Humanosphere, Kyoto University, 3. Kibi International University, 4. National Institute of Information and Communications Technology

Watari et al. [SW 2009], based on the GIC measurements in Hokkaido, Japan (35.7 GM Lat), found that the GIC is well correlated with the y-component magnetic field (By) (correlation coefficients > 0.8) and poor correlations with Bx,z and dBx,y,z/dt. The good correlation between the GIC and By would help predict the GIC if we have capabilities of reproducing the magnetosphere-ionosphere currents responsible for ground magnetic disturbances. To use the GIC- By relationship for the GIC prediction, we need to clarify if the good correlation is valid for any period/time scale (T) of disturbances. To address this issue, we made correlation analyses for the geomagnetic sudden commencements and pulsations (T=1-10m), substorm positive bays (30m), quasi-periodic DP2 fluctuations (20-60m), and geomagnetic storms (1-20h) as well as quiet-time diurnal variations (3-12h). We found that the correlation is good for short period (cc > 0.8 for T < 1 h), but poor for long periods (cc < 0.3 for T > 6 hours). Using the conventional induction theory based on the Faraday’s, Ampere’s and Ohm’s laws, we calculated the electric field (GIE) induced by By as a convolution of dBy/dt and step response of a uniform conductor. The GIE is found to be better correlated with the GIC for the long-period disturbances (cc > 0.9), whereas the correlation with By remains better for short period disturbances. This result requires us to use two models depending on the period of disturbances. To obtain a model applicable to any period, we made constructed a two-layer model with higher conductivity on the top. We show that the two-layer model is capable of reproducing the GIC with high correlations (cc > 0.9) for any period of disturbances ranging from 1 min to 10 hours. It should be noted; however, the capability of the model may depend on the direction of the power transmission line relative to the coast line and also depend on the structure of the Earth’s conductivity.

キーワード：地磁気誘導電流、北海道、電気伝導度2層モデル
Keywords: geomagnetically induced current, Hokkaido, two-layer conductivity model

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

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*Ryuho Kataoka[1], Shiori Uchino[1], yasunori Fujiwara[1], Shigeru Fujita[1], Kazuaki Yamamoto[2]

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1. National Institute of Polar Research, 2. National Institute of Japanese Literature

A fan-shaped aurora was photographed at Memambetsu, Hokkaido Japan during a great magnetic storm on Feb 11, 1958. This is the first and oldest photograph record of auroras as observed in Japan, and many hand-written drawings were also recorded at the same time during the February 1958 event, giving a rare opportunity of the coexistence of photograph images and hand-written drawings. In fact, the combination of photographs and drawings of the 1958 event reminds us of the great red aurora with fan-shaped white pillars as illustrated during other great magnetic storms in 1872 and in 1770. From the analysis of newly digitized microfilm data, it is also found that the fan-shaped aurora appeared during the peak activity of magnetic storm, and moved westward at 0.4 km/s at 400 km altitude at 38-40 deg magnetic latitudes, which is consistent with the enhanced convection pattern in middle latitude during storm time. Such a fan-shaped aurora can be a fundamental characteristic of middle-latitude evening-to-midnight auroras during great magnetic storms, which show the most destabilized transient appearance of the inner magnetosphere.

キーワード：オーロラ、磁気嵐、史料
Keywords: aurora, magnetic storm, historical records

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[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27日(月) 15:30 ~ 17:00 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:草野 完也(名古屋大学)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

15:30 ~ 15:45

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

★Invited Papers

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

15:45 ~ 16:00

[PEM12-20] NICT宇宙天気予報センターにおける宇宙天気予報担当の業務

★招待講演

*酒井 光資[1]、鵜川 健太郎[1]、川原 健太郎[1]、石井 守[2]、久保 勇樹[2] (1.株式会社セック、2.国立研究開発法人情報通信研究機構)

16:00 ~ 16:15

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

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

16:15 ~ 16:30

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

*関 大吉[1,2,3] (1.京都大学大学院総合生存学館、2.ケンブリッジ大学極端リスク研究センター、3.京都大学大学院理学研究科附属天文台)

16:30 ~ 16:45

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

*西塚 直人[1]、久保 勇樹[1]、杉浦 孔明[1]、田 光江[1]、石井 守[1] (1.国立研究開発法人　情報通信研究機構)

16:45 ~ 17:00

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

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

Application Usability Levels: Their evolution and eco-system

*Alexa Jean Halford[1], Adam Kellerman[2], Jeff Klenzing[3], Katherine Garcia-Sage[3], Brett A Carter[4], Daniel T Welling[5], Barbara Thompson[3], Antti A Pulkkinen[3]

1. The Aerospace Corporation, 2. UCLA, 3. NASA/GSFC, 4. RMIT, 5. UT Arlington

As space physics becomes both more interdisciplinary and more intertwined with commercial and government operations, there is a need for a framework to easily identify what projects can be used for specific applications and how close each project is to routine autonomous or on-demand implementation and operation. We have developed the Application Usability Level (AUL) framework and encourage publication of instrument-like papers for delivering and publicizing AULs to help the community quantify the progress of successful applications, metrics, and validation efforts.

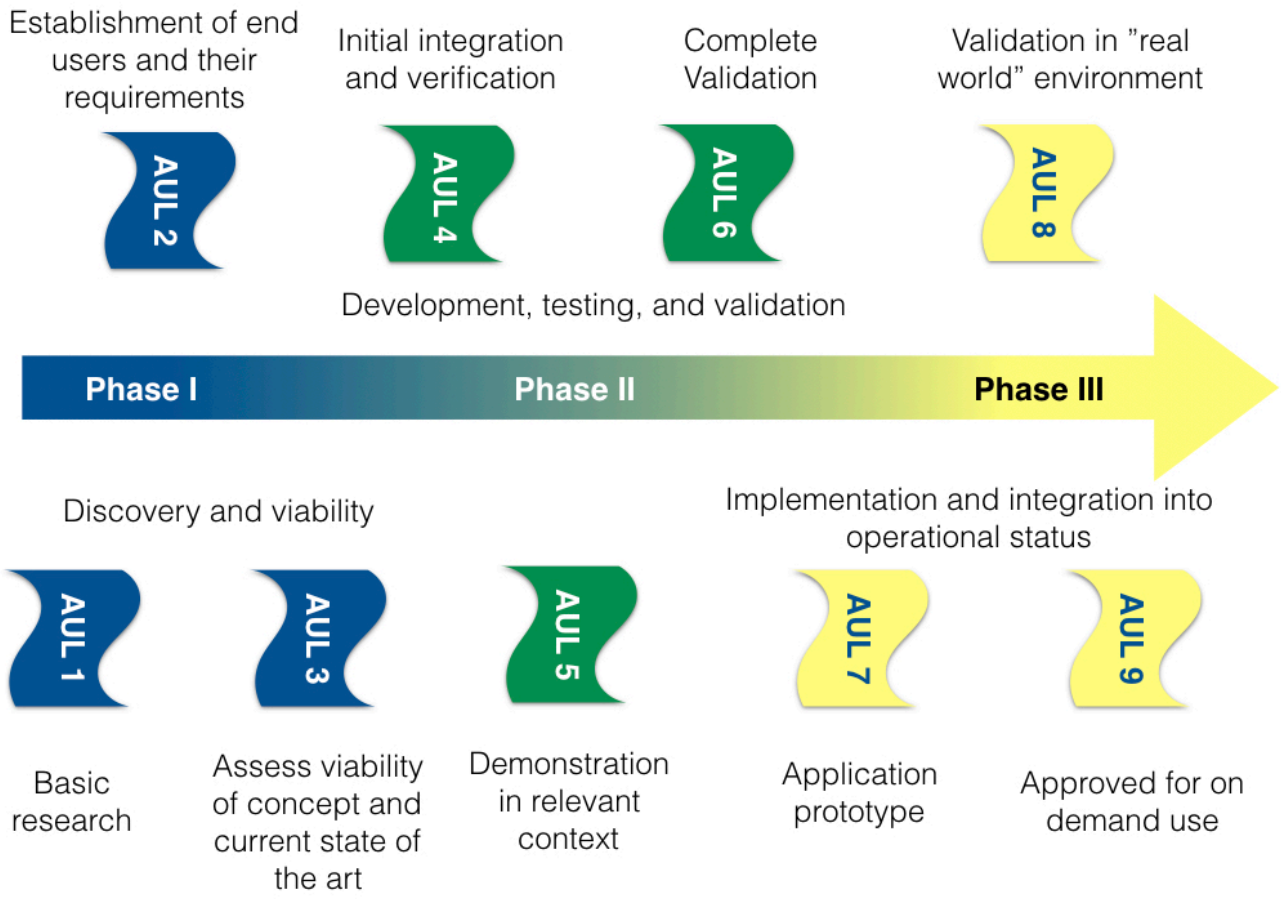
In a given project within the AUL framework, there is typically a diverse eco-system of individuals necessary to ultimately produce a useful space weather product or productive research collaboration. For example, in the case of non-academic fields, users and researchers alike may benefit from a translator, i.e. a *broker*, who may help with the effective transition from research to operations. *Independent validators* are another essential player for validation efforts and comparing like products for a specified application. In many cases, the different players throughout the process will act in multiple roles as well as act in different roles for different projects and AUL pathways.

This paper we discuss the collaborative roles that lead from basic research to successful application within or outside the scientific community and provide examples of how this collaborative application ecosystem is maintained. We will also provide examples of space weather projects using the AUL framework, and show how it can contribute to the project's success. As always, a healthy eco-system can result in benefits for the end user and new exciting research opportunities.

This work has been completed as part of the activities of the Assessment of Understanding and Quantifying Progress working group which is part of the International Forum for Space Weather Capabilities Assessment.

Keywords: Tracking progress, Research to operations, Space Weather

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NICT宇宙天気予報センターにおける宇宙天気予報担当の業務
The Operational Space Weather Forecast at NICT, Japan

*酒井 光資[1]、鵜川 健太郎[1]、川原 健太郎[1]、石井 守[2]、久保 勇樹[2]
*Kosuke Sakai[1], Kentaro Ukawa[1], Kentaro Kawahara[1], Mamoru Ishii[2], Yuki Kubo[2]

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1. Systems Engineering Consultants Co., LTD., 2. National Institute of Information and Communications Technology

情報通信研究機構宇宙天気予報センターでは、宇宙天気の最新24時間概況と今後の予報情報の公開および配信を行っている。
宇宙天気情報の配信は、ISES Regiona Warning Center, Japan として50年以上継続して実施している365日の運用業務であり、その業務を担うのが宇宙天気予報担当員である。
担当員は、毎日、国内外から提供される様々な観測データやシミュレーション結果を収集・分析し、今後24時間の予報を決定するための資料を作成する。
その後、14:30頃に宇宙天気予報会議を開催し、各現象の専門研究者との議論に基づき予報を決定し、16時までに予報を配信する。
月次の定例会を開催し、予報結果を考察し、予報精度向上のためにフードバックしている。
そして、顕著な宇宙天気現象が発生した場合は、即座に臨時情報を配信している。
本発表では、宇宙天気予報担当員の日々の業務内容や予報内容を決定するまでの手順について実際の事例とともに紹介する。
また、年間365日毎日休みなく運用するための工夫などについても紹介する。

キーワード：宇宙天気
Keywords: Space Weather

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PROGRESS: An overview of data products

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1. University of Sheffield

PROGRESS, an EC Horizon 2020 funded project, used state of the art modelling techiniques inorder to derive forecasts for the evolution of geomagnetoc indices, and the fluxes of electrons at geostationary orbit and within the inner magnetosphere. This presentation provides a review of the aims of PROGRESS and an overview of the tools developed to meet these aims.

Keywords: radiation belt forecasts, geomagnetic index forecasts

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The Probability of Satellite Anomalies by a Disastrous Solar Flare

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1. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 2. Centre for the Study of Existential Risk, University of Cambridge, 3. Astronomical Observatory, Kyoto University

The Sun has a potential risk of various socioeconomic impacts on our human society. It often produces various eruptive phenomena such as a solar flare and a coronal mass ejection, which sometimes bring adverse effect to us like satellite anomalies, radiation exposure, and huge blackouts. Recently, it was revealed that a “super-flare”, a flare whose energy is 100 times larger than X10-class flare, can occur once in 1000 years from statistical and theoretical points of view [Maehara et al. 2012, Shibayama et al. 2013, Shibata et al. 2013].

However, though there are many assessment studies of “moderate” solar eruptive phenomena, the assessment of “disastrous” solar eruptive phenomena like a super-flare has been little conducted. For this reason, this research aims to evaluate the frequency (or probability) and the possible socioeconomic damage of a super-flare, especially focusing on satellite anomalies.

Using various data sets about satellites, their anomalies, flares, and plasma environment around the Earth*, 154 X-class flare events with 9 relating parameters (peak flux of X-ray (0.1–0.8 nm), integral fluxes of electron (> 2 MeV) and of proton (> 1, 5, 10, 30, 50, 60, 100 MeV)) were selected. To avoid multi-collinearity, Ridge regression model was used to compute the regression to the satellite anomaly rate (1/satellite/event). Also 10-fold cross validation was performed. After obtaining the model, the possible plasma parameters in case of X1000-class flare assumed by Takahashi et al. 2016 were input into the model.

As a result, we obtained the model with its coefficient of determination of 0.607 and its Pearson correlation coefficients of 0.691 ±0.212 (for 100 times randomly chosen dataset). Assuming that electron and proton with any energy follow the same scaling law, with applying scaling law by Takahashi et al. 2016, 0.573 satellite anomaly rate (57.3% per satellite per event) was obtained. It should be noted that the scaling law provided by Takahashi et al. 2016 is upper limit, so in the actual case, rate should be lower. The validity of assumption, the comparison between this research and others (Pilipenko et al. 2006; Iucci et al. 2005; Odenwald et al, 2006, 2007), and the possible socioeconomic loss will be also discussed.

* NOAA NGDC Spacecraft Anomaly Data, Satellite Catalogue (https://www.celestrak.com/satcat/search.php), NOAA GOES flare report (https://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-features/solar-flares/x-rays/goes/xrs/) , and OMNI 2 database

キーワード：宇宙天気、人工衛星障害、スーパーフレア
Keywords: space weather, satellite anomaly, super-flare

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Operational Forecasting of Solar Flares using Deep Neural Network

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Solar flares are the largest explosive phenomena in the Heliosphere. They affect the earth by X-ray and UV emissions, high energy particles, and magnetic storms, causing troubles of satellites and blackout in a large area. To reduce the risk of social impact caused by solar flares and space weather, it is very important to predict solar flares with high accuracy. In our institute NICT, we have predicted solar flares in the daily forecasting meeting by an empirical method. However, the amount of solar observation data is so huge that we cannot deal with all the data by hands.

Here we developed an operational system of solar flare prediction using a deep neural network (DNN), named Deep Flare Net (DeFN; Nishizuka et al. 2018 ApJ), and we started to run it in the operation. The model can predict probabilities of the maximum class of flares occurring in the following 24 hr. The training dataset is maded by 3x10^5 images during 2010-2015 taken by SDO, from which we detected active regions and calculated 79 features for each region attached with the flare occurrence labels (X, M, C). We used features in our previous work (Nishizuka et al. 2017) and added novel features for operational prediction: coronal hot brightening at 131 A (T=10^7 K) and the histories of X-ray and 131 A emissions 1 and 2 hr before an image. The prediction data in the near real-time is downloaded from JSOC server operated by Stanford University and NASA, and all the active regions and features are automatically detected and calculated. The prediction results will be shown in the web site of NICT. In this talk, we will introduce our DeFN model and operational forecasting system and would like to discuss how it works in the daily operations.

キーワード：太陽フレア、宇宙天気、機械学習、予測、運用
Keywords: Solar Flare , Space Weather, Machine Learning, prediction, Operation

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Spring-Autumnal asymmetry in geomagnetic activity and its origin over last 140 years

*Hao Luo[1], Xiaoming Sha[1]

1. IGGCAS

Spring-Autumnal asymmetry (SA asymmetry) from years 1873-2010 in the geomagnetic activity is investigated based on the geomagnetic indices (aa, Ap and Kp). Results have shown that in general the SA asymmetry of the geomagnetic activity appears to be alternation, except for the interval during which the change of dominant solar dipole magnetic field polarity occurs. Our study implies that both the polarity of the main solar dipole field and the north-south asymmetry of the sunspot area in the two solar hemispheres control the strength of the south component (*Bs*) of the interplanetary magnetic field (IMF) near the Earth and the resulting SA asymmetry of the geomagnetic activity in the corresponding seasons. A simple sector structure model is devised to establish the relationship between the polarity of solar main dipole magnetic field, the IMF *Bs* component and the corresponding SA asymmetry in the geomagnetic activity. This is confirmed by examining the solar wind parameters from the spacecraft observations during the recent decades.

Keywords: Spring-Autumnal asymmetry, Solar magnetic polarity

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[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27日(月) 15:30 ~ 17:00 | 301B 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: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)

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。

15:30 ~ 15:45

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

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

15:45 ~ 16:00

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

*渡辺 路生[1]、建部 洋晶[1]、鈴木 立郎[1]、立入 郁[1] (1.海洋研究開発機構)

16:00 ~ 16:15

[AOS09-20] A Wave Resolving Simulation for Upper Ocean Turbulence Driven by Wave-Current Interaction

*吉川 裕[1]、藤原 泰[1]、松村 義正[2] (1.京都大学大学院理学研究科、2.東京大学大気海洋研究所)

16:15 ~ 16:30

[AOS09-21] **Revisiting the Characteristics of Mixing Efficiency in the Brazil Basin**

*伊地知 敬[1]、Louis St. Laurent[1]、Kurt Polzin[1] (1.ウッズホール海洋研究所)

16:30 ~ 16:45

[AOS09-22] Instabilities of finite-amplitude internal wave beams

*大貫 陽平[1]、田中 祐希[2] (1.九州大学応用力学研究所、2.東京大学大学院理学系研究科地球惑星科学専攻)

16:45 ~ 17:00

[AOS09-23] Evaluation of nutrient flux enhanced by double diffusion in the Kuroshio using glider measurements

*李 根淙[1]、山本 龍[1]、安田 一郎[1]、田中 雄大[2] (1.東京大学　大気海洋研究所、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)

Searching 18.6 year tidal modulation impact in a global gridded ocean oxygen dataset with its improvements

*Shoshiro Minobe[1]

1. Earth and Planetary Sciences, Faculty of Science, Hokkaido University

The 18.6 year modulation of tidal mixing plays important roles in the ocean as reported by regional analyses by Osafune and Yasuda (2006, 2010) and others. In those studies, they found that ocean water properties including dissolved oxygen concentration vary at the 18.6 year period in a manner consistent with the vertical mixing changes due to the tidal mixing modulation. Dissolved oxygen concentration is interesting not only as a tracer but also because it is important in marine ecosystems. In particular, superposition of 18.6 year variability in addition to the oxygen decline trend known as the ocean deoxygenation due to the global warming can cause more serious damages for marine animals in the specific phase of tidal modulation.

The present study aims to understand the impacts of 18.6 year tidal mixing modulation in the ocean oxygen field more systematically than the previous studies did by analyzing a global gridded dataset of dissolved oxygen concentration. A preliminary analysis using the dataset used by Ito et al. (2017 GRL) for upper 1,000 m indicates that the 18.6 year variation of oxygen concentration also occurs in regions where previous studies did not reported tidal modulation influence, including a region near the Izu-Ogasawa Ridge. In order to obtain the better spatial and temporal coverage, the dataset is and will be improved with two steps. One is to expand its vertical coverage to the top 1,000 m to 6,000 m, and the other is to use the latest version of the World Ocean Database released in September 2018. The first step has been completed, and the second step is planned to be completed in this summer. At the presentation, the analysis results based on the latest gridded dataset will be shown.

Keywords: decadal variability, biogeochemistry, climate variability and change

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Contribution of tidal energy dissipation to variations of transient climate response and steric sea level rise through ocean heat uptake

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Micro-scale turbulent mixing due to tide-induced internal wave breaking is a key process to determine the strength and pattern of the global ocean overturning circulation, that redistributes the heat all over the world ocean. Heat redistribution in the ocean have a strong impact on ocean heat uptake (OHU), thus transient climate response (TCR) and steric sea level rise (SLR) under the global warming. To study the impact of the vertical diffusivity distribution on the TCR and steric SLR, we ran a climate model of which value of CO_2 concentration is increased by 1% yr^{-1} for 150 years, employing each of two vertical diffusivity distributions in the ocean, an empirical one-dimensional one (CTRL) and a three-dimensional one considering tidal energy dissipation (TED). In TED under the pre-industrial forcing, the larger sea ice in the Southern Ocean prevents the air-sea heat flux, leading to weaker bottom water formation and lower air temperature than in CTRL. The less effective heat transport to the deep layers in TED causes less OHU and larger TCR than in CTRL by about 0.16˚C. In addition, smaller ocean heat content change in TED than in CTRL leads to significant future sea-level depression of ˜0.4 m in the Southern Ocean. Since OHU under the global warming is controlled by the distribution of vertical diffusivity, it is necessary to clarify its global distribution in the real ocean for reliable TCR estimation and future SLR projection.

キーワード：鉛直拡散係数、過渡的気候応答、海面上昇、地球温暖化、気候モデル、海洋熱吸収
Keywords: diapycnal diffusivity, transient climate response, sea level rise, global warming, climate model, ocean heat uptake

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A Wave Resolving Simulation for Upper Ocean Turbulence Driven by Wave-Current Interaction

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Turbulence in the upper ocean sets bulk properties of the upper ocean. For example, turbulence deepens the surface mixed layer (ML) and entrains low-temperature water below the layer to determine the ML depth and sea surface temperature (SST), which are key parameters for large-scale ocean and climate processes. Quantitative evaluation and parameterization of the upper ocean turbulence thus have crucial importance on the large-scale studies.

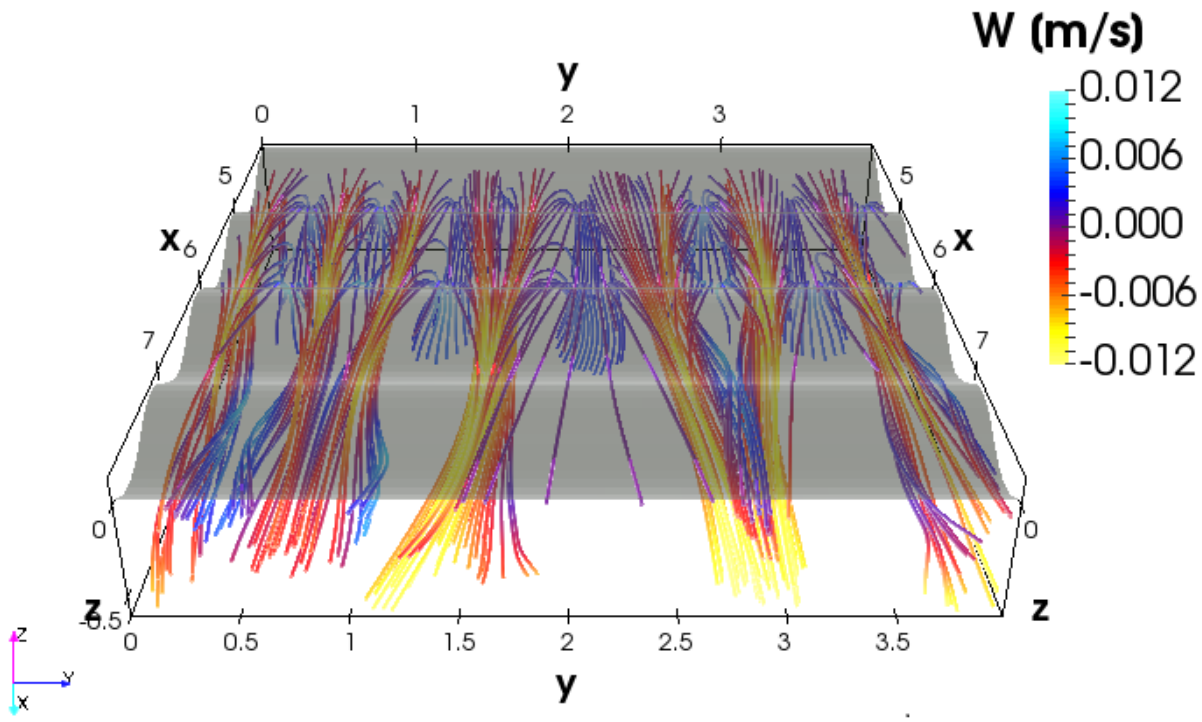
Recent studies revealed that turbulence induced by the surface wave has larger impact on the ML deepening than ever considered. Good example is drastic deepening of the ML and significant decrease in SST simulated in the summer Southern Ocean if parameterized wave-induced mixing is included in the simulation (e.g., Li et al. 2016). Among three types of wave-induced turbulence, surface wave breaking, Langmuir turbulence (LT) and nonbreaking-wave induced turbulence (NBWT), the latter two are considered to have significant impacts on the ML deepening. LT is associated with Langmuir circulations (LCs), the secondary circulations driven by the surface waves interacted with the wind-driven currents (e.g., Leibovich 1980). Previous theoretical studies (Craik and Leibovich 1976) showed that the interaction can be represented solely by the vortex force, vortex tilting by the Stokes drift (the Lagrangian velocity due to the surface wave) in the wave-filtered momentum equation. Many simulations with this vortex force representation have been performed so far (e.g., Skyllingstad and Denbo 1995). However, this theoretically-derived representation has not been validated by field or numerical experiments. As a consequence, there are controversial discussions about the validity of the representation and hence the simulation results with the representaion (e.g., Mellor 2016 and Ardhuin et al. 2017). NBWT on the other hand is suggested to be caused without winds (e.g., Qiao et al. 2004; Babanin 2006), but no detailed mechanism was proposed for the turbulence generation. As a result, some people consider that NBWT is the same as LT, even though LT is dependent on winds while NBWT is not. Thus, mechanism of the wave-induced turbulence is not clearly understood.

The present study is intended to clarify dynamics involved in the wave-induced turbulence. To this aim, we developed a new numerical model in which surface waves are explicity and accurately simulated. This wave-resolving simulation provides an unique opportunity to investigate how the surface waves drive / induce turbulence. We used this model to simulate LC at first (Fujiwara et al. 2018). A wave-tank simulation was performed in which a monochromatic surface wave propagated in the surface wind direction. We found that LCs were successfully reproduced through the wave-current interaction (see attached figure). Vorticity analysis showed that the interaction is well represented by the vortex force. We also performed the simulation without the surface wind, and found that NBWT was certainly generated. The virtual wave stress was found to be a key for NBWT generation in our simulation, which induced velocity shear near the surface that interacted with the surface wave as was found in the LC simulation. The wave-resolving simulation also provided an alternative Eulerian view of the vortex force that was

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originally viewed from the Lagrangian frame (Stokes drift), that is, rectified vortex tilting/shrinking/streatching by orbital motions of the surface waves.

キーワード：海洋表層乱流、波・流れ相互作用、ラングミュア循環、非砕波乱流
Keywords: Upper Ocean Turbulence, Surface Wave - Current Interaction, Langmuir Circulation, Non-Breaking Wave Turbulence



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Revisiting the Characteristics of Mixing Efficiency in the Brazil Basin

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It is still controversial whether or not the dissipation flux coefficient Γ, often referred to as the “mixing efficiency”, is a global constant of 0.2. A primary justification for continuing to use this conventional value comes from a number of dedicated tracer-release/microstructure surveys done over the past three decades. Most notably, studies in the Brazil Basin have been the basis for examining the characteristics of mixing in the abyssal interior of the global ocean. Here, using recent microstructure data also collected in the Brazil Basin, we revisit the characteristics of Γ in the abyssal interior. It is shown that Γ, estimated from averaged profiles of the TKE dissipation rate and the thermal variance dissipation rate, actually lies around 0.2 in the pycnocline, but on the other hand, it tends to increase up to 0.4-0.8 toward the bottom. Such near-bottom high efficiency appears to be associated with weak stratification in the bottom water. Furthermore, one microstructure profile appears to reach down to within the thin bottom boundary layer: Γ abruptly decreases to $O(10^{-2})$ within 50 m above the bottom, which is reasonable given the no buoyancy flux condition at the bottom. We will also examine these results using the earlier generation microstructure datasets collected in the Brazil Basin.

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Instabilities of finite-amplitude internal wave beams

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Previous studies have shown that instability of small-amplitude internal wave beams, generated by a surface tide flowing over topography, is most significant at a particular latitude where parametric subharmonic instability (PSI) excites inertial oscillations. Here we extend the discussion to the case of finite-amplitude beams using a new kind of Floquet approach. The disturbance growth rate obtained is quantified in terms of two non-dimensional parameters A and F: velocity shear divided by the buoyancy frequency and the Coriolis parameter divided by the beam frequency. If A is small, PSI is indeed the principle mode under the condition $F < 0.5$ with the maximum growth rate achieved when the equality holds. As A is increased, however, instability comes to occur even for $F > 0.5$ but the location of the maximum instability shifts towards lower F, thus totally changing its latitudinal dependence. The resulting energy spectrum is significantly Doppler shifted, and therefore distinguished from that made by PSI. These findings are useful to quantify the energy loss of internal wave beams that causes water mixing prevailing in the major generation sites of internal tides.

キーワード：内部波、不安定、海水混合
Keywords: internal wave, instability, ocean mixing

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Evaluation of nutrient flux enhanced by double diffusion in the Kuroshio using glider measurements

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Kuroshio is a very strong current, western boundary current of North Pacific subtropical current system. Strong vertical mixing intensifies through various physical processes were reported in the vicinity of the Kuroshio system. Consequently, this enhanced mixing is considered to supply the nutrients from the lower layer to the euphotic layer and improve the biological productivity.

Extensive measurements were carried out to investigate the detailed structures of turbulence, hydrography, chlorophyll-a using a glider, SeaExplorer manufactured by Alseamar whose 1st science mission, equipped with two shear probes, fast response thermistor, CTD, dissolved oxygen sensor, fluorometer. The fine measurement of 66 casts lasted for 7 days during 20-27, June 2017. Although only 30 % of data acquired by shear probe were survived under the criterion following Peterson et al., (2014), a newly developed method estimating turbulent intensity using a FP07 sensor was introduced.

While, calculated vertical nutrient flux is not quite high supporting biological productivity as we expected. Contribution of double diffusion which intensify the vertical diffusivity could be considered as development of chlorophyll-a patch at subsurface. Previous research already introduced the possibility of enhanced mixing from double diffusion (Nagai et al., 2015, Inoue et al., 2007) and Hamilton et al., (1989) showed underestimation of vertical nutrient flux without using vertical eddy diffusivity for salt in case of salt finger. Interacted with low salinity water which was occurred during our mission show another evidence for supporting this hypothesis.

Following the parameterization of McDougall and Ruddick (1992), mixing efficiency for salt finger and enhancement of salt(nutrient) flux were estimated to be somewhat effective. Parameterized nutrient flux in salt finger favorable layer is 37% larger than the turbulent nutrient flux accepting mixing efficiency 0.2 proposed by Osborn et al., (1980). This value needs to be examined through statistical approach or more careful insight and will be discussed later.
The full path of glider shows Kuroshio interact with various waters with different salinity and temperature. For example, low salinity and low temperature water intruded at subsurface during 23-24, June. Around 600 m during 26-27, June we also found salinity minimum which was assumed with North Pacific Intermediate Water. This feature reminds us considerable nutrient flux with vertical mixing by double diffusive processes in addition to mechanical turbulence. Double diffusive process might be attributed to the intrusion, development, modification of relatively low salinity waters. We found double diffusive regime occurs especially at upper boundary of relatively low salinity layer.

キーワード：鉛直混合、二重拡散、栄養塩フラックス、黒潮
Keywords: Vertical mixing, Double diffusion, nutrient flux, Kuroshio

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[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27日(月) 9:00 ~ 10:30 | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

コンビーナ:伊藤 進一(東京大学大気海洋研究所)、平田 貴文(北海道大学地球環境科学研究院)、Enrique N Curchitser(Rutgers University New Brunswick)、Eileen E Hofmann(Old Dominion University)、座長:伊藤 進一(東京大学)

The ocean accounts for about 50% of global net primary production. This production is significant for carbon cycling and ecosystem functioning, and is related directly or indirectly to a variety of climatic and ecological phenomena. The responses to natural and anthropogenic environmental stressors that influence marine production and diversity can cause perturbations to marine ecosystems that alter trophic dependencies and interactions among organisms at a range of space and time scales. Quantification of the principal mechanisms driving spatio-temporal variability of marine ecosystem remains to be done, especially in terms of evaluation of uncertainty in responses. As a result, evaluating vulnerability of marine ecosystems to environmental change requires systematic and holistic approaches that integrate physics to ecology and are based in observations and modelling. In addition, expectations to deliver these science to public society is raising. This session aims to provide a venue for not only discussing recent advances in understanding marine biogeochemical cycles, ecosystems and their interactions, but also networking with a variety of people to seed new ideas in marine ecological research. Observational, modeling and conceptual studies, including technological development and operational applications, that consider linkages among biogeochemical and ecosystem processes, biodiversity, and the effects of multiple stressors from molecular to planetary scales are encouraged.

9:00 ~ 9:10

Introduction

9:10 ~ 9:30

[AOS12-01] Projected coastal hypoxia in a coupled bio-physical model of the California Current System.

★Invited Papers

*Enrique N Curchitser[1]、Raphael Dussin[1,2]、Charles Stock[3]、Nicoals van Oostende[4] (1.Rutgers University New Brunswick、2.Lamont-Doherty Earth Observatory of Columbia University、3.NOAA Geophysical Fluid Dynamics Laboratory、4.Princeton University)

9:30 ~ 9:45

[AOS12-02] **Decadal salinity variation in the western North Pacific correlated with the strength of the Oyashio and the Kuroshio Extension**

*金子 仁[1]、奥西 武[2]、纐纈 慎也[3]、伊藤 幸彦[1]、瀬藤 聡[4]、黒田 寛[5]、清水 勇吾[4] (1.東京大学 大気海洋研究所、2.水産教育・研究機構 東北区水産研究所、3.海洋研究開発機構、4.水産教育・研究機構 中央水産研究所、5.水産教育・研究機構 北海道区水産研究所)

9:45 ~ 10:00

[AOS12-03] **Multiscale routes to supply nutrients through the Kuroshio nutrient stream**

*長井 健容[1]、Clayton Sophie[2]、内山 雄介[3] (1.東京海洋大学 海洋環境科学部門、2.Ocean, Earth & Atmospheric Sciences, Old Dominion University、3.神戸大学)

10:00 ~ 10:15

[AOS12-04] **Seasonal variability of upper-ocean primary production around the Kuroshio analyzed using a ROMS-NPZD model**

*Xu Zhang[1]、Yusuke Uchiyama[1,2]、Yota Suzue[3]、Hidekatsu Yamazaki[4] (1.Kobe University、2.Port and Airport Research Institute、3.Construction Technique Institute Engineering Co., Ltd.、4.Tokyo University of Marine Science and Technology)

10:15 ~ 10:30

[AOS12-05] Nutrient and light conditions at subsurface chlorophyll maximum: physical-biogeochemical observations along a mid-Pacific meridional transect

*伊藤 幸彦[1]、金子 仁[1]、纐纈 慎也[2]、奥西 武[3]、小川 浩史[1]、佐藤 光秀[4]、齊藤 宏明[1] (1.東京大学大気海洋研究所、2.海洋研究開発機構、3.水産研究・教育機構 東北区水産研究所、4.香港科技大學)

Projected coastal hypoxia in a coupled bio-physical model of the California Current System.

*Enrique N Curchitser[1], Raphael Dussin[1,2], Charles Stock[3], Nicoals van Oostende[4]

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Recent observations have shown an increase of the hypoxic area on the shelf in the California upwelling system. Climate projections suggest this increase would continue over the 21st century. However, the low-resolution ocean component of today’ s climate models in this region are hampered by the flawed representation of upwelling and coastal processes.To achieve a more realistic solution, we ported the NOAA-GFDL biogeochemical model COBALT into the regional ocean model ROMS permitting a seamless representation of the biogeochemistry across scales. With the 7km California Current implementation, we carry out sensitivity experiments for the projected changes in biogeochemical and physical drivers of coastal hypoxia : oxygen and nutrients in source waters, solubility and upwelling-favorable wind. We describe here the results obtained and assess the relative impact of drivers of coastal hypoxia in this system.

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Decadal salinity variation in the western North Pacific correlated with the strength of the Oyashio and the Kuroshio Extension

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*Hitoshi Kaneko[1], Takeshi Okunishi[2], Shinya Kouketsu[3], Sachihiko Itoh[1], Takashi Seto[4], Hiroshi Kuroda[5], Yugo Shimizu[4]

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1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Japan Agency for Marine-Earth Science and Technology, 4. National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 5. Hokkaido National Fisheries Research Institute, Japan Fisheries Research and Education Agency

Decadal changes in salinity around the density (~1026.8 kg m^{-3}) of North Pacific Intermediate Water (NPIW) were investigated in the regions from the Oyashio to the Kuroshio Extension (KE), called as the Mixed Water Region (MWR), based on the long-term-data-sets provided from numerical reanalysis. Based on the reanalysis data provided by an ocean forecast system of the Japan Fisheries Research and Education Agency (FRA-ROMS; 1992–2012, horizontal resolutions of 0.1˚), we found that during increase of the Oyashio velocity in the upstream region, negative salinity anomaly accompanied with the southward velocity at the density was enhanced between 144–145˚E just south of 40˚N. In addition, to examine influences from the downstream region of the Oyashio, we made a lag-correlation analysis focusing on the decadal variation of KE stability calculated from the zonal average (142–165˚E) of the meridional gradient of the sea surface height (34.5–37.0˚E) as the KE strength (KES). The result showed that signals of significant negative correlation appeared around the density from Hokkaido to the north region of KE. Through the composite analysis based on the KE stability, we found that the stable KE could also lead similar anomaly distribution around the north region of KE. We examined relationships between decadal tendency and each component of salinity fluxes at the density along the north-south boundary of the region of 38–40˚N, and 142–145˚E. Concerning estimation of the salinity fluxes, we employed time-mean components (S, V) and eddy components (s', v'), and then, we calculated products of them (Sv', $s'V$, $s'v'$). Decadal tendency of salinity (ds'/dt) was negatively correlated with the meridional difference of Sv' ($-0.5 < r < -0.47$, 95% confidence interval). Whereas Sv' at northern boundary was also negatively correlated with ds'/dt ($-0.45 < r < -0.42$), the correlation between ds'/dt and Sv' at southern boundary was small ($0.03 < r < 0.07$). The result suggested that the southward Oyashio would play an important role for decadal salinity variation in the MWR.

キーワード：北太平洋中層水、十年規模変動、親潮、黒潮続流
Keywords: North Pacific Intermediate Water , Decadal variation, Oyashio, Kuroshio Extension

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Multiscale routes to supply nutrients through the Kuroshio nutrient stream

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In this study, the role of the Kuroshio as a nutrient conduit is discussed using results from eddy-resolving, and nested high-resolution numerical simulations using Regional Oceanic Modeling System (ROMS) coupled with a N^2PZD^2 ecosystem model, and results from recent in-situ observations. The eddy-resolving simulation can reproduce the elevated nutrient concentrations along the Kuroshio compared to those in ambient waters of the same density, similar to the Gulf Stream. The nested simulations show that nutrients in the upstream Kuroshio can be supplied to euphotic zone by strong diapycnal mixing associated with the Kuroshio over topography. This large nutrient input is consistent with the very strong turbulent mixing observed directory in the upstream Kuroshio regions, where the Kuroshio flows over the seamounts and on the continental slope. The autonomous microstructure float observations also suggest that the large turbulent nitrate diffusive flux occurs in the Izu Ridge, along the Kuroshio. These diapycnal processes may explain why the basin scale nutrient elevation on the density surface along the Kuroshio path is maintained. During winter-spring, in the model downstream Kuroshio Extension, a large nitrate induction of O(10 mmol N m^2day^{-1}), comparable to or greater than wintertime diffusive nitrate flux, occurs through the inclined mixed layer base, which is strongly influenced by the mesoscale structures.

キーワード：黒潮、栄養塩ストリーム、栄養塩フラックス
Keywords: Kuroshio, Nutrient stream, Nutrient flux

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Seasonal variability of upper-ocean primary production around the Kuroshio analyzed using a ROMS-NPZD model

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Biological processes have significant influences on the global carbon cycle on all time scales. In the coastal regions, nutrient supply to the surface by river discharge and coastal upwelling leads to active primary production. The Kuroshio, one of the strongest western boundary currents, flows off the Japan, accompanied by intense eddy activities influencing on biogeochemical processes around its path. In general, localized upwelling due to mesoscale cyclonic eddies brings nutrient-rich subsurface water to the nutrient-depleted upper ocean to enhance near-surface primary productivity. In the present study, a climatological ocean modeling is developed for the marginal seas along the Kuroshio off Japan based on ROMS (Shchepetkin and McWilliams, 2005; 2008) coupled with an NPZD biogeochemical model (Fasham *et al.*, 1990; Gruber *et al.*, 2006). The model domain encompasses both the Kuroshio and its Extension regions in a submesoscale eddy-permitting configuration with a horizontal grid spacing of 3 km. The simulation is conducted for 10 years and the results for the 10th year are used for our analysis. A nitrogen budget analysis indicates that nitrogen exists mostly in the phyto- and zooplankton compartments in both the Kuroshio and Kuroshio Extension regions during the spring bloom. The increased zooplankton further enriches detritus that settles down by about 100 m, leading to an increase of ammonium below the mixed layer. In winter, eddy-induced nitrate transport is enhanced in the region about 1˚ away from the Kuroshio axis. The baroclinic instability due to the surface cooling in winter generates meso- and submesoscale eddies and substantially promotes eddy-induced vertical nitrate transport.

Keywords: Kuroshio, eddy-induced nitrate flux, submesoscale eddies, baroclinic instability

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Nutrient and light conditions at subsurface chlorophyll maximum: physical-biogeochemical observations along a mid-Pacific meridional transect

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Subsurface chlorophyll maximum (SCM) occurs in a stratified water column that nutrient is depleted in the surface layer. When fully developed, such as those in calm subtropical regions, SCMs were often observed at depth where both nutrient and light availabilities are at a marginal level. Following resource competition theory, the low resource condition is likely generated by a group of phytoplankton with a low resource requirement, which expels other groups through decreasing nutrients and/or deepening the nutricline. Numerical models formulating the phytoplankton dependency on nutrients and light can reproduce some of characteristics of SCM including seasonal and geographical variability. However, comprehensive observations of the SCM and environmental conditions are still limited especially in the open ocean. In the present study, shipboard physical and biogeochemical observations were conducted along 170˚W from the South Pacific Subtropical Front up to Bering Sea during Boreal and Austral summers.

Characteristics of SCMs were estimated from multiple vertical profiles of chlorophyll fluorescence attached to a Conductivity Temperature Depth profiler (CTD), and nutrient concentrations were determined from water samples. Depths of profiles by sensors and water sample data were determined through projections onto potential density coordinate to eliminate effects of internal wave heaving, which are critical in analyzing processes around SCMs. To evaluate diffusive nutrient flux, vertical diffusivity was calculated using a microstructure profiler and multiplied by vertical gradient of nutrient concentrations. Vertical profiles of photosynthetically available radiation (PAR) were estimated using surface PAR from Moderate Resolution Imaging Spectroradiometer (MODIS), averaged over two weeks until shipboard observation, and diffuse attenuation coefficients of downwelling irradiance calculated from *in situ* PAR measurements.

In subtropical regions from 40˚S to 30˚N, except for that at the equator, SCMs were found in 80–150 m, around or slightly deeper than 1% light level relative to the surface. Depth of SCM was deepest in the middle of subtropical gyres, no shallower than 100 m in 15–25˚. Although considerably shallower than subtropical regions, SCMs were also observed at the equator and temperate and subpolar regions in the range of 15–40 m. There are significant positive correlations between the depths of SCM and 1% light level, where SCM depth was generally deeper than the 1% light level in the subtropical regions. However, PAR at SCMs was not uniform but ranged from 0.1–0.7 mol photon m^{-2} day^{-1} within the subtropical regions, and shows a negative correlation with the SCM depth. The SCM depth also shows a strong positive correlation with the depth of maximum subsurface nitrate flux. Considering effects of pure external factors that are not affected by phytoplankton to the SCM depth, we found a positive relationship

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with absolute dynamic topography indicating the depth of pycnocline.

Although 1% light levels can indicate the SCM depth through the linear correlation for the wide geographical range in the mid-Pacific, it is not concluded that SCM was formed under the limitation of light alone. This is followed by a fact that PAR at the 1% levels is not uniform but depends on the surface PAR, by which the relationship between PAR values at SCMs and depths of SCMs become insignificant. As deep penetration of light is caused by the low productivity in the surface water, we cannot simply consider cause and effect for the above relationship. On the other hand, as the dynamic topography is not affected by phytoplankton, its relationship between the SCM depth suggests that the large-scale hydrographic structure has some influences on the formation of SCMs. In the presentation, we will further discuss the details of the physical processes and their possible impacts on subsurface phytoplankton production.

キーワード：クロロフィル極大、栄養塩拡散フラックス、共制限
Keywords: Subsurface chlorophyll maximum, Diffusive nutrient flux, colimitation

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[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27日(月) 10:45 ~ 12:15 | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

コンビーナ:伊藤 進一(東京大学大気海洋研究所)、平田 貴文(北海道大学地球環境科学研究院)、Enrique N Curchitser(Rutgers University New Brunswick)、Eileen E Hofmann(Old Dominion University)、座長:松村 義正(東京大学大気海洋研究所)

The ocean accounts for about 50% of global net primary production. This production is significant for carbon cycling and ecosystem functioning, and is related directly or indirectly to a variety of climatic and ecological phenomena. The responses to natural and anthropogenic environmental stressors that influence marine production and diversity can cause perturbations to marine ecosystems that alter trophic dependencies and interactions among organisms at a range of space and time scales. Quantification of the principal mechanisms driving spatio-temporal variability of marine ecosystem remains to be done, especially in terms of evaluation of uncertainty in responses. As a result, evaluating vulnerability of marine ecosystems to environmental change requires systematic and holistic approaches that integrate physics to ecology and are based in observations and modelling. In addition, expectations to deliver these science to public society is raising. This session aims to provide a venue for not only discussing recent advances in understanding marine biogeochemical cycles, ecosystems and their interactions, but also networking with a variety of people to seed new ideas in marine ecological research. Observational, modeling and conceptual studies, including technological development and operational applications, that consider linkages among biogeochemical and ecosystem processes, biodiversity, and the effects of multiple stressors from molecular to planetary scales are encouraged.

10:45 ~ 11:05

[AOS12-06] A Lagrangian view of spring phytoplankton blooms

★Invited Papers

*木田 新一郎[1]、伊藤 貴充[2] (1.九州大学・応用力学研究所、2.ジョージア工科大学)

11:05 ~ 11:20

[AOS12-07] Significance of acclimation process in simulating chlorophyll distribution in the Arctic Ocean

*増田 良帆[1]、山中 康裕[1]、平田 貴文[1]、中野 英之[2] (1.北海道大学地球環境科学研究院、2.気象研究所)

11:20 ~ 11:35

[AOS12-08] 瀬戸内海中央部における栄養塩変動に対する低次生態系の応答

*吉江 直樹[1]、水口 隼人[1]、郭 新宇[1]、米田 道夫[2]、阿保 勝之[2]、河野 悌昌[2]、藤田 辰徳[3] (1.愛媛大学沿岸環境科学研究センター、2.水産研究・教育機構、3.香川県水産試験場)

11:35 ~ 11:50

[AOS12-09] Effects of the temperature and fish size on metabolism and swimming performance of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

*郭 晨穎[1]、伊藤 進一[1]、米田 道夫[2]、北野 載[2] (1.東京大学大気海洋研究所、2.（国）水産研究・教育機構)

11:50 ~ 12:05

[AOS12-10] Sensitivity analyses of growth and migration of Japanese anchovy (*Engraulis japonicus*) in the East China Sea using a fish growth-migration model.

*伊藤 進一[1]、瀬藤 聡[2]、米田 道夫[2]、高橋 素光[2]、松山 倫也[3]、郭 晨穎[1]、北川 貴士[1] (1.東京大学大気海洋研究所、2.水産研究・教育機構、3.九州大学)

12:05 ~ 12:15

Discussion

A Lagrangian view of spring phytoplankton blooms

*木田 新一郎[1]、伊藤 貴充[2]
*Shinichiro Kida[1], Taka Ito[2]

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The basic mechanism behind spring phytoplankton blooms is investigated using a 1-dimensional Lagrangian NPZD model, where the movement and transfers of nutrient parcels are solved by tracking a nitrogen parcel. The Lagrangian framework is useful for understanding how the nitrogen cycle works in the ocean since it naturally follows the movement of materials through the turbulent ocean environment. The model reveals that the onset of spring blooms depends on the cumulative euphotic age, which is the total time that inorganic nutrient is exposed to light before the photosynthetic conversion to phytoplankton biomass. This is regardless of the underlying mechanism, such as critical depth hypothesis or critical turbulence hypothesis. The difference between the two modes lies in how cumulative euphotic age is accumulated and this can be distinguished by examining the cumulative euphotic age spectrum. We further examined the impact of mortality by comparing the model experiments with and without mortality. The cumulative euphotic age necessary for a spring bloom is found to increase, as expected, but the spectral shapes remained similar.

キーワード：春季ブルーム、粒子追跡モデル
Keywords: Spring Bloom, Lagrangian model

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Significance of acclimation process in simulating chlorophyll distribution in the Arctic Ocean

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Recently, our team has developed a new oceanic ecosystem model (FlexPFT-3D) based on a novel theory for phytoplankton physiology (Smith et al. 2015). Different from our previous models (NEMURO, MEM), the model represents phytoplankton acclimation processes in which phytoplankton change their stoichiometry (nitrogen:carbon:chlorophyll:iron) according to the change of a surrounding environment. A clear improvement was found in chlorophyll distributions in oceanic interior and the Arctic Ocean. Arctic chlorophyll concentration in the new model is comparable to the observation, while it is underestimated in the previous models. In the Arctic Ocean, significant seasonal environmental change exists especially in a light condition. The new model can represent increase in the rate of chlorophyll to carbon biomass in the summer and resulting increase in the phytoplankton specific growth rate; those contribute to the improvement in simulating Arctic chlorophyll concentration.

キーワード：植物プランクトン、生態系モデル、FlexPFT
Keywords: Phytoplankton, Ecosystem model, FlexPFT

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瀬戸内海中央部における栄養塩変動に対する低次生態系の応答
Responses of lower-trophic level ecosystem to nutrient variation in the central part of the Seto Inland Sea

*吉江 直樹[1]、水口 隼人[1]、郭 新宇[1]、米田 道夫[2]、阿保 勝之[2]、河野 悌昌[2]、藤田 辰徳[3]
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瀬戸内海は豊饒の海と呼ばれ、世界の半閉鎖的海域と比較すると数倍から一桁高い漁業生産性を誇ってきた。その一方で、瀬戸内周辺の狭い集水域には約三千万人が生活し、重化学工業を主体にGDPで比較するとカナダ一国と同程度の経済活動を行ってきた。そのため、高度経済成長期には人間活動に伴う環境負荷により汚濁・富栄養化が進行し、赤潮・貧酸素化などの環境問題が多発した。その後、環境負荷の削減に向けた環境規制と住民・企業などの四十年以上にわたる弛まぬ努力により、瀬戸内海は栄養塩濃度が低く、透明度の高い「きれいな海」へと回復してきた。しかし、近年の栄養塩濃度低下に伴い生物生産が低下している可能性や、水産資源の減少につながっている可能性が指摘されているが、その関連性については明らかになっていない。瀬戸内海の水産資源として非常に重要なカタクチイワシ仔稚魚(シラス)の漁獲量は、瀬戸内海中央部の燧灘において、2005年以降急激に減少している。最新の研究から、この減少の原因は、カタクチイワシの餌料として重要な動物プランクトンの減少と関連していることが明らかになりつつあるが、栄養塩変動と動物プランクトン変動の関連性については明らかになっていない。

そこで本研究では、燧灘における栄養塩濃度変動に対する動物プランクトンを含む低次生態系の応答について生態系モデルを用いて調べた。具体的には、海洋生態系モデルeNEMURO (4N-4P-4Z-3D) を燧灘に適用し、平年的な低次生態系の季節変動を再現できるようにした。そして、カタクチイワシの資源変動に最も関連性が高いカタクチイワシ仔稚魚5月発生群の漁獲量が、豊漁であった2005年と不漁であった2011年における栄養塩濃度の観測値をモデルに与え、両年の低次生態系の季節変動について比較した。その結果、不漁年では春季の栄養塩濃度の大幅な減少に応じて、春季の珪藻ブルームの規模と春季のメソ動物現存量が大きく減少することが明らかとなった。このことから春季の栄養塩濃度の経年変化が珪藻ブルームの規模を左右し、カタクチイワシの餌として重要なメソ動物の現存量の経年変動を引き起こしている可能性が示唆された。

キーワード：生態系モデル、栄養塩、ケイ藻、メソ動物プランクトン、カタクチイワシ
Keywords: ecosystem model, nutrient, diatom, meso-zooplankton, anchovy

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Effects of the temperature and fish size on metabolism and swimming performance of Pacific chub mackerel *Scomber japonicus* in the Northwest Pacific

*郭 晨穎[1]、伊藤 進一[1]、米田 道夫[2]、北野 載[2]
*Chenying Guo[1], Shin-ichi Ito[1], Michio Yoneda[2], Hajime Kitano[2]

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1. Atmosphere and Ocean Research Institute, the University of Tokyo, 2. Fisheries Research and Education Agency Japan

Pacific chub mackerel (*Scomber japonicus*) is a small pelagic and important commercial fish species widely distributed throughout the coastal areas of the Northwestern, Northeastern, and Southeastern Pacific. Swimming energetic and metabolic data of Northwestern stock at two growth stage (young juvenile of 6.1±0.3 cm and immature of 16.5±1.4 cm fork length) were measured under various temperature (18˚C and 24˚C for young juvenile, 14˚C and 18˚C for immature) using a variable-speed swim-tunnel respirometer, and the new data were compared with the previous data from Northeastern Pacific stocks. For young juveniles, the maximum sustainable swimming speeds (U_{max}) was 50.0±6.5 cm s^{-1} at 24˚C, significantly higher than at 18˚C of 30.7±2.5 cm s^{-1}. For the immature individuals, U_{max} showed no significant increase while temperature changed from 14 to 18˚C, and did not vary significantly from Northeastern Pacific individuals within the same size range. At a given temperature of 18˚C, U_{max} of immatures was significantly higher than those of young juveniles. For all individuals, the mass-specific oxygen consumption rate (V_{O2}) increased exponentially with swimming speed (U, in cm s^{-1}). At a given speed, V_{O2} increased with temperature; at a given temperature of 18˚C, V_{O2} of immature individuals were lower than those of young juveniles. These effects of the temperature and fish size on V_{O2} were consistent with previous studies of chub mackerel of Northeastern stocks, however, compared with Northeastern stocks within the same size range, V_{O2} of Northwestern individuals acclimated to 14˚C did not vary at a given speed, while those acclimated to 18˚C showed higher V_{O2} , indicating the Northwestern stock was more sensitive for temperature on metabolism.

キーワード：Pacific chub mackerel、Scomber japonicus、swimming speed、metabolism、respirometer
Keywords: Pacific chub mackerel, Scomber japonicus, swimming speed, metabolism, respirometer

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Sensitivity analyses of growth and migration of Japanese anchovy (*Engraulis japonicus*) in the East China Sea using a fish growth-migration model.

*伊藤 進一[1]、瀬藤 聡[2]、米田 道夫[2]、高橋 素光[2]、松山 倫也[3]、郭 晨穎[1]、北川 貴士[1]
*Shin-ichi Ito[1], Takashi Setou[2], Michio Yoneda[2], Motomitsu Takahashi[2], Michiya Matsuyama[3], Chenying Guo[1], Takashi Kitagawa[1]

1. 東京大学大気海洋研究所、2. 水産研究・教育機構、3. 九州大学
1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Fisheries Research and Education Agency Japan, 3. Kyushu University

Japanese anchovy (Engraulis japonicus) is an important species not only as an exploited species but also as prey for variety of predators including marine mammals, tunas, mackerels, flounders, etc. However, the biomass of Japanese anchovy have shown large fluctuation and is one of the main actors of the fish species alternation responding to basin scale climate variabilities. From the stock management views, three sub-populations are defined in Japan: Pacific stock, Tsushima stock (also called the East China Sea stock), and Seto-inland Sea stock. There is evidence (different weights-at-age and longevity) of three sub-populations of anchovy within the Japan system. While he three sub-populations of anchovy share their spawning grounds, the migration route and nursery grounds are divided. In addition, while Seto-inland Sea sub-populations do not show a large migration, Pacific and Tsushima sub-populations make long distance ontogenetic migrations, On the contrary, there is no evidence of a similar migration of juvenile anchovies in the California Current system. Therefore, we are focusing on the movement (advection and migration) routes of eggs, larvae, and juveniles from the spawning grounds to the adult grounds. We developed a fish-migration and growth model using environmental conditions derived from simulations of a coupled ocean circulation and ecosystem model. For the ocean circulation model, a high resolution (1/10 deg.) FRA-ROMS (Fisheries Research Agency - Regional Ocean Modeling System) was used. For the marine ecosystem model, eNEMURO, an extended version of NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography) was used. The larvae transported to southern part of Kyushu Island in Japan (current main fisheries ground for anchovy larvae) were reasonably reproduced in the model. The sensitivity analyses of swimming efficiency will be conducted respect to the migration route of anchovy.

キーワード：海洋生態系モデル、魚類成長ー回遊モデル、カタクチイワシ
Keywords: marine ecosystem model, fish growth-migration model, Japanese anchovy

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[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27日(月) 13:45 ~ 15:15 | 302 3F

[A-OS12] Marine ecosystems and biogeochemical cycles: theory, observation and modeling

コンビーナ:伊藤 進一(東京大学大気海洋研究所)、平田 貴文(北海道大学地球環境科学研究院)、Enrique N Curchitser(Rutgers University New Brunswick)、Eileen E Hofmann(Old Dominion University)、座長:Enrique Curchitser(Rutgers University)

The ocean accounts for about 50% of global net primary production. This production is significant for carbon cycling and ecosystem functioning, and is related directly or indirectly to a variety of climatic and ecological phenomena. The responses to natural and anthropogenic environmental stressors that influence marine production and diversity can cause perturbations to marine ecosystems that alter trophic dependencies and interactions among organisms at a range of space and time scales. Quantification of the principal mechanisms driving spatio-temporal variability of marine ecosystem remains to be done, especially in terms of evaluation of uncertainty in responses. As a result, evaluating vulnerability of marine ecosystems to environmental change requires systematic and holistic approaches that integrate physics to ecology and are based in observations and modelling. In addition, expectations to deliver these science to public society is raising. This session aims to provide a venue for not only discussing recent advances in understanding marine biogeochemical cycles, ecosystems and their interactions, but also networking with a variety of people to seed new ideas in marine ecological research. Observational, modeling and conceptual studies, including technological development and operational applications, that consider linkages among biogeochemical and ecosystem processes, biodiversity, and the effects of multiple stressors from molecular to planetary scales are encouraged.

13:45 ~ 14:05

[AOS12-11] Micro-scale patchiness enhances trophic transfer efficiency and potential plankton biodiversity

★Invited Papers

*山崎 秀勝[1]、Priyadarshi Anupam[2]、Smith Lan[3]、Mandal Sandip[4]、田中 衛[1] (1.東京海洋大学、2.Banaras Hindu University、3.海洋研究開発機構、4.Public Health Foundation of India)

14:05 ~ 14:20

[AOS12-12] 海底オブザバトリーを使用した微小凝集体の長期観測

*竹内 茉莉香[1,2]、Doubell Mark[3]、Mitchell Jim[2]、山崎 秀勝[1] (1.東京海洋大学、2.Flinders University、3.South Australia Research and Development Institute)

14:20 ~ 14:35

[AOS12-13] An insight into the area characteristic of seasonal change in nitrogen isotope ratio based on a marine nitrogen isotope model

*吉川 知里[1]、重光 雅仁[1]、山本 彬友[1]、岡 顕[2]、大河内 直彦[1] (1.海洋研究開発機構、2.東大大気海洋研)

14:35 ~ 14:50

[AOS12-14] **Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain**

*S. Lan Smith[1]、Yoshikazu Sasai[1]、Chisato Yoshikawa[2] (1.Marine Ecosystem Dynamics Research Group, RCGC, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan、2.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan)

14:50 ~ 15:05

[AOS12-15] Discussions

伊藤 進一[2]、*平田 貴文[1] (1.北海道大学　大学院地球環境科学研究院、2.東京大学　大気海洋研究所)

15:05 ~ 15:15

Discussion

Micro-scale patchiness enhances trophic transfer efficiency and potential plankton biodiversity

*山崎 秀勝[1]、Priyadarshi Anupam[2]、Smith Lan[3]、Mandal Sandip[4]、田中 衛[1]
*Hidekatsu Yamazaki[1], Anupam Priyadarshi[2], Lan Smith[3], Sandip Mandal[4], Mamoru Tanaka[1]

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Recent observations have revealed ubiquitous intermittency in phytoplankton distributions at the micro (mm) scale, and a few recent modelling studies have suggested that this micro-scale variability impacts plankton ecosystem dynamics and biodiversity. Modelling is an essential tool for studying complex food webs, by linking the observed ecological patterns with experimental findings to understand mechanisms and make future predictions. However, so far almost all ecosystem models have been developed based on the mean-field approach, i.e. assuming well mixed environmental conditions within each discretely resolved grid cell. Although this is reasonable for examining patterns at the meso- (km) to global scales, it is not realistic for plankton, which experience micro-scale variability in aquatic environments where predator-prey overlap can substantially enhance trophic transfer. Similar to a recent study that addressed variability at the scale of ocean fronts, we have recently used Reynolds decomposition and truncated Taylor series to develop ‘moment closure’ models accounting for micro-scale variability in the distributions of Nutrients and Phytoplankton (NP closure model), and also Zooplankton (NPZ closure model). Compared to conventional ecosystem models based on the mean-field approach, these closure models yield qualitatively different dynamics.

Using a generalized plankton ecosystem modelling framework, including models of differing trophic complexity and with different grazing functional responses, we investigate how micro-scale variability affects plankton biodiversity and ecosystem function. Specifically, we apply the closure modelling approach to test the functional forms often assumed in ecosystem models against observed micro-scale intermittency as quantified by the coefficient of variation (CV) (ratio of standard deviation to mean) of micro-scale fluorescence field, which is a proxy for phytoplankton biomass. With both saturating and non-saturating grazing functions and in all model configurations considered, we find that micro-scale variability consistently supports the highest trophic level present, i.e. enhances Tansfer Efficiency, and expands the model stability domain, potentially sustaining biodiversity by allowing species with a wider range of trait values to coexist. Based on our observations and model results we hypothesise a novel answer to the “paradox of the plankton” (Hutchinson, 1961) for such calm, low-nutrient oceanic environments: Heretofore under-appreciated high levels of micro-scale variability may explain the great diversity of plankton present in these vast low-nutrient regions of the ocean.

キーワード：プランクトン、乱流、微細構造、生態系モデル
Keywords: plankton, turbulence, microstructures, ecosystem models

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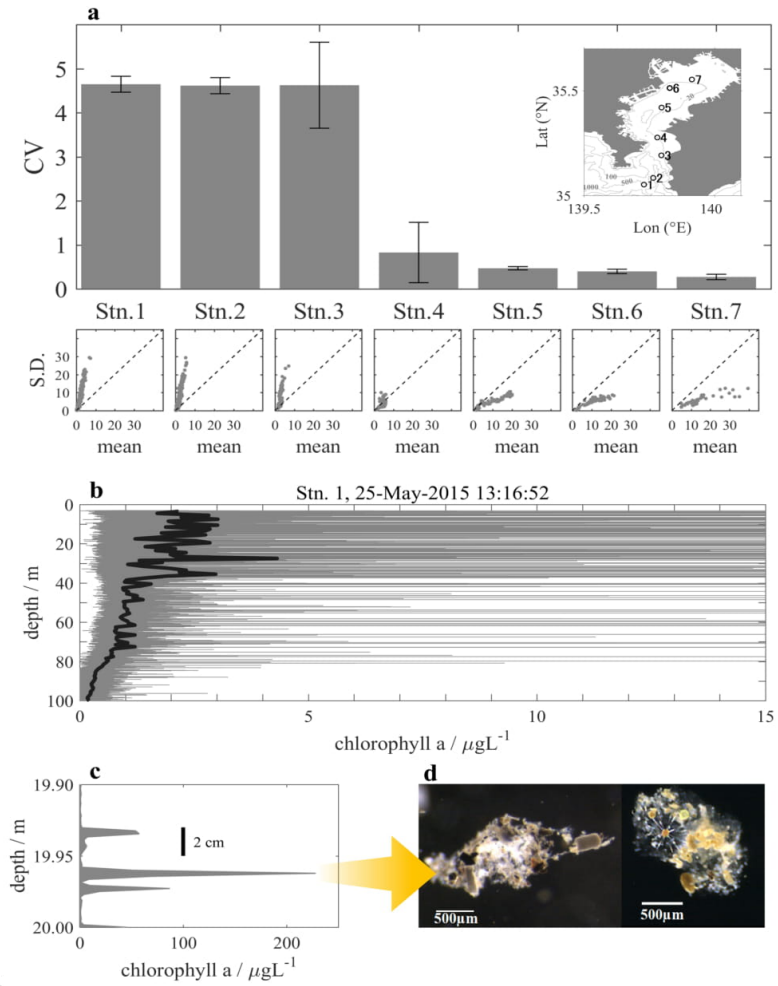


Figure: (a) Observation stations (open, numbered circles) in Tokyo bay, *CV* estimates (bar heights, with error bars indicating 99% confidence intervals) and corresponding scatter plots of observed standard deviation vs. mean of fluorescence data from each station (dotted lines showing one-to-one relationships). (b) Raw data (thin grey lines) and 1 m average values (thick black lines) from a vertical fluorescence profile acquired at stn. 1 by the laser sensor, which was calibrated with *in situ* water samples to obtain values in g chl L^{-1}. (c) A subset of peaks from the same profile around 20 m depth. Vertical thick black bar indicates a scale bar of 2 cm height. (d) Images of typical aggregates.

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海底オブザバトリーを使用した微小凝集体の長期観測
Long term observations of marine snow, using cabled observatory system

*竹内 茉莉香[1,2]、Doubell Mark[3]、Mitchell Jim[2]、山崎 秀勝[1]
*Marika Takeuchi[1,2], Mark Doubell[3], Jim Mitchell[2], Hidekatsu Yamazaki[1]

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Marine aggregates are formed through coagulation of small biogenic and non-biogenic components. Visible ones, known as marine snow, are typically larger than 0.5mm. Aggregates are well recognised as hotspots of microbial and planktonic activities. Aggregates formation is an important pathway for transferring organic matter from surface to deep ocean, hence the impatcs of aggregates in carbon flux is significant. However, field observations of aggregates have been challenging and not many long-term observational results have been reported.
In this study, we analysed in-situ observations of aggregates using a high-resolution plankton camera mounted on cabled observatory OCEANS. OCEANS has been continuously collecting hydrographic data and images of aggregates simultaneously since 2014. Here we will present a few months of in-situ observations results to show aggregates size and population change over time. Turbulence and other plankton distributions are compared to aggregates.

キーワード：マリンスノー、乱流、サイズ分布
Keywords: Marine snow, Turbulence, Size distribution

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An insight into the area characteristic of seasonal change in nitrogen isotope ratio based on a marine nitrogen isotope model

*吉川 知里[1]、重光 雅仁[1]、山本 彬友[1]、岡 顕[2]、大河内 直彦[1]
*Chisato Yoshikawa[1], Masahito Shigemitsu[1], Akitomo Yamamoto[1], Akira Oka[2], Naohiko Ohkouchi[1]

1. 海洋研究開発機構、2. 東大大気海洋研
1. JAMSTEC, 2. AORI

The condition of nitrogenous nutrient in the surface water is an important factor that determines the primary production and the carbon cycle in the ocean. Nitrogen isotope ratios ($\delta^{15}N$) of nitrate, sinking particles, sediments have been widely used as a proxy for the condition of nitrogenous nutrient in the surface water. However, the interpretation of $\delta^{15}N$ values are not simple. The $\delta^{15}N$ value of surface primary producer records $\delta^{15}N$ value of nitrate supplied to the euphotic layer, nitrate utilization efficiency and rate of N_2 fixation. As there are multiple possibilities for the interpretation, $\delta^{15}N$ values should be interpreted with ample consideration of the characteristics of surface nitrogen cycle by region. In this study we show the area characteristic of seasonal change in $\delta^{15}N$ value by using a global ocean nitrogen isotope model in order to improve the interpretation of observed $\delta^{15}N$ values. We installed a marine nitrogen isotope model (Yoshikawa et al., 2005) with denitrification (Shigemitsu et al., 2016) and N_2 fixation (Coles et al., 2007) schemes into an off-line biogeochemical model that is driven by climatological monthly mean physical fields obtained from the outputs of a preindustrial control simulation performed with MIROC 3.2 (K-1 Model Developers, 2004). The simulated $\delta^{15}N$ of sinking particles had a global distribution similar to the observed $\delta^{15}N$ of surface sediments (Tesdal et al., 2013). The simulated sinking particles were enriched in ^{15}N in the eastern and western tropical North Pacific and the Indian Ocean where water column denitrification occurs and were depleted in ^{15}N in the Sargasso Sea, the Kuroshio extension region, and the Indian Ocean where N_2 fixation occurs. The seasonal variations in $\delta^{15}N$ of sinking particles vary considerably from one region to another. In this talk, we will report the seasonal $\delta^{15}N$ patterns categorized by region and the factors in the determination of those seasonal patterns.

キーワード：海洋窒素循環、窒素同位体比、海洋生態系モデル
Keywords: Marine nitrogen cycle, Nitrogen isotope ratio, Marine ecosystem model

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Modeling variability of ^{15}N stable isotope enrichment within the planktonic food chain

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The stable isotope ^{15}N is widely used an indicator of trophic level, and has been incorporated into ecosystem models in order to understand nitrogen cycling and trophic transfer. However, such studies typically consider only the average enrichment per trophic level. We present a recently developed model of the dynamic fractionation of the stable isotope ^{15}N in lower-trophic ecosystems of the North Pacific. The model accounts for the dynamics of trophic transfer from nutrients (nitrate and ammonium) to phytoplankton, and to two idealized zooplankton compartments representing herbivores and carnivores, respectively. The $d^{15}N$ signal of herbivores tracks that of phytoplankton, with a nearly constant offset, i.e., enrichment by a nearly constant factor. However, the modeled $d^{15}N$ difference between carnivores and herbivores varies seasonally, and depends on the mortality rate (turnover time or effective lifespan) of the carnivores. Seasonal variations of modeled $d^{15}N$ signals differ with trophic level because carnivores integrate the signal from their ^{15}N uptake over longer timescales compared to herbivores. Thus, the model reproduces the lower observed variability of $d^{15}N$ for carnivorous zooplankton (chaetognaths) and the more variable $d^{15}N$ for largely herbivorous zooplankton (copepods). Our results imply that for interpreting observed $d^{15}N$ values, it is important to consider not only the average enrichment per trophic level, but also the dynamics of ^{15}N fractionation and the timing of observations, e.g. to avoid unrealistic estimates of trophic linkages based on seasonally biased observations.

Keywords: nutrients, predation, zooplankton, production, transfer efficiency

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Discussions

伊藤 進一[2]、*平田 貴文[1]
Shin-ichi Ito[2], *Takafumi Hirata[1]

1. 北海道大学　大学院地球環境科学研究院、2. 東京大学　大気海洋研究所
1. Faculty of Environmental Earth Science, Hokkaido University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

Discussions

キーワード：海洋生態系、生物地球化学物質循環
Keywords: Marine Ecosystems, Biogeochemistry

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

2019年5月27日(月) 13:45 ~ 15:15 | 104 1F

[A-CG33] 中緯度海洋と大気

コンビーナ:西井 和晃(三重大学大学院生物資源学研究科)、佐々木 克徳(Hokkaido University)、西川 はつみ(北海道大学　低温科学研究所)、大石 俊(名古屋大学　宇宙地球環境研究所　陸域海洋圏生態研究部)、座長:西井 和晃(三重大学)

中緯度域の海洋・大気現象に関連した，メソスケールから海盆規模の現象，短周期変動から温暖化などの長期変動にいたるまでの幅広い時間・空間スケールの研究成果を持ち寄り，更なる中緯度大気海洋相互作用系の理解を深めることを目指す．また乱流・混合や温暖化応答などの物理過程から生態系に至る多角的な観点からの発表も歓迎する。

13:45 ~ 14:05

[ACG33-01] Gulf Stream and Kuroshio are synchronized

★Invited Papers

*神山 翼[1]、三浦 裕亮[1]、木戸 晶一郎[1] (1.東京大学大学院理学系研究科地球惑星科学専攻)

14:05 ~ 14:20

[ACG33-02] A study on mixed layer depth variability in the Kuroshio Extension region based on a frontal Ekman model

*東塚 知己[1] (1.東京大学大学院理学系研究科地球惑星科学専攻)

14:20 ~ 14:35

[ACG33-03] Mechanisms of Reemergence in the North Pacific revealed by Mixed Layer Heat Budget Analysis

*村田 壱学[1]、木戸 晶一郎[1]、東塚 知己[1] (1.東京大学理学系研究科地球惑星科学専攻大気海洋講座)

14:35 ~ 14:50

[ACG33-04] Formation mechanism for the North Pacific Transition domain SST and SSS fronts

*西川 はつみ[1]、三寺 史夫[1]、奥西 武[2]、伊藤 進一[3]、和川 拓[4]、長谷川 大介[2]、美山 透[5]、金子 仁[2] (1.北海道大学　低温科学研究所、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.東京大学　大気海洋研究所、4.国立研究開発法人　水産研究・教育機構　日本海区水産研究所、5.国立研究開発法人　海洋研究開発機構)

14:50 ~ 15:10

[ACG33-05] Impact of the Kuroshio front on frontal structure of an extratropical cyclone associated with heavy precipitation

★Invited Papers

*平田 英隆[1]、川村 隆一[2]、吉岡 真由美[1]、野中 正見[3]、坪木 和久[1] (1.名古屋大学　宇宙地球環境研究所、2.九州大学　大学院理学研究院、3.海洋研究開発機構　アプリケーションラボ)

15:10 ~ 15:15

[ACG33-06] Discussion on future studies on the role of midlatitude oceans

*西井 和晃[1] (1.三重大学大学院生物資源学研究科)

Gulf Stream and Kuroshio are synchronized

*神山 翼[1]、三浦 裕亮[1]、木戸 晶一郎[1]
*Tsubasa Kohyama[1], Hiroaki Miura[1], Shoichiro Kido[1]

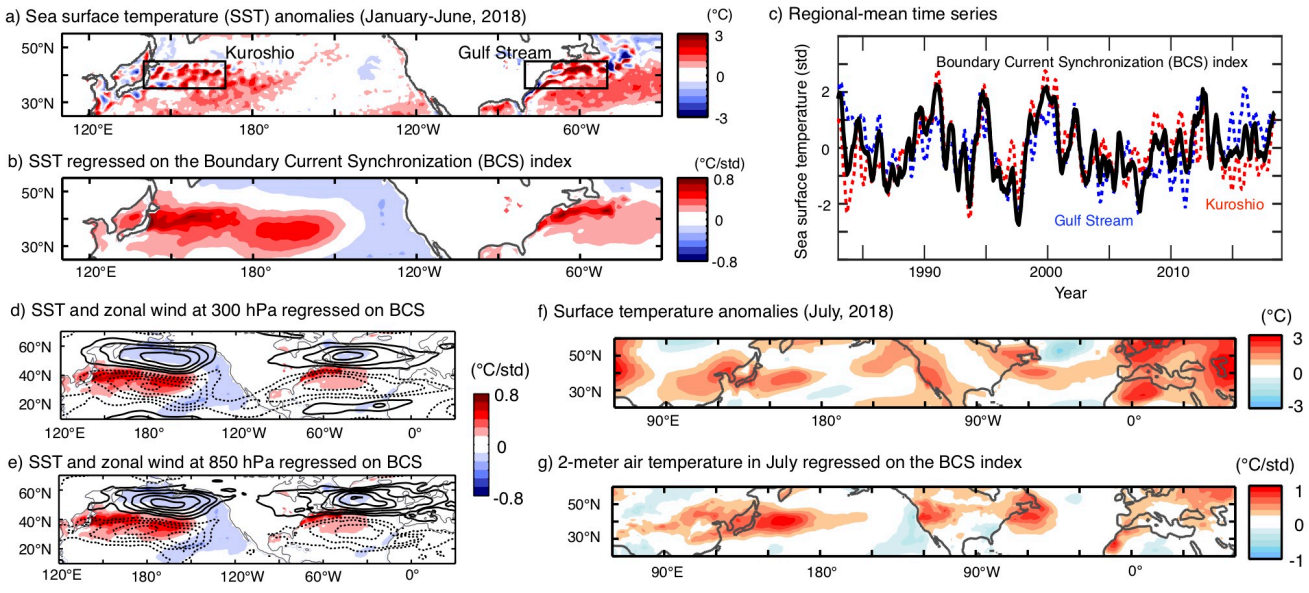
1. 東京大学大学院理学系研究科地球惑星科学専攻
1. Department of Earth and Planetary Science, The University of Tokyo

The Gulf Stream and the Kuroshio transport heat from the tropics to the extratropics, and their temperature variations affect densely-populated areas in the northern hemisphere through extreme weather and fisheries production. The two warm ocean currents are separated by the North American continent, and thus, they cannot exchange heat by the oceanic circulation within a few years.

In this presentation, however, we show that sea surface temperatures (SST) of the two warm currents are synchronized for interannual to decadal time scales. This synchronization, which we refer to as the Boundary Current Synchronization (BCS), is associated with the meridional migrations of the atmospheric jet stream. The singular value decomposition (SVD) analysis between SST and zonal wind shows that, from the conventional viewpoint, BCS is explained as the covariability shared by the Pacific Decadal Oscillation and the Northern Annular Mode. Nevertheless, the SVD time series exhibit high correlations with the zonal-mean meridional SST difference between subtropics and midlatitudes, which supports the notion that BCS may be understood better as the annular mode of the upper ocean.

We also discuss some implications for extreme weather and climate change. The regression map of 2-meter temperature on the BCS index exhibits a similar pattern to the temperature pattern in July 2018, which implies an essential relationship between BCS and the abnormally hot summer. BCS also connects two apparently unrelated global warming responses: the western boundary currents warm faster than the global mean, and that the atmospheric jet stream shifts poleward.

キーワード：大気海洋相互作用、黒潮、メキシコ湾流、大気ジェット気流
Keywords: Atmosphere-Ocean interactions, Kuroshio, Gulf Stream, Atmospheric jet stream



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A study on mixed layer depth variability in the Kuroshio Extension region based on a frontal Ekman model

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*Tomoki Tozuka[1]

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1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

In oceanic frontal regions, surface geostrophic currents have a vertical shear aligned with the density front that can balance a portion of the surface wind stress, and only the portion of the wind stress that is not in balance with the surface geostrophic shear (i.e. "effective wind stress") forces an ageostrophic Ekman spiral. Thus, if the front were uniform with depth, it is expected that the vertical velocity at tthe mixed layer base is better represented by the curl of the effective wind stress, rather than the full wind stress. In this study, we have examined the above in the Kuroshio Extension region, where a prominent sea surface temperature front exists, and some preliminary results based on an analysis of a high-resolution ocean assimilation product are presented.

キーワード：混合層厚、前線エクマンモデル、エクマン・パンピング、黒潮続流
Keywords: Mixed layer depth, Frontal Ekman model, Ekman pumping, Kuroshio Extension

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Mechanisms of Reemergence in the North Pacific revealed by Mixed Layer Heat Budget Analysis

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*Kazumichi Murata[1], Shoichiro Kido[1], Tomoki Tozuka[1]

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Wintertime sea surface temperature (SST) anomalies that disappear in summer and recur in the following winter is called “reemergence”. Previous studies suggested that temperature anomalies that subduct into the subsurface during the shoaling phase of the mixed layer are preserved under the mixed layer due to isolation from atmospheric forcing and reentrained into the surface mixed layer. Since reemergence is considered to play an important role in the Pacific Decadal Oscillation, it is important to understand its mechanisms, but past studies are mostly based on statistical analyses. Therefore, in this thesis, the mechanisms of reemergence in the North Pacific is clarified quantitatively by an online mixed layer heat budget analysis with an ocean model simulation.

Following a method proposed by a previous study, areas with reemergence are detected and the focus of this study is the Reemergence Area (RA, 35˚-40˚N, 155˚-145˚W) in the central North Pacific. In the RA, the Reemergence Years (RYs) are determined and the mixed layer heat budget analysis is conducted with the integration of the Regional Ocean Model System (ROMS) covering the RA. In contrast to past studies that suggested importance of anomalous entrainment term, it is shown that several mechanisms are operating in reemergence. In particular, the anomalous Ekman meridional advection of the mean meridional temperature gradient induced by zonal wind stress anomalies plays an important role in many RYs. Also, coincidence in the sign of SST anomalies in winter and surface heat flux anomalies in the following autumn leads

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to recurrence of SST anomalies in some RYs. On the other hand, the conventional mechanism related to the mean entrainment of anomalous temperature contributes to reemergence in two RYs.

キーワード：海洋再出現過程、北太平洋、混合層熱収支解析
Keywords: Reemergence, North Pacific, mixed layer heat budget analysis

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Formation mechanism for the North Pacific Transition domain SST and SSS fronts

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*Hatsumi Nishikawa[1], Humio Mitsudera[1], Takeshi Okunishi[2], Shin-ichi Ito[3], Taku Wagawa[4], Daisuke Hasegawa[2], Toru Miyama[5], Hitoshi Kaneko[2]

1. 北海道大学　低温科学研究所、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. 東京大学　大気海洋研究所、4. 国立研究開発法人　水産研究・教育機構　日本海区水産研究所、5. 国立研究開発法人　海洋研究開発機構
1. Institute of Low Temperature Science, Hokkaido University, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5. Japan Agency for Marine-Earth Science and Technology

The North Pacific Transition Domain is the area where water exchange between subtropical and subarctic is carried out and there are SST and SSS fronts. The Transition domain is very important area for air-sea interaction, ocean mixed layer formation, biological production, and so on. In this study, to clarify SST and SSS fronts structure and its formation mechanism in the transition domain, we analyzed the data of drifting buoys observation in 2015 and 2017 and modelled particles trajectory.

The buoy trajectories and the modelled trajectories captured the flow structure (i.e. front structure) in detail. They suggest that the flow structure in the transition domain is dominated by low rise bottom topography. We also showed mixing ratio of the subarctic and the subtropical seawater in the Transition domain using the particle tracking. In addition, it was also found that the place where the sea water tends to stagnate well corresponds to the place where the SST deviation appears due to the variation of the Isojet jet J1 indicated by Mitsudera et al. (2018).

キーワード：海底地形、海面水温フロント、海面塩分フロント、亜熱帯ー亜寒帯海水交換
Keywords: bottom topography, SST front, SSS front , Subtropical-Subarctic Seawater exchange

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Impact of the Kuroshio front on frontal structure of an extratropical cyclone associated with heavy precipitation

*平田 英隆[1]、川村 隆一[2]、吉岡 真由美[1]、野中 正見[3]、坪木 和久[1]
*Hidetaka Hirata[1], Ryuichi Kawamura[2], Mayumi K Yoshioka[1], Masami Nonaka[3], Kazuhisa Tsuboki[1]

1. 名古屋大学　宇宙地球環境研究所、2. 九州大学　大学院理学研究院、3. 海洋研究開発機構　アプリケーションラボ
1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Department of Earth and Planetary Sciences, Kyushu University, 3. Application Laboratory, Japan Agency for Marine-Earth Science and Technology

It is well known that sea surface temperature (SST) fronts associated with warm ocean currents create horizontal thermal gradients in the near-surface atmosphere in the mid-latitudes. These thermal gradients may affect frontal structure of extratropical cyclones passing near warm currents. Moreover, fronts influenced by the mid-latitude ocean may be related to the occurrence of heavy precipitation. To answer these questions, we examined the impact of the SST front along the Kuroshio Current (Kuroshio front) on the frontal structure of an extratropical cyclone associated with heavy precipitation by utilizing observational data, objective analysis data, and regional cloud-resolving numerical experiments. This study paid special attention to an extratropical cyclone and related heavy precipitation on Miyake Island in early January 2017. When the cyclone intensified around the Kuroshio front, two surface fronts developed around the cyclone center. One was a warm front. The other was a non-classic front, which was called the outer front in this study, forming on the northern side of the warm front. A line-shaped precipitation band and a comma head-shaped precipitation band appeared along the outer front and along the bent-back warm front, respectively. During the passage of these bands, heavy precipitation was observed on Miyake Island. Looking at the evolution of the outer front, we found that it was located just along the Kuroshio front in its early life. During the formation stage of the incipient outer front, sensible heat supply was evident from the Kuroshio Current, whereas it was small on the northern side of the oceanic front. This meridional difference in sensible heating caused frontogenesis along the Kuroshio front, which led to the initial formation of the front. Thus, the Kuroshio front played an important role in the formation of the incipient outer front, contributing to the occurrence of the heavy precipitation.

キーワード：温帯低気圧、黒潮、大雨
Keywords: extratropical cyclone, Kuroshio, heavy precipitation

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Discussion on future studies on the role of midlatitude oceans

*西井 和晃[1]
*Kazuaki Nishii[1]

1. 三重大学大学院生物資源学研究科
1. Graduate School of Bioresources, Mie University

Here, we will discuss future plans of studies on the role of midlatitude oceans in driving the atmospheric variability, and its feedback onto the midlatitude oceans.

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

2019年5月27日(月) 15:30 ~ 17:00 | 104 1F

[A-CG33] 中緯度海洋と大気

コンビーナ:西井 和晃(三重大学大学院生物資源学研究科)、佐々木 克徳(Hokkaido University)、西川 はつみ(北海道大学　低温科学研究所)、大石 俊(名古屋大学　宇宙地球環境研究所　陸域海洋圏生態研究部)、座長:大石 俊

中緯度域の海洋・大気現象に関連した，メソスケールから海盆規模の現象，短周期変動から温暖化などの長期変動にいたるまでの幅広い時間・空間スケールの研究成果を持ち寄り，更なる中緯度大気海洋相互作用系の理解を深めることを目指す．また乱流・混合や温暖化応答などの物理過程から生態系に至る多角的な観点からの発表も歓迎する。

15:30 ~ 15:45

[ACG33-07] Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

★Invited Papers

*高橋 直也[1]、早坂 忠裕[1] (1.東北大学理学研究科地球物理学専攻大気海洋変動観測研究センター)

15:45 ~ 16:00

[ACG33-08] **Sea surface temperature trend in the East China Sea during the 20th century simulated by a regional ocean model**

*佐々木 克徳[1]、梅田 千智[1] (1.北海道大学)

16:00 ~ 16:15

[ACG33-09] Kuroshio Extension and Gulf Stream’s influences on the variability of near-surface baroclinicity and the associated atmospheric fields

★Invited Papers

*田口 文明[1]、西井 和晃[2]、中村 尚[1,3] (1.東京大学　先端科学技術研究センター、2.三重大学　生物資源学部、3.海洋研究開発機構　アプリケーションラボ)

16:15 ~ 16:30

[ACG33-10] Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

*中山 盛雄[1]、水越 正敏[1]、中村 尚[1]、小坂 優[1]、田口 文明[1]、森 正人[1]、小川 史明[2] (1.東京大学先端科学技術研究センター、2.ベルゲン大学)

16:30 ~ 16:45

[ACG33-11] **Hydro-climatic variation in northwestern China and its multi-decadal to multi-centennial teleconnection with the Pacific Ocean**

*Harry F Lee[1] (1.The Chinese University of Hong Kong)

16:45 ~ 17:00

[ACG33-12] Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

*西井 和晃[1]、田口 文明[2]、中村 尚[2] (1.三重大学大学院生物資源学研究科、2.東京大学先端科学技術研究センター)

Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

*高橋 直也[1]、早坂 忠裕[1]
*Naoya Takahashi[1], Tadahiro Hayasaka[1]

1. 東北大学理学研究科地球物理学専攻大気海洋変動観測研究センター
1. Center for Atmospheric and Oceanic Studies, Graduate School of Science, Tohoku University,

Oceanic low-level cloud (i.e. fog, stratus, and stratocumulus) properties are important to determine radiative cooling at the sea surface via reflecting incident solar radiation, and they strongly interact with sea surface temperature (SST) with positive feedback process (Norris et al. 1998). Despite the importance of the role of low-level cloud in climate change or air-sea interaction, the mechanism of cloud evolution on short time-scale is not well investigated. Thus, the objective of this study is to reveal the evolution of low-level cloud cover (LCC) associated with cloud controlling parameters (e.g. SST, horizontal temperature advection, relative humidity in atmospheric boundary layer, and so on) on short time scale which cannot be revealed by monthly-mean dataset.

For cloud data, we used the level-3 daily gridded data product from MODIS imager (MYD08_D3) with 1 degree of horizontal resolution. OISST and ERA-Interim are used for SST and meteorological parameters, respectively. Spatial and temporal resolutions of these dataset are interpolated into that of MODIS. Target region is western North Pacific (150E-180E, 30N-40N) where standard deviation of LCC in summertime (JJASO) is large. Target period is each summertime from 2003 to 2016. To extract the shorter time-scale variability, we applied Lanczos band-pass filter for each variable. The extracted time scale by the band-pass filter is discussed in the next paragraph.

To investigate dominant time scales of LCC and SST, Fast Fourie Transform (FFT) analysis is applied. The results of FFT analysis for each variable show that 3-7-day and 20-100-day are dominant time-scale for LCC. The dominant time scale of temperature advection (Tadv) is similar to shorter one of LCC, which implies that Tadv is a key factor to control LCC on synoptic time scale rather than SST. On the other hand, for more longer time scale (20-100-day; intra-seasonal time scale), the correlation between SST and LCC is consistent with the previous studies (Norris 2000). To investigate the evolution process of LCC and SST on both time-scale, we applied the band-pass filter to them with two time-scale; (1) 3-7 day and (2) 20-100 day.

We further conducted phase composite analysis for each time scale. The result shows that (1) variation of SST (Tadv) lags (leads) to that of LCC on both time scales but (2) propagating direction of LCC anomaly and associated specific and relative humidity is eastward (westward) on synoptic (intra-seasonal) time scale. The difference in amplitude and propagation direction of LCC on each time-scale depend on different atmospheric dynamics and variation of associated moisture field. The above results also suggest that anomalous dry-cold Tadv is a trigger to increasing in LCC and SST decreasing is followed by them. This lead-lag relationship among each variable is clear on the intra-seasonal time scale. Temperature budget analysis for ocean mixed-layer shows that the SST decreasing is caused by shortwave cooling due to low-level cloud radiative effect and enhanced latent heat release. It emphasizes an importance of anomalous Tadv for the intra-seasonal variations of not only LCC but also SST.

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キーワード：夏季北太平洋、下層雲、総観規模擾乱・季節内振動、大気海洋相互作用、衛星観測データ解析
Keywords: Summertime North Pacific, Oceanic low-level cloud, Synoptic and intra-seasonal variabilities, Air-sea interaction, Satellite observations

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Sea surface temperature trend in the East China Sea during the 20th century simulated by a regional ocean model

*佐々木 克徳[1]、梅田 千智[1]
*Yoshi N Sasaki[1], Chisato Umeda[1]

1. 北海道大学
1. Hokkaido University

It has been reported that the East China Sea is one of the region where the sea surface temperature (SST) trend during the 20th century is a couple of times larger than the global mean SST trend. However, the detailed spatial structure of the SST trend in the East China Sea, especially in the early 20th century, and its quantitative mechanism have not been understood. The present study examines the SST trend in the East China Sea from 1901 to 2010 by using a regional ocean modeling system (ROMS) with an eddy-resolving horizontal resolution (0.1°) from 1871 to 2010. The spatial pattern of our simulation resembles that of the observations. That is, our simulation can reproduce the SST rise along the Kuroshio axis and over the continental shelf along the coast of China. The amplitude of the SST trend in the simulation is within the range between the two observations. The heat budget analysis revealed that the oceanic advection induced the SST rise in both regions. More specifically, the acceleration of the ocean currents plays an important role in the warming of the SST in both regions. In contrast, surface net heat flux acted as the damping of the SST rise.

キーワード：黒潮、地球温暖化、海洋モデル
Keywords: Kuroshio, global warming, ocean model

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Kuroshio Extension and Gulf Stream’s influences on the variability of near-surface baroclinicity and the associated atmospheric fields

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*Bunmei Taguchi[1], Kazuaki Nishii[2], Hisashi Nakamura[1,3]

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Evidence is mounting that mid-latitude western boundary currents (WBCs) can influence large-scale atmospheric circulation variability on interannual-to-decadal time scales. It is, however, still unclear how significantly such extra-tropical oceanic influences stand out of the intense variability intrinsic to the mid-latitude atmosphere. Here we examine the influences of extra-tropical oceanic frontal zone and its variability in the Gulf Stream (GS) and Kuroshio Extension (KE) regions on winter-season atmospheric variability in 20-member ensemble historical AGCM simulations with a horizontal resolution about 100km prescribed with satellite-observed, high-resolution sea surface temperature (SST) and sea-ice variability for the period 1982-2013. We focus on the near-surface baroclinicity $\boldsymbol{B}$ at 925 hPa as the quantity that is crucial for baroclinic eddy growth in the troposphere and is likely to be highly constrained by underlying oceanic frontal zones via air-sea heat exchange. We characterize the $\boldsymbol{B}$ variability separately in the GS and KE regions by applying EOF analysis to DJF-mean $\boldsymbol{B}$ across all the ensemble members and to that based on JRA55 reanalysis and then examine atmospheric and sea surface fields associated with their leading modes.

The simulations capture well the spatial structure of the observed $\boldsymbol{B}$ variability in both the WBC regions. Their leading modes (EOF1), explaining 42% (35%) of the total variance, represents intensifications of $\boldsymbol{B}$ over the GS (KE). While the EOF1 in the GS region is associated with enhanced storm track activity and westerly jet aloft, and geopotential height anomalies that resemble the negative phase of North Atlantic Oscillation (NAO), the EOF1 in the KE region is associated with a meridional dipole in height anomalies that resembles Western Pacific pattern. Further analysis of surface heat flux and SST anomalies contrasts the role of the two WBCs in the variability of $\boldsymbol{B}$ and the associated atmospheric features. Specifically, the enhanced $\boldsymbol{B}$ in the GS region is associated with enhanced heat release from the ocean, but with no SST anomalies, when cold air outbreaks spread across the sharp SST front over the GS. Over the KE, on the other hand, ocean-induced warm SST anomalies enhance heat release from the ocean, strengthening the overlying $\boldsymbol{B}$. Consistently, the evolution of observed PC1 time series is captured by the ensemble mean of the simulated PC1 in the KE region (r=0.46) but not in GS region (r=0.05). The former indicates the KE-induced SST anomalies adds a predictable component to $\boldsymbol{B}$ and the associated atmospheric variability in the North Pacific, while the latter reflects the variability mainly initiated by intrinsic NAO.

キーワード：ストームトラック　、西岸境界流、年々～十年規模変動、偏西風
Keywords: Atmospheric storm track , Western boundary currents , interannual-to-decadal variability, westerly jet

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Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

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*Morio Nakayama[1], Masatoshi Mizukoshi[1], Hisashi Nakamura[1], Yu Kosaka[1], Bunmei Taguchi[1], Masato Mori[1], Fumiaki Ogawa[2]

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1. RCAST, the University of Tokyo , 2. The University of Bergen

Large-scale tropospheric variability in the extratropical Southern Hemisphere is characterized by two major and independent modes. One is the barotropic annular mode or the Southern Annular Mode (SAM), which represents meridional shifts of the eddy-driven polar front jet (PFJ; Thompson and Wallace, 2000). The other is the Baroclinic Annular Mode (BAM), which represents pulsing of stormtrack activity (Thompson and Woodworth, 2014).

In this study, the sensitivity of BAM to the midlatitude oceanic frontal zone is assessed through aqua-planet experiments in which, after the removal of landmasses, zonally symmetric distributions of sea-surface temperature (SST) are prescribed as the lower boundary condition of an atmospheric general circulation model AFES. In our control experiment, climatological SST profiles observed over the South Indian Ocean in austral summer and winter are prescribed in the model northern and southern hemispheres, respectively. The profiles are characterized by frontal SST gradient at 45˚ latitude. In our NF experiment, the frontal SST gradients are removed by raising SST artificially poleward of the front. The two experiments are both conducted over 3600 days under a perpetual condition with insolation fixed to the boreal summer solstice.
As in the observations, BAM signatures in the control experiment represent pulsing of the climatological stormtrack anchored in the vicinity of the oceanic front. By contrast, in the NF experiment without the oceanic frontal zone, BAM cannot be reproduced: BAM-associated anomalies of eddy kinetic energy and poleward eddy heat flux are reduced by ~30% and ~50%, respectively, and their peaks are displaced equatorward by ~5˚ from the oceanic frontal zone. Our experiments therefore suggest that the oceanic frontal zone enhances and anchors the BAM variability by strengthening stormtrack activity through maintaining near-surface baroclinicity. Specifically, anomalous sensible heat flux from the ocean acts to restore the meridional gradients in surface air temperature modified by anomalous meridional eddy heat flux associated with BAM, and this effect is greatly enhanced under the frontal SST gradient.

キーワード：環状モード、海洋前線帯、水惑星実験
Keywords: Annular mode, Oceanic frontal zone, Aqua-planet experiment

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Hydro-climatic variation in northwestern China and its multi-decadal to multi-centennial teleconnection with the Pacific Ocean

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1. The Chinese University of Hong Kong

Northwestern (NW) China region locates in the boundary region between the Westerlies and the Asian Monsoon. Due to its unique geographical setting, scientific studies that examine the long-term dynamics of the hydro-climate there have received particular attention in recent years. However, these studies are often constrained by the availability of instrumental precipitation records. The present study seeks to address this issue. I based on historical drought/flood records to trace the geographic extent of drought anomalies as well as the intra-regional precipitation variability in NW China in AD580–2008, covering the periods with and without instrumental precipitation records. Moving correlation and wavelet analyses were applied to find their significant determinants. Results show that El Niño Southern Oscillation (Indo-Pacific warm pool sea surface temperature) is the major multi-decadal to centennial (centennial to multi-centennial) determinant of the hydro-climatic variability in NW China. The associated mechanism is anchored with the change of Asian Summer Monsoonal precipitation, while it is driven by different factors at different time-scales. The above findings may help predict the occurrence of drought in the boundary region between the Westerlies and the Asian Monsoon in the extratropics.

Keywords: Hydro-climate, northwestern China, Pacific Ocean

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Atmospheric zonal-mean meridional circulation and midlatitude oceanic fronts

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It is known that, in the zonal-mean tropospheric circulation, diabatic heating drives a thermally direct meridional overturning circulation (MOC) called the Hadley cell. While in the midlatitudes, zonal-mean vertical motion is driven mainly by atmospheric eddies, forming a thermally indirect MOC called the Ferrel cell where warmer (cooler) air apparently sinks (rises) in lower (higher) latitudes. Here we found a thermally-direct, shallow MOC embedded in the downward branch of the zonal mean Ferrel cell in the wintertime northern hemisphere in most of the latest generation reanalysis datasets. AGCM simulations reveal that this local MOC, made of upward (downward) motion around latitudes to the equatorward (poleward) side of midlatitude oceanic fronts, is driven by differential diabatic heating across the ocean fronts due to surface turbulent heat flux from the ocean and precipitation brought by synoptic-scale eddies. The compensating meridional flow in the lowermost atmosphere is northerlies, which decelerates surface westerlies just over the oceanic fronts through the Coriolis force. The decelerated surface westerlies by oceanic fronts in turn exert wind-stress curl forcing that tends to weaken oceanic subpolar and subtropical gyres, indicative of an air-sea coupled feedback that would destruct, rather than maintain, the oceanic fronts.

キーワード：中緯度海洋前線、鉛直流、傾圧性
Keywords: Midlatitude oceanic front, vertical motion, baroclinicity

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

2019年5月27日(月) 15:30 ~ 17:00 | 201B 2F

[H-DS11] Subaqueous Landslides and Their Anthropogenic Impact for Coastal Regions

コンビーナ:北村 有迅(鹿児島大学大学院理工学研究科地球環境科学専攻)、山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、座長:北村 有迅(鹿児島大学大学院理工学研究科地球環境科学専攻)、宇都宮 正志(産業技術総合研究所地質調査総合センター地質情報研究部門層序構造研究グループ)、山田 泰広(JAMSTEC)

A large number of people inhabit coastal areas around the world that are susceptible to natural catastrophes and subaqueous landslides are one of such hazards as demostrated recently. The risk associated with the occurrence of subaqueous landslides is not only constrained to passive margins or subduction zones but any of water areas is also susceptible to their occurrence since subaqueous failures can be triggered at very low slope angles. This realization poses a significant challenge that requires the collection of vast amounts of information and data to unravel the true nature of these events and their potential risk to coastal communities. Despite these challenges, recent technical and engineering advances in the acquisition and processing of sea floor and shallow subsurface data are encouraging. There has also been a concerted effort by scientists from different earth-science disciplines to increase interdisciplinary cooperation at an international level to advance our collective understanding of subaqueous landslides and their consequences.
This session calls for technical contributions covering all aspects of subaqueous landslide research including but not limited to: physical properties of deformed sediments (pre- and post- deformation), role of interstitial fluids in subaqueous landslide development, slope stability and risk assessments, geomorphological and sedimentological/stratigraphic descriptions, tsunamigenic risk and modeling, description of ancient subaqueous landslides, sand-box models and numerical simulations of subaqueous landslides. Case studies from lacustrine landslides and subaerial coastal landslides transitioning into the marine realm are also welcome. Case studies associated with the broader topic of subaqueous gravity-driven flows (e.g.: turbidites and transitional flows) and their relationship with seafloor faulting are also of interest to this session. Participants of IUGS project S4SLIDE IGCP-640 sponsor this session.

15:30 ~ 15:45

[HDS11-01] 北海道南部沖日高舟状海盆を埋積する海底地すべり堆積物の分布と堆積学的特徴ーとくに第四系最上部の地すべり堆積体についてー

*荒戸 裕之[1] (1.秋田大学大学院国際資源学研究科)

15:45 ~ 16:00

[HDS11-02] Origin and distribution of mass-transport deposits in the Pleistocene forearc basin, central Japan, deduced from tephro- and biostratigraphy

*宇都宮 正志[1]、山本 由弦[2]、水野 清秀[1] (1.産業技術総合研究所　地質調査総合センター、2.海洋研究開発機構)

16:00 ~ 16:15

[HDS11-03] Physico-chemical properties of sediment cores from Yatsushiro Sea, western Kyushu

*北村 有迅[1]、後藤 滝弥[2]、堀 航喜[2]、池端 雄太[2]、影山 遼[2]、川端 訓代[1]、小山 大輝[1]、山﨑 楓[2]、白鳳丸KH-18-3 乗船研究者 (1.鹿児島大学大学院理工学研究科地球環境科学専攻、2.鹿児島大学理学部地球環境科学科)

16:15 ~ 17:00

Discussion

北海道南部沖日高舟状海盆を埋積する海底地すべり堆積物の分布と堆積学的特徴ーとくに第四系最上部の地すべり堆積体についてー

Distribution and sedimentological characteristics of the submarine landslides filling Hidaka Trough, offshore southern Hokkaido, northern Japan with special attention to the uppermost Quaternary submarine landslide bodies

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*Hiroyuki Arato[1]

1. 秋田大学大学院国際資源学研究科
1. Graduate School of International Resource Sciences, Akita University

In the last few years, many examples of submarine landslides have been reported worldwide, and their systematic and genetic researches have been initiated. The studies in distribution, sedimentary pattern and mechanism of submarine landslides are remarkably important mainly from the following two reasons: (1) Submarine landslides affect significantly the state of surrounding water mass due to long distance migration of huge volume sediment mass within relatively short time period. One of the critical phenomena is megatsunami induced by submarine landslides, (2) Secondly nature of submarine landslides is deeply related to transportation mechanisms of siliciclastic sediments into tectonically formed sedimentary basins and their burial processes. In this study, two dataset of 3D seismic survey are utilized to describe some submarine landslide examples, under the owner’s permission. They are Geophysical Survey and Basin Evaluation Projects “2013FY Hidaka Shujo Kaibon 3D”(hereinafter, called HSK-3D) and “2014FY Hidaka Shujo Kaibon Seibu 3D” (HSKW-3D), acquired at the offshore southern Hokkaido by Ministry of Economy, Trade and Industry (METI).
The surveys cover the northeastern marginal slope and a part of central basin floor of Hidaka Trough elongated NW-SE direction. Water depth of covering area ranges from 577 to 1,156 mBMSL. The seismic reflector indicating seabed have been traced by using “seeded autotracking” function of PETREL, then a time structural contour map for the surface, which is equivalent to bathymetric map, have been drawn. Based on the topographic features, the survey area can be subdivided broadly into two types; one is characterized generally by smooth sea bottom surface, and another by irregular or rough surface in seismic scale. The area of smooth sea bottom cover approximately southwestern two thirds portion of HSKW-3D and a part of the western HSK-3D areas. On the other hand, northeastern one thirds of HSKW-3D, northwestern corner of HSK-3D, and northeastern portion and some extending areas are characterized by irregularly swollen, or roughly heaped unsmooth sea bottom surface. Such irregular topographic features of the seabed can be interpreted formed by Holocene or the youngest Quaternary submarine landslides from the point of view of their distribution within the basin. Within cross sectional views of the seismic data, those landslide bodies are observed as externally discontinuous and internally chaotic layers within orderly stacking parallel layered succession in seismic facies. These youngest submarine landslides seen in recent topography can largely be classified into 4 groups; called i) Shizunai, ii) Urakawa, iii) Samani and iv) Erimo Submarine Landslide, and they are laterally arrayed from northwest to southeast and running down generally from northeast to southwest on the continental slope of Hidaka Trough (Figure).
In addition, many buried submarine landslide bodies in the sediments filling the Hidaka Trough (e.g., Monbetsu SLS) can be recognized by seismic facies interpretation in the cross sections and time slice

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images. In the Hidaka Trough, Cretaceous to Quaternary sediments ranging up to 10km in thickness are present. Four horizons, A, B, C and D had been selected and traced within the sedimentary succession in this study. On the basis of chronostratigraphic correlation to the preceding studies, B, C, and D are correlative to intra-middle Pleistocene equivalent to the base of NPD12, base of middle Pleistocene Calabrian, and base of Pliocene, respectively. Horizon A is inferred as a horizon in the upper Pleistocene or Holocene. At least more than 3 landslide events can be detected in the stratigraphic unit between seabed and horizon A. In the unit between horizons A and B, 3 to 5 events are recognized, and there are equivalent numbers of landslide events in the unit between horizons B and C. Almost sediments are interpreted as chaotic seismic facies below horizon D.

キーワード：海底地すべり、日高舟状海盆、海底地すべり津波、三次元地震探査
Keywords: submarine landslide, Hidaka Trough, submarine landslide-induced tsunami, 3D seismic survey

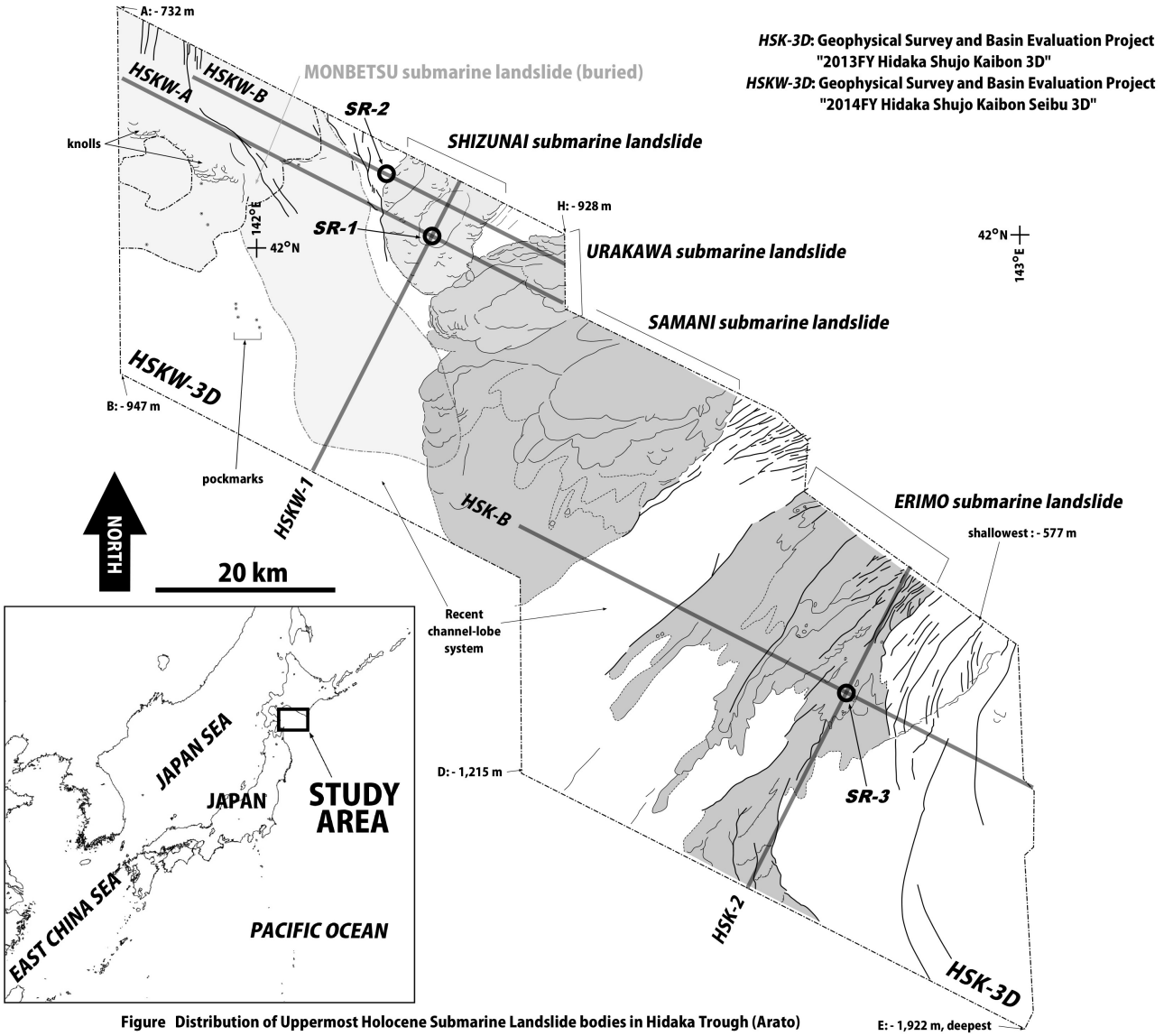


Figure Distribution of Uppermost Holocene Submarine Landslide bodies in Hidaka Trough (Arato)

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Origin and distribution of mass-transport deposits in the Pleistocene forearc basin, central Japan, deduced from tephro- and biostratigraphy

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1. Geological Survey of Japan, AIST, 2. JAMSTEC

We introduce a field-based study on the basin-wide mass-transport deposits (MTDs) by means of biostratigraphy and the marker tephra beds. The Kazusa Group, the Pleistocene forearc-basin fill exposed in central Japan, is characterized by high sedimentation rate and its stratigraphy is well-established. We focused on three MTDs referred to as MTDs-8–10. They consist of folded blocks that range from tens of centimeters to more than tens of meters in width and thickness, in a sandy mud matrix commonly containing volcaniclastics (e.g., pumice grains and euhedral crystals). The overall thickness of these MTDs ranges from ~20 to 100 m. Based on the lateral correlation of the tephra marker beds, these MTDs can be traced laterally for more than several tens of kilometers. MTD-8 (1.3 Ma) and MTD-9 (1.2 Ma) contain blocks characterized by folding, internal minor faulting, different attitude of bedding planes from the general trend, and occasionally overturned. The blocks in MTD-8 contain tephra beds and calcareous nannofossils that are typically found in the older strata down to 250 m below it, which suggest that the blocks are considered to have originated from the upstream excavated area and spread out laterally to cover the open seabed. On the other hand, MTD-10 (1.2 Ma) is characterized by a laterally-stacking pattern showing lamp-flat geometry, and the original stratigraphic positions of the blocks are consistent with the host strata, indicative of translational movement. The sedimentary dykes were observed in the basal slide plane, suggesting excess pore pressure within the slip zone. The different modes of occurrence are likely to be a result of local variation in slope gradient and distance of downslope migration. That is, initial phase of mass transportation on low-gradient slope represented a slide (MTD-10), whereas moving over a sufficiency long distance exhibited more mixtured and deformed slump (MTDs-8 and 9). Combination of studies on MTD textures, tephro- and biostratigraphy has great advantage to know their spatial distribution, original stratigraphic position where the MTDs were initiated, and mechanism to generate variable occurrence of MTDs.

キーワード：submarine landslide、mass-transport deposit、Kazusa Group、calcareous nannofossils、tephra
Keywords: submarine landslide, mass-transport deposit, Kazusa Group, calcareous nannofossils, tephra

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Physico-chemical properties of sediment cores from Yatsushiro Sea, western Kyushu

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*Yujin Kitamura[1], Ryoya Goto[2], Koki Hori[2], Yuta Ikebata[2], Haruka Kageyama[2], Kuniyo Kawabata[1], Daiki Oyama[1], Kaede Yamasaki[2], Hakuho-maru KH-18-3 Scientists

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Submarine active faults in Yatsushiro sea, western Kyushu, constitute the Yatsushiro section of Hinagu fault zone in its southwest end. The 2016 Kumamoto Earthquake was sourced from a part of active faults of the Futagawa-Hinagu fault zones. Earthquake shaking occasionally triggers submarine landslide. As submarine landslide can take place in very gentle slope (< 1˚), Yatsushiro sea is yet to be a scene for it although the area is a shallow and relatively small sedimentary basin. However, any record of submarine landslide in this area has not been reported.

Minamata bay, southern Yatsushiro sea, is known to be mercury pollution from a chemical plant drainage. A complex space-time distribution of mercury content in the sediments has been revealed (Tomuyasu et al., 2014). As the transportation of the mercury-containing clastics depends on sedimentation rate and/or water current, submarine landslide is a candidate for the factor of drastic change in benthic environment.

Here we conducted four-days research cruise Hakuho-maru KH-18-3 in July, 2018 to reveal submarine landslide records and benthic environment in Yatsushiro sea. We conducted subbottom profiling, piston coring at 11 sites, and multiple coring at 13 sites). Recovered cores are analyzed by X-ray CT scanner, multi-sensor core logger, core imaging apparatus, visual core description, color spectroscope, X-ray fluorescence core scanner (Itrax), and so do discrete samples by vane shear tester, picnometer with sediments and by Radon monitor with sea water and pore water.

Our results revealed clear difference in the lower part of each core compared to the upper part. By referring piston cores and their age data by Inoue et al. (2011), these distinctive units is caused by hiatus between about 3 to 8 ka. The lower sediments below the hiatus are characterized by rather high vane shear strength, low porosity and abundant terrigenous sediments. The depth of hiatus varies in site by site, which suggests difference in local depositional environment. Sedimentation rate of recent 50 years which Rifardi et al. (1998) inferred from superficial sediments cannot be applied for whole core, but the rate in longer time scale must be further smaller.

キーワード：タービダイト、浅海堆積物、平成28年熊本地震、水銀、八代海、水俣湾
Keywords: turbidites, shallow marine deposit, 2016 Kumamoto earthquake, mercury, Yatsushiro sea, Minamata bay

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

2019年5月27日(月) 13:45 ~ 15:15 | 301B 3F

[H-CG26] デルタとエスチュアリー：複雑な河口システムへの学際的取り組み

コンビーナ:齋藤 文紀(島根大学エスチュアリー研究センター)、Guan-Hong Lee(Inha University)、David L Dettman(University of Arizona)、堀 和明(名古屋大学環境学研究科地理学講座)、座長:Yoshiki Saito(Shimane Univ/ GSJ, AIST)、David Dettman(University of Arizona)

This session has foci on morphodynamics, material cycling, and sustainability in deltas and estuaries. We invite contributions that advance research on deltas and estuaries as complex river-mouth systems from modern and ancient examples, and that develop integrated frameworks for delta & estuary dynamics modeling on a broad range of temporal and spatial scales: from studies of coastal evolution over the Quaternary to small-scale sediment/material transport processes. We also invite physical processes studies based on field observations, numerical simulation and flume experiments. Finally, the conveners encourage contributions that promote data collection and sharing for both advancing science and local problem solving, that consider policy and governance issues linked to the sustainable development of deltas and estuaries, and that use in-situ and satellite data for modeling and risk assessment.

13:45 ~ 14:15

[HCG26-01] Recent Changes of the Asian Major Deltas

★Invited Papers

*Paul Liu[1] (1.North Carolina State University Raleigh)

14:15 ~ 14:30

[HCG26-02] **Matching trends in channel width, sinuosity, and depth along the fluvial to marine transition zone of tide-dominated river deltas: the need for a revision of depositional and hydraulic models**

★Invited Papers

*Marcello Gugliotta[1]、Yoshiki Saito[1] (1.Shimane University)

14:30 ~ 14:45

[HCG26-03] **Effects of an Estuarine Dam on Sediment Flux Mechanisms in a Macrotidal Estuary**

Steven Miguel Figueroa[1]、*Guan-Hong Lee[1] (1.Inha University)

14:45 ~ 15:00

[HCG26-04] **Late Pleistocene sedimentary evolution of the north Jiangsu coastal plain revealed by OSL dating based chronostratigraphy**

*Lei Gao[1]、Hao Long[1]、Ping Zhang[2]、Toru Tamura[3,4]、Ji Shen[1] (1.Nanjing Institute of Geography and Limnology, CAS,China、2.Geological Survey of Jiangsu Province (GSJP), Key Lab of EFGD, Ministry of LR, China、3.Geological Survey of Japan (GSJ), AIST、4.Graduate School of Frontier Sciences, The University of Tokyo)

15:00 ~ 15:15

[HCG26-05] The sedimentary environments and provenance of the late Quaternary sediments, in South Yellow Sea shelf, eastern China

*Yong Yin[1] (1.School of Geography and Ocean Science, Nanjing University)

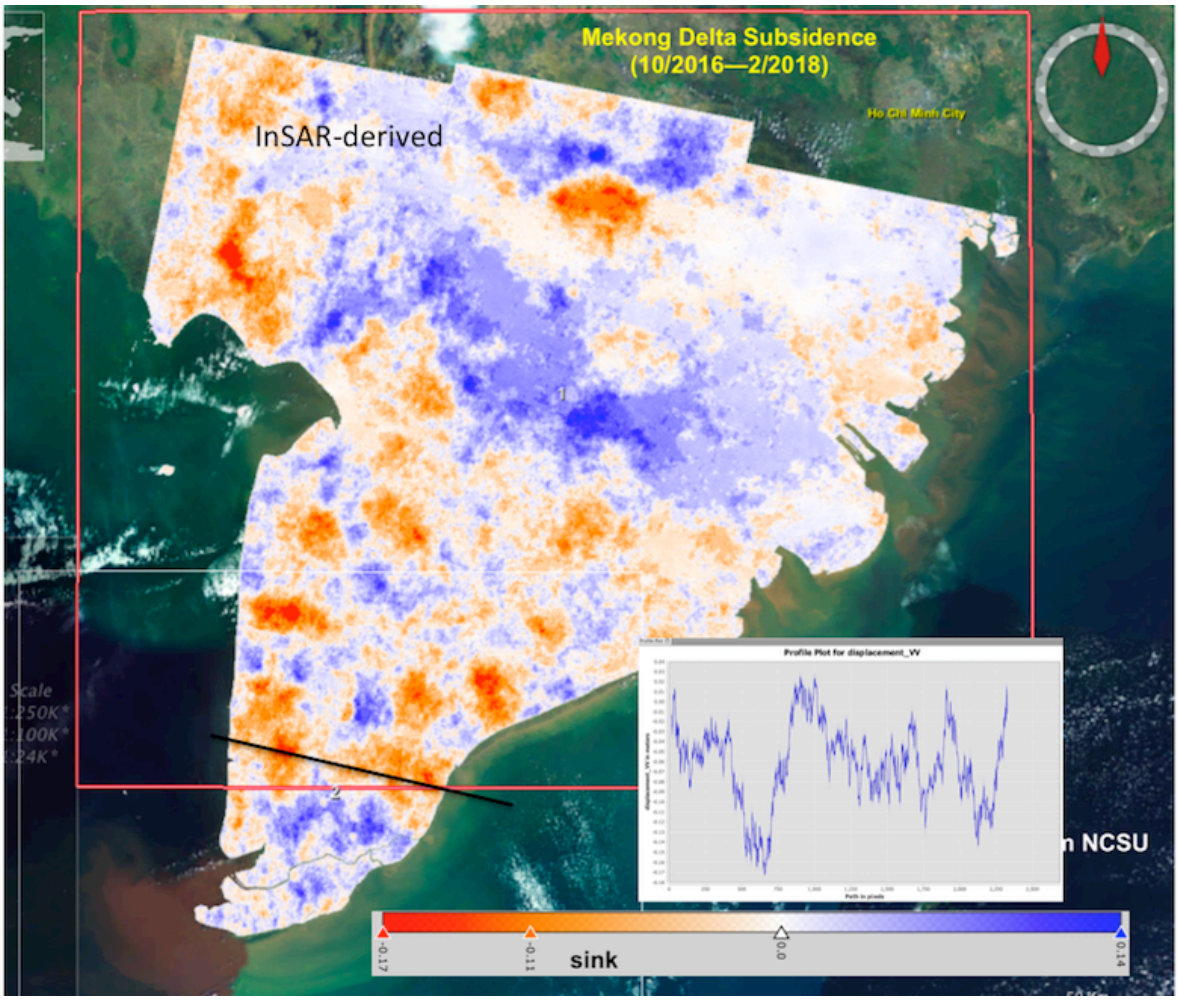
Recent Changes of the Asian Major Deltas

*Paul Liu[1]

1. North Carolina State University Raleigh

In the past 50 years, sediments from major Asian rivers have sharply decreased 80-90% due to the increased human activities (like building dams, overusing water, or sand mining) and climatic changes. Many of those river deltas have been experiencing severe coastal erosions, like the Yellow, Red, Mekong, Chao Phraya, and Indus, etc. Most of these deltas have turned from constructive growing mode to destructive declining mode, for example, the Mekong Delta has shown overall negative net land gain starting ~ 2005. Our studies also show not only the deltaic shorelines are retreating, but also some delta’s subaqueous portions are under strong erosion, such as the Yangtze, Mekong, Chao Phraya and Indus, etc.

Keywords: river delta , sediment decrease , shoreline erosion , subsidence



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Matching trends in channel width, sinuosity, and depth along the fluvial to marine transition zone of tide-dominated river deltas: the need for a revision of depositional and hydraulic models

*Marcello Gugliotta[1], Yoshiki Saito[1]

1. Shimane University

Along their fluvial to marine transition zone, tide-dominated river deltas show upstream to downstream trends in channel width, sinuosity, and depth, which at present have been only partially reported. This review article aims to describe these morphological trends from five modern tide-dominated river deltas using original data collected from satellite images and bathymetric maps and published data from field surveys. All the studied channels show similar trends with two distinct tracts separated by areas of morphological changes. The upstream tracts are characterized by constant width, relatively high sinuosity, and seaward-increasing depth, and are mainly controlled by the fluvial dynamics. The downstream tracts are characterized by seaward-increasing width, relatively low sinuosity, and seaward-decreasing depth, and are mainly controlled by the tidal dynamics. The delineation of this morphological configuration of the channels is crucial to understand the responses of deltas to the interacting riverine and marine processes. Additionally, this has important implications for depositional and hydraulic models, and for the long-term evolution and the assessment of human-induced versus natural modifications of these systems.

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Effects of an Estuarine Dam on Sediment Flux Mechanisms in a Macrotidal Estuary

Steven Miguel Figueroa[1], *Guan-Hong Lee[1]

1. Inha University

Sediment flux convergence traps sediment in many estuaries of the world coast. This sediment flux can be decomposed into a mean-flow flux and correlation flux to better understand the mechanisms driving the sediment trapping in estuaries. Humans have modified and are modifying many natural estuarine systems, however it isn’ t well understood what affects humans can have on sediment flux mechanisms and flux convergence in altered estuaries. Geum Estuary is a shallow, macrotidal estuary on the eastern Yellow Sea which has experienced tidal amplification and enhanced depositional rates following the operation of an estuarine dam since 1994. Geum Estuary thus serves as a good case for studying decomposed sediment fluxes for a shallow, macrotidal estuary affected by an estuarine dam. To quantify the sediment fluxes, we measured current and acoustic backscatter profiles at 1.5 km and 6.5 km seaward of the estuarine dam in Geum Estuary, over a period of two neap-spring cycles during which six episodic dam discharges occurred. Suspended sediment concentration (SSC) was estimated from acoustic backscatter and sediment flux was computed as the product of current velocity and SSC. The flux was decomposed into a mean-flow flux and correlation flux using 36-hr Lanczos filters. Additionally, ship-borne surveys were conducted at the two stations seaward of the estuarine dam to investigate more closely the role of dam-induced horizontal salinity gradient and vertical stratification on sediment resuspension and flocculation tidal asymmetries. Results indicated landward flux at both moorings with a negative flux gradient indicating deposition. Landward directed correlation flux was the dominant term. Its magnitude was proportional to the tidal range and tidal asymmetry and was found to occur in the bottom boundary layer. Seaward directed mean-flow fluxes were caused by the episodic dam discharges. Their magnitude was proportional to the discharge volume and was greatest in the surface layer of the water column. At the seaward station, periodic stratification occurred following the dam discharge and resulted in tidal asymmetries in resuspension and flocculation providing evidence for landward flux due to tidal straining. Overall the data confirms that the estuarine dam controls the seaward mean-flow fluxes, and these fluxes are smaller when the dam is closed. Furthermore, the proportionality of the correlation flux with tidal range provides supports that the dam enhanced the landward correlation fluxes because of the tidal amplification effect. Finally, the tidal straining effect was confirmed to occur in a macrotidal estuary with an estuarine dam.

Keywords: estuary, sediment flux, tidal straining, dam discharge, anthropocene

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Late Pleistocene sedimentary evolution of the north Jiangsu coastal plain revealed by OSL dating based chronostratigraphy

*Lei Gao[1], Hao Long[1], Ping Zhang[2], Toru Tamura[3,4], Ji Shen[1]

1. Nanjing Institute of Geography and Limnology, CAS,China, 2. Geological Survey of Jiangsu Province (GSJP), Key Lab of EFGD, Ministry of LR, China, 3. Geological Survey of Japan (GSJ), AIST, 4. Graduate School of Frontier Sciences, The University of Tokyo

In the past decades, many Chinese geoscientists carried out numerous research works to investigate the sedimentary history of the Jiangsu coastal plain. However, we still have limited understanding of history prior to the Holocene because of the lack of reliable chronology. In this study, we applied quartz optically stimulated luminescence dating (OSL) techniques to determine the ages of 11 sediment samples from a 30-m-long core (EGWY02) drilled from the north Jiangsu coastal plain. The sedimentary facies of the core were identified based on observation, grain-size analysis, colors and textures of sediments. The stratigraphy of the core was then correlated to three cores collected in the adjacent area (Zhang et al., 2010; Xia and Zhang, 2018). In our core, we identified two marine transgressive events T1 and T2 at intervals of 3-5 and 21-27 m deep, respectively. The timing of T1 and T2 were dated as 7.1±0.9 ka and > 77±6 ka, respectively. The interval of T1 is overlain by a littoral sedimentary facies deposited over the last 2 ka. Three layers of “stiff clay” (SC) were identified at depths of 1-2, 8-12 and 27-30 m and are interpreted terrestrial deposits. The first SC layer was dated about 1.8±0.1 ka while the second layer was between 44±3 ka and 72±6 ka. In addition, we recognized fluvial deposits at interval of 12-21 m deep, which was dated from 72 to 77 ka. A lacustrine layer was also identified at 5-8 m deep and dated as 41-44 ka. Our OSL dating application to the core EGWY02 thus clarified that the sedimentary succession represents two transgressive episodes in relation to the last interglacial (MIS 5) and post glacial periods (MIS 1), intervened by the terrestrial environments related to the MIS 4-2. Further application of the OSL dating to the subsurface sediment cores will unveil the pre-Holocene environmental changes in the Jiangsu coastal plain, which was possibly affected by the paleo-Yangtze River.

Keywords: OSL dating, Chronostratigraphy, The north Jiangsu coastal plain , Sedimentary evolution, Late Pleistocene

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The sedimentary environments and provenance of the late Quaternary sediments, in South Yellow Sea shelf, eastern China

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1. School of Geography and Ocean Science, Nanjing University

The late Quaternary sedimentary systems are mainly controlled by sea-level changes, sediment supply and regional subsidence. The late Quaternary source materials of South Yellow Sea shelf were controlled by Yellow and Yangtze rivers. So sediment provenance is very important not only for “source to sink (S2S)” processes but also for land-sea interaction.

The South Yellow Sea is a semi-enclosed epicontinental sea between China to the west and Korea Peninsula to the east. Since the late Quaternary, the South Yellow Sea has experienced several eustatic sea-level changes and sediment supplies alternatively from old Yellow and Yangtze Rivers. Previous work did not documented the late Quaternary environments and sediment provenance in this region. Several boreholes are used: 1) to synthesize the long term sedimentary environments since the late Quaternary; 2) to discriminate the source materials and appraise the contribution of Yellow and Yangtze rivers; 3) to evaluate the driving forces controlling the formation of South Yellow Sea shelf.

The sedimentary facies analysis indicates the South Yellow Sea shelf experienced fluvial and tidal influenced fluvial environments during MIS6. Then the fluvial environment was replaced by tidal flat, estuary and delta front environments during the transgression taking place in MIS5. Delta front environments dominated the South Yellow Sea shelf during the transgression occurred in MIS3. During MIS2, the shelf was cut by network of valleys and filled with coarse materials within the fluvial channels and fine materials beyond the channels. During the Holocene, transgression environment developed in early period followed by tidal dominated coast to shelf environments in late period in South Yellow Sea shelf and estuary to delta environments in Yangtze River mouth area.

Detrital zircon U-Pb ages were employed to analyze the provenance of source materials. By comparison of Yangtze and Yellow rivers U-Pb age spectrum, the Yangtze River is characterized by 100~300Ma and 700~900Ma zircons and Yellow River is dominated by 300~500Ma and 1800~2000Ma zircons. The zircons younger than 150Ma merely found in Yangtze affiliated sediments and the zircons between 1300 and 1600 Ma only found in Yellow River affiliated sediments. For zircons between 1800 and 2000Ma and between 2200 and 2500Ma, the particles from Yellow River are more than those from Yangtze River. The results indicate the late Quaternary sediments are mostly from the old Yangtze River and occasionally influenced by Yellow River, e.g. during some periods in MIS6 and MIS2 and Holocene.

The core-recorded strata have revealed the study area experienced the similar estuary to delta processes in MIS 5 as the Yangtze delta in the Holocene. The deltaic successions dominate the South Yellow Sea shelf during the MIS 5 and MIS 3. The source province indicates the old Yangtze attributed a lot to delta sediments. Sea-level cycles and source material supplies play an important role in the late Quaternary coast and shelf successions.

Keywords: sedimentary environment , source provenance, deltaic successions, zircon U-Pb ages

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

2019年5月27日(月) 9:00 ~ 10:30 | 301B 3F

[H-CG27] 混濁流:発生源から堆積物・地形形成まで

コンビーナ:横川 美和(大阪工業大学情報科学部)、成瀬 元(京都大学大学院理学研究科)、泉 典洋(北海道大学大学院工学研究院)、池原 研(産業技術総合研究所地質情報研究部門)、座長:横川 美和(大阪工業大学)、泉 典洋(北海道大学)

最近の観測技術の発展、アナログ・数値実験ならびに理論解析の進展により、混濁流やそのベッ
ドフォームについてそのダイナミックな実態がわかりつつある。また、これらを地層記録に適用
することにより、広い意味でのタービダイトの理解が進んできた。そのトリガーやソースによっ
て、流れの性質が異なり、これはすなわち、混濁流が作る地形や堆積物の違いをもたらす。自然
災害の影響評価、資源開発、地層・地形形成の理解など、様々な場面において、混濁流について
様々な分野から得られる知識の統合が必要である。この国際セッションでは、現地観測、アナロ
グ・数値実験、理論解析、地層解析など、あらゆる分野・手法での混濁流へのアプローチを歓迎
する。

9:00 ~ 9:15

[HCG27-01] Inverse analysis of turbidity currents using two dimensional shallow water model

*成瀬 元[1] (1.京都大学大学院理学研究科)

9:15 ~ 9:30

[HCG27-02] 深度学習によるタービダイト逆解析手法の実験的検証

*Cai Zhirong[1]、成瀬 元[1]、姚 奇峰[1] (1.京都大学)

9:30 ~ 9:45

[HCG27-03] Conditions for development of depositional submarine channels: examination by flume experiments

*Justine Poppeschi[1]、Kazushi Nakata[1]、Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

9:45 ~ 10:00

[HCG27-04] Cyclic steps formed by long-runout turbidity currents

*Zhuyuan Wu[1]、Norihiro Izumi [1] (1.Hokkaido University)

10:00 ~ 10:15

[HCG27-05] 表層堆積物の再懸濁は地震起源混濁流発生のより普遍的なメカニズムか？南海トラフ西端と日本海溝の海底コアの放射性炭素年代測定から

*池原 研[1]、金松 敏也[3]、Tobias Schwestermann[2]、喜岡 新[2]、Michael Strasser[2] (1.産業技術総合研究所地質情報研究部門、2.インスブルック大学、3.海洋研究開発機構)

10:15 ~ 10:30

[HCG27-06] 日本海溝海溝軸の表層浅部イベント層序

*Kioka A.[1]、Schwestermann T.[1]、Moernaut J.[1]、Ikehara K.[2]、Kanamatsu T.[3]、Strasser M.[1,4] (1.インスブルック大学、2.産業技術総合研究所、3.海洋研究開発機構、4.ブレーメン大学)

Inverse analysis of turbidity currents using two dimensional shallow water model

Inverse analysis of turbidity currents using two dimensional shallow water model

*成瀬 元[1]
*Hajime Naruse[1]

1. 京都大学大学院理学研究科
1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

Quantitative reconstruction of flow properties from turbidites is a long-standing problem in deep-sea sedimentology. If this is realized, magnitudes of past hazardous events may be estimated from geologic records containing seismo-(tsunami-)generated turbidites. Also, entire geometry of turbidite reservoir can be inferred by flow reconstruction. Thus, inverse analysis of turbidity currents contributes to disaster-risk assessment, and is of economic importance. Here we propose a new methodology to reconstruct flow properties of turbidity currents from three-dimensional geometry of deposits. In this method, a two-dimensional shallow-water model of turbidity currents was employed as the forward model. Numerical simulation was repeated to obtain horizontal distribution of thickness of turbidites under various initial conditions, and then this synthetic data set was used for supervised training of a deep-learning neural network (DNN). After the training phase finished, DNN properly estimated initial conditions of turbidity currents (e.g. initial flow height, velocity, etc.) from artificial test data set that was also produced from the forward model. To summarize, the machine learning produced the inverse model of turbidity currents that can estimate paleo-hydraulic conditions from synthetic or ancient turbidites. In previous methods, the computational cost of two dimensional model was too high to be employed as the forward model for turbidite inversion. On the other hand, our methodology can reconstruct initial conditions of turbidity currents instantaneously. Although production of the training data set requires 1000s times repetition of calculation, the problem of calculation efficiency can be easily solved by using PC cluster. In future study, it is expected to apply the new methodology to actual turbidites measured in 3D seismic profiles or by high-resolution sampling on modern sea floor.

キーワード：sediment gravity flow、turbidite、inverse analysis、machine learning
Keywords: sediment gravity flow, turbidite, inverse analysis, machine learning

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深度学習によるタービダイト逆解析手法の実験的検証
Inverse Analysis of Experimental Scale Turbidity Currents by Deep Learning Neural Network

*Cai Zhirong[1]、成瀬 元[1]、姚 奇峰[1]
*Cai Zhirong[1], Hajime Naruse[1], Qifeng Yao[1]

1. 京都大学
1. Kyoto University

In this study, inverse analysis of turbidite deposited in flume experiments will be performed using a new machine learning method. The results of inverse analysis will serve to verify the accuracy of the machine learning method.

Understanding of the hydraulic conditions of turbidity current remains limited due to its destructive nature and its unpredictable occurrences. Thus, the inverse analysis of turbidity currents from ancient deposits of submarine fans is required for estimating the conditions of flows in the natural environments.

In the past, inverse modeling of turbidity currents was done in a trial and error fashion by adjusting initial conditions of numerical models, which is high in calculation load, making such technique very expensive and highly impractical. Naruse (2017 AGU Fall Meeting) developed a completely new method for inverse analysis of turbidity currents using a deep learning neural network. In this method, training data is generated by a numerical model, and a neural network for reconstructing hydraulic conditions of turbidity currents from turbidite is produced by machine learning of the training dataset. However, validity of this new inverse model has not yet been tested in actual deposits. Therefore, this study aims to verify the method by flume experiments.

Currently, the initial conditions of a dataset produced by a flume experiment sized forward model program is used to test the applicability of the neural network method when applied to flume experiment size data. Three thousand sets of training data were fed into the neural network as training data. Another two hundred separate cases were used as test data to verify the accuracy of prediction by neural network. Result shows initial flow velocity can be predicted relatively accurately. The initial concentrations of the finer grain size class and the initial flow height was partially reconstructed. The flow duration, the coarser grain size classes and the slopes within the flume could not be predicted. After tuning of the neural network and the forward model, the neural network trained for flume sized data will be applied to flume experiment results.

キーワード：水槽実験、機械学習、混濁流
Keywords: Machine Learning, Flume Experiment, Turbidite

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Conditions for development of depositional submarine channels: examination by flume experiments

*Justine Poppeschi[1], Kazushi Nakata[1], Hajime Naruse[1]

1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University

Although submarine channels are ubiquitously observed in various submarine fans, it is also known that submarine fans lacking continuous leveed channels are common depending on regions. However, the governing parameters to determine this diversity in developments of leveed channels has not been clarified yet. This is because there has been no previous researches that successfully reproduced depositional leveed channel topography in experimental flumes. Therefore, the formative conditions of depositional submarine channels have not been clarified yet. Here, we conducted flume experiments, aiming to reproduce depositional submarine channels for understanding their formative conditions. As a result, we succeeded to form experimental topography that resemble natural depositional submarine channels showing a ceiling river structure with levees in all five experiments. Comparing the experimental topography with the actual submarine fans, the relative depth of the experimental channel was slightly shallow, but features such as the spatial variation of the channel width showed similar trends to those of the actual submarine channels. Thus, we imply that purely depositional submarine channels can be formed without presence of precursor of erosive features. Furthermore, experimental conditions of this study were in the region where the previous study predicted that submarine channels cannot be formed, suggesting that further investigation is needed to discover the governing parameters for developments of submarine leveed channels.

Keywords: turbidity currents, flume experiment, submarine fan

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Cyclic steps formed by long-runout turbidity currents

*Zhuyuan Wu[1], Norihiro Izumi [1]

1. Hokkaido University

It has been found that a variety of submarine morphology such as submarine fans, submarine rivers, and submarine canyons, has been formed by turbidity currents which travel relatively long distance (long-run out turbidity currents). The long-run out turbidity currents have a number of features similar to open channel flow. They have an equilibrium (or quasi-equilibrium at least) state, and are accompanied by hydraulic jumps when they transition from supercritical to subcritical flow regimes. In this research, with the use of the assumption that an equilibrium state can be achieved in the high-concentrated lower layer near the bottom of long-run out turbidity currents, we propose an analytical model with the use of the layer-averaged governing equations, which reproduces cyclic steps with relatively long wavelengths accompanied by periodic internal hydraulic jumps.

Integrating the Reynolds-averaged Navier-Stokes equations and continuity equation over the high concentrated lower layer, we obtain the boundary layer approximated (layer-averaged) momentum and continuity equations. In the integration, it is possible to simplify the governing equations by ignoring the entertainment from the top of the high concentrated lower layer with the assumption that the Reynolds stress becomes almost zero and the shear stress almost vanishes there. In addition to the momentum equations and continuity equation, we employ the diffusion/dispersion equation of suspended sediment, and the continuity equation of sediment (Exner equation).

The unknown variables in the problem are four: the velocity, the layer thickness, the layer-averaged suspended sediment concentration, and the bed elevation. The governing equations are the layer-averaged momentum and continuity equations, the layer-averaged diffusion/dispersion equation of suspended sediment, and the continuity equation of sediment (Exner equation). The boundary conditions for this problem are that the momentum has to be continuous before and after each hydraulic jump. More specifically, the velocity and the layer thickness have to satisfy the jump condition before and after each jump. In addition, the suspended sediment concentration has to be continuous at the jump.

We solve the problem numerically, and obtain the wavelengths of steps. The wavelength of a long-run out turbidity current is determined by the thickness of the high-concentration layer near the bottom. It is shown that the wavelengths obtained in the analysis agree relatively well with the observation.

Keywords: cyclic steps, turbidity currents, submarine bedform

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表層堆積物の再懸濁は地震起源混濁流発生のより普遍的なメカニズムか？南海トラフ西端と日本海溝の海底コアの放射性炭素年代測定から
Is surface sediment remobilization more popular mechanism for generating earthquake-induced turbidity current? Evidence of radiocarbon dates from the westernmost Nankai and Japan Trench subduction zones

*池原 研[1]、金松 敏也[3]、Tobias Schwestermann[2]、喜岡 新[2]、Michael Strasser[2]
*Ken Ikehara[1], Toshiya Kanamatsu[3], Tobias Schwestermann[2], Arata Kioka[2], Michael Strasser[2]

1. 産業技術総合研究所地質情報研究部門、2. インスブルック大学、3. 海洋研究開発機構
1. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology, 2. Universität Innsbruck, 3. Japan Agency for Marine-Earth Science and Technology

Deep-sea turbidite has been used for reconstructing past large earthquake history. Surface sediment remobilization is a relatively new idea for generating earthquake-induced turbidite, although submarine landslide has been considered as major mechanism for earthquake-induced turbidite deposition. Surface sediment remobilization has been reported from the Chilean lakes, forearc slopes along the Nankai and Japan Trench subduction zones. However, the detailed mechanism of surface sediment resuspension, remobilization and initiation of turbidity current is still unknown. For better understanding of the mechanism, it is important to understand the spatio-temporal occurrence of surface sediment remobilization. We obtained some cores from a small basin on the forearc slope in Hyuga-nada off Kyushu, and the Japan Trench floor. Fine-grained turbidites were found in the cores. Paired radiocarbon dates of the turbidite muds and hemipelagic muds between the turbidites show only small age differences. This indicates that it is unnecessary to occur bathymetry-scale (with >several meters bathymetric change) submarine landslides by earthquake ground shaking for generation of the turbidites. Large surface sediment resuspension by earthquake ground shaking at the sedimented slope near the depositional area (basin) is thought to be an important process for repeated deposition of earthquake-induced turbidites in the basin.

キーワード：surface sediment remobilization、turbidite、earthquake、radiocarbon dating
Keywords: surface sediment remobilization, turbidite, earthquake, radiocarbon dating

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日本海溝海溝軸の表層浅部イベント層序
Shallow-subsurface event stratigraphy along the hadal trench axis of the Japan Trench

*Kioka A.[1]、Schwestermann T.[1]、Moernaut J.[1]、Ikehara K.[2]、Kanamatsu T.[3]、Strasser M.[1,4]
*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], M. Strasser[1,4]

1. インスブルック大学、2. 産業技術総合研究所、3. 海洋研究開発機構、4. ブレーメン大学
1. Universität Innsbruck, Austria, 2. GSJ-AIST, Japan, 3. JAMSTEC, Japan, 4. MARUM-U. Bremen, Germany

The giant AD 2011 Tohoku-oki earthquake has been documented to remobilize a wide area of surface sediment, redistributing from the slope into the >7 km deep Japan Trench forming distinct event deposits in hadal terminal basins (Ikehara et al., 2016; Kioka et al., 2019). Other than the 2011 earthquake, similarly large earthquakes are historically known along the Japan Trench, and respective deposits have been described in recent studies from cores retrieved from the Japan Trench (Ikehara et al., 2016). Yet, little is understood about (i) the temporal and spatial distribution of event deposits along the entire trench axis, (ii) how the spatial extent may link to the rupture area of historically-reported earthquakes, and (iii) whether older deposits may indicate prehistoric large earthquakes along the Japan Trench. We herein study dm-scale vertical resolution subbottom profiler data acquired during 2012–2018 using PARASOUND and TOPAS recording systems installed on R/Vs Sonne and Shinsei-Maru over the entire Japan Trench area (36.0˚–40.5˚N), in order to investigate the event-stratigraphic distribution of acoustically-transparent layers that represent sediment remobilization event deposits. The subbottom profiler data generally record well up to ~40 m below the seafloor. Transparent bodies of the upper ~10 m correlate well to event layers reported from sediment cores linked to major historic earthquake such as the AD 2011 Tohoku-oki, AD 1454 Kyotoku, and AD 869 Jogan events. Mapping of these event deposits in the spatially-extensive subbottom profiler data allows to study the spatial distribution of these events and its comparison to their reconstructed rupture areas. Furthermore, the lower part of the hitherto only acoustically-imaged stratigraphic succession of isolated trench-floor basins along the Japan Trench also documents several thick acoustically-transparent bodies. Preliminary interpretation suggests several of the bodies could be event deposits triggered by old large earthquakes. While ground-truth of this interpretation and absolute dating requires long coring efforts in the ultra-deep Japan Trench, our study yields relative stratigraphic information and quantitative constraints of along strike variation of sediment volumes redistributed by episodic events along the Tohoku seismogenic margin.

キーワード：日本海溝、超深海、イベント堆積物、海底地形、サブボトムプロファイラー
Keywords: Japan Trench, Hadal zone, Event deposit, Bathymetry, Subbottom profiler (SBP)

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

2019年5月27日(月) 10:45 ~ 12:15 | 301B 3F

[H-CG27] 混濁流:発生源から堆積物・地形形成まで

コンビーナ:横川 美和(大阪工業大学情報科学部)、成瀬 元(京都大学大学院理学研究科)、泉 典洋(北海道大学大学院工学研究院)、池原 研(産業技術総合研究所地質情報研究部門)、座長:成瀬 元(Kyoto University)、池原 研(産総研)

最近の観測技術の発展、アナログ・数値実験ならびに理論解析の進展により、混濁流やそのベッ
ドフォームについてそのダイナミックな実態がわかりつつある。また、これらを地層記録に適用
することにより、広い意味でのタービダイトの理解が進んできた。そのトリガーやソースによっ
て、流れの性質が異なり、これはすなわち、混濁流が作る地形や堆積物の違いをもたらす。自然
災害の影響評価、資源開発、地層・地形形成の理解など、様々な場面において、混濁流について
様々な分野から得られる知識の統合が必要である。この国際セッションでは、現地観測、アナロ
グ・数値実験、理論解析、地層解析など、あらゆる分野・手法での混濁流へのアプローチを歓迎
する。

10:45 ~ 11:07

[HCG27-07] Canyon changes caused by an earthquake-triggered turbidity current in the 2016 M7.8 Kaikōura Earthquake, New Zealand

★Invited Papers

*Joshu J Mountjoy[1]、Jamie D Howarth[2]、Alan R Orpin[1]、Philip M Barnes[1]、David A Bowden[1]、Ashley A Rowden[1]、Alexander C. G. Schimel[1]、Caroline Holden[3]、Huw J Horgan[2]、Scott D Nodder[1]、Jayson R Patton[4]、Geoffroy Lamarche[1,5]、Matt Gerstenberger[3]、Aaron Micallef[6]、Arne Pallentin[1]、Tim Kane[1] (1.NIWA, Wellington. New Zealand、2.VUW, Wellington. New Zealand、3.GNS Science, Lower Hutt. New Zealand、4.HSU, Arcata CA. USA、5.UoA, Auckland. New Zealand、6.UoM, Msida. Malta)

11:07 ~ 11:29

[HCG27-08] Far More Prolonged Deep-sea Turbidity Currents triggered by typhoon and earthquake in the Gaoping Submarine Canyon

★Invited Papers

*Yanwei Zhang[1]、Zhifei Liu[1]、Yulong Zhao[1]、Xiaodong Zhang[1] (1.Tongji University)

11:29 ~ 11:51

[HCG27-09] **Filling the gap between turbidity current processes and products in British Columbia fjords**

★Invited Papers

*Sophie Hage[1,2,3] (1.School of Ocean and Earth Sciences, University of Southampton, United Kingdom、2.National Oceanography Centre Southampton, United Kingdom、3.Department of Geography, Durham University, United Kingdom)

11:51 ~ 12:13

[HCG27-10] **Sediment transfer from shelf to abyss through giant ganyons and valleys system in deep-sea carbonate slopes (Bahamas)**

★Invited Papers

*Thierry Mulder[1]、Hervé Gillet[1]、Vincent Hanquiez[1]、Audrey Recouvreur[1]、Kelly Fauquembergue[1]、Johan Le Goff[2]、John J.G. Reijmer[2]、Emmanuelle Ducassou[1]、Margot Joumes、Thibault Cavailhes[1]、Elsa Tournadour[5]、Jean Borgomano[3]、Emmanuelle Poli[4] (1.University of Bordeaux, UMR CNRS 5805 EPOC, Allée Geoffroy Saint Hilaire, Pessac, France、2.King Fahd Univ. of Petroleum. and Minerals, Dhahran, Saudi Arabia.、3.Aix Marseille University, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France.、4.Total, CSTJF, avenue Larribau, Pau, France、5.Ifremer, Centre de Brest, Plouzané)

12:13 ~ 12:15

Discussion

Canyon changes caused by an earthquake-triggered turbidity current in the 2016 M7.8 Kaikōura Earthquake, New Zealand

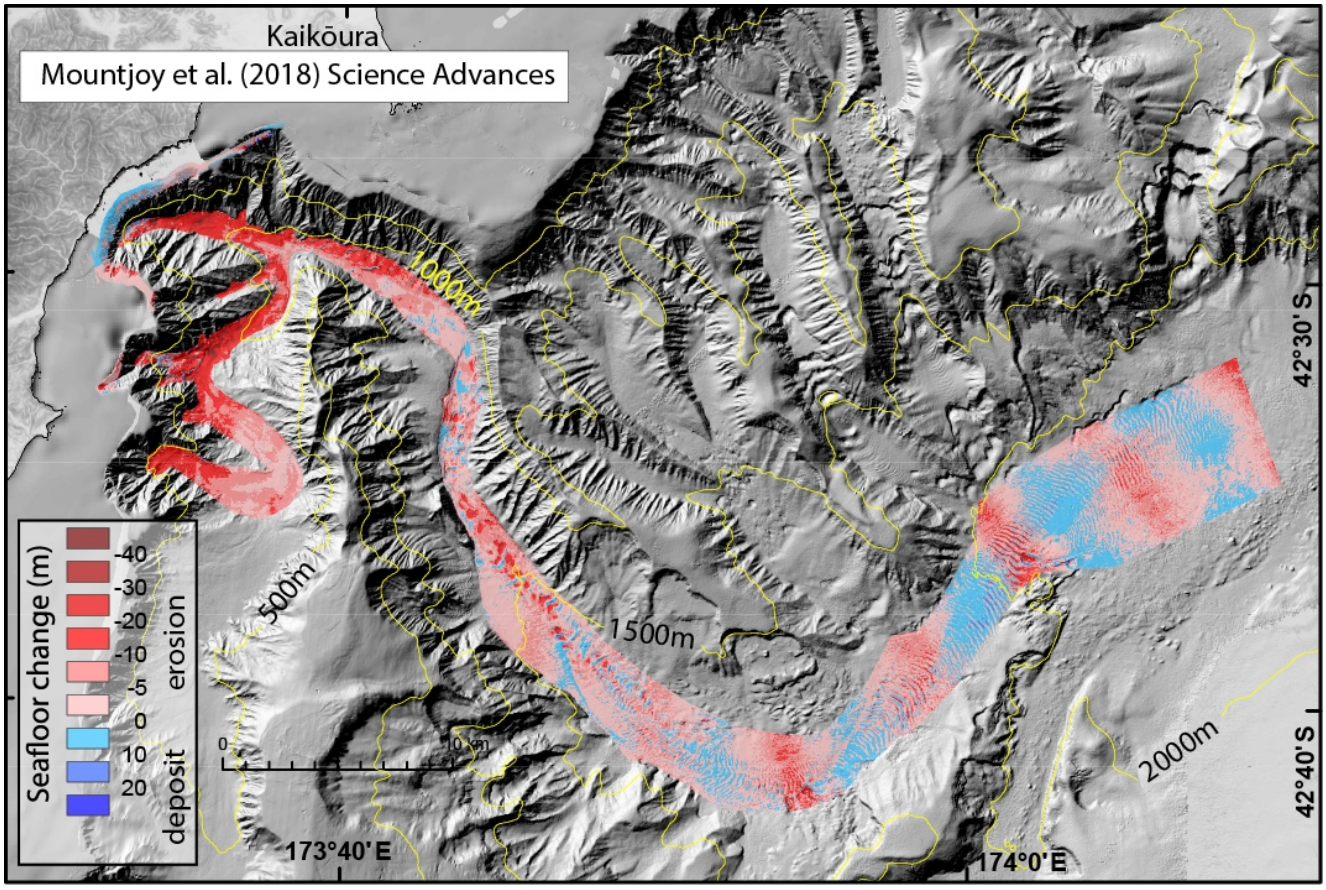
*Joshu J Mountjoy[1], Jamie D Howarth[2], Alan R Orpin[1], Philip M Barnes[1], David A Bowden[1], Ashley A Rowden[1], Alexander C. G. Schimel[1], Caroline Holden[3], Huw J Horgan[2], Scott D Nodder[1], Jayson R Patton[4], Geoffroy Lamarche[1,5], Matt Gerstenberger[3], Aaron Micallef[6], Arne Pallentin[1], Tim Kane[1]

1. NIWA, Wellington. New Zealand, 2. VUW, Wellington. New Zealand, 3. GNS Science, Lower Hutt. New Zealand, 4. HSU, Arcata CA. USA, 5. UoA, Auckland. New Zealand, 6. UoM, Msida. Malta

Based on repeat seafloor measurements and samples we show that the M_w 7.8 November 2016 Kaikōura earthquake (New Zealand) triggered widespread landslides in a large-scale bedrock submarine canyon. These landslides initiated a powerful “canyon-flushing” event and turbidity current that travelled > 680 km along one of the world’s longest deep-sea channels, the Hikurangi Channel. To our knowledge these observations provide the first direct quantification of seafloor landscape change and large-scale sediment transport associated with an earthquake-triggered full canyon flushing event. Our results augment observations from smaller scale turbidites confined to large submarine canyons (e.g. repeat surveying in Monterey Canyon) that move stored material within canyons but do not export sediment to the deep ocean or erode into underlying substrate. The inter-event period for the Kaikōura Canyon flushing event, calculated from back analysis of triggering strong ground motion, is ~140 years. Combined with observed erosion into bedrock this indicates a canyon incision rate of 40 mm y^{-1}, substantially higher than most terrestrial rivers. Significant geomorphic change occurred within the canyon including erosion up to 60m depth in the upper canyon, scour hole formation, and down canyon movement of mega-scale bedforms constructed of gravel-boulder sized sediments. The event synchronously transferred 850 Mt of sediment and 7 Mt organic carbon to the deep ocean. Our observations demonstrate that earthquake-triggered canyon flushing is a primary driver of submarine canyon development and material transfer from active continental margins to the deep ocean.

Keywords: submarine canyon, earthquake, multibeam bathymetry, submarine landslide, seafloor erosion

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Far More Prolonged Deep-sea Turbidity Currents triggered by typhoon and earthquake in the Gaoping Submarine Canyon

*Yanwei Zhang[1], Zhifei Liu[1], Yulong Zhao[1], Xiaodong Zhang[1]

1. Tongji University

Submarine turbidity currents are argued to deliver more sediment along their long-runout propagation than other dynamic processes from shelf to deep sea. The *in situ* temporal and spatial features of turbidity currents are urgently required for a better quantitative constraints on sediment transport and deposition in the deep sea. Here, we document yearlong direct monitoring of turbidity currents in the middle reach at a water depth of 1265 m and the lower reach at 2425 m on the margin of the Gaoping Submarine Canyon off Taiwan, which has the wettest typhoons and active earthquakes. Both the two moorings (~35 km apart) were equipped with sediment traps and various sensors to collect particles consecutively with 18 days interval and to record velocity, sediment concentration, temperature and salinity with 20 min interval. Seven turbidity currents are identified consistently at these two reaches with enhanced sediment flux, which was recorded by a time-series sediment trap at 30 m above the seafloor. By combining the atmospheric measurements and earthquake data, four turbidity currents are triggered by the four powerful typhoons crossed Taiwan during typhoon season in boreal summer 2015, and one event is attributed to the M_L 6.5 Kaohsiung earthquake in southern Taiwan in February 2016. The two types of turbidity currents associated with individual typhoon and earthquake show a sustained duration ranging from 9 to 41 days, far more prolonged than the longest documented deep-sea turbidity currents (~10 days) in other locations. The flow velocity observed on the margin (~0.2 m/s) is much weaker than that in the thalweg of the canyon (> 5.8 m/s) inferred from the break of cables. For the first time, our observation provides the variability of the timing and hydrographic properties of the turbidity currents triggered by individual mechanisms for better constraints on flow capacity and sediment redistribution.

Keywords: in situ mooring observation, prolonged turbidity currents, typhoon and earthquake

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Filling the gap between turbidity current processes and products in British Columbia fjords

*Sophie Hage[1,2,3]

1. School of Ocean and Earth Sciences, University of Southampton, United Kingdom, 2. National Oceanography Centre Southampton, United Kingdom, 3. Department of Geography, Durham University, United Kingdom

Turbidity currents are one of the volumetrically most important processes to transfer sediments from land to sea. Fast-moving, powerful turbidity currents can damage seafloor infrastructure and carve submarine channels. These submarine channels feed deep sea fans, which are the largest sediment accumulations on Earth. Such huge sediment accumulations sequester organic carbon over geologic timescales and are thus thought to play a role in the global carbon cycle. Despite the global significance of turbidity currents, the link between flow processes (e.g. triggering mechanisms, seafloor erosion) and depositional products is still poorly constrained. This lack of knowledge is mainly due to the difficulty to monitor flows and to directly sample the associated deposits to these flows. Here we present direct observations of turbidity currents and their deposits in two Canadian fjords: Howe Sound and Bute Inlet in British Columbia. As these two fjords are connected at their head to glacier-fed rivers, they are excellent sites to study the transport and fate of particles from land to submarine sites. Using these new observations, this talk will cover three research themes: 1) How do dilute river plumes generate turbidity currents? 2) What is the depositional architecture/facies resulting from supercritical turbidity currents and crescentic bedforms? 3) How are organic carbon mixtures distributed in turbidites and what are the implications for the carbon cycle?

Keywords: turbidity current, turbidite, organic carbon, crescentic bedforms

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Sediment transfer from shelf to abyss through giant ganyons and valleys system in deep-sea carbonate slopes (Bahamas)

*Thierry Mulder[1], Hervé Gillet[1], Vincent Hanquiez[1], Audrey Recouvreur[1], Kelly Fauquembergue[1], Johan Le Goff[2], John J.G. Reijmer[2], Emmanuelle Ducassou[1], Margot Joumes, Thibault Cavailhes[1], Elsa Tournadour[5], Jean Borgomano[3], Emmanuelle Poli[4]

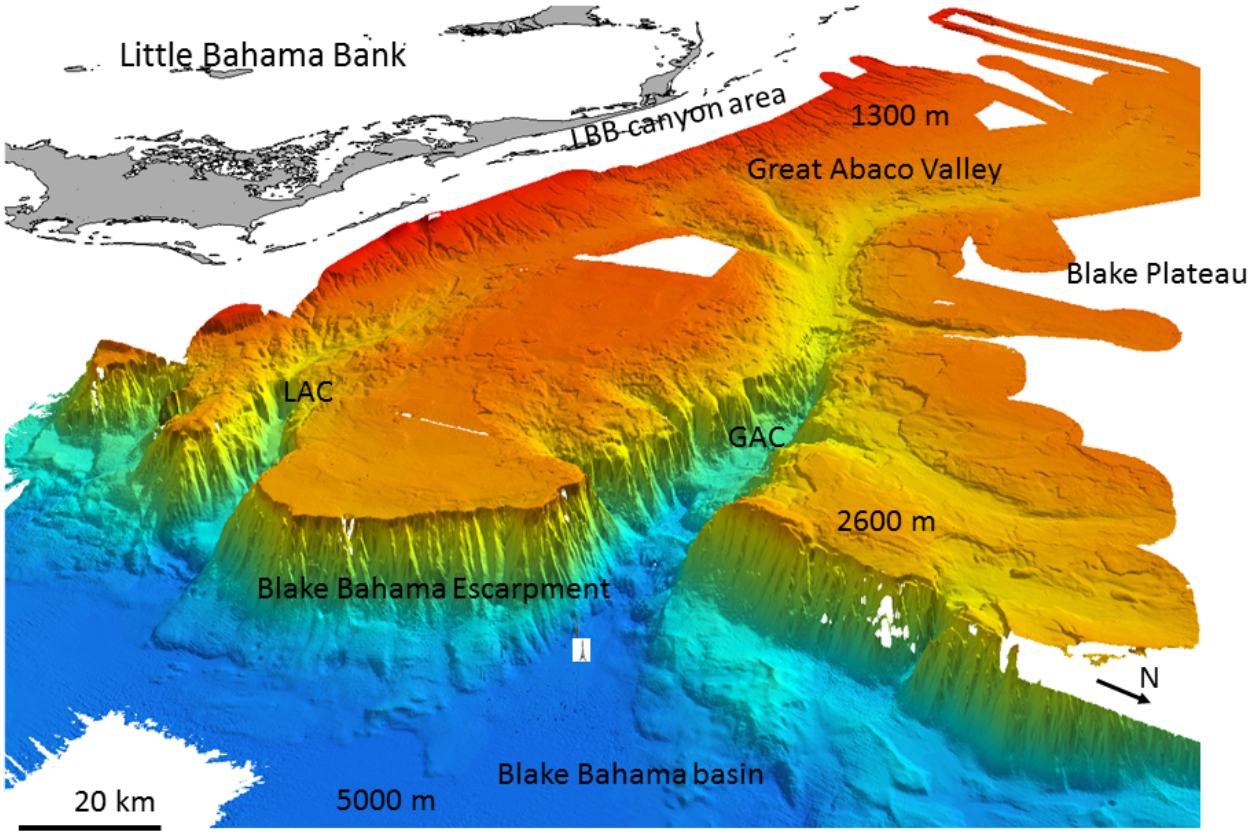
1. University of Bordeaux, UMR CNRS 5805 EPOC, Allée Geoffroy Saint Hilaire, Pessac, France, 2. King Fahd Univ. of Petroleum. and Minerals, Dhahran, Saudi Arabia., 3. Aix Marseille University, CNRS, IRD, Collège de France, CEREGE, Aix-en-Provence, France., 4. Total, CSTJF, avenue Larribau, Pau, France, 5. Ifremer, Centre de Brest, Plouzané

Bahamas are one of the rare present-day study areas in the world that allows to understand carbonate particle transfer from platform to deep-sea. A lot of ancient (DSDP/ODP, Bacar cruises) and recent (Carambar Cruises) dataset have been collected from 30 m to 5,000 m water depth. It includes high-resolution multibeam mapping, backscatter imaging, very-high resolution seismics and gravity cores. These new high-resolution data expose in great details the deep-water sedimentary system in the southern part of Exuma Sound (ES) and the northern part of Little Bahama Bank (LBB, Bahamas). The data reveal the detailed and complex morphology of giant valleys like the Great and Little Abaco canyons (GAC and LAC) along the LBB slope, the Great Bahama Canyon between LBB and Eleuthera Island, being the deepest canyon in the world, and the Exuma Valley/Canyon in the ES area. In all cases, present-day off-bank transport is initiated by two ways: (1) When a cold atmospheric front occurs, high-density, cold surface water sinks and entrains fine-grained particles through density cascading. This process is at the origin of the deposition of the Holocene Prograding Wedge that began to form 13.6 ka ago with a maximum growing at 4 ka when the platform was flooded. (2) During hurricanes when the fine-grained particles deposited on the shelf are resuspended and pushed off the platform through tidal passes. There, acceleration of tidal currents generates tidal flushing. On the LBB smooth slopes, coarse-grained particles (ooids and bioclasts) are trapped in tidal deltas and only fine-grained carbonate particles reach the upper slope. In Exuma area, steeper slopes allow transfer of coarse-grained particles that reach the ES slope and finally supply coarse-grained (bioclasts-rich) turbidity currents and concentrated/hyperconcentrated flows that are channeled down to the Atlantic Abyssal Plain though giant valleys. Along the valley, they form classical spill-over levee deposits. Four of these large valleys extending parallel to the shelf are presented. They all probably extend along structural directions. In GAC, finely-grained sediments originate essentially from the canyon flanks, driven by sediment slides as well as many secondary slope gullies and smaller tributaries. In LAC, gullies directly drain the upper LBB slope providing coarser particles. In the Exuma Valley/Canyon, a part of the material comes from the slope of adjacent islands and cays through small-scale gravity processes and mass failures. A substantial part of the sediments also originate from along-slope sediment flow erosion. In all areas, the valleys abruptly turn into deep canyons incising the Bahama Escarpment (BE). The canyons link the LBB and ES sedimentary systems to the deep abyssal plain of the Western North Atlantic where water depth exceeds 5,000 m. The transition occurs through major knickpoints with outsized chutes exceeding several hundred of meters in height. The sudden transformation from a wide valley to a deep narrow canyon occurs as a result of flow erosion of the underlying lower Cretaceous carbonate platform stack. Huge hydraulic jumps as well as enormous and permanent plunge pools and related deposits were identified at the transition. Dissolution processes in the carbonate deposits may also play a part in the formation of theses outsized plunge pools. In ES, the high kinetic flow energy constrained by narrow and deeply incised canyon formed a wide fan-shaped channel-levee complex on the abyssal plain. The latter is made up of coarse-grained carbonate turbidites and concentrated density-flow deposits that are mixed with fine-grained siliciclastics transported along

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the BE by the energetic Western Boundary Undercurrent. Conversely the canyon mouth of the LBB system only reveals a small channeled lobe. Seismic data on this system at water depth > 4500 show the distalmost deposits are younger than mid-Miocene, suggesting that the activity of the canyon is very recent.

Keywords: Turbidity currents, Carbonate slope, giant canyons, Bahamas, Plunge pools



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[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27日(月) 15:30 ~ 17:00 | A10 東京ベイ幕張ホール

[S-SS07] Rigorous Seismicity Modelling and Hypothesis Testing

コンビーナ:庄 建倉(統計数理研究所)、Schorlemmer Danijel(GFZ German Research Centre for Geosciences)、Matt Gerstenberger(GNS Science)、鶴岡 弘(東京大学地震研究所)、座長:Matthew Gerstenberger(GNS Science, New Zealand)、Danijel Schorlemmer(GFZ-Potsdam, Germany)

Probabilistic models have been developed for describing, analyzing, and forecasting seismicity since more than 100 years and, with the advent of large-scale digital networks, in high resolution during the last 30 years. These models include recurrence and stress-release models for long-term earthquake hazard assessment, and short-term models describing earthquake clustering, e.g. the ETAS model. Some models have become standard tools in seismic hazard assessment. However, the overall probabilities remain on the low end and the uncertainties of the forecasts are not well described. Rigorous data-based development and testing of models will help further improving forecasting power and accuracy of these models. Similarly, new hypotheses shall be evaluated rigorously using some existing model as the null hypothesis model or in dedicated tests addressing the hypothesis directly. In this context, the Collaboratory for the Study of Earthquake Predictability and its Japan branch provides the necessary testing capabilities for rigorous and unbiased evaluation of models and hypotheses. This session focuses on research that increases information on seismicity, being with respect to a reference model or as an independent hypothesis. We solicit contributions of model developments and hypothesis formulation based on the increased understanding of the physical process of earthquakes, such as the preparation and rupture processes of the earthquake source and the interaction between earthquakes and tectonic environments. We also welcome development and implementation of improved statistical methods for testing and validating physical hypotheses based on observed data. In particular, we welcome contributions about model- or hypothesis-test experiments that could be implemented in the Japan testing center.

15:30 ~ 15:45

[SSS07-01] Improving medium-term earthquake forecasts by compensating the EEPAS model for the time-lag

★Invited Papers

David Rhoades[1]、Christophersen Annemarie[1]、*Matt Gerstenberger[1] (1.GNS Science)

15:45 ~ 16:00

[SSS07-02] Earthquake probability forecast incorporating non-seismic data

*Peng Han[1]、Jiancang Zhuang[2]、Yosihiko Ogata[2]、Katsumi Hattori[3] (1.Southern University of Science and Technology, Shenzhen, China、2.The Institute of Statistical Mathematics, Tokyo, Japan 、3.Chiba University, Chiba, Japan)

16:00 ~ 16:15

[SSS07-03] Extended versions of the space-time ETAS model and application to the 2016 Kumamoto earthquake sequence

★Invited Papers

*YICUN GUO[1]、Jiancang Zhuang[1]、Yosihiko Ogata[1] (1.The Institute of Statistical Mathematics, Tokyo, Japan)

16:15 ~ 16:30

[SSS07-04] CSEP Japan の結果と今後に向けて

*平田 直[1]、鶴岡 弘[1]、Schorlemmer Danijel[3]、庄 建倉[2] (1.東京大学地震研究所、2.統計数理研究所、3.GFZ)

16:30 ~ 16:45

[SSS07-05] From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

★招待講演

*Ma Kuo-Fong[1,2,3]、Yen Mingshen [1]、Liao Yiwun[1]、Su Henyi[2] (1.Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC、2.Department of Earth Sciences, National Central University, Taiwan, ROC、3.Institute of Earth Sciences, Academia Sinica, Taiwan, ROC)

16:45 ~ 17:00

[SSS07-06] **首都圏直下の３次元高解像度地震活動予測**

★招待講演

*尾形 良彦[1,2]、桂 康一、鶴岡 弘[2]、平田 直[2] (1.大学共同利用機関法人　情報・システム研究機構　統計数理研究所、2.東京大学地震研究所)

Improving medium-term earthquake forecasts by compensating the EEPAS model for the time-lag

David Rhoades[1], Christophersen Annemarie[1], *Matt Gerstenberger[1]

1. GNS Science

The “Every Earthquake a Precursor According to Scale” (EEPAS) model treats every earthquake as a precursor of larger earthquakes to follow it in the medium term. Each earthquake contributes a transient increment to the expected rate of earthquake occurrence in its vicinity, based on empirical predictive scaling relations associated with the precursory scale increase phenomenon. Incomplete information on precursory earthquakes causes the EEPAS model to under-predict the expected number of earthquakes when forecasting across a time-lag. We modify EEPAS to compensate for the time-lag when calculating future forecasts. Given a set of model parameters, the completeness of precursory information can be expressed as a function of the target earthquake magnitude and the time-lag. The EEPAS model has a time-varying component and a background component. We consider two end-members for compensating the model for incompleteness: one entirely in the background component, and the other entirely in the time-varying component. We estimate an optimal mixture of these two end-members for time-lags out to 12 years using several different versions of the EEPAS model and subsets of the New Zealand earthquake catalogue to which EEPAS was previously fitted. Performance is checked on an independent test period. The optimal compensated model having increasingly high information gains over the original EEPAS model with increasing time-lags. Using catalogue data complete to 2018, the compensated models forecast increased annual probabilities of earthquake occurrence above magnitude thresholds from 6.0 to 8.0 in central New Zealand in the period 2019-2030 relative to the preceding period 2008-2018.

Keywords: earthquake forecasting, EEPAS, hypothesis testing, New Zealand

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Earthquake probability forecast incorporating non-seismic data

*Peng Han[1], Jiancang Zhuang[2], Yosihiko Ogata[2], Katsumi Hattori[3]

1. Southern University of Science and Technology, Shenzhen, China, 2. The Institute of Statistical Mathematics, Tokyo, Japan , 3. Chiba University, Chiba, Japan

This study aims to develop statistical models for earthquake temporal occurrences based on both earthquake catalogs and other geophysical observations. As an example, the seismomagnetic signals at Kakioka (KAK) station are utilized to illustrate the modeling strategies, because previous studies suggest they might contain certain precursory information of local sizable earthquakes. Self-exciting, external-exciting, and combined models modified from Ogata’ s LIN-LIN algorithm have been applied to forecast the occurrences of M>4.05 earthquakes within 100 km from the KAK station. The self-exciting and external-exciting models perform significantly better than the Poisson Model, implying there are explanatory power in earthquake catalogs and magnetic anomalies, respectively. The combined model, which integrates information from catalogs and magnetic observations, is greatly superior to any of the other three models. Additional tests show that external exciting component derived from the magnetic data is not post-seismic in character, and is more likely to cooperate with large earthquakes. The combined model proposed in this study could also be useful to incorporate other non-catalog observations and may have potential value in improving Time-dependent hazard maps for operational forecasting.

Keywords: Probabilistic forecasting, Seismomagnetic, Modelling and interpretation, Japan

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Extended versions of the space-time ETAS model and application to the 2016 Kumamoto earthquake sequence

*YICUN GUO[1], Jiancang Zhuang[1], Yosihiko Ogata[1]

1. The Institute of Statistical Mathematics, Tokyo, Japan

We proposed an extended version of the space-time ETAS model which simultaneously incorporates focal depths and rupture geometries of large earthquakes. The depth component is decoupled from earthquake hypocenters and assumed to follow the Beta distribution. This 3D-hypocenter finite-source ETAS model is applied to the 2016 Kumamoto earthquake sequence. Results from other versions of ETAS models are also obtained as comparisons. To model the dynamically triggered seismicity in Yufuin-Beppu region, an extended source which is more than two times' length of the ruptured fault of the Kumamoto mainshock is taken as its triggering source. Our results show that about 11.2% of the total seismicity is the background rate. Within the triggering source of mainshock, proportions of earthquakes being recognized as direct aftershocks of two foreshocks and the mainshock are 3.6%, 2.7%, and 23.3%, respectively. The reconstructed patterns of aftershock productivity show significant migrations in space and time. In near field (10km from slip > 1m areas), the decay of aftershock productivity follows an inverse power law of distance, verifying that aftershocks occur as an effect of stress changes imparted by the mainshock. Areas of high aftershock productivity form complementary patterns for coseismic slips, meaning that aftershocks contribute to the postseismic relaxation process.

Keywords: ETAS model, aftershock productivity, dynamic triggering

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CSEP Japan の結果と今後に向けて
CSEP Japan results and future developments

*平田 直[1]、鶴岡 弘[1]、Schorlemmer Danijel[3]、庄 建倉[2]
*Naoshi Hirata[1], Hiroshi Tsuruoka[1], Danijel Schorlemmer[3], Jiancang Zhuang[2]

1. 東京大学地震研究所、2. 統計数理研究所、3. GFZ
1. Earthquake Research Institute, the University of Tokyo, 2. Institute of Statistical Mathematics, 3. GFZ German Research Centre for Geosciences

CSEPに基づく地震発生予測実験が日本では2009年11月から開始され，ほぼ10年が経った．日本においては，3つのテスト領域と4つのテストクラスが設定され，160を超えるモデルが日本のテストセンターにおいて評価されている．

実験が開始されてすぐに太平洋東北沖地震が発生し，予測結果の成績がよくなかった期間があったが，その後は回復傾向である．ただし，太平洋東北地震の影響を考慮したモデル改良によりモデルのパフォーマンスが向上することもわかった．また，地震数の予測が多くのモデルで比較的困難であるということもわかった．

予測結果の評価は，CSEP標準のテストであるN-test, M-Test, S-Test, L-testにより実施されているが，モデル間の比較のためには，対数尤度や情報利得（あるいは確率利得）が直接的で有効であることも明らかとなった．

実験が開始され10年が経ち，テストセンターにおけるハードウェアの老朽化への対策や学習データの増加により大きな配列数の確保などモデルの修正などが必要となっている．また，現在の実験はマグニチュード４あるいは5以上を予測するテストクラスが設定されているが，より大きなマグニチュードを予測するテストクラスの設定が必要である．

キーワード：地震予測可能性、CSEP
Keywords: Earthquake Predictability, CSEP

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From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

From the studies of historical earthquakes to the implication of single fault to multiple fault segments ruptures in seismic hazard analysis

*Ma Kuo-Fong[1,2,3]、Yen Mingshen [1]、Liao Yiwun[1]、Su Henyi[2]
*Kuo-Fong Ma[1,2,3], Mingshen Yen[1], Yiwun Liao[1], Henyi Su[2]

1. Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC、2. Department of Earth Sciences, National Central University, Taiwan, ROC、3. Institute of Earth Sciences, Academia Sinica, Taiwan, ROC
1. Earthquake - Disaster & Risk Evaluation and Managment (E-DREaM) Center, National Central University, Taiwan, ROC, 2. Department of Earth Sciences, National Central University, Taiwan, ROC, 3. Institute of Earth Sciences, Academia Sinica, Taiwan, ROC

Historically, significant crustal damaging earthquakes in Taiwan mostly were from complicated fault system rather than from a single fault segment, which was not incorporated in the seismic hazard analysis of TEM PSHA2015, but, included in current developed new seismic hazard map of TEM PSHA2019. The 1906 M7.1 Meishan earthquake, recently, had been resolved to be from a fault system of blind NE strike thrust with EW surface breaching fault (one of the identified seismogenic structures). And, the 1935 M7.1 was occurred with bilateral rupture from a blind fault to strike-slip mechanism to the south and thrusting mechanism to the north. We employed the rupture kinematic modeling to the historical geodetic data with comparison to the intensity pattern to understand the possible involvement of the fault system. In addition to the damaging earthquakes from seismic active region, an ancient 1604 M7.5-M8.0 Quanchao damaging Earthquake in southeastern coast China region was also explored from literature intensity to understand the seismic potential of less seismic active regime in Taiwan strait. These historical and past events suggest that a single fault segment evaluation for seismic hazard might be inadequate. But, we have not yet had solution to solve this inadequacy to pin down the partition of slip rate within an identified fault system. We examined the fault rupture system from kinematic and dynamic modeling of the historical events, and examined the possible partition in slip rate for the fault segments in this identified fault system. We, further then compare its influence to the estimation of seismic hazard analysis. For development in PSHA and its application, we suggest the importance of resolving historical damaging earthquakes from modern developed seismology to seismic hazard assessment and risk management.

キーワード：fault system、seismic hazard analysis
Keywords: fault system, seismic hazard analysis

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首都圏直下の３次元高解像度地震活動予測
High resolution space-time models forecasting 3D seismicity beneath the Greater Tokyo Area

*尾形 良彦[1,2]、桂 康一、鶴岡 弘[2]、平田 直[2]
*Yosihiko Ogata[1,2], Koichi Katsura, Hiroshi Tsuruoka[2], Naoshi Hirata[2]

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経度、緯度および深さに関する3次元空間の統計モデルの開発は関東平野直下100km深までの地震活動の解析・予測のために特に必要である。関東直下ではフィリピン海プレートと太平洋プレートのスラブが重なって北米プレートに沈み込み、各プレート間やプレート内の地震活動の相互作用が複雑であり、２次元以下の時空間モデルでは詳細な解析結果や確率予測を得ることが難しいためである。

３次元空間の階層的時空間ETASモデルは、任意の時刻 t と位置 (x, y, z) での地震活動度が過去の地震発生履歴の関数として記述されるものである。なかでも常時地震活動度 m（background seismicity）や余震生産性K（aftershock productivity）は、地域性の変化が特に大きいので，位置の関数と考え地震活動の特徴を定量化する。さらに現在の関東直下の地震活動度は東北地方太平洋沖地震によって誘発された活動度として大森・宇津型の関数で記述する。ここで関東直下における東北沖地震からの影響度K_{M9}の地域的な違いを位置依存性として定量化する。さらに将来の大地震の確率予測のために関東直下におけるマグニチュード頻度分布が必要でGutenberg-Richter則のb-値にも３次元位置依存性を仮定する。これらの解により関東直下の地震活動を特徴づけ、大地震の長期予測や余震の確率予報に適用する。

かくて、震源データから関数 $m\,(x,y,z)$, $K\,(x,y,z)$, $K_{M9}\,(x,y,z)$ 及び $b\,(x,y,z)$を定義し推定するために、関東直下100kmまでの直方体を震源などを頂点とする小４面体にデロネ分割し、これらの関数型を決める係数はデロネ多面体網の頂点での値であり、任意の位置 (x, y, z) における関数値は、その位置を囲むデロネ多面体（tetrahedron）内で線形的に内挿したものである。このような局所的に線形な関数をデロネ関数と呼ぶ。しかし、それらの係数は極めて多数なので最尤法は適用不可であり、求める係数間に制約を付けて安定した解を求める。すなわちデロネ関数の変化が平滑になるように、デロネ関数の局所的な傾きにデロネ多面体の体積を乗じたものの２乗和をペナルティ関数とし、これを付加した対数尤度（penalized log likelihood）を考える。ペナルティの強さを赤池ベイズ情報量規準（経験的ベイズ法）の最小化によって決め、ペナルティ付き対数尤度を最大化する係数を最適解として得る。

キーワード：赤池ベイズ情報量規準(ABIC)、地震予測、拡張階層時空間ETASモデル、誘発地震活動、東北沖M9地震
Keywords: Akaike Bayesian Information Criterion (ABIC), Earthquake forecast, Extended 3D hierarchical space-time ETAS model, Induced seismicity, Tohoku-Oki Earthquake of M9

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[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27日(月) 9:00 ~ 10:30 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:Anselme Borgeaud、土屋 卓久

近年の高圧実験の進歩で、地球中心部に至る温度圧力条件での鉱物の物性測定が可能となってきた。一方、高精度な古地磁気測定、地球物理学観測、精密地球物理学分析、地球ニュートリノによる地球深部放射性物質の直接観測などの発展と共に、マントル対流や地磁気ダイナモの数値シミュレーション技術も大きく発展して、地球内部の状態の理解が進んできた。本セッションでは、地球及び惑星における核ーマントル相互作用と進化に焦点をあてた、様々な研究分野の成果を一堂に会する機会を提供し、情報交換を進めることを目的とする。異なる分野間の連携を発展させるための日本版地球・惑星深部研究グループ(J-SEDI）の形成に関わる講演も歓迎する。

9:00 ~ 9:15

[SIT21-01] The role of stishovite as a deep nitrogen carrier indicated from high-pressure and high-temperature experiments

*福山 鴻[1]、鍵 裕之[1]、井上 徹[2,3]、新名 亨[3]、柿澤 翔[3]、菱田 俊一[4]、佐野 有司[5]、高畑 直人[5] (1.東京大学大学院理学系研究科附属地殻化学実験施設、2.広島大学大学院理学研究科地球惑星システム学専攻、3.愛媛大学地球深部ダイナミクス研究センター、4.国立研究開発法人物質・材料研究機構、5.東京大学大気海洋研究所)

9:15 ~ 9:30

[SIT21-02] 3-D P- and S-velocity structure of the D″ layer beneath Central America and the Caribbean using waveform inversion

★Invited Papers

*Anselme F. E. Borgeaud[1,2]、Kenji Kawai[1]、Robert J. Geller[1] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo、2.Institute of Earth Sciences, Academia Sinica)

9:30 ~ 9:45

[SIT21-03] D111型高圧発生装置を用いたブリッジマナイトの一軸変形実験

★招待講演

*辻野 典秀[1]、山崎 大輔[1]、西原 遊[2] (1.岡山大学・惑星物質研究所、2.愛媛大学・地球深部ダイナミクス研究センター)

9:45 ~ 10:00

[SIT21-04] **Waveform inversion for 3D anisotropic structure in D″ beneath the Northern Pacific: Constraints on mineralogy and flow in the lowermost mantle**

*鈴木 裕輝[1]、河合 研志[1]、ゲラー ロバート[1] (1.東京大学大学院理学系研究科地球惑星科学専攻)

10:00 ~ 10:15

[SIT21-05] Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

*柿澤 翔[1]、井上 徹[1,2,3]、阿部 綾太郎[1]、黒田 みなみ[4]、坂本 直哉[5]、圦本 尚義[4,5,6] (1.愛媛大学地球深部ダイナミクス研究センター、2.広島大学大学院理学研究科、3.広島大学プレート収束域の物質科学研究拠点、4.北海道大学大学院理学院、5.北海道大学創成研究機構、6.宇宙航空研究開発機構宇宙科学研究所)

10:15 ~ 10:30

[SIT21-06] Origin and role of lost continents

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The role of stishovite as a deep nitrogen carrier indicated from high-pressure and high-temperature experiments

*福山 鴻[1]、鍵 裕之[1]、井上 徹[2,3]、新名 亨[3]、柿澤 翔[3]、菱田 俊一[4]、佐野 有司[5]、高畑 直人[5]
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Nitrogen occupies about 80% in the Earth's atmosphere and is one of essential elements of life. For these reasons, nitrogen is an important volatile element in various aspects of geoscience, including climates (e.g. Goldblatt et al., 2009; Wordsworth and Pierrehumbert, 2013) and the origin of life. However, we couldn't have still understood details of behavior or cycle of nitrogen in the Earth's interior. For example, it is known that the amount of nitrogen in deep Earth is more depleted than that of other volatile elements (Marty, 2012). This is called "missing" nitrogen and suggested to be caused by nitrogen stored in the upper mantle, the mantle transition zone, and the lower mantle through magma ocean from experimental researches (e.g., Li et al., 2013; Yoshioka et al., 2018). However, only two experiments corresponding to the lower mantle were conducted in the previous study (Yoshioka et al., 2018). In addition, subducting slab have played important role for volatile cycle into the deep Earth.

In this research, in order to investigate how much nitrogen is incorporated into stishovite which can carry nitrogen to the lower mantle, we conducted high-pressure and high-temperature experiments using multi-anvil apparatus installed at Geodynamics Research Center, Ehime University. All experimental pressure conditions were 27 GPa and temperature conditions ranged from 1400 ℃ to 1700 ℃. Fe-FeO buffer was used to control the redox state equal to the lower mantle. Nitrogen in recovered samples were analyzed using NanoSIMS installed at Atmosphere and Ocean Research Institute, The University of Tokyo. Nitrogen implanted standard samples were prepared in order to estimate nitrogen solubility in silicate minerals at National Institute for Materials Science.

A series of experimental results revealed that stishovite can incorporate 39-418 ppm nitrogen which is higher than nitrogen solubility in bridgmanite (5-50 ppm nitrogen solubility reported by Yoshioka et al. (2018)). Stishovite is mainly formed by the transition of nitrogen-rich sedimentary rocks transported to the lower mantle via subducting slabs. Our study suggests that nitrogen would continue to be supplied to the lower mantle via subducting slabs since when the plate tectonics had begun. This implies that "hidden" nitrogen reservoir was formed in the lower mantle approximately 4 billion years ago. Furthermore, this " hidden" nitrogen reservoir may play a role in decreasing high-concentration nitrogen which had enhanced greenhouse effect in the early atmosphere (Goldblatt et al., 2009) to the present nitrogen concentration level. Thus, our experimental results support the young faint Sun paradox explained by high-concentration nitrogen in the early Earth (e.g. Goldblatt et al., 2009; Wordsworth and Pierrehumbert, 2013) and suggest that "missing" nitrogen has been caused by forming a "hidden" nitrogen reservoir in the lower mantle.

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キーワード：枯渇した窒素、地球深部窒素循環、プレートテクトニクス、スティショバイト、暗い太陽のパラドクス
Keywords: "Missing" nitrogen, Deep nitrogen cycle, Plate techtonics, Stishovite, The faint young Sun paradox

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3-D P- and S-velocity structure of the D″ layer beneath Central America and the Caribbean using waveform inversion

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We present 3-D P- and S-velocity models of the lowermost mantle (0–400 km above the core-mantle boundary) beneath Central America and the Caribbean inferred from waveform inversion of a large dataset of ~16,000 USArray waveforms data. The origin of seismic velocity anomalies in the D″ region, e.g., thermal, chemical, or due to the phase transition from Bridgemanite (brg) to post-perovskite (pPv), is still debated. Insights into the origin of velocity anomalies can be obtained by comparison of P- and S-velocity models (Wentzcovitch et al. 2006). Previous tomographic studies have reported large S-to-P velocity ratio in the lowermost mantle based mainly on normal modes, which can constrain the large-scale structure of the mantle (e.g., Masters et al. 2000; Koelemeijer et al. 2018). There are, however, few local high-resolution models of the 3-D P- and S-velocity structure of the lowermost mantle due to the difficulty of measuring the arrival-time of the small-amplitude PcP phase. Since waveform inversion does not require measuring arrival times, it might provide a more robust way of using the PcP phase to constrain the high-resolution structure of the lowermost mantle. In this study, we use ~7000 transverse component and ~7000 vertical component records from ~38 intermediate and deep-focus earthquakes in South-America recorded at USArray stations between 2004–2015. The records are cut ~10 s before the arrival of the P (S) phase, and ~40 s after the arrival of the PcP (ScS) phase. Resolution tests shows that we can resolve separately the P- and S-velocity structure of the lowermost mantle on scales less than ~300 km. Our preliminary results show a relatively good correlation between S- and P-wave anomalies on small-scales, with a large S-to-P velocity ratio in the range 100–300 km above the CMB, and a smaller ratio 0–100 km above the CMB, in general agreement with the results of Koelemeijer et al. (2018).

Keywords: Waveform inversion, Lowermost mantle

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D111型高圧発生装置を用いたブリッジマナイトの一軸変形実験

Uniaxial deformation experiments of bridgmanite using D-111 type high pressure apparatus

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One dimensional viscosity models of the Earth’s mantle proposed by geophysical observations suggested that the lower mantle had the largest viscosity in the Earth’s mantle. In order to understand mantle dynamics in the Earth’s interior, it is important to know the viscosity of the Earth’s lower mantle. However, there are large variations of viscosity in the lower mantle between suggested models because of limitation of locations for geophysical observations. Therefore it is important to determine viscosity of lower mantle minerals by high pressure experiments in order to discuss mantle dynamics. Bridgmanite would be the most abundant mineral in the lower mantle. This mineral could dominate the lower mantle viscosity. In this study, we conducted in-situ stress-strain measurements of uniaxial deformation experiments of bridgmanite aggregate using D-111 type high pressure apparatus.
In-situ measurements were conducted using MAX III with D111 type guide block at PF-AR NE7A beam line. Mg-pure bridgmanite aggregates were used as starting material. Experimental conditions are 1473-1673 K and 24-27 GPa. WC second cubic anvils with cone (6.5˚) to take 2D X-ray diffraction, was used along X-ray path. Two-dimensional X-ray diffraction patterns were corrected for 240 s using flat panel detector. To calculate pressure and the stress magnitude of bridgmanite, (112) X-ray diffraction peaks were used. Strain of bridgmanite was measured by X-ray radiographies taken using an imaging system composed of a YAG crystal and a CMOS camera.
Largest strain was reached to approximately 20 %. It is confirmed that strain rate can be well controlled using stroke speed of differential rams. Steady state creep were observed at 1473 K –1673 K and 5 $\times 10^{-6}$ –3.8 $\times 10^{-5}$ /s. At normalized strain (10^{-5} /s), the creep strength of bridgmanite in this study is the largest in constituent mantle minerals reported by D-DAI apparatus.

キーワード：ブリッジマナイト、変形実験、クリープ強度
Keywords: Bridgmanite, Deformation experiments, Creep strength

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Waveform inversion for 3D anisotropic structure in D″ beneath the Northern Pacific: Constraints on mineralogy and flow in the lowermost mantle

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The D″ region is the lowermost several hundred km of the mantle immediately above the core-mantle boundary (CMB) and its base is in contact with the liquid outer core composed of iron alloy. Since the D″ region is the thermal boundary layer (TBL) at the base of the Earth's mantle, and the solidus of its constituent materials is thought to be close to the mantle geotherm, vertical and lateral variations of temperature and chemical composition associated with the Earth's thermal evolution are expected. Since chemically and thermally distinct subducted slabs would interact with the hot TBL above the CMB, and disturb the lowermost mantle, understanding the thermal and chemical evolution processes of the D″ region under subduction zones is essential to better understand the Earth's evolution.
The D″ region beneath the northern Pacific is of particular geodynamical interest because the paleo-Izanagi and present Pacific plates have been subducting beneath the northwestern margin of Laurentia since ~250 million years ago (Müller et al. 2016), which implies that paleoslabs could have reached the lowermost mantle. Suzuki et al. (2016) inferred the detailed three-dimensional S-velocity structure in the lowermost 400 km of the mantle beneath the northern Pacific. They hypothesized a prominent sheet-like lateral high-velocity, interpreted as paleoslabs, and a prominent low-velocity anomaly block immediately above the CMB below the high-velocity anomalies, which they interpreted as a TBL. In order to verify the above hypothesis and obtain geodynamical information, we infer 3D anisotropic structure beneath the northern Pacific in this study.
We conduct waveform inversion (Kawai et al. 2014) to infer the variation of the values of the TI (transverse isotropic, i.e. radial anisotropic) elastic constants L and N (Note that L is related to V_{SV} and N is related to V_{SH} when the shear wave propagates horizontally) straightforwardly in the lowermost mantle beneath the Northern Pacific, using a total of ~18,000 (~9,000 transverse and ~9,000 radial component) broadband body-wave seismograms. We used deep- and intermediate-focus events recorded at epicentral distances 70 to100 degrees at seismic stations of the USArray. The data are filtered in the period range of 20 to 200 s (i.e. 0.005 to 0.05 Hz) using a Butterworth bandpass filter. By using an S/ScS time window which is sensitive to the D″ structure we could image small-scale structure with finer resolution than previous tomographic studies.
The observed anisotropy is interpreted as due to the deformation-induced alignment of crystal caused by mantle flow for either Mg-perovskite (Mg-Pv), Mg-post-Perovskite (Mg-pPv), Ferro-periclase (Fp) or a combination thereof. In order to relate the flow geometry to the anisotropic geometry, we assume the dominant glide system and elastic constants of each mineral under the lowermost mantle condition based on high pressure experiment and theoretical calculation studies (e.g., Tsujino et al. 2016, Yamazaki et al. 2006 for deformation experiments; Wentzcovich et al. 2006 for ab initio calculation). We interpret the inferred 3D anisotropic structure based on above assumption, and we find the horizontal flow which could be related to subducted paleo-slabs is dominant in this region, and we also find vertical flow which could be related to the plume induced by slab sinking.

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キーワード：最下部マントル、波形インバージョン、異方性、D"領域
Keywords: the lowermost mantle, waveform inversion, anisotropy, D" region

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Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

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The Earth initially contained ~2 wt% H_2O, if it was formed by the mixture of C1 chondrite and enstatite chondrite [Ringwood, 1977]. However, the mass of the Earth’s ocean is only 0.02 wt% of that of the Earth. Thus, most of the H_2O or molecular H may have been lost from the Earth since then, or it may still be stored in the Earth’s deep interior. Water significantly influences the physical and chemical properties of the mantle minerals and rocks. Therefore, it is important to clarify the effect of water to understand the evolution and dynamics of the Earth. A part of water in the deep mantle can be dissolved in nominally anhydrous minerals. Wadsleyite and ringwoodite which are the major constituent minerals in the mantle transition zone, can contain ~2-3 wt% H_2O [e.g., Inoue et al., 1995; Kohlstedt et al., 1996]. On the other hand, water solubility of bridgmanite which is the most abundant mineral in the lower mantle, is a matter of debate [e.g., Bolfan-Casanova et al., 2004; Murakami et al., 2003]. Recently, Al-bearing hydrous bridgmanite contained ~0.8 wt% water was synthesized by Inoue et al. (under review). This report suggests that lower mantle can become a water reservoir in the Earth. However, the effects of pressure and Fe content on maximum water solubility of Al-bearing bridgmanite have not been clarified yet.
To determine the maximum water solubility of Al-bearing hydrous bridgmanite, high pressure and high temperature experiments were conducted under the conditions of 25-48 GPa and 1600℃. The starting materials were prepared by the mixtures of MgO, SiO_2, $Mg(OH)_2$, and $Al(OH)_3$ reagents with clinochlore [$Mg_5Al_2Si_3O_{10}(OH)_8$], Fe-bearing natural chlorite [$Mg_{4.9}Al_{1.6}Si_{3.2}Fe_{0.3}O_{10}(OH)_8$], and Fe-bearing hydrous pyrolite compositions. The water contents of the recovered run products were measured by SIMS. The water contents of Al-bearing hydrous bridgmanite increased with increasing pressure, at least up to 48 GPa. This is considered to occur the following two hydrous coupling substitutions with increasing pressure: $Si^{4+} = Al^{3+} + H^+$ and $2Mg^{2+} = Al^{3+} + H^+ + V_{Mg}$. These substitutions were dominant at low Al content, and Tschermak substitution ($Mg^{2+} + Si^{4+} = 2Al^{3+}$) became dominant with increasing Al content above Al = ~0.1 per formula unit (pfu, O = 3). The water content decreased as a result of Tschermak substitution, thus the maximum water solubility of bridgmanite is expected to be about 1.0 wt% at Al = ~0.1 pfu. In addition, the water solubility of Al-bearing hydrous bridgmanite decreased in the presence of Fe, and it became clear that it depends on the amount of Al and Fe in bridgmanite. Because of these properties, the maximum water solubility of bridgmanite in pyrolite and MORB are expected to be ~0.1 and ~0.2 wt%, respectively. When ringwoodite with high H_2O content is subducted to the lower mantle, the dehydration would occur at the top of the lower mantle. The dehydrated water should decrease melting temperature of the surrounding rocks and generates magma. Moreover, when chlorite dominant rock with high Al and low Fe content is subducted to the lower mantle, water heterogeneity would be predicted in the lower mantle, because the water content of bridgmanite generated by chlorite is significantly higher than that generated by pyrolite.

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キーワード：地球深部、下部マントル、ブリッジマナイト、水
Keywords: deep mantle, lower mantle, bridgmanite, water

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Origin and role of lost continents

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<Purpose>

Continental crust had long been regarded that it cannot subduct into mantle forever because of lower density. If so, the Earth must have extraordinary thick continental crust over 300km in thickness. But, of course, not. We elucidate where continental curst has gone?

<Method>

Recently, on-going process of direct subduction of island arcs off Japan was reported (Yamamoto et al., 2007), as well as tectonic erosion of hanging wall of continental crust (von Huene and Scholl, 1991), the physical process by numerical simulation (Ichikawa et al., 2009), the presence of abundant TTG materials in MTZ (Kawai et al., 2013), and spatial distribution of the second continents in the MTZ over the world (Maruyama et al., 2008).

<Result>

We revealed continental curst is subducted into mantle and accumulated as “lost continent”. The estimated mass of the lost continent in MTZ (depth range of 520-660km) is 7.5 times more than total volume of TTG crust on the surface Kawai et al (2009; 2013), and the existing material is expected to be TTG, not MORB or harzuburgite based on seismology. Kawai et al. (2007) also predicted that D” layer ca. 300km thick right above CMB could be another lost continent, which anorthosite and KREEP dominated. However, this idea cannot explain reasonable enough that the density of KREEP basalt is close to that of surrounding peridotites. According to more recent estimate by Greaux et al. (2018), lost continent on CMB is expected to be fractionated KREEP and anorthosite. If KREEP lower crust of the Hadean continent subducted and segregated at 660km depth, these material could be falling preferentially into lower mantle, and they must have been accumulated on the CMB.

<Discussion>

It is pointed out that those lost continents may have played critical role for the thermal history of Earth, because most radiogenic elements such as U, Th, and K were predominantly concentrated into the primordial continents, whereas these elements were rare in the mantle. Radiogenic elements contained in lost continents must have contributed as the heat generator of the inner Earth and controlled thermal history of the Earth. One of the most significant next research targets is to conduct the quantitative estimates of lost continent. The idea of lost continents would change the concept of mantle dynamics.

キーワード：KREEP玄武岩、ロストコンティネント、マントルダイナミクス

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Keywords: KREEP basalt, Lost continent, mantle dynamics

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[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27日(月) 10:45 ~ 12:15 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:太田 健二、飯塚 理子

近年の高圧実験の進歩で、地球中心部に至る温度圧力条件での鉱物の物性測定が可能となってきた。一方、高精度な古地磁気測定、地球物理学観測、精密地球物理学分析、地球ニュートリノによる地球深部放射性物質の直接観測などの発展と共に、マントル対流や地磁気ダイナモの数値シミュレーション技術も大きく発展して、地球内部の状態の理解が進んできた。本セッションでは、地球及び惑星における核ーマントル相互作用と進化に焦点をあてた、様々な研究分野の成果を一堂に会する機会を提供し、情報交換を進めることを目的とする。異なる分野間の連携を発展させるための日本版地球・惑星深部研究グループ(J-SEDI）の形成に関わる講演も歓迎する。

10:45 ~ 11:00

[SIT21-07] Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

★Invited Papers

*Zhongqing Wu[1] (1.University of Science and Technology of China)

11:00 ~ 11:15

[SIT21-08] Discussion

*太田 健二[1] (1.東京工業大学大学院理工学研究科地球惑星科学専攻)

11:15 ~ 11:30

[SIT21-09] ***Ab initio* anharmonic lattice dynamics for Fe-bearing lower mantle minerals**

*出倉 春彦[1]、土屋 卓久[1] (1.愛媛大学地球深部ダイナミクス研究センター)

11:30 ~ 11:45

[SIT21-10] **Measurements of high pressure-temperature thermal conductivity of the Earth's lower mantle minerals in a laser-heated diamond anvil cell**

*太田 健二[1]、長谷川 暉[1,2]、八木 貴志[2]、奥田 善之[1]、恩賀 皓太郎[1]、廣瀬 敬[3,4]、大石 泰生[5] (1.東京工業大学理学院地球惑星科学系、2.産業技術総合研究所、3.東京工業大学　地球生命研究所、4.東京大学 大学院理学系研究科　地球惑星科学専攻、5.高輝度光科学研究センター)

11:45 ~ 12:00

[SIT21-11] Is there evidence for a paleo-LLSVP beneath Eurasia?: Implications for the origin of the Siberian Traps

*上 翼[1]、鈴木 裕輝[1]、河合 研志[1] (1.東京大学大学院理学系研究科地球惑星科学専攻固体地球講座)

12:00 ~ 12:15

[SIT21-12] Alに富んだ無水ブリッジマナイトの存在可能組成領域

*井上 徹[1,2]、野田 昌道[2]、柿澤 翔[2] (1.広島大学大学院理学研究科地球惑星システム学専攻、2.愛媛大学地球深部ダイナミクス研究センター)

Thermal conductivity anomaly in spin-crossover ferropericlase under lower mantle conditions

*Zhongqing Wu[1]

1. University of Science and Technology of China

Thermal conductivity of the mantle minerals is one of the key parameters that control mantle convection. The heat flux from the core, which is determined by the heat conductivity of the thin layer overlying the core-mantle boundary (CMB), is critical to the understanding of many processes such as the Earth’s evolution, mantle convection, and geodynamo. Iron in ferropericlase experiences a spin crossover from a high spin to a low spin under lower mantle conditions, which generates anomalies in many properties such as the heat capacity and sound velocity (Wu et al., 2009, 2013). Since the thermal conductivity is proportional to the heat capacity and the square of the sound velocity, the spin-state crossover of iron in the lower mantle minerals may profoundly affect the lattice thermal conductivity of the lower mantle. However, knowledge of the spin-crossover effect on the lattice thermal conductivity is very limited.

Here, I found that the spin crossover completely changes the conventional pressure and temperature dependences of the thermal conductivity. The pressure dependence of the thermal conductivity of ferropericlase will show a double-valley feature across the spin-crossover region. Thermal conductivity of ferropericalse may increase with the temperature in some temperature region. The spin crossover can explain the anomalous reduction in thermal conductivity of ferropericlase observed recently by Ohta et al (2017) in the spin crossover region. The unusual effect of spin crossover on the thermal conductivity can be expected in other minerals with spin crossover. Since the spin-crossover region of ferropericlase covers the CMB conditions, the spin crossover effect needs serious consideration when estimating the thermal conductivity at the core-mantle boundary

Wu, Z., J. F. Justo, C. R. S. da Silva, S. de Gironcoli, and R. M. Wentzcovitch (2009), Anomalous thermodynamic properties in ferropericlase throughout its spin crossover transition, *Phys. Rev. B*, *80*(1), 014409.

Wu, Z. Q., J. F. Justo, and R. M. Wentzcovitch (2013), Elastic Anomalies in a Spin-Crossover System: Ferropericlase at Lower Mantle Conditions, *Phys. Rev. Lett.*, *110*(22).

Ohta, K., T. Yagi, K. Hirose, and Y. Ohishi (2017), Thermal conductivity of ferropericlase in the Earth's lower mantle, Earth and Planetary Science Letters, 465, 29-37.

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Discussion

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*Kenji Ohta[1]

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Discussion

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Ab initio anharmonic lattice dynamics for Fe-bearing lower mantle minerals

*出倉 春彦[1]、土屋 卓久[1]
*Haruhiko Dekura[1], Taku Tsuchiya[1]

1. 愛媛大学地球深部ダイナミクス研究センター
1. Geodynamics Research Center, Ehime University

Determination of lattice thermal conductivity (κ_{lat}) of lower mantle (LM) minerals is a key to understanding the dynamics and evolution of the earth’ s deep interior. Some recent experimental studies have shown that κ_{lat} of MgO and $MgSiO_3$ bridgmanite (Brg) are substantially reduced by Fe incorporation (Manthilake et al., 2012; Goncharov et al., 2015; Ohta et al., 2017; Hsieh et al., 2017). In contrast, Okuda et al. (2017) reported a very different result on Brg with a marginal effect of Fe. Besides, the effect of Fe on $MgSiO_3$ post-perovskite (PPv) has never been reported. Therefore, in this study, we investigate κ_{lat} of Fe-bearing LM minerals (ferropericlase (FP), Brg, and PPv) in the LM pressure and temperature conditions, based on the *ab initio* anharmonic lattice dynamics techniques with fully solving the phonon Boltzmann transport equation (Dekura and Tsuchiya, 2017) combined with the internally consistent LDA+*U* technique for more precisely describing the Fe-O bond (Wang et al., 2015). Calculations demonstrate strong negative solid solution effects of low-spin Fe on κ_{lat} of FP and high-spin Fe on κ_{lat} of Brg and PPv, as a linear decrease in log κ_{lat} of FP with increasing the Fe concentration. Our detailed analyses indicate that such strong effects occur primarily due to the substantial changes in harmonic properties and are found to be Brg > PPv >FP. The present results improve the conventional estimation of the effective LM conductivity (e.g., Stacey 1992). It is estimated to be ~2-3 $Wm^{-1}K^{-1}$ for the pyrolytic aggregate (FP + Brg) and ~4-5 $Wm^{-1}K^{-1}$ (FP+PPv) at 136 GPa and 4000 K, which are ~60-80% smaller than the conventional value of 10 $Wm^{-1}K^{-1}$.

キーワード：下部マントル鉱物、格子熱伝導率、第一原理計算
Keywords: Lower mantle minerals, Lattice thermal conductivity , First-principles calculation

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Measurements of high pressure-temperature thermal conductivity of the Earth’s lower mantle minerals in a laser-heated diamond anvil cell

*太田 健二[1]、長谷川 暉[1,2]、八木 貴志[2]、奥田 善之[1]、恩賀 皓太郎[1]、廣瀬 敬[3,4]、大石 泰生[5]
*Kenji Ohta[1], Akira Hasegawa[1,2], Takashi Yagi[2], Yoshiyuki Okuda[1], Koutarou Onga[1], Kei Hirose[3,4], Yasuo Ohishi[5]

1. 東京工業大学理学院地球惑星科学系、2. 産業技術総合研究所、3. 東京工業大学　地球生命研究所、4. 東京大学 大学院理学系研究科　地球惑星科学専攻、5. 高輝度光科学研究センター
1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2. National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, 3. Earth-Life Science Institute, Tokyo Institute of Technology, 4. Department of Earth and Planetary Science, The University of Tokyo, 5. Japan Synchrotron Radiation Research Institute

The thermal transport properties of the Earth’s constituents are important information to understand thermal evolution and the heat budget of the Earth. Thus, the experimental determination of thermal conductivity of deep Earth materials are required. The diamond anvil cell (DAC) is capable of accessing the pressure-temperature conditions of the Earth’s deep interior, and is compatible with laser optical techniques. The pulsed light heating thermoreflectance (TR) method has been applied to a DAC in order to measure thermal conductivity and diffusivity of condensed material [1,2]. This TR with DAC method successfully obtained the thermal conductivity of the Earth’s lower mantle minerals to the pressure condition equal to the Earth’s core-mantle boundary (135 GPa) but at room temperature [3]. To extend measurable temperature range, the TR method may be combined with a laser-heated DAC (LHDAC) technique that is able to generate the pressure-temperature condition equivalent to the center of the Earth.

We recently developed a new instrument to measure the thermal diffusivity (and thus thermal conductivity) of sample *in-situ*at high pressure and temperature based on the combination of the TR method and the LHDAC system. We use a double-sided high-power CW laser heating technique to generate stable high temperature conditions of sample in a DAC. A pulsed pump laser and a CW probe laser are also irradiated to the sample to determine heat diffusion time through the sample via the thermoreflectance phenomena. Details of the thermoreflectance technique in a DAC may be found in our previous studies [2]. Using the developed method, we measured the thermal conductivity of the main minerals in the Earth’s lower mantle, MgO periclase, $MgSiO_3$bridgmanite, post-perovskite and $CaSiO_3$ perovskite*in-situ*at high pressures and high temperatures. These are the first experimental demonstrations of thermal conductivity of the lower mantle minerals at the conditions below the mid-part of the Earth’s lower mantle. The new thermal conductivity measurement system will shed light on the controversial thermal transport properties of the Earth’s deep interior [4].

References:[1] Hsieh, W.-P. et al., *Phys. Rev. B*, **80**, 180302 (2009).[2] Yagi, T. et al., *Meas. Sci. Technol.,* **22**, 024011 (2011). [3] Okuda, Y. et al., *Earth Planet. Sci. Lett.*, **474**, 25–31 (2017). [4] Kavner, A. and Rainey, E.S.G., *Deep Earth: Physics and Chemistry of the Lower Mantle and Core*, 31–42 (2016).

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キーワード：熱伝導率、下部マントル、高温高圧実験
Keywords: Thermal conductivity, Lower mantle, High P-T experiment

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Is there evidence for a paleo-LLSVP beneath Eurasia?: Implications for the origin of the Siberian Traps

*上 翼[1]、鈴木 裕輝[1]、河合 研志[1]
*Tsubasa Ue[1], Yuki Suzuki[1], Kenji Kawai[1]

1. 東京大学大学院理学系研究科地球惑星科学専攻固体地球講座
1. Department of Earth and Planetary Sciences, Graduate School of Science, The University of Tokyo

The massive eruption during the latest Permian, which precipitated the Earth's most severe known extinction event, is one of the largest known volcanic events on Earth. However, the cause of the active volcanism remains incompletely understood. Recent seismological analysis has revealed that currently active volcanoes are related to seismic low-velocity anomalies which are almost vertically continuous from the core-mantle boundary (CMB) to shallow depths. Here we infer the seismic velocity structure beneath Eurasia in order to confirm whether formerly active volcanism is also related to a mantle upwelling.

We apply the 3-D localized waveform inversion methods to about 5,500 transverse-component of broadband body-wave seismograms observed at Japan for 3 intermediate and deep earthquakes occurred in Europe, European stations for 116 events occurred beneath the western Pacific subduction zone and Canadian stations for 5 events occurred beneath the Hindu Kush. We use waveform data obtained from the National Research Institute for Earth Science and Disaster Prevention (NIED), Observation & Research Facilities for European Seismology (ORFEUS) and Canadian National Data Centre (CNDC).

We found a high-velocity anomaly about 100 km above the CMB beneath Lake Baikal and two low-velocity anomalies immediately above the CMB beneath the cities of Perm and Irkutsk, Russia, respectively. Plate reconstructions show there are some large igneous provinces (LIPs) and slab remnants beneath Eurasia. Our results suggest two scenarios: one where two low-velocity anomalies used to be united and larger than present size but divided and weakened by the subducted cold slab and another where two low-velocity anomalies were originally separated with each other and became different LIPs. In either case, our findings suggest that the cause of a massive eruption during the latest Permian was a plume upwelling from the CMB.

キーワード：ディーダブルプライム、ウェーブフォームインバージョン、ペルムアノマリー、リップス、S波速度構造
Keywords: D″, Waveform inversion, Perm Anomaly, LIPs, S velocity structure

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Alに富んだ無水ブリッジマナイトの存在可能組成領域
Possible compositional region of Al-bearing anhydrous bridgmanite

*井上 徹[1,2]、野田 昌道[2]、柿澤 翔[2]
*Toru Inoue[1,2], Masamichi Noda[2], Sho Kakizawa[2]

1. 広島大学大学院理学研究科地球惑星システム学専攻、2. 愛媛大学地球深部ダイナミクス研究センター
1. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2. Geodynamics Research Center, Ehime University

Bridgmanite should be a major constituent mineral in the Earth's lower mantle, and Irifune (1994) reported that bridgmanite can incorporate almost Al_2O_3 component in lower mantle. The Al substitution mechanism is supposed to be complicated, because there are two types of Al substitution mechanisms in anhydrous bridgmanite, Tschermak and oxygen vacancy substitutions (e.g. Kojitani et al., 2007). However, the pure Tschermak and oxygen vacancy substitutions bridgmanite has not been reported so far in low Al content, when we checked the previous studies carefully (e.g. Irifune et al, 1996; Kubo and Akaogi, 2000). The previous studies have used powder samples as the starting materials, so we considered that the absorbed water may affect the results, because we have a knowledge of the possible existence of hydrous bridgmanite which has a water content of ~0.8 wt%. Therefore, we tried to investigate the possible existence of the Al substitution mechanism in bridgmanite as a function of Al content in extremely anhydrous condition.

The high pressure experiments were conducted at 28 GPa and 1600-1700℃ for 1 hour using a Kawai type apparatus. Some different Al content samples were prepared as the starting materials along the ideal substitution line of Tschermak and oxygen vacancy substitutions, respectively. Glass rods were used as the starting materials to eliminate the absorbed water on the sample surface. Moreover, the glass rods were enclosed in a rhenium capsule to prevent the water incorporation from the surrounding cell assembly. In addition, all parts of the cell assembly were dried just before the synthesis experiments. The chemical compositions of the starting materials were examined by SEM-EDS, and the recovered samples were identified by X-ray and neutron (in J-PARC) diffractions and SEM-EDS.

Our results show that it is possible to exist both Tschermak and oxygen vacancy substitution bridgmanites in low Al content in anhydrous condition. The maximum Al content for pure oxygen vacancy substitution bridgmanite was ~0.025 pfu in total cation of 2, and the existence of oxygen vacancy substitution component was restricted to be less than Al=~0.1 pfu. The present result combining with our previous study in hydrous condition, shows that hydration in Al-bearing bridgmanite should occur easily if hydrogen exists in the system (lower mantle) in pyrolite (MgO-excess) composition. Thus the large deviation from the Tschermak substitution in the previous studies mainly should come from the hydration from the absorbed water.

キーワード：下部マントル、ブリッジマナイト、Al2O3成分、無水条件、含水条件
Keywords: lower mantle, bridgmanite, Al2O3 component, anhydrous condition, hydrous condition

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[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27日(月) 13:45 ~ 15:15 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:五味 斎、飯塚 毅

近年の高圧実験の進歩で、地球中心部に至る温度圧力条件での鉱物の物性測定が可能となってきた。一方、高精度な古地磁気測定、地球物理学観測、精密地球物理学分析、地球ニュートリノによる地球深部放射性物質の直接観測などの発展と共に、マントル対流や地磁気ダイナモの数値シミュレーション技術も大きく発展して、地球内部の状態の理解が進んできた。本セッションでは、地球及び惑星における核ーマントル相互作用と進化に焦点をあてた、様々な研究分野の成果を一堂に会する機会を提供し、情報交換を進めることを目的とする。異なる分野間の連携を発展させるための日本版地球・惑星深部研究グループ(J-SEDI）の形成に関わる講演も歓迎する。

13:45 ~ 14:00

[SIT21-13] Evolution of the Earth mantle and its possible interaction with core: view from olivine and its inclusions study

★Invited Papers

*Alexander V Sobolev[1]、Valentina G. Batanova[2] (1.ISTerre Institute of Earth Sciences、2.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygina str. 19, Moscow 119991, Russia.)

14:00 ~ 14:15

[SIT21-14] Discussion

*飯塚 毅[1] (1.東京大学)

14:15 ~ 14:30

[SIT21-15] Ultralow-velocity zones possibly explained by light element-enriched iron compounds

*Liang Yuan[1]、Eiji Ohtani[1]、Xiang Wu[2]、Shengxuan Huang[3]、Daijo Ikuta[1]、Tatsuya Sakamaki[1]、Seiji Kamada[1]、Hiroshi Fukui[4,5]、Satoshi Tsutsui[6]、Hiroshi Uchiyama[6]、Daisuke Ishikawa[5,6]、Naohisa Hirao[6]、Alfred Q. R. Baron[5] (1.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, Sendai 980-8578, Japan、2.State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China、3.Key Laboratory of Orogenic Belts and Crustal Evolution, MOE, Peking University and School of Earth and Space Sciences, Peking University, Beijing 100871, China、4.Center for Novel Material Science under Multi-Extreme Conditions, Graduate School of Material Science, University of Hyogo, Hyogo 678-1297, Japan、5.Materials Dynamics Laboratory, RIKEN SPring-8 Center, Hyogo 679-5148, Japan、6.Japan Synchrotron Radiation Research Institute (JASRI), SPring-8, Hyogo, 679-5198, Japan)

14:30 ~ 14:45

[SIT21-16] High-precision $^{142}W/^{144}W$ ratios of oceanic island basalts and Large Igneous Province basalts.

賞雅 朝子[1]、*鈴木 勝彦[1]、深海 雄介[2]、飯塚 毅[3] (1.海洋研究開発機構・海底資源研究開発センター、2.海洋研究開発機構・深海・地殻内生物圏研究分野、3.東京大学・大学院理学系研究科)

14:45 ~ 15:00

[SIT21-17] Some technological developments in high temperature generation using KMA and precise melting/phase relations of minerals and rocks under deep mantle conditions

*入舩 徹男[1,2]、周 佑黙[1]、有本 岳史[1]、桑原 秀治[1]、野村 龍一[3]、西 真之[1]、山口 桃子[1]、丹下 慶範[4]、栗林 貴弘[5]、劉 兆東[6] (1.愛媛大学地球深部ダイナミクス研究センター、2.東京工業大学地球生命研究所、3.京都大学白眉

センター/大学院人間・環境学研究科、4.高輝度光科学研究センター利用研究促進部門、5.東北大学理学研究科、6.吉林大超硬材料研究所)

15:00 ~ 15:15

[SIT21-18] Zr isotope constraints on early Earth differentiation

*飯塚 毅[1]、板野 敬太[1]、山本 伸次[2] (1.東京大学、2.横浜国立大学)

Evolution of the Earth mantle and its possible interaction with core: view from olivine and its inclusions study

*Alexander V Sobolev[1], Valentina G. Batanova[2]

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The rate and style of mantle convection, as well as production and recycling of crust into the mantle, control the evolution of the Earth. Present knowledge of mantle evolution is mostly restricted to the Phanerozoic, for which fresh mantle-derived lavas and relevant geophysical data are available. Information about the Precambrian mantle comes almost entirely from the compositions of altered rocks, which lack data on the contents of mobile and volatile elements and their isotopes. Such data are crucial for geodynamic reconstructions and understanding of surface rock recycling into the deep mantle. Fortunately, this information is preserved within inclusions of melt in relicts of olivine phenocrysts in komatiites.

In this presentation we will address the compositional evolution of the terrestrial mantle, from the Archean to the Phanerozoic, using compositions and temperatures of primary mantle-derived melts reconstructed from the study of melt inclusions and host olivine. We will report an extensive range of geochemical parameters, including mobile and volatile element (Pb, B, Rb, Ba, Sr, Cl, S, H2O, CO2) concentrations and isotopic compositions of H in homogenized melt inclusions and the elemental compositions of host olivines and inclusions of spinel. We will present data for komatiites and picrites that originated at different depths and cratons between 3.3 and 0.09 Ga. We will apply published and new models to constrain the temperatures and compositions of their mantle sources to relate our observations to the evolution of mantle convection and plate tectonics. We will, therefore, address the following issues: the rate of crustal growth and recycling through time; the timing of the onset of large-scale subduction and plate tectonics; the concentration and origin of H2O and halogens in the deep mantle, and the extent (if any) of core-mantle interaction.

We will present evidence of the significant excess of H2O and Cl in the mantle sources of komatiites and will show that hydrogen isotope composition of komatiites is significantly more depleted in deuterium than all surface reservoirs and typical mantle but resembles that in dehydrated subducted slabs. We will demonstrate temporal trends of Pb/Ce and oxygen fugacity of primary komatiite melts.

Our results suggest that lithosphere recycling into the deep mantle, arguably via subduction, started before 3.3 Ga and interaction of mantle and core probably took place all this time.

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Discussion

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Discussion

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Ultralow-velocity zones possibly explained by light element-enriched iron compounds

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The core–mantle boundary (CMB) is the most fundamental chemical discontinuity in the Earth. Recent experiments showed that, when water meets iron at the CMB, hydrogen-bearing iron peroxide FeO_2H_x can be produced. The results indicate that water can interact with iron metal very differently than it does on the surface of the earth. Seismic waves speeds in this hydrogen bearing iron peroxide are much slower compared with lower-mantle silicate solid phases, and therefore it may help explain the seismic anomalies at the CMB.

Given the steep geothermal gradient across the CMB, the hydrogen-bearing iron peroxide FeO_2H_x likely undergoes high-temperature decomposition into anhydrous iron oxides (e.g., Fe_2O_3) and fluids. We measured the sound velocity of Fe_2O_3 post-perovskite (ppv) through inelastic X-ray scattering up to 132 GPa and 1,800 K, relevant to the lowermost mantle. Combined with first-principles investigations, we are able to show that Fe_2O_3 ppv has very low sound velocities and strong anisotropy with respect to lower-mantle silicates. Therefore, both hydrogen-bearing iron peroxide FeO_2H_x and post-perovskite Fe_2O_3 are candidate phases for ultralow-velocity zones at the CMB.

Funding acknowledgment: This work was supported by the JSPS Japanese–German Graduate Externship.

Keywords: Core–mantle boundary, Ultralow-velocity zones, Light elements, Iron compounds

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High-precision $^{142}W/^{144}W$ ratios of oceanic island basalts and Large Igneous Province basalts.

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Among five W isotopes, ^{182}W is a product of b-decay of ^{182}Hf with the relatively short half life of 8.9 m.y. As Hf and W are lithophile and siderophile, respectively, the ^{182}Hf-^{182}W radiometric system could constrain metal-silicate (core-mantle) differentiation, especially core segregation, in the very early Earth system because of its large fractionation between metal-silicate and the short half life of ^{182}Hf. Recent improvements of analytical techniques of W isotope analyses using TIMS and MC-ICP-MS equipped with a desolvating device allow to obtain highly precise $^{182}W/^{184}W$ ratios of terrestrial rocks. These led to findings of $m^{182}W$ anomalies (mostly positive) in old komatiites (2.4 –3.8 Ga) and young volcanic rocks with positive anomalies of 12 Ma Ontong Java Plateau and 6 Ma Baffin Bay (Rizo et al., 2016) and with negative anomalies of those such as the Loihi and Samoa basalts (Mundl et al., 2017). Recently, Kruijer and Kleine (2018) proposed that the ^{182}W excesses for an OJP sample by Rizo et al. (2016) may result from the nuclear field shift effect leading to defect of ^{183}W, as the NTIMS analyses utilized a double normalization involving the $^{183}W/^{184}W$ ratio.

In our study, high-precision W isotope ratio measurement with MC-ICP-MS (Thermo co. Ltd., NEPTUNE PLUS) equipped with desolvating nebulizer (ARIDAS II) following the chemical separation using both cation and anion exchange resin has been developed. We have measured the W standard solution (SRM 3163) and obtained the isotopic compositions with a precision of ±5ppm. However, the standard solution, which was processed by the cation or anion exchange chemistry in the same way as for rock samples, has systematic $^{182}W/^{184}W$ drift of -5ppm, which was also observed by Willbold et al. (2011) and Kruijer and Kleine (2018). This shift likely resulted from the nuclear field shift effect as mentioned by Kruijer and Kleine (2018). Therefore, we corrected the measured W isotope ratios of samples with the standard solution processed by the same method as that of the samples. This technique led to obtaining of the W isotopic compositions with reproducibility of several ppm. We have obtained negative $\mu^{182}W$ for the basalts with the high $^{3}He/^{4}He$ isotopic composition from the Loihi, Hawaii, through the developed analytical method. This result is consistent with that of Mundl et al., (2017). As the Earth’ s core should have a negative $\mu^{182}W$ value of ca. -210, the Loihi sample we analyzed probably contains a component with a signature of core-mantle interaction. We have obtained the high-precision W isotope data for the fresh drilled basalts from Louisville. Louisville is known to have been originated from the primordial deep mantle source. We will discuss the obtained results and the early evolution of the deep mantle.

Acknowledgement –JSPS Grant-in-Aid has supported this project. We are grateful to M. Kawamura for experimental help and Y. Orihashi, T. Hanyu, M. Tejada for providing samples.

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キーワード：タングステン同位体、核ーマントル相互作用
Keywords: tungsten isotope, core-mantle interaction

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Some technological developments in high temperature generation using KMA and precise melting/phase relations of minerals and rocks under deep mantle conditions

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1. Geodynamics Research Center, Ehime University, 2. Eearth Life Science Institute, Tokyo Institute of Technology, 3. Hakubi Center/ Graduate School of Human and Environmental Studies, Kyoto University, 4. Research & Utilization Division, Japan Synchrotron Research Institute, 5. Graduate School of Science, Tohoku University, 6. Institute of Super Hard Materials, Jilin University

Technological developments in stable and homogeneous high temperature generation have been made using conventional $LaCrO_3$ or Re heater for Kawai-type multianvil apparatus (KMA) with tungusten carbide (WC) and sintered diamond (SD) anvils. For WC-KMA, stable temeperature generation to ~3000 K has been achieved under the pressures up to ~27 GPa mainly for quench experiments. Temperatures of ~2000-2300 K have been produced stably for 20-180 minutes at pressures to ~65 GPa for *in situ* X-ray measurements using SD-KMA, in addition to the *ex situ* experiments.

Some experimental studies for precise determination of subsolidus and melting phase relations have successfully been made for some simple mineral systems, such as $MgSiO_3$-Al_2O_3, $MgSiO_3$-$FeSiO_3$, $MgSiO_3$-$CaSiO_3$, $CaSiO_3$-SiO_2, Al_2O_3-SiO_2, $KAlSi_3O_8$-$NaAlSi_3O_8$, Al_2SiO_5, $Ca_3Al_2Si_3O_{12}$, etc. at temperatures near and above the typical geotherm at pressures corresponding to those of the mantle transition region to the middle part of the lower mantle. These studies have provided firm experimental databases for the mineralogy of the deep mantle, and also led to findings of some new high-pressure phases stable only under the very high-temperture conditions. Melting and associated partioning of some key trace elements in more complex chemical compositions have also been conducted under the pressures of the uppermost lower manlte to constrain the differentiation and evolution of the deep mantle.

キーワード：下部マントル、マルチアンビル装置、融解関係、相関係、高温高圧実験、技術開発
Keywords: lower mantle, multianvil apparatus, melting relations, phase relations, high pressure and high temperature experiment, technological development

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Zr isotope constraints on early Earth differentiation

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The radionuclide 92Nb decays to 92Zr with a half-life of 37 Ma [1]. Because Nb and Zr can fractionate from each other during partial melting of the mantle and mineral crystallization as well as metal-silicate differentiation, Nb-Zr isotope systematics can potentially place chronological constraints on early planetary differentiation. Considering the initial abundance of 92Nb in the solar system (92Nb/93Nb = 1.7 ×10-5), yet, the possible Zr isotopic variation on the Earth would be highly restricted [2]. For instance, even a 4.53 Ga reservoir having a Nb/Zr ratio four times higher than that of CHUR is expected to display a 92Zr anomaly of only +10 ppm. Such reservoir with an elevated Nb/Zr ratio might be formed if Fe-Ti oxide and sulfide minerals presented as a liquidus phase during differentiation on the infant Earth.
Here we report our search for a Zr isotopic vestige of early Earth differentiation using ancient terrestrial zircons. Zirconium isotopic ratios in single zircon grains were measured using MC-ICP-MS with the desolvating nebulization technique, which allows us to achieve analytical precision of ±˜10 ppm. So far, the high-precision Zr isotopic analysis has been applied to detrital zircons with ages up to 4.3 Ga from the Jack Hills in the Yilgarn Craton, Western Australia and igneous zircons from the 4.0–3.6 Ga orthogneisses in the Acasta Gneiss Complex, northwestern Canada. These Acasta rock samples were previously studied for zircon Lu–Hf isotope systematics and the results indicated that their magmatic sources contained Hadean crustal components [3]. Our Zr isotopic data for the Jack Hills and Acasta zircons display no 92Zr anomalies larger than 10 ppm. By combining the Hf isotopic data for these zircon grain, we indicate the development of a 4.5 Ga enriched reservoir on the Earth that had a Lu/Hf of 0.07 and a Nb/Zr less than 0.4. Such reservoir could form via fractional crystallization processes within the shallow or upper mantle.
[1] Holden (1990) Pure Appl. Chem. 62, 941–958. [2] Iizuka et al. (2016) Earth Planet. Sci. Lett. 439, 172–181. [3] Iizuka et al. (2009) Chem. Geol. 259, 230–239.

キーワード：冥王代、マグマオーシャン、ジルコニウム同位体、ジルコン
Keywords: Hadean, magma ocean, Zr isotopes, zircon

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-CG 固体地球科学複合領域・一般

2019年5月27日(月) 15:30 ~ 17:00 | A07 東京ベイ幕張ホール

[S-CG49] ハードロック掘削科学～陸上掘削から深海底掘削、そしてオマーン～

コンビーナ:道林 克禎(名古屋大学大学院環境学研究科地球環境科学専攻地質・地球生物学講座岩石鉱物学研究室)、高澤 栄一(新潟大学理学部地質科学科)、秋澤 紀克(東京大学　大気海洋研究所　海洋底科学部門)、座長:道林 克禎

ハードロック掘削計画が進展している．本セッションでは，オマーン掘削プロジェクトを中心としてICDPならびにIODPの掘削プロジェクトの成果発表を期待する．さらに，掘削研究にこだわらず，関連するオフィオライト研究などの野外研究や実験研究等の発表の機会となることも期待したい．

15:30 ~ 15:45

[SCG49-01] Geochemical and Geochronological Constraints on the Origin and Emplacement of the East Taiwan Ophiolite: Implication for Subduction Initiation of the South China Sea.

*林 秋婷[1]、ロン ハリス[2]、孫 衛東[1]、張 国良[1] (1.中国科学院海洋研究所深海研究中心、2.ブリガムヤング大学地質科学科)

15:45 ~ 16:05

[SCG49-02] Towards a complete profile of hydrothermal alteration in the lower oceanic crust and uppermost mantle; Insights from the Oman Drilling Project and ChikyuOman2017 and 2018

★Invited Papers

*Damon A H Teagle[1]、Michelle Harris[2]、Gretchen Früh-Green[3]、Eiichi TAKAZAWA[4]、 Katsuyoshi Michibayashi[5]、Peter B Kelemen[6]、Oman Drilling Project Science Team[1] (1.Ocean & Earth Science, National Oceanography Centre Southampton, University of Southampton, SO14-3ZH, Southampton, UK、2.School of Geography, Earth and Environmental Sciences, Plymouth University, UK、3.Earth Sciences, ETH Zürich, Switzerland、4.Geology, Niigata University, Japan、5.Earth and Planetary Sciences, Nagoya University, Japan、6.LDEO, Columbia University, New York, USA)

16:05 ~ 16:25

[SCG49-03] Peridotite alteration in OmanDP cores

★Invited Papers

*Peter B Kelemen[1]、Juan Carlos de Obeso[1]、Craig Manning[2]、Marguerite Godard[3]、Wolfgang Bach[4]、Merry Yue Cai[1]、Saebyul Choe[5]、Judith Coggon[6]、Eric Ellison[7]、Alireza Eslami[8]、Katy Evans[9]、Michelle Harris[10]、Wolf-Achim Kahl[4]、Jürg Matter[6]、Katsu Michibayashi[11]、Keichi Okazaki[12]、Philippe Pézard[3]、Damon A.H. Teagle[6]、Alexis Templeton[7]、OmanDP Oman Drilling Project Science Team (1.LDEO、2.UCLA、3.U. Montpellier、4.U. Bremen、5.AMNH、6.U. Southampton、7.U. Colorado、8.U. Tehran、9.Curtin U.、10.U. Plymouth、11.Nagoya U.、12.JAMSTEC)

16:25 ~ 16:40

[SCG49-04] Oman Drilling Project Phase 1 のリストヴェナイト中のドロマイト脈に薄い塩水からなる流体包有物があるぜよ

*川本 竜彦[1]、佐藤 宏樹[2]、髙橋 藤馬[3]、Juan Miguel Guotana[4]、森下 知晃[4]、Peter Kelemen[5]、Jude Coggon[6]、Michelle Harris[7]、Juerg Matter[6]、道林 克禎[8]、高澤 栄一[9]、Damon Teagle[6]、The Oman Drilling Project Phase 1 Science Party (1.Department of Geoscience, Faculty of Science, Shizuoka University、2.Faculty of Science, Kyoto University、3.Faculty of Geosciences and Civil Engineering, Kanazawa University、4.Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa University、5.Lamont-Doherty Earth Observatory, Columbia University、6.School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton、7.School of Geography, Earth and Environmental Sciences, Plymouth University、8.Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya University、9.Institute of Science and Technology, Niigata University)

16:40 ~ 17:00

[SCG49-05] Hydration and development of fracture network within oceanic lower crust: an evidence from CM1A of Oman Drilling

★Invited Papers

*岡本 敦[1]、吉田 一貴[1]、大柳 良介[2]、Oman Drilling Project Phase 2 Science Party[3] (1.東北大学大学院環境科学研究科、2.海洋研究開発機構、3.Oman Drillng Project Phase 2 Science Party)

Geochemical and Geochronological Constraints on the Origin and Emplacement of the East Taiwan Ophiolite: Implication for Subduction Initiation of the South China Sea.

*林 秋婷[1]、ロン ハリス[2]、孫 衛東[1]、張 国良[1]
*Chiou-ting Lin[1], Ron A. Harris[2], Wei-dong Sun[1], Guo-liang Zhang[1]

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1. Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, 2. Department of Geology, Brigham Young University

The East Taiwan Ophiolite (ETO) occurs as blocks and thrust sheets associated with the Lichi Mélange in the Coastal Range of eastern Taiwan. The blocks consist of serpentinized harzburgite, serpentinite breccia, gabbro, dikes of dolerite and plagiogranite, pillow basalts, and red clay within a mud- and serpentinite-rich mélange matrix. New U-Pb zircon dating of a pegmatite gabbro yields a weighted mean age of 16.65±0.20 Ma. This age is earlier than the North Luzon Arc, but overlaps with the late–stage spreading of the South China Sea. ETO glassy basalt has low K_2O, MgO and high CaO contents, similar to MORB. REE and trace element patterns show both N-MORB patterns with LREE depletion and E-MORB patterns with slight LREE enrichment. A few samples show slight depletion in Nb-Ta, and Ti and enrichment in Rb, Ba, U and Sr, indicating a hint of subduction influence. Most ETO basalt plots within the overlapping fields of N-MORB and BABB on Ti-V, Cr-Y, Nb/Yb- Th/Yb and Hf/3-Th-Ta discrimination diagrams. The geochemical compositions of the ETO basalt are emblematic of mid-ocean ridge or back-arc lava, and the Pb isotope values are similar to those of MORB of the South China Sea from IODP Expedition 349. We interpret ETO basalt as fragments of the subducted South China Sea basement that were scrapped off and accreted to the Luzon forearc during the process of subduction initiation along the nascent Manila Trench. Blocks of mantle material in the mélange may originate from the upper plate of the arc-continent collision and were mixed with lower plate crustal material in a subduction channel now represented by the Lichi Mélange.

キーワード：東台湾オフィオライト、リチ・メランジュ、南中国海、背弧海盆、沈み込み開始、島弧と大陸の衝突
Keywords: East Taiwan Ophiolite, Lichi Mélange, South China Sea, back-arc basin, subduction initiation, arc-continent collision

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Towards a complete profile of hydrothermal alteration in the lower oceanic crust and uppermost mantle; Insights from the Oman Drilling Project and ChikyuOman2017 and 2018

*Damon A H Teagle[1], Michelle Harris[2], Gretchen Früh-Green[3], Eiichi TAKAZAWA[4], Katsuyoshi Michibayashi[5], Peter B Kelemen[6], Oman Drilling Project Science Team[1]

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Drilling a continuous section through the lower oceanic crust and into the uppermost mantle has been an unfulfilled scientific ambition for more than 60 years since before the development of plate tectonics. Although an imperfect analogue of in situ, intact ocean crust, the 96 Ma Samail ophiolite of Oman is the largest and best preserved on-land exposure of ancient ocean crust that formed in some type of fast spreading ocean ridge, in the Tethyan ocean shortly before its obduction on to the Arabian margin. Offset drilling by Oman Drilling Project has now sampled critical intervals of the mid to lower oceanic crust and the uppermost mantle preserved in the Samail ophiolite. In a series of 400 m-deep diamond-cored boreholes the Oman Drilling Project has made with near 100 % rates of recovery, continuous objective observations from the lower sheeted dikes and the dike-gabbro transition zone (Hole GT3A), the mid-crustal transition from foliated to layered cumulate gabbros (Hole GT2A), deep layered gabbros including mineralised fault zones (Hole GT1A), and across the crust-mantle transition from layered gabbros through dunites into residual harzburgites of the Samail upper mantle (Holes CM1A and CM2B). Observations of drillcore, complemented by instrumental (e.g., X-ray CT, Infrared scanning) and geophysical wireline logging, now provide the opportunity to objectively quantify the conditions and extent of seawater-rock exchange in the mid to lower oceanic crust and uppermost mantle. These new observations will lead to better understand the role and influence of deep hydrothermal circulation on the accretion of the lower oceanic crust and the improved quantification of geochemical and isotopic exchanges between the oceans and new crust formed at mid-ocean ridges.

Keywords: ocean crust, hydrothermal alteration, ophiolite, Oman Drilling Project

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Peridotite alteration in OmanDP cores

*Peter B Kelemen[1], Juan Carlos de Obeso[1], Craig Manning[2], Marguerite Godard[3], Wolfgang Bach[4], Merry Yue Cai[1], Saebyul Choe[5], Judith Coggon[6], Eric Ellison[7], Alireza Eslami[8], Katy Evans[9], Michelle Harris[10], Wolf-Achim Kahl[4], Jürg Matter[6], Katsu Michibayashi[11], Keichi Okazaki[12], Philippe Pézard[3], Damon A.H. Teagle[6], Alexis Templeton[7], OmanDP Oman Drilling Project Science Team

1. LDEO, 2. UCLA, 3. U. Montpellier, 4. U. Bremen, 5. AMNH, 6. U. Southampton, 7. U. Colorado, 8. U. Tehran, 9. Curtin U., 10. U. Plymouth, 11. Nagoya U., 12. JAMSTEC

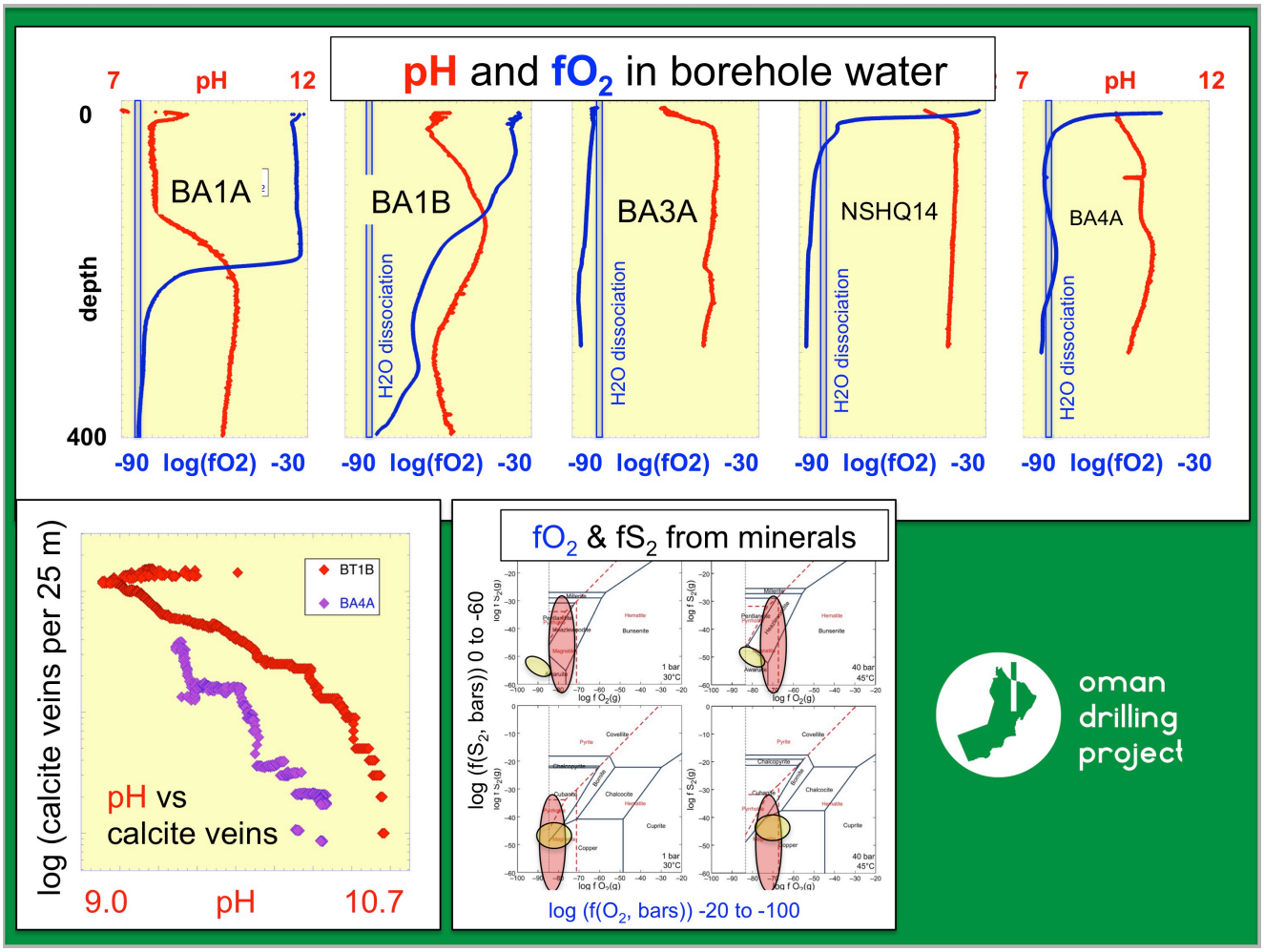
Here we present some preliminary results constraining peridotite alteration in cores from several Oman Drilling Project (OmanDP) boreholes, from the Samail ophiolite in the Sultanate of Oman. Hole BT1B in Wadi Mansah east of Fanjah was drilled through 200 m of fully carbonated and/or serpentinized peridotites of the mantle wedge, through the basal thrust of the ophiolite, into the metamorphic sole. Holes BA1B, BA3A and BA4A were drilled into extensively serpentinized peridotite of the eastern Wadi Tayin massif.

Fully carbonated peridotites (listvenites) and serpentinites of Hole BT1B reflect carbonation and hydration by fluids rising from the Cretaceous subduction zone at the base of the ophiolite, at about 100° C (Falk & Kelemen GCA 2015). Though there is extensive, 0.01-10 m scale chemical variation, the average, volatile-free composition of the listvenites is almost identical to that of partially serpentinized harzburgites throughout the ophiolite mantle section. This observation and thermodynamic modeling indicate that, during addition of CO2, H2O, Ca and K from subduction zone fluids, Mg/Fe/Si ratios were nearly unchanged, suggesting very minor export of dissolved, major elements. In turn, this requires a large increase in solid volume. One possibility is that major volume expansion occurred at a serpentinization front, perhaps advancing via reaction-driven cracking, followed by smaller amounts of expansion at the carbonation front. Observed mineral parageneses and thermodynamic modeling require relatively CO2-rich aqueous fluids, and perhaps an exsolved, CO2-dominated fluid. CO2 contents were higher than for fluids in equilibrium with underlying metasediments at any likely depth for formation of the observed listvenite, and thus suggest that fluids derived from higher temperature and pressure devolatilization migrated up the subduction zone to this site.

Highly serpentinized peridotites from Holes BA1B, BA3A and BA4A record steep chemical gradients, with sharply decreasing f(O2) and f(CO2) downhole, beginning at the present-day erosional surface. Moreover, inferred conditions based on mineral parageneses are consistent with present-day borehole water compositions. Oxygen fugacity reaches the limit for H2 production from H2O at < 100 meters below the surface. These borehole observations are consistent with previous observations (14C in carbonates, reduced sulfides, oxides and metals, highly alkaline and reduced fluids, H2 gas) and thermodynamic modeling indicating that carbonation and serpentinization-related redox reactions are ongoing. Given experimental data suggesting that serpentinization of olivine is slow, evidence for low temperature “serpentinization” raises interesting questions about natural rates, and the nature of reactants and products, in the present-day weathering environment.

Keywords: Global carbon cycle, Oman Drilling Project, Peridotite weathering, Serpentinization, Carbon mineralization aka mineral carbonation, Natural production of H2 hydrogen gas

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Oman Drilling Project Phase 1 のリストヴェナイト中のドロマイト脈に薄い塩水からなる流体包有物があるぜよ
Low-salinity aqueous fluid inclusions in dolomite veins of a listvenite of Oman Drilling Project Phase 1

*川本 竜彦[1]、佐藤 宏樹[2]、髙橋 藤馬[3]、Juan Miguel Guotana[4]、森下 知晃[4]、Peter Kelemen[5]、Jude Coggon[6]、Michelle Harris[7]、Juerg Matter[6]、道林 克禎[8]、高澤 栄一[9]、Damon Teagle[6]、The Oman Drilling Project Phase 1 Science Party
*Tatsuhiko Kawamoto[1], Hiroki Sato[2], Toma Takahashi[3], Juan Miguel Guotana[4], Tomoaki Morishita[4], Peter B Kelemen[5], Jude Ann Coggon[6], Michelle Harris[7], Juerg Michael Matter[6], Katsuyoshi Michibayashi[8], Eiichi TAKAZAWA[9], Damon A H Teagle[6], The Oman Drilling Project Phase 1 Science Party

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1. Department of Geoscience, Faculty of Science, Shizuoka University, 2. Faculty of Science, Kyoto University, 3. Faculty of Geosciences and Civil Engineering, Kanazawa University, 4. Division of Natural Sciences, Graduate School of Natural Science and Technology, Kanazawa University, 5. Lamont-Doherty Earth Observatory, Columbia University, 6. School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, 7. School of Geography, Earth and Environmental Sciences, Plymouth University, 8. Department of Earth Planetary Sciences, Graduate School of Environmental Studies, Nagoya University, 9. Institute of Science and Technology, Niigata University

Oman Drilling Project Phase 1 のリストヴェナイト(試料名: z68w)は白色ないし緑色を呈するリストヴェナイトでマグネサイトと石英からなる。そのリストヴェナイトにはドロマイトからなる脈が存在し、ドロマイト中に気体と液体からなる流体包有物がたくさん存在する。多くのものは6ミクロンメートル以下と小さく、顕微ラマン分光法で気体と液体の同定ができるものは限られる。まれにある6ミクロンメートル以上の大きな流体包有物からは、顕微ラマン分光法でH_2Oのスペクトルを得られるが、これら大きい流体包有物は冷却加熱実験中に破壊されて顕微鏡下で暗くなってしまい、凝固点降下を観察することはできない。これまで顕微ラマン分光法で流体包有物から得られたスペクトルはH_2Oのみで、メタンや二酸化炭素のスペクトルは得られていない。そして、リンカム社製の冷却加熱ステージとニコン社製の100倍の対物レンズを組み合わせて測定した凝固点降下から、流体包有物は 1.1 ±0.5 wt% NaCl 当量と推定する (n=42, Figure 1)。これは海水の3.5%よりも薄い塩水であることを示す。流体包有物の均質化温度は139 ±31˚C (n=8, Figure 2)で、この以上の高温条件で形成されたことを示す。流体包有物はドロマイト脈中に存在し、それはマグネサイトと石英を切っている(Figure 3)ことから、流体包有物を作る薄い塩水はドロマイト脈の形成時に存在したことを示す。海水が炭素を運びカンラン岩または蛇紋岩と反応することによってリストヴェナイトを形成したと仮定するならば、その過程でなにかの相に塩素を吸収されるか、天水などとの混合によって、海水が薄い塩水になったと考える必要がある。

キーワード：海水、炭素循環、蛇紋岩、蛇紋石、炭酸塩、炭酸塩岩化
Keywords: seawater, carbon cycling, serpentinite, serpentine, carbonate, carbonation

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Figure 1 Histogram of salinity.

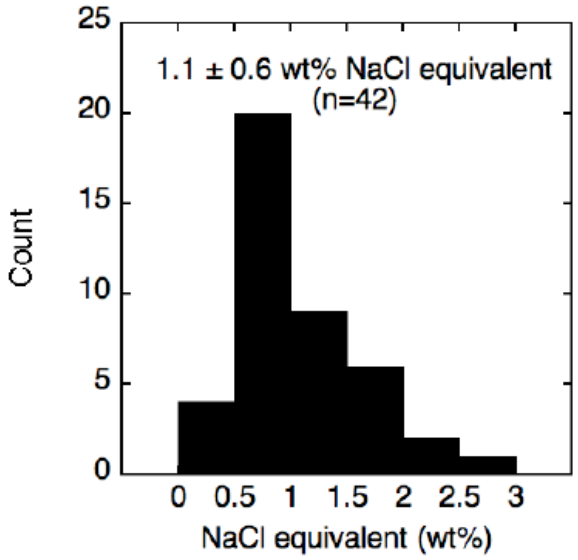


Figure 2 Homogenization T vs salinity.

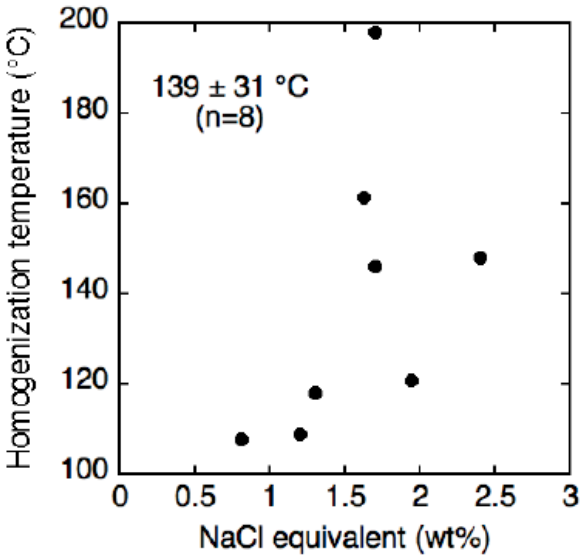
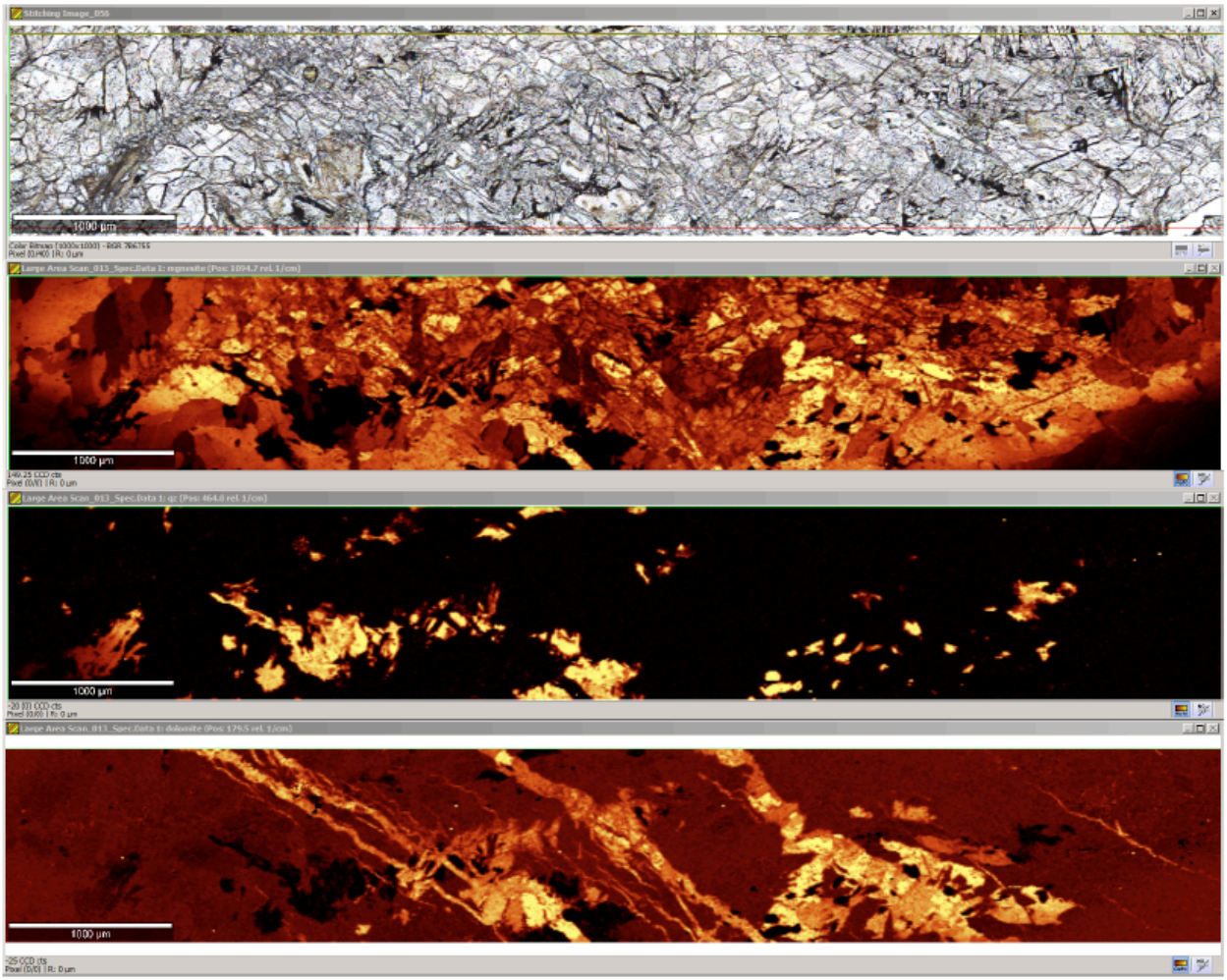


Figure 3 Microphotograph of a listvenite under transparent light (7.5mm wide) and Raman mapping images showing the distribution of magnesite, quartz, and dolomite.



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Hydration and development of fracture network within oceanic lower crust: an evidence from CM1A of Oman Drilling

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The rate and extent of hydration of oceanic lithosphere are of special importance for understanding of the global water budget, the physical properties of crust-mantle boundary and potential limit of microbial activities in the crusts. It has been suggested that Moho transition zone and uppermost mantle has been highly serpentinized. If the fluid source for serpentinization is seawater, the fluid infiltration through the “less permeable” lower crust should occur. In this study, we report the nature of serpentinization in olivine within the lower crusts that was recovered from the CM1A site of the Oman Drilling Project, and discuss the relationship between hydration, fluid flow and fracturing based on the modeling of distinct element method (DEM).

The gabbroic rocks of the lower crust showed layer structures composed of light and dark colored layers with few to several tens millimeter thickness. The former is mainly composed of plagioclase and clinopyroxnene and the latter is enriched in olivine. The olivine grains were serpentinized with forming mesh-like textures, and the extent of serpentinization increases with increasing the modal abundance of olivine. The serpentine veins within the olivine grains do not always contain brucite, and show the zoning of Al, indicating an influx of silica and aluminum from plagioclase during serpentinization. The large amount of magnetite was formed in the serpentine mesh veins, indicating that olivine with high Fe content (Mg# = ~0.82) effectively produce hydrogen compared to the common mantle peridotite (Mg# = ~0.9). Radial cracks, which are filled with chlorite, are also developed around the serpentinized olivine grains. These features indicated that the reaction-induced fracturing occurred as the force of crystallization exceeds the tensile strength of the matrix minerals as suggested by the previous studies (Jamtveit et al., 2008; Kelemen and Hirth, 2012). It is also noted that fractures in olivine tends to developed in horizontal direction (parallel to the gabbroic layering) whereas those with in the plagioclase developed in vertical direction.

We conducted the DEM simulation on serpentinization in layered gabbro, which treats the reaction, advective fluid flow and fracturing, and the reaction rate is defined as a function of fluid pressure (Okamoto and Shimizu, 2015; Shimizu and Okamoto, 2016). The model reproduces a simultaneous development of contrasting fracture patterns inside and outside of the olivine grains, and shows the development of fracture network connecting the olivine grains, and shows the positive feedback of serpentinization, fracturing and permeability enhancement in vertical direction. These results indicate that the reaction-induced fracturing play essential roles on the fluid infiltration through the lower crusts and mantle hydration.

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9-18. Shimizu, H., Okamoto, A., 2016. Contrib Mineral Petrol, 171, 73.

キーワード：層状はんれい岩、離散要素法、蛇紋岩化作用、オマーン掘削プロジェクト、反応に起因した破壊
Keywords: layered gabbro, distinct element method, serpentinization, Oman Drilling Project, reaction induced fracturing

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[E] 口頭発表 | セッション記号 B (地球生命科学)：B-BG 地球生命科学・地圏生物圏相互作用

2019年5月27日(月) 15:30 ~ 17:00 | 201A 2F

[B-BG01] Elemental cycling in terrestrial and coastal ecosystems- Carbon and Nitrogen perspectives

コンビーナ:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata)、座長:Punyasloke Bhadury(Indian Institute of Science Education and Research Kolkata)

Biogeochemical cycling of carbon and nitrogen hold the key to cropping cycle, monsoonal patterns and climate globally. Biological communities that make up the biosphere are essential for cycling of carbon and nitrogen and their functions are regulated by numerous factors including redox conditions, trace metal availability, and energy sources. At the same time temporal and spatial variability of biological communities such as those observed in microbes strongly affect the rate of carbon and nitrogen cycling in various environments including land and marine systems. In this session, submissions are welcomed from scientists including early career scientists working on various aspects of carbon and nitrogen cycling across terrestrial, coastal and oceanic environments. Submissions are also encouraged addressing challenges related to estimation of carbon and nitrogen budgets representing local, regional and global scales.

15:30 ~ 15:35

Introduction

15:35 ~ 16:00

[BBG01-01] **Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem**

★Invited Papers

*Santanu Ray[1] (1.Systems ecology and ecological modelling laboratory, Dept. of Zoology, Visva-Bharati University, Santiniketan 731235, India)

16:00 ~ 16:15

[BBG01-02] ^{17}O-rich nitrate as a tracer for constraining nitrogen transformations in coastal sediments

*Chawalit Charoenpong[1,2]、Scott D Wankel[2]、Carolyn Buchwald[3,2]、Wiebke Ziebis[4] (1.Chulalongkorn University、2.Woods Hole Oceanographic Institution、3.Dalhousie University、4.University of Southern California)

16:15 ~ 16:30

[BBG01-03] **Exploring changes in bacterioplankton community structure in response to tannic acid, a major component of litterfall, in a mangrove ecosystem: a laboratory mesocosm approach**

*Anwesha Ghosh[1] (1.Integrative Tax Microb Ecol Res Group, Dept. of Biol Sci, IISERK)

16:30 ~ 16:45

[BBG01-04] **Diel variations of dissolved inorganic carbon in the Pearl River plume and the northern South China Sea shelf upwelling during summer**

*Wei-Jen Huang[1]、Kai-Jung Kao[1]、Yu-Shih Lin[1]、James T. Liu[1]、Chen-Tung Arthur Chen[1] (1.National Sun Yat-sen University)

16:45 ~ 17:00

[BBG01-05] **Spatial and vertical variations of carbon and nitrogen isotopes of larch forest and NDVI in Eastern Siberia**

*Aleksandr Nogovitcyn[1]、Atsuko Sugimoto[2]、Ruslan Shakhmatov[1]、Tomoki Morozumi[1]、Shunsuke Tei[2]、Yumiko Miyamoto[2]、Trofim Maximov[3,4] (1.Graduate School of Environmental Science, Hokkaido University, Sapporo, Hokkaido, Japan、2.Arctic Research Center, Hokkaido University, Sapporo,

Hokkaido, Japan、3.Institute for Biological Problems of Cryolithozone, Siberian Blanch of Russian Academy of Sciences, Yakutsk, Yakutia, Russia、4.International Center for Biogeoscience Educational and Scientific Trainings (BEST), North-Eastern Federal University, Yakutsk, Yakutia, Russia)

Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem

*Santanu Ray[1]

1. Systems ecology and ecological modelling laboratory, Dept. of Zoology, Visva-Bharati University, Santiniketan 731235, India

Hooghly estuary of India is very rich in natural resources and receives large amountof nutrients through litterfall from adjacent mangrove forest. Nitrogen and carbon as important nutrients occur in various forms and plays a crucial role in the regulation of productivity in this estuarine system. Modelling of nitrogen and carbon dynamics from mangrove litterfall and particularly the release of dissolved inorganic nitrogen and carbon in this estuarine system is important because of their roles in augmenting growth of phytoplankton and other higher plants and all other biological components of grazing food chain. Considering the importance of nitrogen and cabron, two dynamic models both with seven compartmentsare proposed. In these models, nitrogen and carbon of the mangrove litterfall are considered as source and its conversion into different organic and inorganic forms are considered as state variables. Some physical and chemical factors and also rate parameters such as nitrogen fraction of litter biomass, litter biomass, redox potential, soil temperature, conversion rates of nitrogen of one form to another form, phytoplankton uptake rate of dissolved inorganic nitrogen and carbon, dissolved oxygen, water temperature and water pH are considered as graph-time functions in this model. These data are collected over two years from field works and experiments. Other rate parameters are calibrated following standard procedure. Sensitivity analysis is performed before calibration. Model simulation results are properly validated with observed data. Sensitivity analysis reveals that the leaching rate of soil organic nitrogen to total organic nitrogen of water and loss rate of soil organic nitrogen as humic acid and fulvic acids are very sensitive parameters in this system. Redox potential plays an important role in the conversion of soil total nitrogen to soil inorganic nitrogen whereas soil temperature is considered to be key factor regulating the microbial activity for the conversion of soil organic nitrogen to soil inorganic nitrogen. Similarly inwater, total organic nitrogen of water including dissolved organic nitrogen and particulate organic nitrogen is dependent on soil organic nitrogen. The dissolved organic nitrogen, particulate organic nitrogen and soil inorganic nitrogen ultimately get converted into dissolved inorganic nitrogen and accumulated in water which is taken by phytoplankton and microflora as minerals.For carbon cycle model results show seasonal variations of litterfall and which is the main source of SOC pool and ultimately transportedto the estuary. Other than litterfall, the death of organisms in soil and water enriches the SOC and POC respectively. pH of water is governing factor and depending on this factor, DIC is converted to DCO_2 and DBC, which are taken up by phytoplankton during photosynthesis. Mineralization rate of SOC to SIC and uptake rate of DCO_2 and DBC are the sensitive parameters.

Keywords: Dynamic models, litterfall, inorganic, organic, tropical estuary

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Modelling nitrogen and carbon cycles in Hooghly estuary along with adjacent mangrove ecosystem

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Abstract

Hooghly estuary of India is very rich in natural resources and receives large amountof nutrients through litterfall from adjacent mangrove forest. Nitrogen and carbon as important nutrients occur in various forms and plays a crucial role in the regulation of productivity in this estuarine system. Modelling of nitrogen and carbon dynamics from mangrove litterfall and particularly the release of dissolved inorganic nitrogen and carbon in this estuarine system is important because of their roles in augmenting growth of phytoplankton and other higher plants and all other biological components of grazing food chain. Considering the importance of nitrogen and cabron, two dynamic models both with seven compartmentsare proposed. In these models, nitrogen and carbon of the mangrove litterfall are considered as source and its conversion into different organic and inorganic forms are considered as state variables. Some physical and chemical factors and also rate parameters such as nitrogen fraction of litter biomass, litter biomass, redox potential, soil temperature, conversion rates of nitrogen of one form to another form, phytoplankton uptake rate of dissolved inorganic nitrogen and carbon, dissolved oxygen, water temperature and water pH are considered as graph-time functions in this model. These data are collected over two years from field works and experiments. Other rate parameters are calibrated following standard procedure. Sensitivity analysis is performed before calibration. Model simulation results are properly validated with observed data. Sensitivity analysis reveals that the leaching rate of soil organic nitrogen to total organic nitrogen of water and loss rate of soil organic nitrogen as humic acid and fulvic acids are very sensitive parameters in this system. Redox potential plays an important role in the conversion of soil total nitrogen to soil inorganic nitrogen whereas soil temperature is considered to be key factor regulating the microbial activity for the conversion of soil organic nitrogen to soil inorganic nitrogen. Similarly inwater, total organic nitrogen of water including dissolved organic nitrogen and particulate organic nitrogen is dependent on soil organic nitrogen. The dissolved organic nitrogen, particulate organic nitrogen and soil inorganic nitrogen ultimately get converted into dissolved inorganic nitrogen and accumulated in water which is taken by phytoplankton and microflora as minerals.For carbon cycle model results show seasonal variations of litterfall and which is the main source of SOC pool and ultimately transportedto the estuary. Other than litterfall, the death of organisms in soil and water enriches the SOC and POC respectively. pH of water is governing factor and depending on this factor, DIC is converted to DCO_2 and DBC, which are taken up by phytoplankton during photosynthesis. Mineralization rate of SOC to SIC and uptake rate of DCO_2 and DBC are the sensitive parameters

Keywords: Dynamic models; litterfall; inorganic; organic; tropical estuary

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^{17}O-rich nitrate as a tracer for constraining nitrogen transformations in coastal sediments

*Chawalit Charoenpong[1,2], Scott D Wankel[2], Carolyn Buchwald[3,2], Wiebke Ziebis[4]

1. Chulalongkorn University, 2. Woods Hole Oceanographic Institution, 3. Dalhousie University, 4. University of Southern California

Coastal sediments are often replete in organic matter and exhibit sharp gradient in redox conditions. In addition, the oxic-anoxic interfaces are often around a few centimeters if not less below the sediment surface. This make this environment poised to harbor both oxidative and reductive nitrogen transformations. As such, the use of a single or a couple of isotope-labeling tracers to determine the rates of these many processes might suffer from the systems being underconstrained. In this work, we demonstrate how naturally-occurring, ^{17}O-rich nitrate can aid in the studying these complex systems through the ability to follow the transformations of added nitrate (NO_3^-) into other different pools of N-species and closely investigate the triple isotopic compositions (δ^{15}N, δ^{18}O, and Δ^{17}O). While we followed five different pools of N-species namely NO_3^-, NO_2^-, N_2O, NH_4^+, and total reduced N (NH_4^+ plus DON), we chose to focus this work on the intermediate nitrite, NO_2^-. For all intact flow-through core incubations done on the sediments collected from Sylt Island, Germany, sediments acted as sources for NO_2^- in all experimental manipulations including sediment type, dissolved oxygen level, and NO_3^- loading. Unlike in the environments that are solely driven by reductive processes where the changes in δ^{15}N and δ^{18}O are coupled, the co-occurrence of both oxic and anoxic in the sediments such as ones from this study cause the δ^{15}N and δ^{18}O to decouple primarily because O is often subject to more processes than N. By using three isotope systems along with the change in concentrations, we demonstrate how we can use a natural abundance appraoch and rely on a series of mathematical equations to solve for different N transformation rates.

Keywords: nitrogen, isotope, 17O, sediments

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Exploring changes in bacterioplankton community structure in response to tannic acid, a major component of litterfall, in a mangrove ecosystem: a laboratory mesocosm approach

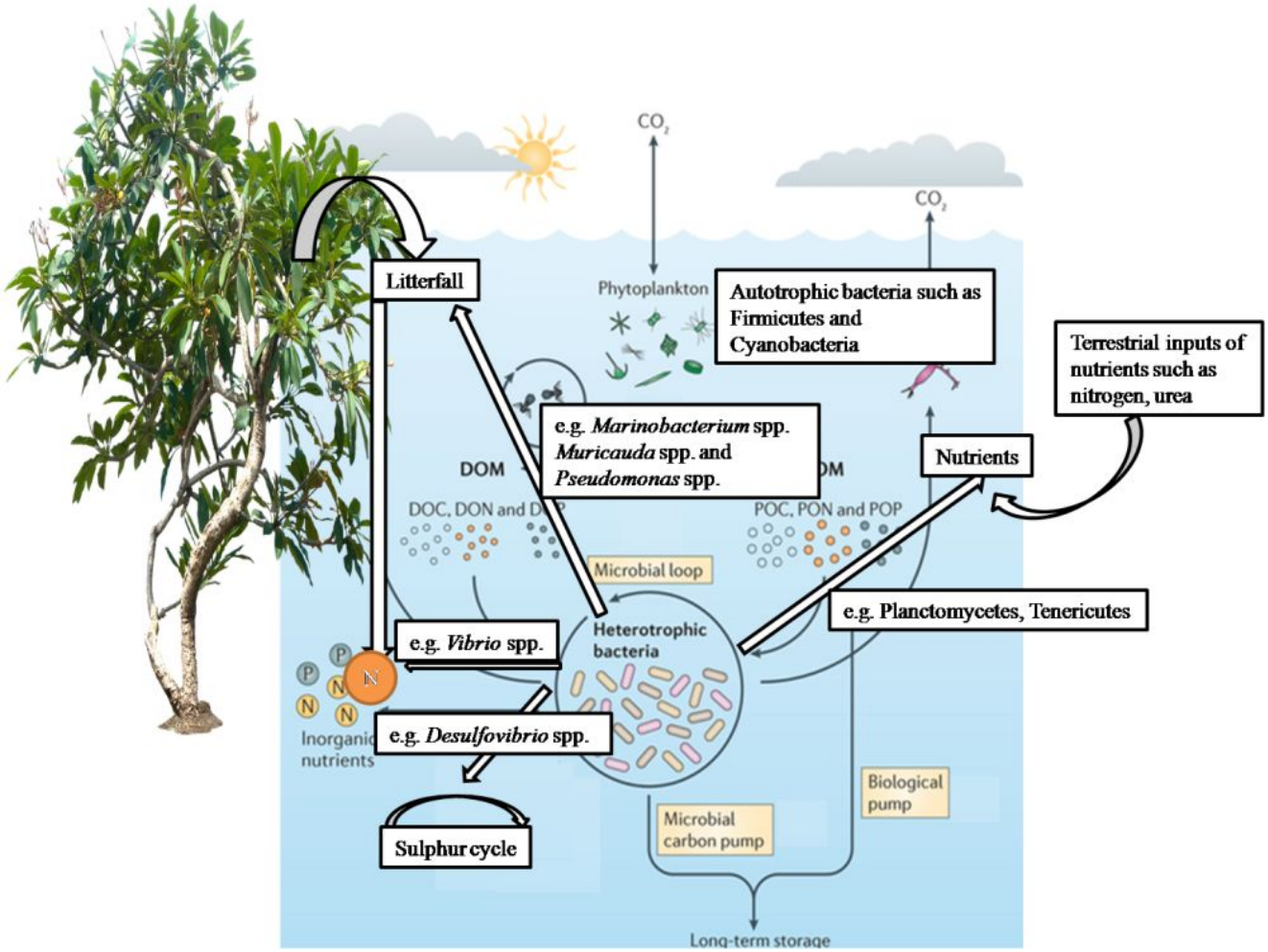
*Anwesha Ghosh[1]

1. Integrative Tax Microb Ecol Res Group, Dept. of Biol Sci, IISERK

Litterfall constitutes a major source of allochthonous matter for bacterioplankton communities in estuarine mangroves. Tannic acid, an abundant component of mangrove litterfall, leaches out and contributes substantially to DOC and DOM pools of the adjacent estuaries. About 50% of mangrove litterfall maybe degraded and channelized into the marine microbial loop. Estuarine conditions of Sundarbans, world’ s largest contiguous mangrove, was mimicked in a laboratory mescocosm set-up using barrels to understand the influence of tannic acid on bacterioplankton communities. Estuarine water from a station, Stn3 of Sundarbans Biological Observatory Time Series (SBOTS) was enriched with tannic acid and the change in functional bacterioplankton community structure was analysed on the start (Day 0), intermediate (Day 7) and end (Day 15) of the experiment. Bacterioplankton community structure was elucidated by sequencing the V3-V4 region of 16S rRNA on an Illumina MiSeq platform. Concentration of tannic acid, gallic acid, trace elements, dissolved nutrients such as nitrate and *ortho* -phosphate along with hydrological parameters were determined on a daily basis. Degradation of tannic acid was tracked by decrease in concentration of tannic acid and generation of gallic acid, one of the final products of tannic acid degradation. Tannic acid was shown to significantly affect the concentration of dissolved nitrate and trace elements in the barrels. Proteobacteria was found to be the most dominant bacterial phylum in Control and tannic acid enriched barrels (Barrel 1 and 2) on Day 0. With the progression of experiment, the abundance of Proteobacteria decreased significantly in the Control barrel indicating the dependence of this phylum on steady flux of nutrients. The abundance of Proteobacteria in the tannic acid enriched barrels remained high indicating that members of Proteobacteria may be capable of using tannic acid as a source of carbon and nitrogen. Tannic acid appeared to inhibit other bacterioplankton phyla including Actinobacteria, Acidobacteria and Verrucomicrobia that existed in large abundance in the Control barrel on Day 15 but were absent in the tannic acid enriched barrels. At class level, Bacteroides was found to be present in highest abundance in the tannic acid enriched barrels. Bacteroides are capable of breaking down tannic acid using tannase as an enzyme. This experiment indicated that bacterioplankton communities of Sundarbans could harbour genes necessary for breakdown of complex components of litterfall and recycle them into the marine microbial loop. Breakdown of tannic acid could influence the marine nitrogen and carbon cycling by releasing DON and DOC respectively into the adjacent estuaries. An understanding of the breakdown of tannic acid and other components of mangrove litterfall and its influence on the resident biological communities of estuarine mangroves could be essential for our understanding of functioning of coastal ecosystems.

Keywords: bacterioplankton, mangrove, litterfall

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Diel variations of dissolved inorganic carbon in the Pearl River plume and the northern South China Sea shelf upwelling during summer

*Wei-Jen Huang[1], Kai-Jung Kao[1], Yu-Shih Lin[1], James T. Liu[1], Chen-Tung Arthur Chen[1]

1. National Sun Yat-sen University

Strong river-to-sea mixing, stratification, and coastal eutrophication are usually observed on a plume dominated-continental shelf, but the effects of diel variations and upwelling on the carbonate system are still unclear on the northern South China Sea continental shelf. The Pearl River plume and upwelling at the northern South China Sea were surveyed at the near-field (1 day), the mid-field (6 days), and the far-field sites (1day) along the plume trajectory. We sampled total alkalinity (TA) and dissolved inorganic carbon (DIC) and calculated buffer capacity at the near-surface and near-bottom waters. We also estimated primary productivity (PP, based on $d^{13}C$) at the near-field site and calculated net community productivity (NCP) in the mid-field site after removing the mixing effect. At this plume-upwelling hybrid system, lower salinity, TA, and DIC value and higher buffer capacity and NCP were observed in the near-surface water than the values in the near-bottom water. A good correlation between the common logarithm of light intensity and PP was observed; suggesting that the diel variation of PP was dominated by day-night light cycle. Moreover, the changes of net biological uptake (36% to 76%) were higher than the changes of salinities (3% to 8%) during the subsurface upwelling (from development, maxima, and decline stages at the middle-field site). We suggest that respiration-associated biological activities in addition to PP and physical mixing dominated the near-surface water during subsurface upwelling. Finally, at this coupled plume and upwelling system, the diel variation of carbonate system can be dominated by PP induced by periodic sunlight cycle and further affected by respiration strengthened by intensive upwelling.

Keywords: Pearl River plume, inorganic carbon, upwelling, CO2

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Spatial and vertical variations of carbon and nitrogen isotopes of larch forest and NDVI in Eastern Siberia

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Under a global climate change, taiga forest ecosystem is expected to change. Tree ring data obtained at northeast Siberian Taiga indicated tree growth decrease during warm climate (Tei et al., 2014), consequently primary production may decrease in the future. As tools for monitoring ecosystem changes, stable isotope of carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$ are widely applied in ecological research. The $\delta^{13}C$ is a common proxy for water use efficiency in plants, and the $\delta^{15}N$ is for nitrogen availability that is important because boreal forest on permafrost is usually poor in the nitrogen (Popova et al., 2013).

Observations were conducted at Spasskaya Pad forest station (62°25’ N, 129°62’ E) near Yakutsk, Russia. The forest is usually dry, but after the extreme wet event in 2007, wet sites were distributed in the forest. Transect (60m x 510m) with 30m x 30m plots, in total 33, was set including dry sites and wet sites, to obtain needle samples from 104 trees at the height of 5-6 m were obtained in order to investigate spatial variations in $\delta^{13}C$, $\delta^{15}N$, and N contents. These spatial variations were compared with satellite-derived Normalized difference vegetation index (NDVI) using Landsat images with the resolution of 30 m. Lower NDVI and lower foliar N content were observed at wet sites than those at dry sites. A high $\delta^{13}C$ and high $\delta^{15}N$ were also observed at a wet site. After extreme wet event happened, ecosystem (and N availability) changes and NDVI also changes. We also obtained the needles from two trees at different heights in a jungle gym to investigate the vertical variations in $\delta^{13}C$ and $\delta^{15}N$. There were large differences in $\delta^{13}C$, $\delta^{15}N$ and N contents vertically.

Tei, S., A. Sugimoto, H. Yonenobu, T. Ohta, T. C. Maximov. Growth and physiological responses of larch trees to climate changes deduced from tree-ring widths and $\delta^{13}C$ at two forest sites in eastern Siberia. *Polar Science*, 8, 183-195, doi:10.1016/j.polar.2013.12.002, 2014

Popova A.S., N. Tokuchi, N. Ohte, M.U. Ueda, K. Osaka, T.Ch. Maximov and A. Sugimoto. Nitrogen availability in the taiga forest ecosystem of northeastern Siberia. *Soil Science and Plant Nutrition*, 59, 427-441, doi:10.1080/00380768.2013.772495, 2013

Keywords: taiga (boreal) forest, NDVI, carbon isotope, nitrogen isotope

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[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27日(月) 9:00 ~ 10:30 | A07 東京ベイ幕張ホール

[M-IS02] 地球掘削科学

コンビーナ:山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、針金 由美子(産業技術総合研究所)、黒柳 あずみ(東北大学学術資源研究公開センター東北大学総合学術博物館)、山口 耕生(東邦大学, NASA Astrobiology Institute.)、座長:黒柳 あずみ(東北大学)、Kan Hsiung(海洋研究開発機構)

これまでに実施された科学掘削データ・試料の解析・分析結果などの研究成果の報告と、今後の科学掘削計画に関する最新情報の紹介を目的とする。固体地球科学、古環境学、地球生命科学などの様々な分野からの成果を共有し、科学掘削を基軸とした学際的研究を推進する。最近１年間に実施されたICDPプロジェクトとIODP航海の概要報告を中心に、これまでに実施された掘削航海に関連して得られた最新研究成果と、今後数年間に具体化される科学掘削計画、掘削科学に関連する新規手法や技術開発研究等の報告を歓迎する。

9:00 ~ 9:15

[MIS02-01] 南シナ海IODP Exp.367 U1499における浮遊性有孔虫生層序

*古澤 明輝[1]、林 広樹[1] (1.島根大学　総合理工学研究科)

9:15 ~ 9:30

[MIS02-02] High heat with slow cooling of rift margin in the South China Sea, IODP Exp.368

*坂口 有人[1,2]、大園 宣明[1]、中野 敬太[1] (1.山口大学、2.海洋研究開発機構)

9:30 ~ 9:45

[MIS02-03] 酸化的な遠洋性堆積物中に存在する大量の微小マンガン粒について（IODP Exp. 329）

*浦本 豪一郎[1,2]、諸野 祐樹[2]、富岡 尚敬[2]、若木 重行[2]、中田 亮一[2]、和穎 朗太[3]、上杉 健太朗[4]、竹内 晃久[4]、星野 真人[4]、鈴木 芳生[4,5]、光延 聖[6]、白石 史人[7]、菅 大暉[5]、武市 泰男[8]、高橋 嘉夫[5]、稲垣 史生[2] (1.高知大学、2.海洋研究開発機構、3.農業・食品産業技術総合研究機構、4.高輝度光科学研究センター、5.東京大学、6.愛媛大学、7.広島大学、8.高エネルギー加速器研究機構)

9:45 ~ 10:00

[MIS02-04] **Regional stratigraphic framework, Gas Hydrate occurrence and distribution of National Gas Hydrate Program Expedition 02 (NGHP-02) Area-B, offshore eastern India**

*熊 衍昕[1]、斎藤 実篤[1]、金松 敏也[1]、真田 佳典[1]、山田 泰広[1]、MOE KYAW[1]、濱田 洋平[1]、中村 恭之[1]、呉 泓昱[1] (1.国立研究開発法人海洋研究開発機構)

10:00 ~ 10:15

[MIS02-05] Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

*井尻 暁[1]、若木 重行[1]、西尾 嘉朗[2]、濱田 洋平[1]、石川 剛志[1]、稲垣 史生[1] (1.国立研究開発法人海洋研究開発機構、2.高知大学)

10:15 ~ 10:30

[MIS02-06] Recent progress and perspective on paleomagnetism by means of deep-sea drilling

*山崎 俊嗣[1]、山本 裕二[2]、金松 敏也[3]、熊谷 祐穂[4]、中村 教博[4] (1.東京大学大気海洋研究所、2.高知大学海洋コア総合研究センター、3.海洋研究開発機構、4.東北大学)

南シナ海IODP Exp.367 U1499における浮遊性有孔虫生層序
Planktonic foraminiferal biostratigraphy in the South China Sea IODP Exp. 367 U 1499

*古澤 明輝[1]、林 広樹[1]
*Akira Furusawa[1], Hiroki Hayashi[1]

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南シナ海は世界でもっとも暖かい海域として知られているWPWP（western Pacific warm pool）の直上にあたり，生物進化の起点として数多くの研究が行われている．その為，IODP(International Ocean Discovery Program)などの国際的な研究が盛んな地域でもある．

南シナ海におけるIODP Exp.367次航海で私は微古生物学者として乗船し研究を行った際の船上分析においてコアキャッチャー試料から幾つかの浮遊性有孔虫生層序の認定を行った．私は航海を終えて試料を持ち帰り，掘削されたU 1499コアから得られた試料に基づいて浮遊性有孔虫化石を用いてより詳細な年代順序の考察を行った．調査対象としたのは私の主な研究範囲である0～5Maの範囲であり，コア長としては0～約300ｍの区間である．私は，その区間中の1H1W-35X7Wまでの227試料を観察し，年代指標種の確認を行った．その結果，船上研究の時点よりも数多くの年代基準面を認定することができた．しかし，それらの結果を使用していくのには同時に問題点も多く見つかった．その問題点とは，いくつかの層準で確認できた生層序に矛盾する点が存在してしまうことである．私はその問題を解決する為に，近隣海域での先行研究である（Tian et al ,.2008）の結果との比較や，ODP leg 184の試料を取り寄せ実際に観察することで，解決の糸口を検討した．

本発表はその成果の一部をを報告する為に行うものである．

キーワード：国際深海科学掘削計画（IODP）、浮遊性有孔虫生層序
Keywords: International Ocean Discovery Program: IODP, Planktonic foraminiferal biostratigraphy

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High heat with slow cooling of rift margin in the South China Sea, IODP Exp.368

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*Arito Sakaguchi[1,2], Nobuaki Osono[1], Keita Nakano[1]

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The cooling rate of the crust may depend on thermal setting including heat source, heat transportation system and thermal properties. The heat flow of the ocean plate decreases with reversed root of the plate age, and this implies that the plate tectonics is thermo dynamic system. Thermal analysis can be applied to more complex tectonic region such as marginal sea and continental divisions.

The IODP Exp. 368 has carried out at the Paleogene South China Sea, and the sediment must record thermal history of the formation of rift margin. The site U1501 is located at the most landward outer margin high of the continent-ocean transition of the rift zone. It is expected that the sediment records thermal history of initial stage of rifting. During the cruise, early Oligocene to late Eocene sediment was cored to 697 m, and high geothermal gradient of 81.4˚C/km was obtained using in-situ temperature measurement (Jian et al., 2018). The terrigenous sediment of this core includes many vitrinite fragment, and its reflectance is sensitive geo-thermometer for sediment.

The result of vitrinite reflectance from 0.21 to 0.34 % are obtained from 340 to 510 mbsf. The estimated maximum paleo-temperature is from approximately 27 to 70˚C, and obtained paleo-geothermal gradient is >250˚C/km. This is higher than present measurement value, and quite higher than world average value of the crust. In case of hot basement covers with thin sediment, apparent geo-thermal gradient gets higher, and thickening history of sediment can be measured from the deposition rate of 11mm/Ky in average (Jian et al., 2018). To satisfy the obtained vitrinite reflectance profile, this site must cool by 2.8% in million years. This cooling rate is much slower than general rate of reversed root of the plate age. This might be due to heat being transferred for a long time or being warmed by the cover sediment layer.

キーワード：リフト帯、地殻熱流量、冷却レート、ジョイデスレゾリューション号、ビトリナイト反射率、南シナ海
Keywords: Rift margin, heat flow, cooling rate, Joides Resolution, vitrinite reflectance, South China Sea

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酸化的な遠洋性堆積物中に存在する大量の微小マンガン粒について（IODP Exp. 329）

Abundant ferromanganese microparticles in oxic pelagic sediments (IODP Exp. 329)

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マンガンは地殻に存在する金属元素の中で鉄、チタンに次いで存在量が多く、また、酸化還元状態のような化学的な環境変化に反応して希少金属を伴って沈殿物を形成または分解するため、環境中での金属元素の挙動を理解する上で、重要な元素として注目されてきた。深海底ではマンガン団塊やコバルトリッチクラストのような球状ないし板状の金属酸化物として広く存在し、近年はその成因について調査研究が進められている。ただし、鉄マンガン酸化物の生成が大規模に生じていると考えられる広大な外洋環流域海底下の酸化的な地層環境内で、どのように鉄マンガン酸化物が存在するか、その実態は分かっていなかった。

本研究は、統合国際深海掘削計画第329次航海で得られた南太平洋環流域の酸化的な海底堆積物 [1] の微細構造を詳しく調べた結果、直径数ミクロンの鉄マンガン酸化物微粒子（以下「微小マンガン粒」）が、堆積物1ccあたり1億～10億個存在することを発見した [2]。微小マンガン粒は、外洋域の酸素に富む堆積物にのみ見つかり、外洋地層全体での存在量を計算した結果、10^{28}～10^{29}個の微小マンガン粒が海底下に存在することが分かった。さらに、比重分画と鉱物の光学的性質から、こうした微粒子を堆積物から分離する技術を確立した。その上で主要・微量元素の組成を分析した結果、微小マンガン粒は海水中で形成されたことが示唆され、鉄やマンガン等の主要金属元素だけでなく、レアアースのような有用希少金属を多く含むことが分かった。特にマンガンについては、地層中に含まれるマンガンの30～60%、重さにして1.28～7.62 兆トンのマンガンに相当することが明らかとなった。これは、海底表層のマンガン団塊やコバルトリッチクラストに含まれるマンガン総量の100～1000倍に相当し、膨大なマンガンが微粒子状の形で海底下に埋もれていることを示している。以上から、これまで存在すら知られていなかった金属酸化物の微粒子が、海洋での金属元素循環や物質保持メカニズムを理解する上で重要な役割を果たすことが明らかなった。また、本研究で確立した環境試料から特定の微細粒子を精密かつ高速に分離・回収する技術は、今後、微粒子解析の基礎技術として、様々な応用展開が期待される。

[1] D’Hondt, S., Inagaki, F., Zarikian, C. A., Abrams, L. J., Dubois, N., Engelhardt, T., Evans, H., Ferdelman, T., Gribsholt, B., Harris, R. N., Hoppie, B. W., Hyun, J.-H., Kallmeyer, J., Kim. J., Lynch, J. E., McKinley, C. C., Mitsunobu, S., Morono, Y., Murray, R. W., Pockalny, R., Sauvage, J., Shimono, T., Shiraishi, F., Smith, D. C., Smith-Duque, C., Spivack, A. J., Steinsbu, B. O., Suzuki, Y., Szpak, M., Toffin, L., Uramoto, G., Yamaguchi, T. Y., Zhang, G., Zhang, X.-H., and Ziebis, W. Presence of oxygen and aerobic communities from seafloor to basement in deep-sea sediment. *Nature Geosciences,* 8(4), 299-304, 2015.

[2] Uramoto, G.-I., Morono, Y., Tomioka, N., Wakaki, S., Wagai, R., Uesugi, K., Takeuchi, A., Hoshino, M., Suzuki, Y., Shiraishi, F., Mitsunobu, S., Suga, H., Nakada, R., Takeichi, Y., Takahashi, Y., and Inagaki, F.,

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Significant contribution of subseafloor microparticles to the global manganese budget. *Nature Communications*. **10**, 400, https://doi.org/10.1038/s41467-019-08347-2, 2019

キーワード：微小マンガン粒、酸化的堆積物、IODP第329次航海
Keywords: Mn-microparticle, oxic pelagic clay, IODP Exp. 329

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Regional stratigraphic framework, Gas Hydrate occurrence and distribution of National Gas Hydrate Program Expedition 02 (NGHP-02) Area-B, offshore eastern India

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Gas hydrates, one of the important resources for the future energy, are abundant in nature existing in a wide variety of forms in land and marine environments. Krishna-Godavari Basin was formed along the rifted eastern continental margin of India in the Late Jurassic to Early Cretaceous, receiving amount sediments with numerous tilted fault blocks and growth faults. The offshore Krishna–Godavari Basin is considered a potential gas hydrate province as well as the presence of bottom-simulating-reflectors. The Indian National Gas Hydrate Program Expedition 02 (NGHP-02) was designed to study the occurrence of gas hydrate along the margin. Area-B of NGHP-02 contains important world-class gas hydrate accumulations and represent ideal sites for the consideration of future gas hydrate production testing. The primary goal was to explore for highly saturated gas hydrate occurrences and distribution in seismic reflectors that would become targets for future production tests.

Twelve holes were logged and measured with logging-while-drilling (LWD) and five holes were cored in Area-B of NGHP-02. This study summarized the log- and litho-units in Area-B and establish the Integrated-Units A, B and C based on the data from twelve LWD and five coring sites in Area-B. Most of the downhole log and core inferred gas hydrate occurrences are in the Late Miocene Integrated-Unit B with several sets of reservoir sections exhibiting favorable conditions for hosting gas hydrate. Based on the core-log-seismic integration, the LWD and coring results in Area-B helped to understand the geological significance of sequence stratigraphy in Krishna-Godavari Basin and identified the occurrence of gas hydrate. The thickness variations associated with the Reflectors R1 and R2 are possibly associated with the development anticlinal structure and are likely related to syn-sedimentary growth of the folding structures. Major gas hydrate zones exist in and around the Reflectors R1 and R2 near the BSR depth, and mostly have coincident with the fractures and mass-transport deposits. The Hydrate-bearing intervals can be identified by resistivity and sonic velocity logs and classified into pore-filling type, fracture-filling type, and a mixture of pore- and fracture-filling types based on borehole image characteristics. In addition, the spatial distribution of gas hydrate in the Reflectors R1 and R2 reservoirs is highly influenced by the anticlinal structure.

キーワード：NGHP-02、Krishna-Godavari Basin、Logging-while-drilling、Gas hydrate occurrence、Core-log facies analysis、D/V Chikyu
Keywords: NGHP-02, Krishna-Godavari Basin, Logging-while-drilling, Gas hydrate occurrence, Core-log facies analysis, D/V Chikyu

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Fluid flow and diagenetic process in frontal thrust zone off Cape Muroto in the Nankai Trough

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During the International Ocean Discovery Program (IODP) Expedition 370 “Temperature Limit of the Deep Biosphere off Muroto” (T-Limit) in 2016, the drilling was conducted at the protothrust zone in the Nankai Trough off Cape Muroto by using the D/V *Chikyu*, which penetrated the plate boundary fault (dé collement) between 758.2 and 796.4 meters below seafloor (mbsf) and recovered the accretionary deposits down to the basement. Expedition 370 aimed to explore the limits of subseafloor life and the biosphere where temperature exceeds the known temperature maximum of microbial life (~120ºC) at the sediment/basement interface at ~1.2 km below seafloor. Within the protothrust zone, it is thought that deep sourced water and energy, which are necessary for maintaining microbial activities, are supplied by fluid flow through faults. In order to clarify the origin and migration paths of the fluid, we analyzed the stable hydrogen and oxygen isotopic composition of water (δ D and δ^{18}O), the isotopic compositions of $^{87}Sr/^{86}Sr$ and $^{7}Li/^{6}Li$ ratios of the porewaters, and compared those isotopic compositions to the chemical compositions of porewater analyzed on-board. The previous study of the in-situ strength of sediments using drilling parameters shows that there are mechanically strong (potential impermeable layers) and weak (potential fluid pathway) zones at 602–648 mbsf and 800–1050 mbsf, respectively. The especially weak zone is observed between 836 and 870 mbsf. The concentration of chloride ion (Cl^-) suddenly decreases from 530 mM at ~600 mbsf to 480 mM at ~660 mbsf, below which it slightly decreases with depth and shows the minimum value of 450 mM at around ~950 mbsf. The concentration again increases from ~460 mM at ~1000 mbsf to ~550 mM, which is similar to the seawater value, at 1126 mbsf (just above the basement rock). The decrease of Cl^-concentration suggests that the dilution of the original porewater by the addition of fresh water. The depth profiles of δ D and δ^{18}O show the trends corresponding to that of Cl^-. The δ D value scatters in the range from −12 to −8‰ between 600 and 940 mbsf, and shows the minimum value of −12‰ around ~940 mbsf, below which it increases to −4‰ at 1126 mbsf. The δ^{18}O value increases from −4‰ at ~600 mbsf to −1.5‰ at ~800 mbsf with depth. Then the value increases to −0.6‰ at ~960 mbsf. Below the depth, it decreases to −1.2‰ at 1126 mbsf. The decrease of δ D and increase of δ^{18}O accompanied with the depletion of Cl^-between ~600 and ~1000 mbsf suggest the addition of freshwater derived from in-situ clay mineral dehydration and the lateral fluid flow. The sharp decrease of the Cl^-concentration between ~600 and ~650 mbsf suggests that the sediments at this interval is a boundary of low permeability, corresponding to the mechanically strong zone estimated by the drilling parameters. Around décollement (758.2–796.4 mbsf), no remarkable changes were observed in chemical compositions in porewater. Instead, the vicinity of ~900 to ~1000 mbsf, where the lowest Cl^-concentration was observed, is probably associated with the main fluid pathway at present. On the other hand, the depth profiles of the isotopic compositions of Sr and Li as well as their concentrations were not corresponding to that of the Cl^-concentration. The maximum concentrations of Sr and Li, ~620 μM and ~790 μM, respectively, were observed at ~1080 mbsf, together with the high $^{87}Sr/^{86}Sr$ and the lowest $^{7}Li/^{6}Li$ ratio. The high concentration of Li and low δ^{7}Li around ~1080 mbsf indicate that the fluid was experienced by relatively high temperature conditions; i.e., presumably the deep sourced fluid. The discrepancy between the depth profile of $Cl^-$and those of Li and

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Sr suggests that there is (or was) another fluid pathway at the vicinity around ~1080 mbsf.

キーワード：付加体先端部、流体移動、間隙水化学
Keywords: ptotothrust zone, fluid flow, porewater chemistry

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Recent progress and perspective on paleomagnetism by means of deep-sea drilling

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We review recent progress of paleomagnetism using deep-sea drilling cores since the beginning of IODP in 2003, in particular for estimations of paleomagnetic-field intensity (paleointensity) from sediments, and discuss problems to be resolved and perspectives.

For the establishment of the high-resolution relative paleointensity stack for the last 1.5 m.y., sediment cores of Exp. 303/306 from the North Atlantic were utilized. While only few records were available before about 3 m.y. previously, some Eocene to Miocene relative paleointensity records were obtained from the cores in the east equatorial Pacific taken during Exp. 320/321. Applicability of relative paleointensity to inter-core correlations and age estimations has extended to older ages accordingly. On the other hand, contamination of sediment lithological variations induced by paleoclimate changes, in particular fluctuations of the proportion of biogenic and terrigenous magnetites, to paleointensity estimations has become widely recognized. It is urgently necessary to resolve this problem and recover reliable long-term paleointensity records for tackling fundamental issues in geomagnetism such as possible dependence of field intensity to the length of polarity intervals and a possible relation between Earth’s orbital parameters and the geomagnetic field. Better understanding of the role of biogenic magnetite in remanent magnetization acquisition processes is important to solve the contamination problem. Information on the variations of time-averaged field in 10^5 to 10^6 year time-scales is also important for geomagnetism. Departure from the geocentric axial dipole (GAD) field of these time-scales may reflect boundary conditions of the geodynamo at the core-mantle boundary. The departure from GAD emerges as inclination anomalies in sediment cores. IODP cores may be useful for such studies although little studied before.

Acquisition of long deep-sea sediment cores is still required for obtaining continuous paleomagnetic records of Miocene and older ages, and IODP will continue to be the only means for this. Paleointensity estimations from sediments of older ages are hindered by dissolution of magnetite by reductive diagenesis; as sediments are buried deeper, reductive diagenesis becomes more serious. Successful expeditions resulted from the strategic selections of drilling sites; for example, the sediments of target ages are not covered with thick younger sediments (Exp. 320/321), and sediments in relatively oxic environments exist even buried under thick sediments (drift sediments of Exp. 363). Recently, the importance of silicate-hosted magnetic minerals as a carrier of remanent magnetization of sediments becomes recognized; they could escape from dissolution even in anoxic conditions. We need to revisit anoxic sediment cores to investigate the possibility for recovering paleomagnetic records from such sediments. Previously paleomagnetists just discarded them without detailed studies.

キーワード：古地磁気学、古地磁気強度、国際深海科学掘削計画

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Keywords: paleomagnetism, paleointensity, IODP

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[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27日(月) 10:45 ~ 12:15 | A07 東京ベイ幕張ホール

[M-IS02] 地球掘削科学

コンビーナ:山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、針金 由美子(産業技術総合研究所)、黒柳 あずみ(東北大学学術資源研究公開センター東北大学総合学術博物館)、山口 耕生(東邦大学, NASA Astrobiology Institute.)、座長:山口 耕生(東邦大学)、山田 泰広(JAMSTEC)

これまでに実施された科学掘削データ・試料の解析・分析結果などの研究成果の報告と、今後の科学掘削計画に関する最新情報の紹介を目的とする。固体地球科学、古環境学、地球生命科学などの様々な分野からの成果を共有し、科学掘削を基軸とした学際的研究を推進する。最近１年間に実施されたICDPプロジェクトとIODP航海の概要報告を中心に、これまでに実施された掘削航海に関連して得られた最新研究成果と、今後数年間に具体化される科学掘削計画、掘削科学に関連する新規手法や技術開発研究等の報告を歓迎する。

10:45 ~ 11:00

[MIS02-07] Patterns in natural fractures during transitions between stress regimes

*Nikita Dubinya[1] (1.The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences)

11:00 ~ 11:15

[MIS02-08] ICDP DSeis 1: Introduction into JpGU 2019 papers on Drilling into Seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

*小笠原 宏[1]、Liebenberg Bennie[2]、Ziegler Martin[3]、矢部 康男[4]、Durrheim Ray[5]、Manzi Musa[5]、Onstott Tullis C[6]、Thomas Weirsberg[7] (1.立命館大学理工学部、2.Moab Khotsong mine, South Africa、3.ETH, Zurich Dep. Earth Sciences、4.Graduate School of Science, Tohoku Univ.、5.Univ. Witwatersrand, School of Geoscience, South Africa、6.Princeton Univ., Dept. Geoscience, USA、7.GFZ, Potzdam, Germany)

11:15 ~ 11:30

[MIS02-09] ICDP DSeis 2: Preliminary results of physical property measurement and XRD analysis of the M5.5 fault material recovered from DSeis Project

*廣野 哲朗[1]、横山 友暉[1]、金木 俊也[2]、小笠原 宏[3]、矢部 康男[4]、松崎 琢也[5]、山本 裕二[5]、徳山 英一[5]、Tullis C. Onstott[6]、Martin Ziegler[7]、Durrheim Ray[8]、Esterhuizen van Heerden[9]、Bennie Liebenberg[9]、The ICDP DSeis team (1.大阪大学 大学院 理学研究科 宇宙地球科学専攻、2.京都大学 防災研究所、3.立命館大学、4.東北大学、5.高知大学 海洋コア総合研究センター、6.Princeton University、7.ETH Zurich、8.Witwatersrand University、9.Moab Khotsong mine)

11:30 ~ 11:45

[MIS02-10] ICDP DSeis 3: Spatial variation in stress state in the source region of Orkeny earthqauke (M5.5) based on analyses of the ICDP-DSeis borehole cores

*矢部 康男[1]、石田 亮壮[2]、杉村 幸祐[2]、兼松 慎[2]、東 充也[2]、吉田 峻輔[2]、Liebenberg Bennie[7]、伊藤 高敏[3]、船戸 明雄[5]、Watson Bryan[6]、Durrheim Raymond[4]、小笠原 宏[2] (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、2.立命館大学理工学部、3.東北大学流体科学研究所、4.School of Geoscience, University of the Witwatersrand、5.深田地質研究所、6.School of Mining Engeneering, University of the Witwatersrand、7.Moab Khotsong mine)

11:45 ~ 12:00

[MIS02-11] コア変形法を適用した原位置地殻応力測定ー防災科研地震観測井コアへの適用例ー

*小村 健太朗[1]、林 為人[2]、伊藤 高敏[3]、船戸 明雄[4] (1.防災科学技術研究所、2.京都大学大学院工学研究科、3.東北大学流体科学研究所、4.深田地質研究所)

12:00 ~ 12:15

[MIS02-12] 阿蘇火山地帯にある深度700メートルの鉛直掘削孔内の温度分布

*林 為人[1]、澁谷 奨[1,2]、佐渡 耕一郎[2]、神谷 奈々[1]、杉本 達洋[1]、佐野　暉[1]、石塚 師也[1]、楊 小秋[4]、林 愛明[3] (1.京都大学大学院工学研究科、2.地圏総合コンサルタント、3.京都大学大学院理学研究科、4.中国科学院南海海洋研究所)

Patterns in natural fractures during transitions between stress regimes

*Nikita Dubinya[1]

1. The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences

The study is aimed at analysis of transitions between different stress regimes –Normal Fault, Strike-Slip and Reverse Fault following Anderson’s classification –in terms of natural shear fractures corresponding to each regime. The study is mostly focused on spatial orientations of shear fractures emerging at each stress regime.

It is clear that not all natural fractures existing in a rock mass have the same response to changes in surrounding stresses. Some fractures are considered to be critically stressed in the given stress state which means that a small increase in differential stress (difference between maximum and minimum principal stresses) leads to fracture growth. The fracture is considered as critically stressed if shear stress acting on its plane exceeds normal stress multiplied by internal fraction coefficient of the medium. Normal and shear stresses are calculated from principal stresses’ values and fracture spatial orientation with regard to stress tensor principal axes. That means that for any given stress tensor one is capable of obtaining all the possible spatial orientations of critically stressed fractures.

In the current paper this problem is solved for different stress states for obtaining the typical patterns of fractures’ spatial orientations when stresses are varied considerably enough to change the stress regime. Figure 1 represents a transition between Normal Fault and Strike-Slip regimes: a series of contours on Wolff nets serve as borderlines for poles to critically stressed fractures’ planes. Each color represents its own triad of principal stresses (tables provide necessary match between color and stresses’ values); maximum horizontal stress σ_H is assumed to act in North-South direction. Minimum horizontal stress σ_h and vertical stress σ_V are fixed at the values of 10 and 50 MPa respectively, while transition is caused by increase in σ_H magnitude from 10 to 160 MPa. During the first stage of transition (fig. 1(A), σ_H is between 10 and 30 MPa) poles to fractures tend to gather in Eastern and Western parts of the stereonet. On the second stage (fig. 1(B), σ_H is between 40 and 90 MPa) fractures’ orientation remains stable with slight increase observed in east-northeast, west-northwest, west-southwest, and east-southeast directions. This tendency continues at final stage of transition (fig. 1(C), σ_H is between 100 and 120 MPa) where four main areas typical for Strike-Slip fracture orientation emerge. The same analysis may be completed for other analogous transitions with two fixed principal stresses and one being varied.

Transition between stress regimes may also be observed if principal axes of stress tensor rotate with principal stresses’ magnitudes remaining constant. This scenario may take place near Earth's surface or near large faults due to changes in principal stresses' trajectories. Figure 2 represents transition from Normal Fault to Strike-Slip with principal stresses being fixed at 50, 20, and 10 MPa, while angle ϕ –angle between maximum principal stress direction and vertical –is varied between 0 and 90 degrees. Blue lines still serve as borderlines for the orientations of critically stressed fractures in each case; circles represent the directions of principal stresses (red for maximum, yellow for intermediate, and green for minimum principal stress). It should be noted that lower hemisphere Lambert equal area stereonet is used in this case.

Analogous constructions may be completed for any given stress tensor broadening the understanding of natural fractures’ patterns and their relation to stress geomechanics providing a possibility to solve the

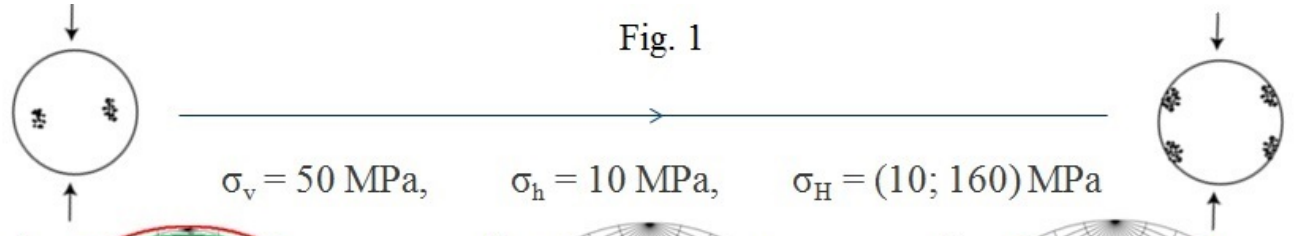
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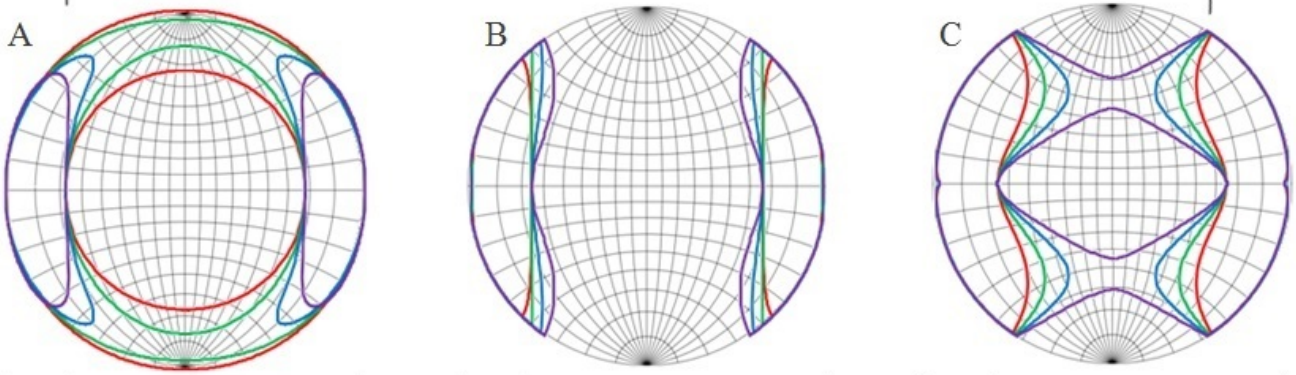
inverse problem of in-situ stresses estimation and their changes near geological structures utilizing the previously developed methods. As a result, some problems of drilling in vicinity of faults - one of primary objects for scientific drilling - may be solved, reducing the drilling risks and costs.

Keywords: Critically stressed fractures, Stress regimes, Stereonet, Drilling near faults

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Fig. 1



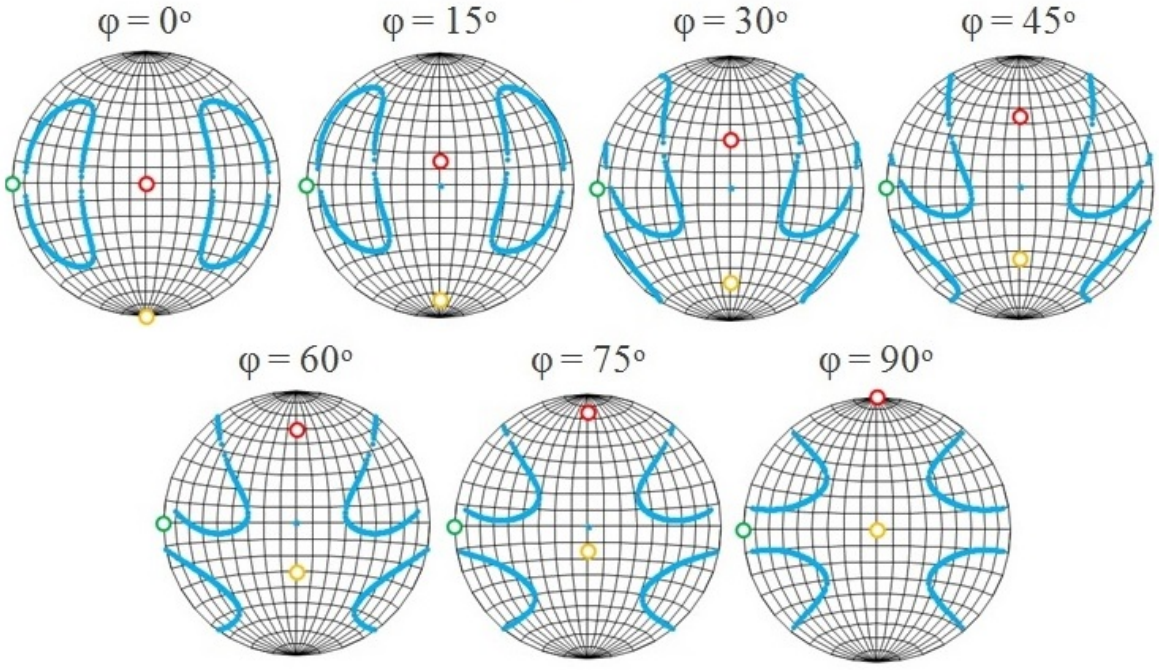


A	σ_H [MPa]
	10
	15
	20
	30

B	σ_H [MPa]
	40
	50
	70
	90

C	σ_H [MPa]
	100
	120
	140
	160

Fig. 2



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ICDP DSeis 1: Introduction into JpGU 2019 papers on Drilling into Seismogenic zones of M2.0-5.5 earthquakes in South African gold mines

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The 2014-2019 ICDP Science plan states: “reaching the depths of the seismogenic zone where earthquakes nucleate has always been a challenge for fault-zone drilling projects” (Mori and Ellsworth, 2013). However, during 2016-2018, we could recover cores with a total length of about 1.6 km from seismogenic zones ahead of mining faces, M3.5 and M5.5 earthquakes by drilling collared from depths of 1.0 to 3.3 km below surface in deep South African gold mines. The drilling targets had been already elucidated by tens of near-field seismic sensors. Talc, biotite, and amorphous were found at the M5.5 fault intersection (Kaneki et al. SSJ 2018).

The reliable measurement of the magnitude and orientation of stress at depth is a significant challenge (Brodsky et al., 2009). However, we overcame the difficulty. We intersected hypersaline water where geomicrobiologists started water and gas monitoring.

This paper reviews the scientific drilling and associated activities and briefly introduces the other reports (ICDP DSeis 2-10) presented in JpGU 2019 as shown below:

Hirono et al. (ICDP DSeis 2) ICDP DSeis 2: Preliminary results of physical property measurement

and XRD analysis of the M5.5 fault material recovered from DSeis Project,

Yabe et al. (ICDP DSeis 3) on the spatial variation of stress in the seismogenic zones,

Yoshida et al. (poster; ICDP DSeis 4): drilling, core logging, and in-hole geophysical logging of ICDP DSeis drilling into the M5.5 aftershock zones in a South African gold mines.

Sugimura et al. (poster) ICDP DSeis 5: Diametrical Core Deformation Analysis of the M5.5 aftershock zone core - stress concentration at reflective intrusives and transition in stress regimes.

Kanematsu et al (poster) ICDP DSeis 6: Deformation Rate Analysis of the M5.5 aftershock zone core - stress concentration at reflective intrusives.

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Higashi et al. (poster) ICDP DSeis 7: compilation of stress information and comparison with calculated stresses in the M5.5 aftershock zones,

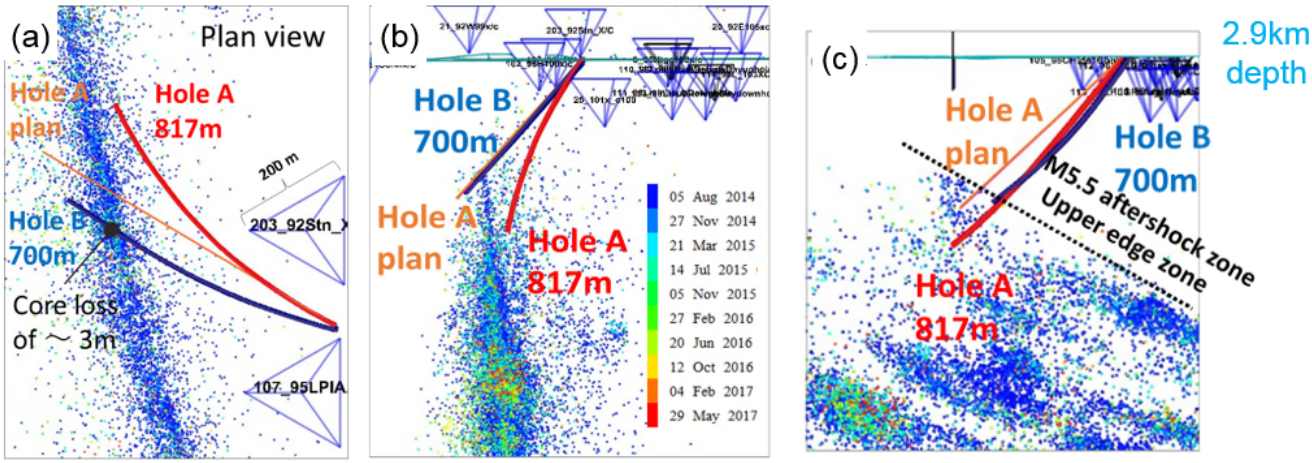
Noda et al. (poster) ICDP DSeis 8: the M5.5 fault structure and reflective intrusives in legacy 3D seismic reflection data

Tadokoro et al. (poster) ICDP DSeis 9: streaks in the M5.5 aftershocks potentially located on highly stressed intrusive

Mori et al. ICDP DSeis 10: Near-field Observations for the M5.5 Orkney, South Africa Earthquake

Acknowledgement: The DSeis team includes co-authors of the papers ICDP DSeis 2-9 and members shown at https://www.icdp-online.org/projects/world/africa/orkney-s-africa/details/. We thank Harmony Gold, Anglogold Ashanthi, Lesedi, Digital Surveying, OHMS, Seismogen, 3D Geoscience. ICDP, JSPS, SA NRF, MEXT Japan, US NSF, German DRF, and Ritsumeikan Univ. financially support the project.

キーワード：ICDP DSeis、地震発生場掘削、南アフリカ金鉱山
Keywords: ICDP DSeis, Seismogenic zone drilling, South African gold mines



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ICDP DSeis 2: Preliminary results of physical property measurement and XRD analysis of the M5.5 fault material recovered from DSeis Project

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Drilling into seismogenic zones of M2.0-M5.5 earthquakes in deep South Africa gold mines (DSeis Project) was undertaken in 2017–2018 near Orkney, South Africa, to understand principal mechanism of earthquakes nucleate and propagate. Drilling at two main holes, Hole A (817 m) and Hole B (700 m), was completed at the Moab Khotsong mine, and the latter hole penetrated the fault zone that slipped at the 2014 M5.5 earthquake. Fault-related material and its surrounding host rocks were successfully recovered from the hole, and the samples were analyzed in the Center for Advanced Marine Core Research, Kochi University, Japan. The main damaged zone is characterized by highly fragmented fault breccia with high amount of talc and amorphous material, which is likely to related to recent earthquake event. Nondestructive continuous measurements of physical properties (X-ray CT image, density, magnetic susceptibility, and natural gamma ray) are in progress. We will show the preliminary results about the characteristics of the M5.5 fault zone and its implication for generation of the M5.5 earthquake.

キーワード：断層深部掘削、国際陸上掘削計画
Keywords: Deep fault drilling, ICDP

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ICDP DSeis 3: Spatial variation in stress state in the source region of Orkeny earthqauke (M5.5) based on analyses of the ICDP-DSeis borehole cores

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The Orkney earthquake (M5.5), South Africa, occurred on 5 August 2014 beneath a deep gold mine, of which the deepest mining horizon is ~3 km depth from ground surface. Hypocenter of the Orkney earthquake and the shallowest aftershocks were located at ~5 km and ~3.5 km depths from ground surface. Therefore, the ICDP-DSeis project was devised to investigate the geological, geomechanical and geochemical environments in and around the source region of the Orkney earthquake. Two 800 m-long boreholes (Holes A and B) were drilled from a drilling site established on a tunnel at a depth of 2.8 km in the mine. While Hole A reached the seismogenic depth, it did not intersect the aftershock cluster. Hole B success fully penetrated to the aftershock cluster. Borehole cores were almost fully recovered from these holes, though they were not oriented during drilling. Therefore, the core orientation was determined by comparing in-hole optical images and unrolled core images in this study. Then, Diametrical Core Deformation Analysis (DCDA, Funato and Ito, 2017) and Deformation Rate Analysis (DRA, Yamamoto et al., 1990) were applied to borehole cores to evaluate a spatial variation in stress state in and around the aftershock cluster. Finally, a numerical elastic model in which the depth variations along Hole A and B were reproduced was developed to understand a spatial distribution of stress state in and around the aftershock cluster that extended along upper extension of the source fault of the Orkney earthquake.

Acknowledgement. This study was supported by ICDP, JSPS-NRF bilateral research project, JSPS Core-to-Core program, Ritsumeikan University and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Earthquake and Volcano Hazards Observation and Research Program. The authors thank Harmony Gold Ltd. for kindly providing an opportunity of drilling from Moab Khotsong mine.

キーワード：ICDP-DSeis、応力測定、変形率変化法、コア変形法、南アフリカ大深度金鉱山
Keywords: ICDP-DSeis, Stress measurement, DRA, DCDA, Deep mines in South Africa

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コア変形法を適用した原位置地殻応力測定ー防災科研地震観測井コアへの適用例ー

Applications of DCDA method for in-situ crustal stress measurement - Rock core samples from NIED seismic observation wells -

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地殻の原位置の絶対応力を知ることは、地震発生の過程やテクトニック活動を理解する上で、重要な情報である。しかし、信頼性の高い地殻応力データは、地震観測や地殻変動観測データに比べていまだ乏しい状況にある。本研究は、岩石コアの形状から原位置地殻応力値を推定する方法である「コア変形法(DCDA, Diametrical Core Deformation Analysis法)」を既存のボーリング岩石コアに適用して、原位置地殻応力を推定することを試みた。コア変形法は、掘削孔内で特殊な計測をする必要がなく、岩石コアを採取し、岩石の弾性定数とともにコア周にそった形状を計測する方法なので、過去に採取された岩石コアに適用できることが期待される。そして、岩石コアの採取された地点を含む、広域にわたり、原位置地殻応力データが得られる可能性がある。

今回、防災科研の7地点のHi-net観測井で深度が100m～200m（1地点だけ2000m）から採取した硬岩の岩石コアを利用した。それらは採取後、10年以上経過したものである。Funato and Ito (2017, IJRMMS)で設計された装置でコア外周にそった直径を測定した。測定された岩石コアは、外周にそった直径の変化がサインカーブを示し、岩石コア断面が応力開放にともない楕円状に弾性変形していることが推測される。一方で、堆積岩コアでは、明確に層理面に関係した楕円状の断面形状が計測された。これら結果は、岩石コアの堆積構造に注意すれば、既存孔井地点で、コア変形法により原位置地殻応力が推定できる見込みがあることを示している。

キーワード：コア変形法、原位置地殻応力、岩石コア、地震観測井
Keywords: DCDA method, in-sitsu crustal stress, rock core, seismic observation well

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阿蘇火山地帯にある深度700メートルの鉛直掘削孔内の温度分布
Temperature depth profile in a 700 m deep vertical borehole in Aso volcanic zone

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火山や地震などに係わる様々な地球科学的な現象の解明ならびに関連する地球工学的な応用の分野においては、地下の温度構造ならびに地殻熱流量を知ることが不可欠である。本研究では、阿蘇火山の西麓域に位置する布田川断層帯の温度構造を明らかにする目的で、当該断層帯を貫く深度700 mの鉛直掘削孔を利用して、その孔内の温度分布を測定した。

2016年4月16日に横ずれ断層タイプの布田川断層を震源断層として、Mw 7.1の熊本地震の本震が発生した。その後、深度700 mの掘削調査孔(略称：FDB孔)は断層試料採取のために、2017年9月～2018年3月の間に熊本県益城町で掘削され、布田川断層を貫通した。

本研究では、2018年5月からFDB孔の温度分布を2～3か月に１回の頻度で繰り返し測定を行った。低温の掘削泥水の影響による局所的な地層の温度擾乱が認められ、その回復に伴う局所的な温度の経時変化があったものの、深度約50～650 mにおいて、再現性の高い温度プロファイルを得ることができた。地表の影響がないと考えられる深度約200～310 mおよび深度430～650 mの区間では、深くなるにつれほぼ直線的に地温が高くなる温度構造が認められた。その地温勾配は55 ℃/km程度であり、平均的な地温勾配の20～30 ℃/kmより高いが、阿蘇火山地帯の特徴であると考えられる。しかし、FDB孔の深度約310～430 mの120 m間においては、ほぼ一定の温度（地温勾配が約1 ℃/km）となり、この深度区間以外の平均的な地温勾配よりはるかに小さい結果となった。この120 m区間での極めて低い地温勾配1 ℃/kmは、当該掘削孔から採取されたコア試料で実測された熱伝導率の変化から説明できず（佐野ほか、2019JpGU）、非常に特異的なものであると考えられる。今後、この温度構造が本当の天然現象なのか否か、観測等を積み重ね、慎重に確かめる予定である。また、これが本当の天然現象であれば、地下水流動が関係すると推測され、これの形成メカニズムを解明したい。

キーワード：掘削孔、温度、地温勾配
Keywords: Drilling , Temperature, Geothermal gradient

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[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27日(月) 13:45 ~ 15:15 | A07 東京ベイ幕張ホール

[M-IS02] 地球掘削科学

コンビーナ:山田 泰広(海洋研究開発機構　海洋掘削科学研究開発センター)、針金 由美子(産業技術総合研究所)、黒柳 あずみ(東北大学学術資源研究公開センター東北大学総合学術博物館)、山口 耕生(東邦大学, NASA Astrobiology Institute.)、座長:針金 由美子(産総研)、阿部 なつ江(海洋研究開発機構 海洋掘削科学研究開発センター)

これまでに実施された科学掘削データ・試料の解析・分析結果などの研究成果の報告と、今後の科学掘削計画に関する最新情報の紹介を目的とする。固体地球科学、古環境学、地球生命科学などの様々な分野からの成果を共有し、科学掘削を基軸とした学際的研究を推進する。最近１年間に実施されたICDPプロジェクトとIODP航海の概要報告を中心に、これまでに実施された掘削航海に関連して得られた最新研究成果と、今後数年間に具体化される科学掘削計画、掘削科学に関連する新規手法や技術開発研究等の報告を歓迎する。

13:45 ~ 14:00

[MIS02-13] Estimation of Shear Stress and Lithology Prediction Using Machine Learning and Surface Drilling Data

井上 朝哉[1]、*田中 隆太[1]、石渡 隼也[1] (1.国立研究開発法人海洋研究開発機構)

14:00 ~ 14:15

[MIS02-14] Overview of drilling of crust-mantle boundary of Oman ophiolite: the ICDP Oman Drilling Project

*高澤 栄一[1,4]、Damon Teagle[2]、道林 克禎[3]、田村 芳彦[4]、Jude Coggon[2]、Juerg Matter[2]、Peter Kelemen[5]、Oman Drilling Project Phase 2 Science Party (1.新潟大学理学部地質科学科、2.サウサンプトン大学、3.名古屋大学、4.海洋研究開発機構、5.コロンビア大学)

14:15 ~ 14:30

[MIS02-15] Geophysical Logging of Crust-Mantle boundary at Oman Ophiolite

*山田 泰広[1]、Kyaw Moe[1]、Philippe Pezard[2]、Juerg Matter[3]、OmanDP Science Party (1.海洋研究開発機構、2.モンペリエ大学、3.サウザンプトン大学)

14:30 ~ 14:45

[MIS02-16] Overview of the physical property measurements, ChikyuOman 2017 and 2018: Crust and Mantle sections from ICDP Oman Drilling Project Phase I and II

*阿部 なつ江[1]、岡崎 啓史[1,11]、片山 郁夫[2]、畠山 航平[2]、赤松 祐哉[2]、Ildefonse Benoit[3]、Ulven Ole[4]、Hong Gilbert[5]、Zhu Wenlu[6]、Cordonnier Benoit[4]、道林 克禎[7]、高澤 栄一[8]、Harris Michell[12]、Teagle Damon[10]、ケレメン ピーター[9]、Godard Marguerite[3]、Matter Jurg[10]、Coggon Jude[10]、Science Party The Oman Drilling Project (1.国立研究開発法人海洋研究開発機構、2.広島大学、3.モンペリエ大学、4.オスロ大学、5.ソウル大学、6.メリーランド大学、7.名古屋大学、8.新潟大学、9.コロンビア大学、10.サウザンプトン大学、11.金沢大学、12.プリマス大学)

14:45 ~ 15:00

[MIS02-17] Exploring the deep subseafloor biosphere and biogeochemical carbon cycling beneath the Arctic ocean

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15:00 ~ 15:15

Discussion

Estimation of Shear Stress and Lithology Prediction Using Machine Learning and Surface Drilling Data

井上 朝哉[1]、*田中 隆太[1]、石渡 隼也[1]
Tomoya Inoue[1], *Ryuta Tanaka[1], Junya Ishiwata[1]

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Introduction

JAMSTEC operates the scientific deep-sea drilling vessel Chikyu. Chikyu conducted the Japan Trench Fast Drilling Program (JFAST) for study on the Tohoku earthquake. Chikyu has also started to conduct the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE).
The main purpose of the scientific drillings is to obtain core samples from sediment layers under the seabed. However, we are facing the situation that we cannot have enough core samples because the operation philosophy defines that core samples are generally assigned for a lot of separate examinations including geological, chemical, and biological examinations. It is also the reason that the coring operations are conducted at spots. This means that analyzed data, for example the shear stress, can be obtained just at spot(s).
As one of the primary goals of scientific drilling is to evaluate sediment properties, it is highly beneficial to obtain the properties of drilling layers and to characterize the lithology over the full drilling depth during drilling operations. Even an approximation of these properties could potentially provide valuable information for conducting coring operations.

Methods/Procedure

A previous study attempted to discuss the properties of sediment layers using surface drilling data, and estimated the shear stress of the sediment. In this study, we first summarize the method applied in the previous paper for estimating the torque at the drill bit, which leads to estimation of shear stress of sediment layer from the surface measured drilling data for NanTroSEIZE deep riser drilling operation.
The surface drilling data was obtatined using the surface drilling data acquisition system that we developed. The surface drilling data includes the torque of the power swivel (HPS torque) that is equipmenti to provide a torque and rotation to the drillstring. This HPS torque includes not only the drilling torque but also other torques such as friction toque between riser and drill pipe, and mechanical torque inside HPS. This paper proposes to estimate the drilling torque at the drill bit from the surface drilling data by removing other torques based the torque during a “bottom’s” up operations.
We also used machine-learning approaches to predict the lithology, where learning data was created from surface drilling data and lithology information from core samples obtained during past scientific drilling operations. Machine learning was then applied using neural network algorithms by tuning L1 regularization coefficient and the number of layers to create a predictive model. This paper discusses the preliminary attempt to predict the lithology using machine-learning approaches for NanTroSEIZE and JFAST data.

Result/Conclusions

We presented a method for estimating the drilling torque, which was compared to downhole-measured data with logging while drilling (LWD). The result of the calculation shows that the drilling torque at the bit differed from the surface measured torque, where this difference increased with increasing drilling depth. In addition, the estimated drilling torque was validated using downhole-measured torque data obtained

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from LWD operations. Although the deviation of the mean values between the drilling torque and the downhole measured torque was large, our method is considered valid from the viewpoint of correcting the characteristics of the depth for the surface measured torque.
This study also presented the lithilogy predicution from machine learning approaches. Preliminary results were presented using NanTroSEIZE and JFAST data including surface drilling data and core sample data. The prediction performance obtained from the generated neural networks indicated that the lithology properties could be predicted by machine learning approaches as an interpolation problem; however, the prediction is sensitive to the structure and parameters of the neural network, along with the selection of training data due to the small learning dataset. In addition, it can be difficult to clearly classify the lithology from core samples as the core sometimes contains several rock types, leading to uncertain classification. We will continue to study lithology prediction using machine-learning methods in future studies.

Acknowledgments
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キーワード：船上掘削データ、岩質予測、機械学習、せん断応力、海洋掘削
Keywords: surface drilling data, lithology prediction, machine Learning, shear stress, ocean drilling

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Overview of drilling of crust-mantle boundary of Oman ophiolite: the ICDP Oman Drilling Project

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From the winter of 2017 to 2018 the drilling of crust-mantle transition zone (MTZ) was conducted at Wadi Zeeb (CM1&2 sites) in Wadi Tayin massif by the International Continental Scientific Drilling ProgramOman Drilling Project [6]. The MTZ of Oman ophiolite has been characterized by thick dunites accompanied by thin veins or clots of plagioclase and clinopyroxene and several centimeters to meters thick gabbro sills and wehrlite intrusions. The origin of MTZ is still under debate [2-5]. To clarify this origin, more detailed research by continuous core through MTZ is necessary.

Geological mapping on ground associated with information from the recovered cores in CM1&2 sites the thickness of the MTZ is estimated as about 150 m. The upper and lower boundaries of the MTZ has a strike in the east-west direction, and it is inclined about 30 degrees south. In the summer of 2018, the drilled cores were carefully described by scientists on the deep-sea drilling vessel "CHIKYU". The stratigraphy has been divided into four igneous sequences based on the abundance of different lithologies: Layered Gabbro Sequence, Dunite Sequence, Dunite with Gabbro Sequence, and Mantle Sequence. Dunite Sequence and Dunite with Gabbro Sequence are summarized as Crust - Mantle Transition.

Hole CM1A is inclined 60˚ northward. The upper 160 m of the core is the Layered Gabbro Sequence, mostly composed of olivine gabbro, interlayered with gabbro and a small amount of wehrlite, dunite, anorthosite and troctolite. From 160 to 310 m the Crust-Mantle Transition is divided into an upper 90 m Dunite Sequence and a lower 60 m Dunite with Gabbro Sequence containing small lenses of gabbro, troctolite and wehrlite. The dunites are highly serpentinized, and rodingite and diopsidite commonly replace minor gabbroic rocks in these sequences. The lower 80 m of the hole is the Mantle Sequence, with alternating layers of dunite and increasingly abundant, residual mantle harzburgite.

Hole CM2B is a vertical hole located 400 m north of CM1A, and samples the Crust-Mantle Transition and the Mantle Sequence. As in CM1A, the transition is divided into an upper Dunite Sequence and a lower Dunite with Gabbro Sequence. In contrast to Hole CM1A, a small amount of olivine has escaped complete serpentinization in the lower portions of the CM2B transition zone. In the Mantle Sequence, harzburgite is dominant. Dunite accounts for about 25% of this Sequence, less than in CM1A. The lowermost peridoties in Hole CM2B are strongly altered to talc+carbonate.

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キーワード：オマーンオフィオライト、国際陸上科学掘削プログラム、オマーン掘削プロジェクト、地殻-マントル境界、モホ遷移帯
Keywords: Oman ophiolite, ICDP, Oman Drilling Project, crust-mantle transition, Moho Transition Zone

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Geophysical Logging of Crust-Mantle boundary at Oman Ophiolite

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The boundary between the crust and mantle is a horizon that human being can reach in the Earth interior. The nature of this surface has been proposed from viewpoints of petrology, geochemistry and geophysics, and the answer needs to wait until future scientific drilling.

The Samail ophiolite exposed in Oman is one of most well-known surface exposures of the exhumed lowest part of the oceanic crust and upper part of mantle.

The Oman Drilling Project (OmanDP) drilled 12 holes at 7 sites in this ophiolite from 2016 to 2018, and has conducted a comprehensive borehole geophysical survey as logging operation in most of these holes in 2017 and 2018. The data acquired include: electrical resistivity, spectral gamma ray, magnetic susceptibility, full waveform sonic, optical / acoustic / resistivity borehole wall imaging. The extensive logging operation also includes high-definition spectroscopy measurements that contribute to further geochemical investigations. The outline of these datasets and our preliminary analysis will be presented.

キーワード：oceanic crust、upper oceanic mantle、borehole geophysics、alteration
Keywords: oceanic crust, upper oceanic mantle, borehole geophysics, alteration

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Overview of the physical property measurements, ChikyuOman 2017 and 2018: Crust and Mantle sections from ICDP Oman Drilling Project Phase I and II

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We report physical property measurements of core samples from the Samail ophiolite in Oman, drilled by the ICDP Oman Drilling Project. Onboard core logging was conducted on D/V Chikyu for 4 months in total in the summers of 2017 and 2018. We analyzed 4 holes (GT1A, GT2A, GT3A and BT1B) in 2017, and 5 holes (CM1A, CM2B, BA1B, BA3A and BA4A) in 2018. The total core length of those 9 holes is about 3200 m. Cores from Holes GT1A and GT2A in the lower crust section of the ophiolite are mainly composed of gabbros (gabbro and olivine gabbro), with small amounts of ultramafic rocks (wehrlite and dunite), whereas those from Hole GT3A at the boundary between the sheeted dikes and gabbro are mainly composed of basalt and diabase, followed by gabbros (gabbro, olivine gabbro and oxide gabbro). Minor felsic trondhjemite and tonalite dikes intrude the mafic rocks. In contrast, Hole BT1B penetrated from mantle section through the basal thrust and into the metamorphic sole. The CM holes were drilled through the crust-mantle transition, from gabbroic lower crust, through dunite with minor gabbros, and in to residual mantle harzburgite. BA holes were taken from the mantle section and are composed of dunite and harzburgite intruded by minor gabbroic and pyroxenite dikes. Ultramafic rocks at both sites were extensively serpentinized, but the names of igneous protoliths are used here.

Whole-round data, including X-ray CT images, natural gamma radiation (NGR), gamma ray attenuation (GRA) density, magnetic susceptibility (MS), P-wave velocity (Vp) and noncontact electrical resistivity were obtained. Split core color spectroscopy data were also collected. Magnetic susceptibility, electrical resistivity under both nominally dry and brine-saturated conditions, P-wave velocity, bulk/grain density, porosity and thermal conductivity were measured in discrete samples. Nearly 100% core recovery allowed us to take a large data set of petrophysical data on the cores from Oman ophiolite including fault zones and highly altered intervals.
Generally, gabbroic rock types have higher density, P-wave velocity, and electrical resistivity, and lower porosity than ultramafic lithologies. Serpentinized dunite have lower density, P-wave velocity and electrical resistivity, and higher porosity than serpentinized harzburgite, and these physical properties are correlated with magnetic susceptibility, probably due to crystallization of magnetite during alteration. Average X-ray CT values are also correlated with many other physical properties in most lithologies.

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キーワード：陸上掘削、地球深部探査船「ちきゅう」、オマーン掘削、オフィオライト、海洋地殻
Keywords: ICDP, D/V Chikyu, Oman Drilling Project, ophiolite, oceanic crust

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Exploring the deep subseafloor biosphere and biogeochemical carbon cycling beneath the Arctic ocean

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Despite the Arctic cryosphere is the most sensitive and vulnerable to the global environmental change, the nature of deep subseafloor arctic environments remains largely unknown. Active processes on the drastic climate change, including the anthropogenic global warming and subsequent ice melt, are presumably similar to those mechanisms that formed some of the major hydrocarbon resources we presently use, deeply buried in the subseafloor sediment over millions of years at high atmospheric CO_2 and global warm conditions. Continuing to advance understanding of the natural analogues beneath the Arctic ocean through scientific drilling is a powerful approach for the discoveries and understanding of life and Earth co-operating systems, and consequently will illuminate the possible resilience and sustainable strategies adopted by human society towards the future. Here, we are keenly interested in the Arctic deep biosphere and biogeochemical carbon cycling, which presumably be tightly associated with tectonics and biotic/abiotic processes through paleoceanographic events of seawater stagnations, perturbations and fertilizations in the Paleogene to Cretaceous period, and perhaps still continuing in situ over geologic time. How is diagenetic activity and microbial diversity linked to variability in Cenozoic climate and environmental changes? To what degree is carbon diagenesis linked to biotic/abiotic and tectonic processes? What fluid flow and energy transformation processes support microbial activity in situ and govern carbon sink in the Arctic sedimentary basin? How does alternation of deep oceanic crust contribute to microbial life and biogeochemical carbon cycling in the shallower habitat? In addition, what is the nature of the Arctic basement? These important scientific issues on the most climate-sensitive place on Earth remain to be explored, but using the *Chikyu*' s riser-drilling and onboard facilities, it can be addressed by the state-of-the-art interdisciplinary analyses of core samples and the long-term borehole observatory.

キーワード：Arctic ocean、scientific ocean drilling、deep subseafloor biosphere、biogeochemical carbon cycle
Keywords: Arctic ocean, scientific ocean drilling, deep subseafloor biosphere, biogeochemical carbon cycle

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-TT 計測技術・研究手法

2019年5月27日(月) 9:00 ~ 10:30 | 104 1F

[M-TT46] 統合地球観測システムとしてのGPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Yusaku Ohta

GNSSは、大気圏、電離圏、固体地球の基盤となる統合観測システムとなっている。地上及び宇宙基地型GNSS観測は、2006年より数値気象予報の改善に貢献している。近年では反射波を用いて高度、地面粗度、土壌水分、積雪深、湿度や植生インデックスを導出する研究が発展している。船舶やブイなど海洋上のGNSS観測は、海面高度に加えて海洋上の水蒸気観測の能力を持つ。Multi-GNSSがもたらす観測データの増加は、統合地球観測システムとしてのGNSSの能力を拡大させる。
本セッションの目的は、GNSS研究の最新成果を共有し、あらたな学際研究を促進することにある。GNSSを用いた大気（対流圏、電離圏）、GNSS-R、またGNSS-音響観測による海底測位のようなの異なる観測の統合に関する投稿を歓迎する。

9:00 ~ 9:30

[MTT46-01] 準天頂衛星システムの現状と将来構想

★招待講演

*小暮 聡[1] (1.内閣府宇宙開発戦略推進事務局準天頂衛星システム戦略室)

9:30 ~ 9:45

[MTT46-02] Application of the GNSS-A for other academic fields and fundamental marine information network

*横田 裕輔[1]、石川 直史[2]、渡邉 俊一[2] (1.東京大学生産技術研究所、2.海上保安庁海洋情報部)

9:45 ~ 10:00

[MTT46-03] Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

*田中 優介[1]、太田 雄策[1]、宮崎 真一[2] (1.東北大学、2.京都大学)

10:00 ~ 10:15

[MTT46-04] Assimilation experiments of GNSS-derived ZTD and Sentinel-derived products into WRF to improve forecasts of severe rain events in Italy

*Eugenio Realini[1]、Martina Lagasio[2]、Luca Pulvirenti[2]、Antonio Parodi[2]、Andrea Gatti[1]、Giulio Tagliaferro[1]、Giovanna Venuti[3]、Stefano Barindelli[3]、Emanuele Passera[4]、Alessio Rucci[4]、Nazzareno Pierdicca[5]、Bjorn Rommen[6] (1.Geomatics Research & Development srl、2.CIMA Research Foundation、3.Dept. of Civil and Environmental Engineering, Politecnico di Milano、4.TRE Altamira srl、5.Dept. of Information Engineering, Electronics and Telecommunications, Sapienza Univ. of Rome、6.European Space Agency (ESA-ESTEC))

10:15 ~ 10:30

[MTT46-05] **An analysis of tropospheric delays using goGPS software on all GEONET stations during the passage of Typhoon Jebi in September 2018**

*Andrea Gatti[1]、Eugenio Realini[1]、Giulio Tagliaferro[1] (1.Geomatics Research & Development srl)

準天頂衛星システムの現状と将来構想
The latest status of Quasi-Zenith Satellite System (QZSS) and its future expansion

*小暮 聡[1]
*Satoshi Kogure[1]

1. 内閣府宇宙開発戦略推進事務局準天頂衛星システム戦略室
1. QZSS Straetegy Office, National Space Policy Secretariate, Cabinet Office

The Quasi-Zenith Satellite System (QZSS) is a regional space-based Position, Navigation and Timing (PNT) system developed and operated by Japanese government as their important national infrastructure. Three consecutive launches were successfully conducted in 2017. The official operational service has been launched since November 1, 2018. The expansion to 7 satellite constellation is now being investigated. The presentation shows the latest status of the QZSS program as well as its future expansion.

キーワード：準天頂衛星システム、衛星測位システム、全世界衛星航法システム
Keywords: QZSS, Space-cased Position Navigation and Timing system, GNSS

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Application of the GNSS-A for other academic fields and fundamental marine information network

*横田 裕輔[1]、石川 直史[2]、渡邉 俊一[2]
*Yusuke Yokota[1], Tadashi Ishikawa[2], Shun-ichi Watanabe[2]

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1. Institute of Industrial Science, The University of Tokyo, 2. Hydrographic and Oceanographic department, Japan Coast Guard

The GNSS-A observation technology had detected coseismic deformation fields just above the megathrust earthquake [Sato et al., 2011, Science; Kido et al., 2011, GRL], postseismic deformations [Watanabe et al., 2014, GRL; Tomita et al., 2017, Sci. Adv.] and interseismic coupling condition [Yokota et al., 2016, Nature]. In addition, we recently upgraded the GNSS-A methodology in aspects of observation frequency and accuracy and detected a longer-term sequence of slow slip events (SSEs). The detected undersea SSEs led a new discussion about a diverse behavior of SEQs and provide many questions, i.e., their stress loading for coupling region and difference of geological condition in the SSE, other SEQs and coupling regions, to be solved by the future seafloor, submarine and onshore geophysical monitoring.

In the development process of this new GNSS-A system, new oceanographic information in km scale region was found to be extractable from the GNSS-A data [Yokota et al., 2018, MGR]. This data has features consistent and inconsistent with the JCOPE2 model [Miyazawa et al., 2009, JO], so the GNSS-A system has a potential to provide new observation data of very narrow marine region.

These observations have extremely high scientific potential from the viewpoint of seismology, earthquake disaster prevention engineering and submarine geology about megathrust subduction zones and unknown potential about new multidisciplinary aspects called the nano-scale GNSS-A oceanography and the marine GNSS meteorology. In order to promote the distribution of data to the earthquake science community and different academic fields, it is necessary to establish a simple data format and manage using doi. In particular, for carrying out long-term and stable observation, we must construct strong management and evaluation system to perform appropriately data collection and observation operation. The realization of such a solid fundamental marine observation network will also have a positive effect on new research and development.

Moreover, it is necessary to enhance the GNSS-A observation system to upgrade the observation density, continuity and real-time property for understanding the subduction zone and disaster prevention. Eventually, we should construct next-generation fundamental network that aggregates the marine information system that utilize total data in real time based on numerical simulation and data assimilation.

キーワード：GNSS-A、海底測地観測網、海洋観測
Keywords: GNSS-A, seafloor geodetic observation network, marine observation

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Feasibility of the GNSS carrier phase to fault slip approach for the estimation of slip phenomena in subduction zone

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*Yusuke Tanaka[1], Yusaku Ohta[1], SHINICHI MIYAZAKI[2]

1. 東北大学、2. 京都大学
1. Tohoku University, 2. Kyoto University

Precise detection of coseismic deformation and estimation of its source model are especially important in the case of earthquake occur in subduction zones, because it is directly related to accurate tsunami forecasting. Recent years, many researchers have tried to estimate earthquake source model and/or tsunami wave field in real-time using Global Navigation Satellite System (GNSS). However, conventional GNSS-based monitoring requires huge computational cost for positioning analysis. Using coordinate time series for observation also causes difficulty to evaluate accuracy of separation between deformation and other unknown parameters such as tropospheric delay. Additionally, current positioning analysis strongly depends on precise orbit information which is provided externally.

According to such background, we investigate the feasibility of deformation monitoring based on the GNSS carrier phase to fault slip approach for subduction zone. This method, which we call PTS (Phase To Slip) detects fault slip directly from GNSS carrier phase variation without positioning analysis. As PTS method estimates all unknown parameters in parallel, computational costs for real-time seismic monitoring can be reduced. Moreover, PTS does not require high-quality satellite orbit because it relies only on changes in azimuthal site-to-satellite ranges (Tanaka, Ohta, and Miyazaki, GRL, 2019).

Here we applied the PTS method to the largest aftershock of the 2011 Tohoku-Oki earthquake. In the analysis, we used both precise orbit provided by International GNSS Service (IGS) and broadcast orbit submitted from satellite without any network connection. As a result, we obtained very similar coseismic slip distribution in the two cases. Inferred fault slip showed clear thrust slip and was equivalent to M_w 7.8. These results well agree with the estimation based on conventional GNSS analysis such as Nishimura et al. (EPS, 2011). Calculated surface displacements also agree with independent conventional GNSS analysis result. These results indicate that the PTS method can be useful as a supplementary system of current deformation monitoring, which does not require any external information. Furthermore, once we could obtain slip distribution, we can also convert it into deformation of sea bottom, which is equivalent to initial tsunami source. Thus, our results suggest potential feasibility of PTS method for tsunami forecasting.
In the presentation, we will describe application of the PTS method to whole process of Tohoku-Oki earthquake, including its foreshock, mainshock and following aftershocks. Beside detail of its result, we will also demonstrate quantitative evaluation of parameter separation accuracy inside PTS analysis.

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Assimilation experiments of GNSS-derived ZTD and Sentinel-derived products into WRF to improve forecasts of severe rain events in Italy

*Eugenio Realini[1], Martina Lagasio[2], Luca Pulvirenti[2], Antonio Parodi[2], Andrea Gatti[1], Giulio Tagliaferro[1], Giovanna Venuti[3], Stefano Barindelli[3], Emanuele Passera[4], Alessio Rucci[4], Nazzareno Pierdicca[5], Bjorn Rommen[6]

1. Geomatics Research & Development srl, 2. CIMA Research Foundation, 3. Dept. of Civil and Environmental Engineering, Politecnico di Milano, 4. TRE Altamira srl, 5. Dept. of Information Engineering, Electronics and Telecommunications, Sapienza Univ. of Rome, 6. European Space Agency (ESA-ESTEC)

The Italian peninsula is frequently struck by severe floods and flash floods causing losses of lives and significant damages every year. Improving the accuracy of rain forecasts is a fundamental goal to limit social and economic damages. Forecasts based on numerical weather prediction (NWP) models are challenged by the uncertainty related to the initial state of the atmosphere at small spatial-temporal scales. The inevitable model spin-up often results in an inaccurate simulation of the timing, the location and the severity of convective events. This challenge becomes even more relevant when the model grid spacing is approaching the kilometer scale, mainly because of the lack of high spatiotemporal resolution observations. In this scenario the STEAM (SaTellite Earth observation for Atmospheric Modelling) project, funded by the European Space Agency (ESA), has the aim of investigating to what extent GNSS-derived and Sentinel SAR-derived tropospheric delay data, as well as other Sentinel-derived products (i.e. soil moisture, soil and sea temperature, wind over sea) can be used to better understand and predict, with high spatial-temporal resolution, the atmospheric phenomena resulting in severe rain events and intense atmospheric turbulence. About 400 GNSS stations distributed throughout Italy were processed by the precise point positioning (PPP) technique, by means of the free and open source software goGPS, to estimate zenith total delay (ZTD) time series. Atmospheric phase screens (APS) were generated from Sentinel-1 observations, calibrated and converted to absolute tropospheric delays by using data from the Generic Atmospheric Correction Online Service for InSAR (GACOS). Surface soil moisture maps were retrieved from Sentinel-1 observations, by means of a multi-temporal algorithm that uses time series of Sentinel-1 data and ancillary data, such as a plant water content map, as inputs. Soil and sea temperature are directly available from ESA as level-2 products based on Sentinel-3, as well as the wind field over sea, based on Sentinel-1.
The experimental results concern two intense rainfall events and subsequent floods that occurred in Italy in Autumn 2017. The best results were obtained by assimilating the wind field (in the first test case) and the GNSS-derived ZTD (in the second test case). Promising results were achieved also by performing a combined assimilation of wind field and ZTD, and direct insertion of soil moisture. The outcomes of this study seem to confirm the synergy between high-resolution numerical weather models and a set of GNSS-derived and Sentinel-derived Earth Observation products, at least for the forecast of severe rain events.

Keywords: GNSS, SAR, Sentinel, NWP, Assimilation

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An analysis of tropospheric delays using goGPS software on all GEONET stations during the passage of Typhoon Jebi in September 2018

*Andrea Gatti[1], Eugenio Realini[1], Giulio Tagliaferro[1]

1. Geomatics Research & Development srl

Nowadays, tropospheric delays estimated from GPS observations are widely used for studying weather events all over the world. Some meteorological agencies already use Zenith Tropospheric Delays (ZTD), or similar observables, by assimilation into numerical weather prediction (NWP) models; however, the increasing number of satellites from newer GNSS constellations (Galileo, QZSS, BeiDou, IRNSS), the advent of low-cost receivers and the advancement of techniques and models left space for further studies on the topic.

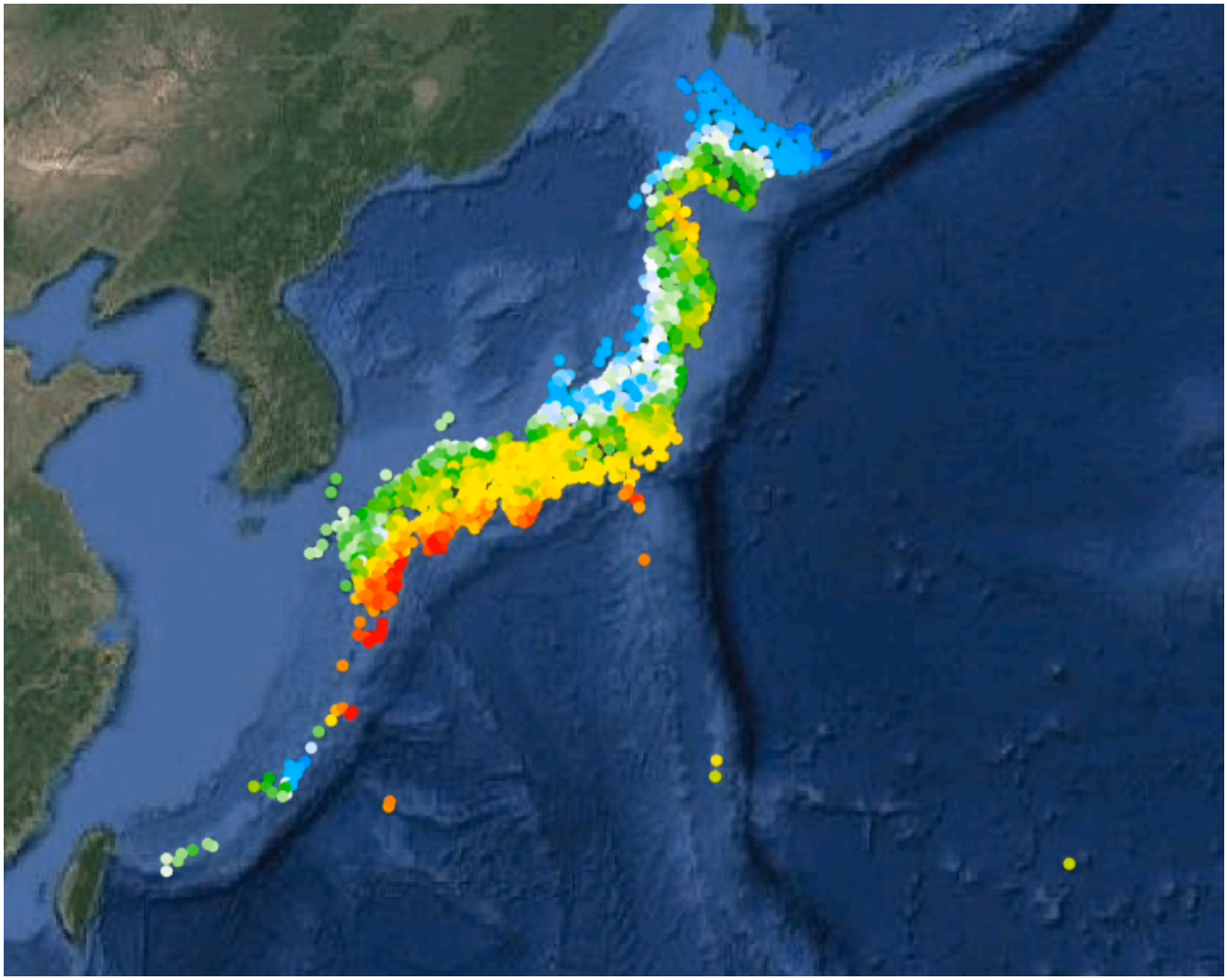
The new version of the open-source goGPS MATLAB software has been written to be a simple tool to perform efficient analysis of GNSS data from both geodetic and low-cost receivers. With its capability to download automatically all the resources needed by the selected algorithms, the relative easiness of use, and its flexibility with the possibility of trying different configurations in a fast way, goGPS presents itself as a convenient tool for students or researches who want to prototype new algorithms or perform studies on GNSS data.

To demonstrate the capabilities of the software, 1312 stations of the Japanese GEONET GNSS network are processed from September 2, 2018, to September 5, 2018, during the passage of Typhoon Jebi.

A 32-core machine running MATLAB 2016a and the latest beta version of goGPS 1.0 is used to process in a single parallel run the entire 4 days of the dataset. The execution performs for all the stations a multi-epoch precise point positioning (PPP) least squares (LS) adjustment in about two hours of computation time. Series of tropospheric delays and gradients are generated and used to produce maps and animations in order to observe the development of the event. Different solutions including multi-constellation results are presented and discussed.

Keywords: GNSS, Troposphere, Software, Typhoon

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-TT 計測技術・研究手法

2019年5月27日(月) 10:45 ~ 12:15 | 104 1F

[M-TT46] 統合地球観測システムとしてのGPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Takuya Tsugawa

GNSSは、大気圏、電離圏、固体地球の基盤となる統合観測システムとなっている。地上及び宇宙基地型GNSS観測は、2006年より数値気象予報の改善に貢献している。近年では反射波を用いて高度、地面粗度、土壌水分、積雪深、湿度や植生インデックスを導出する研究が発展している。船舶やブイなど海洋上のGNSS観測は、海面高度に加えて海洋上の水蒸気観測の能力を持つ。Multi-GNSSがもたらす観測データの増加は、統合地球観測システムとしてのGNSSの能力を拡大させる。
本セッションの目的は、GNSS研究の最新成果を共有し、あらたな学際研究を促進することにある。GNSSを用いた大気（対流圏、電離圏）、GNSS-R、またGNSS-音響観測による海底測位のようなの異なる観測の統合に関する投稿を歓迎する。

10:45 ~ 11:05

[MTT46-06] 全球GNSS-TEC観測データを用いた磁気嵐時の電離圏ダイナミクスに関する新知見

★招待講演

*新堀 淳樹[1]、大塚 雄一[1]、惣宇利 卓弥[1]、津川 卓也[2]、西岡 未知[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)

11:05 ~ 11:20

[MTT46-07] Ionospheric space weather studies for GNSS users

*津川 卓也[1]、穂積 コンニャナット[1]、Jamjareegulgarn Punyawi[2]、Pornchai Supnithi[2]、斎藤 享[3]、大塚 雄一[3,4]、浜 真一[1]、直井 隆浩[1]、石井 守[1] (1.情報通信研究機構、2.KMITL、3.電子航法研究所、4.名古屋大学)

11:20 ~ 11:35

[MTT46-08] QZSS-TECでみる電離圏

*日置 幸介[1] (1.北海道大学大学院理学研究院地球惑星科学部門)

11:35 ~ 11:50

[MTT46-09] Precise estimation of total electron content by double-shell model using local receiver network

*丸山 隆[1,2]、穂積 コンニャナット[1]、G Ma[2]、Q Wan[2] (1.国立研究開発法人情報通信研究機構、2.中国科学院国家天文台)

11:50 ~ 12:05

[MTT46-10] Investigation of sea surface height detection by Global Navigation Satellite System Reflectometry (GNSS-R)

*磯口 治[1]、市川 香[2]、北澤 幸人[3] (1.（一財）リモート・センシング技術センター、2.九州大学、3.JAXA 宇宙科学研究所)

12:05 ~ 12:15

[MTT46-11] Discussion

全球GNSS-TEC観測データを用いた磁気嵐時の電離圏ダイナミクスに関する新知見

A new perspective of the storm-time dynamics of the ionosphere using global GNSS-TEC observation data

*新堀 淳樹[1]、大塚 雄一[1]、惣宇利 卓弥[1]、津川 卓也[2]、西岡 未知[2]
*Atsuki Shinbori[1], Yuichi Otsuka[1], Takuya Sori[1], Takuya Tsugawa[2], Michi Nishioka[2]

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The Earth’s atmosphere is divided into four regions: troposphere, stratosphere, mesosphere and thermosphere by the temperature structure. A part of neutral gases in the mesosphere and thermosphere is ionized by solar extreme ultraviolet (EUV) radiation in a wavelength of less than 100 nm. The region having the ionized gasses (plasmas) is called the ionosphere. The height profile of the electron density in the ionosphere becomes maximum at a height of 300 km is determined by the chemical and dynamical processes in addition to the solar EUV ionization. Due to the interaction between the ionospheric electrons and electric fields of electromagnetic waves, the ionosphere gives a significant influence on the ionospheric transmissions with satellites for communications, positioning, and navigation. The ionosphere changes greatly in association with the activities of the sun, magnetosphere, and the lower atmosphere, and their ionospheric variations interfere with satellite communication and enhances satellite positioning errors in the Global Navigation Satellite System (GNSS), including GPS. The most major factor of the positioning errors is the propagation delay of GNSS signals in the ionosphere. Therefore, a global total electron content (TEC) map or ionospheric model is required to investigate global ionospheric variations associated with geomagnetic storms and lower atmospheric activities and to evaluate the ionospheric delay for GNSS positioning. A scale of the ionospheric variations (traveling ionospheric disturbances (TIDs), equatorial plasma bubbles (EPB), auroral ionospheric irregularity) is in a range between several 100 km and 1000 km. A storm enhanced density (SED) phenomena observed in the mid- and low-latitude ionosphere during the main phase of geomagnetic storms appears with a wide longitudinal extent. In order to clarify generation and propagation mechanisms of these ionospheric phenomena and to investigate their effects on the GNSS positioning, dense and wide-coverage ionospheric observations and the corresponding TEC data are needed. Under these backgrounds, we have built a global TEC database (absolute TEC, detrended TEC, and ROTI) with high time and spatial resolutions and developed a TEC data analysis system in a corroboration with NICT and the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) and PWING (Study of dynamical variation of particles and waves in the inner magnetosphere using ground-based network observations) projects. For the development of the TEC database, we have collected all the available GNSS receiver data in the world. The number of the GNSS stations reaches more than 8500 in January 2019. These GNSS data are provided by the International Geoscience Services (IGS), the University NAVSTAR Consortium (UNAVCO), Scripps Orbit and Permanent Array Center (SOPAC), and other global and regional data centers (more than 50 data providers in all). In this talk, we introduce an overview of recent new scientific results of temporal and spatial variations in the ionosphere during the development and decay of geomagnetic storms as seen in the global GNSS-TEC variations.

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キーワード：全地球測位システム、電離圏、磁気嵐、測位誤差、全電子数、データベース
Keywords: Global Navigation Satellite System (GNSS), Ionosphere, Geomagnetic storm, Positioning error, Total electron content (TEC), Database

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Ionospheric space weather studies for GNSS users

*津川 卓也[1]、穂積 コンニャナット[1]、Jamjareegulgarn Punyawi[2]、Pornchai Supnithi[2]、斎藤 享[3]、大塚 雄一[3,4]、浜 真一[1]、直井 隆浩[1]、石井 守[1]
*Takuya Tsugawa[1], Kornyanat Hozumi[1], Punyawi Jamjareegulgarn[2], Supnithi Pornchai [2], Susumu Saito[3], Yuichi Otsuka[3,4], Shinichi Hama[1], Takahiro Naoi[1], Mamoru Ishii[1]

1. 情報通信研究機構、2. KMITL、3. 電子航法研究所、4. 名古屋大学
1. NICT, 2. KMITL, 3. ENRI, 4. Nagoya Univ.

NICT has observed ionosphere using Ionosondes and GNSS receiver networks in Japan and Southeast Asia for the nowcast and forecast of the ionospheric condition.Two-dimensional ionospheric total electron content (TEC) maps have been derived from dense ground-based GNSS receiver networks and applied to studies of various ionospheric disturbances since mid-1990s. For the purpose of monitoring and researching ionospheric conditions and ionospheric space weather phenomena, we have developed TEC maps over Japan using GEONET. Currently, we are providing high-resolution two-dimensional maps of absolute TEC, detrended TEC, rate of TEC change index (ROTI), and loss-of-lock on GPS signal over Japan in real-time basis.

We have collected all the available GNSS receiver data in the world to expand the TEC observation area. To expand the two-dimensional TEC observation are with high-resolution, we have conducted Dense Regional And Worldwide International GNSS TEC observation (DRAWING-TEC) project, which consists of the three items: (1) standardizing GNSS-TEC data, (2) developing a new high-resolution TEC mapping technique, and (3) sharing the standardized TEC data or the information of GNSS receiver network. One of other effective methods to expand TEC observation area would be to use the maritime GNSS buoys.

NICT have started a new research project to validate the ionospheric effect of precise positioning technique using GNSS including quasi-zenith satellite (QZSS) since 2017. In this project, we will investigate ionospheric effects on individual positioning techniques (single frequency, DGPS, and RTK-PPP) and consider methods to mitigate and/or prevent the positioning errors under sever ionospheric conditions. We have tried to use multi-GNSS data including GPS and QZSS for routine data collection and processing. In the Southeast Asia, it is important to identify which satellite-receiver path suffers from plasma bubble structures for verifying the ionospheric effects on GNSS positioning. we have a plan to install VHF radar at Chumphon (Thailand) and multi-GNSS receivers at Chumphon, Bac Lieu (Vietnam), and Cebu (Philippines) at the magnetic equator.

キーワード：電離圏、GNSS、宇宙天気
Keywords: Ionosphere, GNSS, Space Weather

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QZSS-TECでみる電離圏
QZSS geostationary satellite for ionospheric TEC observations

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Most Global Navigation Satellite System (GNSS) satellites employ orbital periods with a half sidereal day. This makes the satellites move rapidly in the sky when observed from ground receivers. This is important in relative positioning by observing carrier phases and in estimating zenith tropospheric delays. However, measurement of ionospheric total electron content (TEC) could be done instantaneously by comparing phases of the two carrier waves, and the changes in the satellite azimuth and elevation becomes a nuisance. The change in STEC (slant TEC) comes from (1) temporal change and (2) spatial changes of ionosphere, and (3) apparent U-shaped changes coming from the elevation changes. We can mitigate (3) by using VTEC, i.e. removing the inter-frequency biases and multiplying the bias-free STEC with cosine of the line-of-sight penetration angle. Nevertheless, discrimination of (1) and (2) is difficult and becomes possible only by processing the whole data sets of dense networks. The Japanese Quasi-zenith Satellite System (QZSS) is currently composed of four satellites, 3 satellites with quasi-zenith orbits (PRN01, 02, 03) and 1 satellite with geostationary orbit (PRN07). The latter enables continuous observation of certain points in ionosphere fixed to the Earth, i.e. the changes in TEC come entirely from temporal changes.

The Japanese GEONET network GNSS receivers continuously track GPS, GLONASS, Galileo, and QZSS, and their raw data are available on line as the RINEX (Receiver independent exchange format) Ver.3.02 files. I made a software system to read them and convert the phase data to TEC time series. With TEC observations from the geostationary satellite, we could study temporal changes in ionosphere without being bothered by spatial variations. This implies certain benefits in studying ionospheric disturbances, such as LSTID (Large-Scale TID), MSTID (Medium-scale TID) (Otsuka et al., 2011), Es (sporadic-E) (Maeda & Heki, 2015), artificial ionospheric electron depletion due to launches of satellites and ballistic missiles (Hashimoto & Heki, 2018), and preseismic ionospheric anomalies (Heki, 2019). In contrast, geostationary satellites are not suitable for studying coseismic ionospheric disturbances by acoustic waves (Cahyadi & Heki, 2015) and those by volcanic eruptions (Nakashima et al., 2015). This is because stronger signals always appear in poleward line-of-sights from ground stations located at the equatorward side of the epicenters/volcanoes (Heki, 2019).

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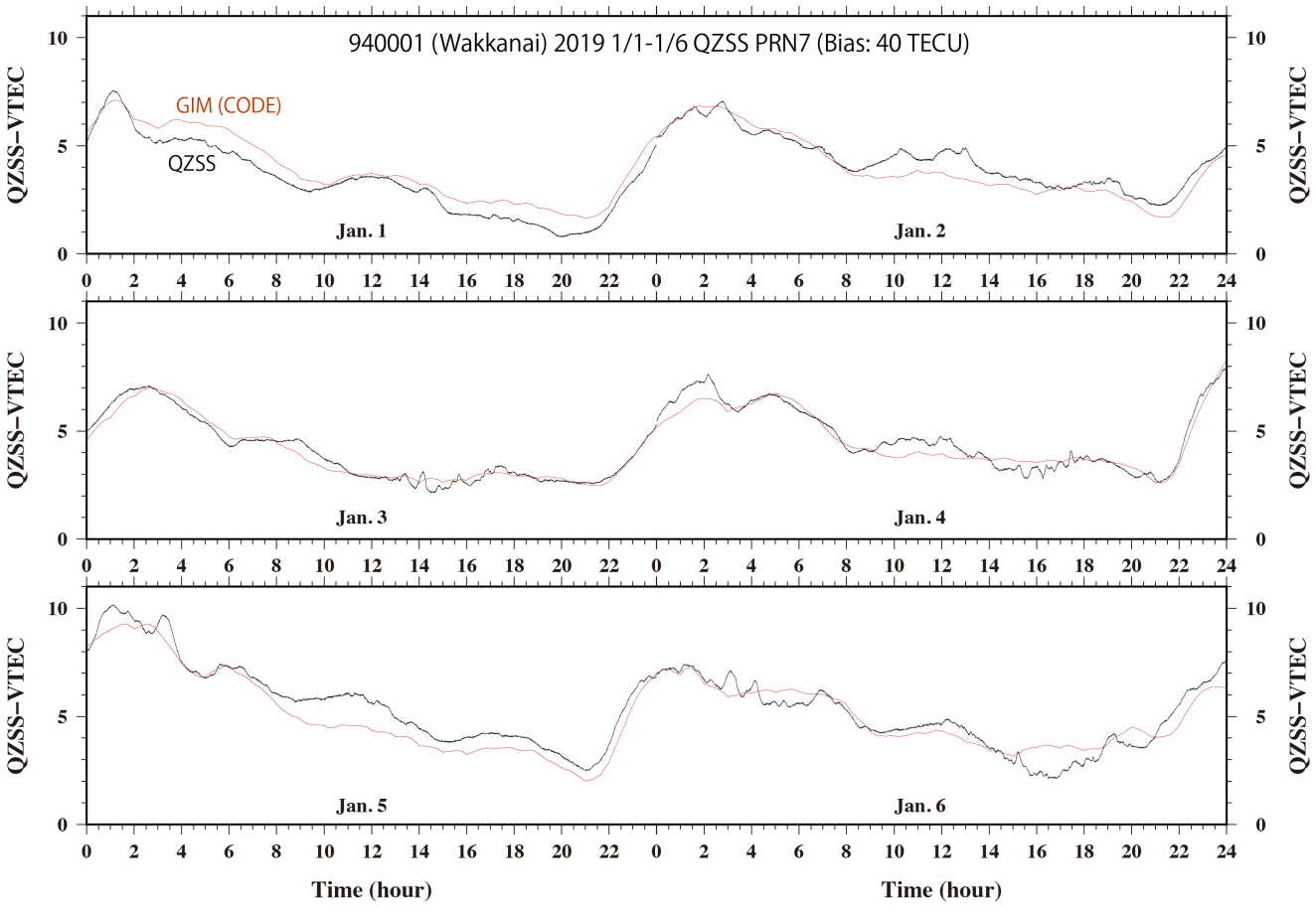
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キーワード：GNSS-TEC、準天頂衛星システム、電離圏擾乱
Keywords: GNSS-TEC, QZSS, ionospheric disturbance



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Precise estimation of total electron content by double-shell model using local receiver network

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The total electron content (TEC) derived from the differential group delay of the code signals of GNSS on two frequencies has been a basic parameter in ionospheric studies. In most applications, the thin-layer approximation is used to convert the measured slant TEC to vertical TEC at the ionosphere pierce point. Usually the thin-layer height is assumed to be constant regardless of the location and time, which is unrealistic and can be a source of error in TEC estimations. This is a serious problem at low latitudes where the ionospheric height greatly varies by the action of the vertical EXB drift due to the zonal electric field and field-aligned transport due to the meridional neutral wind drag. In this paper, we parameterized the ionosphere by two thin-layers (double-shell model) at 250 and 1100 km to avoid this inconvenience. The variation of partial electron content related to each layer was approximated by the spherical harmonics expansion to minimize the error of slant TEC between the measurements and the sum of contribution from the two layers. In the harmonics expansion calculation, the longitude parameter was the sun-fixed longitude or the local time measured in angle. Thus data obtained in a whole day were used. Another problem with the conventional technique is the leveling procedure, where phase measurements with a small noise are leveled to the noisy code signal data. Therefore, noises and multipath effect on the code delay are not resolved by the leveling. To avoid this inconvenience, the leveling to the code data was not applied in our study. Instead, the total bias including instrumental (satellite and receiver) code biases and phase ambiguity for each arc (i.e., total arc bias) was determined in conjunction with TEC.
The technique was applied to datasets obtained by a local receiver network near the magnetic equator. Results were compared with those of the conventional (single) thin-layer model. A significant difference was found in the ratio of TECs at the equatorial anomaly crests and trough. The double-shell model captured the equatorial anomaly more correctly than the conventional method. Another outcome of the double-shell model was the different patterns of TEC variations at the two heights, as expected. Equatorial anomaly crests and the evening TEC bite-out at the equator were prominent in the lower shell. The TEC peak at the higher shell appeared later than the lower shell. Two shells exhibited different features of north-south asymmetry of TEC, depending on the local time. These results provide information on the ionospheric dynamics, such as the ionosphere-thermosphere coupling through the field-aligned transport and variations of the evening enhancement of zonal electric field.

キーワード：電離圏全電子数、二重薄殻モデル、赤道異常
Keywords: TEC, double-shell model, equatorial anomaly

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Investigation of sea surface height detection by Global Navigation Satellite System Reflectometry (GNSS-R)

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1. RESTEC, 2. Kyushu Univ., 3. ISAS/JAXA

In recent years, the possibility of detecting ocean parameters such as sea surface height (SSH), ocean wind from the Global Navigation Satellite System reflectometry (GNSS-R) was shown. The Cyclone GNSS (CYGNSS) mission aiming to contribute to the forecast of extreme weather phenomena by observing the sea surface wind in the cyclone is in progress operating eight small satellites and ocean wind speed products are being delivered. In GNSS-R, it is theoretically possible to measure the SSH from the ellipsoid by measuring the delay of the reflected wave and the direct wave. The investigation of SSH detection using TDS-1 which was developed and operated mainly by Surrey Satellite Technology Ltd (SSTL) in the UK has been reported. Even in our group, SSH detection was performed using TDS-1 data observed near Japan and the detected ones was compared with the mean SSH constructed by the altimeter observations. It was confirmed that the SSH can be detected with an error of about 1m at observation with good conditions (antenna gain is 7.5 dBi or more). Regarding CYGNSS, SSH is not calculated as an official product and it is limited to detectability study. In this report, we used CYGNSS data to investigate SSH detection from GNSS-R like TDS-1.

The CYGNSS data used for the present study is a full resolution Delayed Doppler Map (DDM) provided as special data through the GNSS Reflectometry for Ocean Waves, Tides and Height (GROWTH) project, which is a member of NASA CYGNSS External Science Member. The size of DDM is 20 (Doppler) ×128 (Delay) bin. On the other hand, the size of the normal DDM is 11 (Doppler) ×17 (Delay) bin in the Level 1 ver 2.1 data provided by NASA's The Physical Oceanography Distributed Active Archive Center (PO.DAAC). Thus, the data are compressed to 1/2 in the doppler direction and 1/8 in the delay one. Since the resolution in the delay direction affects the range measurement, it is expected that the detection resolution by the full DDM will be improved over the usual L1 data. The data provided was data acquired mainly in the East China Sea and acquired for the purpose of demonstrating the possibility of detecting the SSH related to the large tide amplitude.

Since the provided full resolution data are those in which only a part of data on DDM is stored, L1 ver 2.1 data at the same time were collected and the positions of the transmitting GNSS satellite and the receiving CYGNSS, the position of the reflection point and the delay information of the reflection point corresponding to the full DDM were extracted to calculate the SSH. A random variation of about 6m in standard deviation was confirmed in the delay information of the reflection point, so we with calculated weighed average with the 1/e scale of 75 km after excluding the abnormal values. Based on the above information, the SSH along the reflection point was calculated and compared with the mean SSH data calculated based on the altimeter data. A large spatial error that can be approximated by a linear equation of the distance was confirmed for the difference between the two SSHs, and therefore the relative SSH was evaluated by subtracting the approximate expression. The RMS error along the 4 passes of the observation on April 18, 2018 was about 0.8 m to 1.5 m, which was almost the same accuracy as TDS-1.

In the present study, the possibility of SSH detection as a spatial relative altitude was suggested. However

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since the large spatial error remains, whether the SSH variation in the East China Sea with O (1 m) can be detected will be a subject for further study. In particular, since corrections to the ionosphere and the troposphere delays have not been made at the stage of this study, it is considered necessary to estimate their influences from model data.

キーワード：GNSS反射波、海面高度、CYGNSS
Keywords: GNSS-R, Sea surface height, CYGNSS

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[E] 口頭発表 | セッション記号 M (領域外・複数領域) | M-TT 計測技術・研究手法

[M-TT46] 統合地球観測システムとしての GPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Takuya Tsugawa

2019年5月27日(月) 10:45 〜 12:15 104 (1F)

GNSSは、大気圏、電離圏、固体地球の基盤となる統合観測システムとなっている。地上及び宇宙基地型GNSS観測は、2006年より数値気象予報の改善に貢献している。近年では反射波を用いて高度、地面粗度、土壌水分、積雪深、湿度や植生インデックスを導出する研究が発展している。船舶やブイなど海洋上のGNSS観測は、海面高度に加えて海洋上の水蒸気観測の能力を持つ。Multi-GNSSがもたらす観測データの増加は、統合地球観測システムとしてのGNSSの能力を拡大させる。

本セッションの目的は、GNSS研究の最新成果を共有し、あらたな学際研究を促進することにある。GNSSを用いた大気（対流圏、電離圏）、GNSS-R、またGNSS-音響観測による海底測位のようなの異なる観測の統合に関する投稿を歓迎する。

12:05 〜 12:15

[MTT46-11]Discussion

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-TT 計測技術・研究手法

2019年5月27日(月) 15:30 ~ 17:00 | 106 1F

[M-TT46] 統合地球観測システムとしてのGPS/GNSSの新展開

コンビーナ:小司 禎教(気象研究所気象衛星・観測システム研究部第２研究室)、市川 香(九州大学応用力学研究所)、太田 雄策(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)、津川 卓也(情報通信研究機構)、座長:Yoshinori Shoji(Meteorological Research Institute)

GNSSは、大気圏、電離圏、固体地球の基盤となる統合観測システムとなっている。地上及び宇宙基地型GNSS観測は、2006年より数値気象予報の改善に貢献している。近年では反射波を用いて高度、地面粗度、土壌水分、積雪深、湿度や植生インデックスを導出する研究が発展している。船舶やブイなど海洋上のGNSS観測は、海面高度に加えて海洋上の水蒸気観測の能力を持つ。Multi-GNSSがもたらす観測データの増加は、統合地球観測システムとしてのGNSSの能力を拡大させる。
本セッションの目的は、GNSS研究の最新成果を共有し、あらたな学際研究を促進することにある。GNSSを用いた大気（対流圏、電離圏）、GNSS-R、またGNSS-音響観測による海底測位のようなの異なる観測の統合に関する投稿を歓迎する。

15:30 ~ 15:45

[MTT46-12] Study on tropospheric delay variations extracted from a short baseline analysis and their application to meteorological observation

*吉原 貴之[1]、斎藤 享[1]、毛塚 敦[1]、齊藤 真二[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

[MTT46-13] Water vapor estimation using digital terrestrial broadcasting waves
- Field test in Tokyo metropolitan area and trial production of small devices -

*川村 誠治[1]、花土 弘[1]、太田 弘毅[1]、松村 喜修[2]、森 良輔[2]、野田 一善[2]、長谷川 照晃[2] (1.国立研究開発法人 情報通信研究機構、2.株式会社ソシオネクスト)

16:00 ~ 16:15

[MTT46-14] 920MHz通信無線の伝搬遅延計測による水蒸気推定

*志賀 信泰[1]、安田 哲[1]、川村 誠治[1]、花土 弘[1]、市川 隆一[1]、岩井 宏徳[1]、佐藤 晋介[1] (1.国立研究開発法人　情報通信研究機構)

16:15 ~ 16:30

[MTT46-15] Comparison of a water vapor observation with GPS and high sensitivity microwave radiometer, KUMODeS

*長崎 岳人[1]、田島 治[2]、市川 隆一[3]、瀧口 博士[4]、荒木 健太郎[5]、石元 裕史[5] (1.大学共同利用機関法人　高エネルギー加速器研究機構　素粒子原子核研究所、2.京都大学、3.国立研究開発法人　情報通信研究機構、4.国立研究開発法人　宇宙航空研究開発機構、5.気象庁気象研究所)

16:30 ~ 16:45

[MTT46-16] 局地的豪雨予測のための水蒸気ラマンライダーの開発と観測

*永井 智広[1]、酒井 哲[1]、吉田 智[1]、泉 敏治[2]、横田 祥[1]、瀬古 弘[1]、小司 禎教[1]、白石 浩一[3] (1.気象庁　気象研究所、2.気象庁、3.福岡大学)

16:45 ~ 17:00

[MTT46-17] Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

*小司 禎教[1]、加藤 照之[2]、寺田 幸博[3]、津田 敏隆[4]、矢吹 正教[4] (1.気象研究所気象衛星・観測システム研究部第２研究室、2.神奈川県温泉地学研究所、3.高知工業高等専門学校、4.京都大学生存圏研究所)

Study on tropospheric delay variations extracted from a short baseline analysis and their application to meteorological observation

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This paper discusses variation of 10cm order in tropospheric delay differences between two ground-based GNSS stations, which are located with a horizontal scale of about 2km. This typical value of tropospheric delay differences is represented as a tropospheric delay difference projected to the zenith direction for a common satellite between the two stations. The variation also corresponds to an order of 50 mm/km in tropospheric delay spatial gradient. Such large differences of tropospheric delay with short baselines of several 100m had been reported in safety assessment and validation activities for aircraft high category precision approach and landing system called as GBAS (Ground-Based Augmentation System) [1,2,3]. They also reported that their temporal variations are highly correlated with the surface wind velocities under fine weather conditions.

A GBAS ground station typically has four GNSS stations with separation of several 100m each other. Electronic Navigation Research Institute (ENRI) participated in the safety assessment and validation activities, which were performed to validate draft international standards for high category GBAS. As one of the activities, ENRI developed a prototype system and installed it in New Ishigaki airport (24.40N, 124.25E). The system has the typical four GNSS stations within a horizontal scale of 400m and an additional GNSS station called as ionosphere field monitor (IFM), which is located as about 2km away from the four stations. These GNSS stations consists of dual frequency antenna and receiver and continuously collect GNSS data. Additionally, we set up a different GNSS receiver which can accept multi-RF signal inputs. Combining the receiver with Radio-over-Fiber (RoF) devices, we can use a common clock for signal processing two GNSS signals received at the both ends of the baseline with a length of 2.3km [4]. This additional system enables us to examine a tropospheric difference for each GNSS satellite without correction of difference of receiver clock drift components between two received signals although it is required to distinguish tropospheric delay differences from ionospheric effects and multipath errors using dual frequency measurements and characteristics of multipath variations [5].

In this study, we mainly examine tropospheric delay difference data with the baseline length of 2.3km, including GNSS data collected from the prototype system. Considering geometry of GNSS satellite propagation paths and observational errors, we will discuss candidate meteorological phenomena and application to future meteorological observation.

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キーワード：GNSS、対流圏遅延、短基線、気象観測への応用
Keywords: GNSS, Tropospheric delay, Short baseline, Application to meteorological observation

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Water vapor estimation using digital terrestrial broadcasting waves - Field test in Tokyo metropolitan area and trial production of small devices -

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We have developed a method to measure water vapor in horizontal direction using digital terrestrial broadcasting waves [1]. Radio waves are delayed due to water vapor through propagation. Water vapor can be estimated using propagation delay of digital terrestrial broadcasting waves. The basic idea of using propagation delay is the same as that of retrieving PWV by using GNSS. In this study, we estimate water vapor near a ground surface from the horizontal propagation delay of digital terrestrial broadcasting waves. The main features of this observation are, no need for transmitters (small and low cost due to receiving only), applicability wherever digital terrestrial broadcasting is available, and its high time resolution. Our target is to improve the accuracy of numerical weather forecast for severe weather phenomena such as localized heavy rainstorms in urban areas through data assimilation.
We have developed a real-time delay measurement system with a software-defined radio (SDR) technique, whose main components are USRP-N210 and PC (prototype). Seven measurement systems are now under operation around Tokyo metropolitan area. Although the main source of digital terrestrial broadcasting waves in Tokyo area is the Tokyo Skytree, some small radio towers that transmit Television Saitama, Chiba Television, Television Kanagawa, and do on can be also available. If plural radio waves from different radio towers are available, we can use plural base-lines to estimate water vapor. Outline of demonstration experiment in Tokyo metropolitan area and its initial results are introduced.
Small devices which can measure propagation delay using digital terrestrial broadcasting waves are now under trial production through a joint research by NICT and Socionext. These devices use FPGA for calculate propagation delay of digital terrestrial broadcasting waves. Their size and electricity consumption is smaller than those of prototype. If many small receivers are deployed, 2-D water vapor variations can be monitored with high time and space resolutions. Such a network system will contribute to increasing the accuracy of numerical weather forecast for severe weather phenomena such as localized heavy rainstorms.

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キーワード：水蒸気、伝搬遅延、地上デジタル放送
Keywords: water vapor, propagation delay, digital terrestrial broadcasting

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920MHz通信無線の伝搬遅延計測による水蒸気推定
Water vapor estimation via propagation delay of 920MHz wireless communication signal

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920MHz通信無線チップを用いて伝搬遅延の変動を高精度(6mm)、高頻度(20回／秒)に計測する通信モジュールを開発した。このモジュールを4.25km離れた2地点に設置して直達波の伝搬遅延の変動をモニターしたところ、計測された伝搬遅延の変動は気象測器のデータによって見積もった伝搬遅延とよく一致した。地表付近の水蒸気分布をモニターする目的のためには、本技術による地表水平方向の伝搬遅延計測の方が、主として鉛直方向の伝搬遅延計測を計測するGNSSよりも適している。

本技術が将来的に地表水蒸気の分布を高精度、高頻度、高解像度、かつ安価に計測することを期待して、社会実装への道筋を模索している。

キーワード：水蒸気推定、時空間同期、伝搬遅延計測、通信無線モジュール
Keywords: water vapor estimation, space-time synchronization, propagation delay measurement, wireless communication module



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Comparison of a water vapor observation with GPS and high sensitivity microwave radiometer, KUMODeS

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GPSに代表されるように、大気中を飛翔させた電波を利用した測地システムは近年有効に利用されている。しかしながら、大気を飛翔する電波は水蒸気による遅延を免れることはできなく、特定の測定システムでは不定性の大きな要因となっている。一方、大気中の水蒸気量を同定する装置として地上設置型のマイクロ波放射計が以前より存在する。

新たに開発を行ったマイクロ波放射計”KUMODeS(クモデス)”は、大雨や積乱雲下で生じる竜巻等の局所的・突発的自然災害の早期発見を目的とし、大気中に存在する水分子から放射される輝線 (20-30 GHz 帯) ならびに酸素分子からの輝線 (50-60 GHz 帯) の広いスペクトルを同時に測定する。これにより大気中の水蒸気量等の推定を高精度で行う。クモデスの特徴として、電波天文観測技術の応用により冷却受信機を採用することで高感度(低雑音)を実現した。加えて冷凍機によって冷却する温度較正源を搭載し、遠隔操作での長期運用を可能とし、またこれまでよりも高い空間分解能を得られるシステムとするなど、既存のマイクロ波放射計に対して利便性の向上を図っている。クモデスを用いて、つくば市において半年間以上の長期観測を行った。また同地点にてGPSアンテナによる水蒸気量測定を行い、観測結果の妥当性の検証を行った。加えて、クモデスの発展としてより小型かつ低消費電力を目指した２号機の開発も実施した。本講演では、システムの概要ならびにつくば 市における大気観測の結果を報告する。

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キーワード：大気水蒸気、マイクロ波放射計
Keywords: water vapor, microwave radiometer

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局地的豪雨予測のための水蒸気ラマンライダーの開発と観測
Development and Observation of Water Vapor Raman Lidars for Localized Torrential Rainfall Prediction

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近年、雨の降り方が局地化・集中化し、局地的な豪雨による災害の激甚化が進行している。このような豪雨は、降雨の発生している地域に、大気下層で水蒸気を豊富に含んだ気塊が連続して供給されることが要因の一つであると考えられている。このため、局地的な豪雨を予測するためには、豪雨の風上側において、豪雨に供給される大気下層の水蒸気の鉛直分布を連続観測することが重要である。気象研究所では、水蒸気鉛直分布を測定するためのラマンライダーを開発し、2017年と2018年の夏期に首都圏において観測を行った。装置は、豪雨を発生させる水蒸気が運ばれる大気下層のなるべく低高度から、また、昼夜を問わずに観測を可能とするように注意して設計した。製作したライダーのうちの1台は容易に移動できる可搬型の装置とし、首都圏で発生する豪雨の風上にあたる海岸域の3ヶ所を観測点とした。ライダーで取得した水蒸気混合比のデータを使い、降雨予測のための初期的な数値実験として、ライダーで観測した水蒸気混合比を同化する実験を行ったところ、豪雨の発生が予期される地点の風上側のライダーで観測された水蒸気分布を同化することで、水蒸気の解析場が大きく変化したことが確認できた。さらに、九州で頻発する豪雨の量的な予測を向上させるため、水蒸気ライダー等を展開してデータ同化実験を行う新たな研究計画を開始したところである。

キーワード：水蒸気、ライダー、豪雨、データ同化、天気予報
Keywords: water vapor, lidar, heavy rain, data assimilation , weather prediction

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Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

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Japan is an archipelago located easternmost of East Asia and influenced by the East Asian monsoon, which is characterized by moist air inflow coming from the ocean that often causes heavy rainfall (Kato 2006, Tsuguti and Kato 2014, Kato 2018). From June 28 to July 8, 2018, extreme rainfall frequented western Japan to the Tokai region, wherein more than 1,000 mm, at the maximum of 1,852.5 mm, precipitation was recorded in several regions (Tsuguti et al. 2018). A press release of Japan Meteorological Agency (JMA) (JMA, 2018) attributed the event to the concentration of two massively moist air streams over western Japan and persistent upward flow. With the frequency of extreme precipitation events, water vapor monitoring over the ocean becomes one of the important issues in Japan. Shoji et al. 2009 exhibited the improvement of a heavy rainfall prediction method by assimilating precipitable water vapor (PWV) estimated via the Global Positioning System (GPS) observation network in East Asia, as well as Japan’s nationwide dense GPS network. The result insisted the importance of water vapor monitoring upstream.

Unlike ground-based fixed GNSS stations, ocean-platform (ship and buoy) GNSS measurements face difficulties in analyzing the variable antenna position simultaneously with the atmospheric delay. However, recent advancement of kinematic precise point positioning technology is beginning to overcome these difficulties. Shoji et al (2017) installed two GNSS antennas on a research vessel, the RYOFU MARU of the Japan Meteorological Agency (JMA), and conducted experimental observations to assess the GNSS derived precipitable water vapor (PWV) from October 19, 2016, to August 6, 2017. The GNSS derived PWVs showed good agreement with the radiosonde observations on the vessel (1.7 mm root mean square difference, −0.7 mm bias, and 3.6% rejection rate).

Kato et al. (2018) introduced a GNSS buoy system for a synthetic geohazard monitoring. The buoy is located about 40 km south of Cape Ashizuri, west of Shikoku, Japan. We succeeded continuous PWV retrieval from June to September 2018. Retrieved PWVs vividly captured water vapor variations associated with north-south shifting of the “BAIU” seasonal rain front and passages of heavy rainfalls and typhoons. The GNSS buoy PWVs also suggest that, compared to over land, uncertainty of water vapor field in JMA’s objective analysis is larger over the ocean (Shoji et al. 2019).

In the year of 2018, we started a new research project to monitor PWV over the ocean west of Kyushu, Japan, getting supports from eight vessels (six regular line cargo vessels, one fisheries research vessel, and one JMA’s research vessel). The purpose of this study is to assess the impact of water vapor monitoring in upward of west Japan on heavy rainfall prediction. Preliminary PWV analyses show about 3 mm rms with about -1 mm bias against JMA’s operational regional objective analysis.

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キーワード：水蒸気、豪雨、GNSS
Keywords: Water Vapor, Heavy rainfall, GNSS

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